The Diversity of Debt Crises in Europe

Jerome L. Stein

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Abstract

The foreign debts of the European countries are at the core of the current crises. Generally, the crises are attributed to government budget deficits in excess of the values stated in the Stability and Growth Pact (SGP)/Maastricht treaty. Proposals for reform generally involve increasing the powers of the European Union to monitor fiscal policies of the national governments and increasing bank regulation. My article is concerned with the following issues. [Q1] How can one explain the inter country differences in the debt crisis in Europe? Is there a single explanation, cause? [Q2] Specifically, were the crises due to government budget deficits or to the private sector? The answer will determine what is the appropriate policy to prevent a recurrence. [Q3] The Stability and Growth Pact/Maastricht Treaty and the European Union focused upon rules concerning government debt ratios and deficit ratios. They ignored the problem of "excessive" debt ratios in the private sector that led to a crisis in the financial markets. Neither the markets nor the Central Banks anticipated the crises until it was too late. My basic questions are: What is an "excessive" private sector debt ratio that is likely to lead to a crisis? What are theoretically based, not empirical ad hoc, Early Warning Signals (EWS) of debt crises? The answers determine to a large extent how one should evaluate proposals for economic reform, to avert future crises?

Jerome L. Stein
Department of Economics
Brown University
Providence / USA
Jerome_Stein@Brown.edu

Basic Statistics related to the Origins of the Crises.

Table 1 presents the Government Structural Balance as a percentage of potential GDP. It refers to the general government cyclically adjusted balance adjusted for nonstructural elements beyond the economic cycle. Table 2 presents the Government Net Debt as a percent of GDP. Both are derived from EconStats, IMF, World Economic Outlook.

Table 1. Government Structural Balance % GDP (SBGDP)

	Euro	Spain	Ireland	Portugal	Greece
1998	-2.03	-1.736	1.219	-3.4	-2.86
1999	-1.6	-1.02	0.269	-3.38	-1.89
2000	-1.969	-1.22	1.673	-4.7	-2.68
2001	-2.676	-1.757	-1.8	-5.5	-3.647
2002	-2.86	-1.1	-2.757	-4.9	-4.1
2003	-3.1	-0.976	-3.167	-4.89	-6.03
2004	-2.98	-0.978	-2.75	-5.2	-8.638
2005	-2.67	-1.598	-3.756	-5.7	-6.01
2006	-2.07	-1.275	-4.0	-3.9	-4.9
2007	-1.83	-1.132	-7.3	-3.4	-6.795
2008	-2.58	-4.9	-11.26	-4.02	-11.47
1998-2007, Mean (st. dev.)	-2.38 (0.54)	-1.28 (0.31)	-2.24 (2.71)	-4.5 (0.09)	-4.76 (2.11)

Sources: Tables 1,2. EconStats, IMF World Economic Outlook

Table 1 shows that the General government structural balances as a percent of potential GDP (SBGDP) in Greece and Portugal are different from Ireland and Spain. The last row contains the mean and standard deviation in the *pre crisis period 1998 - 2007*. In Greece and Portugal the SBGDP have been on average twice as high as in the Euro area, whereas in Spain the SBGDP have been significantly lower and in Ireland they have been similar to the Euro area.

Table 2 presents the ratio of Government debt as a percentage of GDP. When the crisis in the private banking sector occurred in some countries particularly Ireland and Spain, the government bailed out the banks by purchasing private debt in exchange for public debt. The government/taxpayers then became the debtor to foreign investors. The effect of the government bailout of the private banking sector is seen in row labeled 2009/2007. It is the government net debt ratio in the post crisis year 2009 relative to its level in the pre crisis year 2007. The difference relates both to the bailout and to the loss of tax revenues from the recession.

Table 2 shows that the government debt ratio and hence debt burden – interest payments/GDP –was rising in Greece and Portugal from 1998 to 2007 before the crisis. The ratio of debt burden in the row 2007/1998 was Portugal 1.42, Greece 1.16, Spain 0.53 and Ireland 0.43. One infers from these two tables that the trend in fiscal policy/government budgetary policy – where structural deficits led to debt burdens - was primarily at the origin of the crises in Greece and Portugal, whereas the origin of the crisis in Ireland and Spain (explained below) was primarily the private banking sector and subsequent government bailout. The crucial questions answered below are what are the origins of these public and private debts and what are "excessive" debts?

Table 2. Government net Debt % GDP.

	Spain	Ireland	Portugal	Greece
1998	57.37	53.22	42.96	71.73
1999	54.48	47.8	42.01	75.85
2000	50.27	36.67	41.97	77.41
2001	47.54	27.3	46.39	81.15
2002	44	25.13	48.12	84.47
2003	41.3	22.7	51.22	81.93
2004	38.58	19.94	53.28	82.88
2005	34.71	15.92	57.95	84.07
2006	30.53	12.16	58.77	81.66
2007	26.52	12.18	58.1	80.35
2008	30.36	23.04	61.13	83.4
2009	43.73	36.41	72.08	96.83
1998-2007 mean (sd)	42.53 (10.16)	27.3 (14.53)	50.08 (6.77)	80.25 (4.14)
2009/2007	1.65	2.99	1.24	1.21
2007/1998	0.53	0.43	1.42	1.16

Role of the private sector in the crises in Ireland and Spain

In Ireland and Spain the structural budget deficits were lower than in the Euro area (table 1). In these countries, the private sector – housing and banks - was the origin of the debt crisis. First, I describe what happened in these countries. Second I explain the economics underlying the bubble/crash, which leads into an analysis of Early Warning Signals.

Ireland

I draw upon The Irish Banking Crisis (2010). The Celtic Tiger boom in the late 1980s brought sustained growth in employment, income and household formation. Ireland's becoming a founding member of the Euro zone brought a sustained fall in nominal interest rates, which in turn led to higher asset valuations. The growing construction boom was financed by Irish banks which in turn were financed by external financial markets where inexpensive funds were available. In the last four years of the boom from 2003 onwards banks competed aggressively in the mortgage markets with little regard for the creditworthiness of the mortgagors. At the end of 2003, net indebtedness of Irish banks to the world was over 10% GDP. By 2008, borrowing mainly for property jumped to over 60% GDP.

Even before the failure of Lehman Brothers (Sept. 2008) Irish residential properties had been falling for more than eighteen months. At no point throughout the period – even as the crisis neared - did the Central bank and Financial Services Authority of Ireland staff believe that any of the institutions were facing serious underlying difficulties let alone insolvency problems.

When the crisis occurred, the collapse of construction and the fall in property prices led to the insolvency of banks. Their net worth vanished. The state took large equity stakes in most banks and issued government guaranteed bonds. Although Ireland's public debt immediately prior to the crisis was low, the fiscal deficit and public sector borrowing surged. See table 2 row labeled 2009/2007. The primary reason for the surge in the deficit was the collapse of tax revenues in 2008-09 due to the collapse of the housing sector.

Spain

I draw upon Banco de Espana report (2008). Throughout the 1989-2006 period, demand in the Spanish economy grew at 4.7% pa whereas output expanded by 3.8% pa, driven by immigration and increased labor force participation. There was scarcely any

growth in productivity. Since absorption exceeded production, external debt grew and the real exchange rate – equal to the nominal rate times relative prices - appreciated. Insofar as the nominal exchange rate was fixed in the Euro area, Spanish prices and costs rose relative to the rest of the Euro area. The Spanish economy lost competitiveness.

Unlike previous expansions, the resort to financing was not chiefly by the public sector which reduced its debt throughout the period. See table 2. Instead it was the Spanish households and firms that swiftly increased their debts. The real estate market propelled the expansion. Housing prices climbed from an average rate of 1% pa between 1995- 97 to 18% pa between 2003-04, or an annual average increase between 1995-2007 of 10%.

What facilitated the growth in the debt was the availability of cheap credit in the international financial markets. As a result, the Spanish economy, which needed virtually no foreign funding in 1996, became a borrower. In 2008 total net borrowing from the rest of the world was 9.1 % GDP.

When housing prices fell, the banks – which financed the housing sector - were unable to repay their loans to the international lenders. Governments responded forcefully to the intensification of the financial crisis. At first, measures had focused on the selective bail-out of ailing systemic banks, supplementing the actions of central banks to prevent liquidity problems in the banking sector from becoming insolvency problems. However, the risks of financial collapse and the increasingly evident and heightened prospect of global recession led to the widespread approval of plans to support the financial sector and to boost aggregate demand via fiscal stimulus. The breadth of the measures adopted and the volume of resources mobilized were on an unprecedented scale. The *effect* of the crisis raised the ratio of government debt 2009/2007 in table 2 to 1.65.

Quantitative summary of the role of the private sector in the European Crises: Growth, Housing price appreciation/capital gains and low interest rates

In Ireland and Spain, unlike Greece and Portugal, the private sector – housing and banks - was the origin of the debt crisis. Table 3 and figure 1 provide a quantitative summary of this phenomenon among countries.

The low world rates of interest and high domestic growth led to a rise in housing prices. In the period 1991-2000 the growth rates in Ireland and Spain were very high, and generated a boom in housing prices.

Table 3 indicates the large capital gains resulting from investment in housing in Ireland and Spain, relative to the Euro area. The mean capital gain was Ireland 13.2%, Spain 9.71% and the Euro area 5.16%. Irish and Spanish banks borrowed abroad at low rates of interest (see figure 1) and loaned these funds to the housing industry. The anticipated return was the marginal product of capital plus the anticipated capital gain. Investors within and without the Euro area ignored the default risk and creditors in the Euro area did not have to consider an exchange rate risk.

Table 3. Residential property prices EU countries, annual % change, new and existing houses.

	Germany	Ireland	Greece	Portugal	Spain	Italy	France	Euro area
1996	-1.1	-	9.9	1.7	1.4	2.4	-	2.0
1997	-1.9	-	8.2	3.6	2.8	3.4	0.1	2.3
1998	-1.6	22.6	14.4	4.5	5.8	-1.4	1.9	2.5
1999	1.4	22.5	8.9	9	7.7	0.8	7.1	4.9
2000	0.2	20.5	10.6	7.7	8.6	3.9	8.8	6
2001	0.2	14.0	14.4	5.4	9.9	6.0	1.9	5.5
2002	-1.9	6.1	13.9	0.6	15.7	12.6	8.3	6.8
2003	-1.2	14.3	5.4	1.1	17.6	7.2	11.7	6.4
2004	-1.4	11.5	2.3	0.6	17.4	7.0	15.2	7.2
2005	-1.5	7.2	10.9	2.3	13.4	8.6	15.3	7.6
2006	0.3	13.4	12.2	2.1	10.4	5.8	12.1	6.4
2007	0.3	0.9	-	1.3	5.8	5.0	6.1	4.3
Mean	-0.68	13.3	10.1	3.3	9.71	5.11	8.05	5.16
St.dev.	1.1	7.23	3.8	2.8	5.43	3.7	5.27	1.97

Source: BIS Housing Statistics IFC Bulletin #31 annex 1.

Role of the Capital Market

The capital market assumed that, since these countries are in the Euro area/common currency, there is neither an exchange rate risk nor a default risk. The capital market treated these countries alike insofar as interest rates were concerned, and did not charge countries a risk premium relative to the rest of the Euro area during the period 2000 - 2008. Figure 1 graphs, for Ireland, Greece and Portugal, interest rate spreads relative to the German Bund (Plagnol, 2010/Reuters). From the time of the Greek entry in 2000 until 2008 when there was the Lehman Brothers failure, the spread was negligible. Hence no debt problem was anticipated for these three countries. Effectively,

there was a large supply of international funds at low interest rates to finance the gap between investment and social saving – resulting from the structural government budget deficit –in Greece and Portugal (figure 1).

The Credit default Swap (CDS) rate is the premium paid for insurance against default. (A CDS rate of y basis points bp means that it costs $1000y to insure $10 million of debt for five years). The CDS rates for Ireland and Greece indicated little doubt about default until 2009. The rates for both were below 100 bp until the beginning of 2009. The CDS rate for Ireland ranged between 100 and 150 bp whereas for Greece the rate rose to 400 bp.

The situation only changed when Lehman Brothers failed. Then the CDS rates and interest rates on Greek and Irish securities rose. The conclusion is that the market for bonds denominated in Euros did not reflect doubts about default until quite late in the crisis. There were not Early Warning Signals that were used by the markets. The precipitating factor in the recognition of default risk in Europe was the failure of Lehman Brothers. By then it was too late.

The ignoring of default risk stands in contrast with the U.S. experience where, despite having a common currency, the market evaluates municipalities according to the default risk. Neither the Treasury nor the Federal Reserve intervenes in the fiscal policies of the municipalities nor contemplates bailouts when they are experiencing difficulties in servicing their debts. Table 4 presents the distribution of ratings, and hence interest rates that the capital market charges the various U.S. municipalities. Unlike Europe the discipline comes from the markets and not from the government.
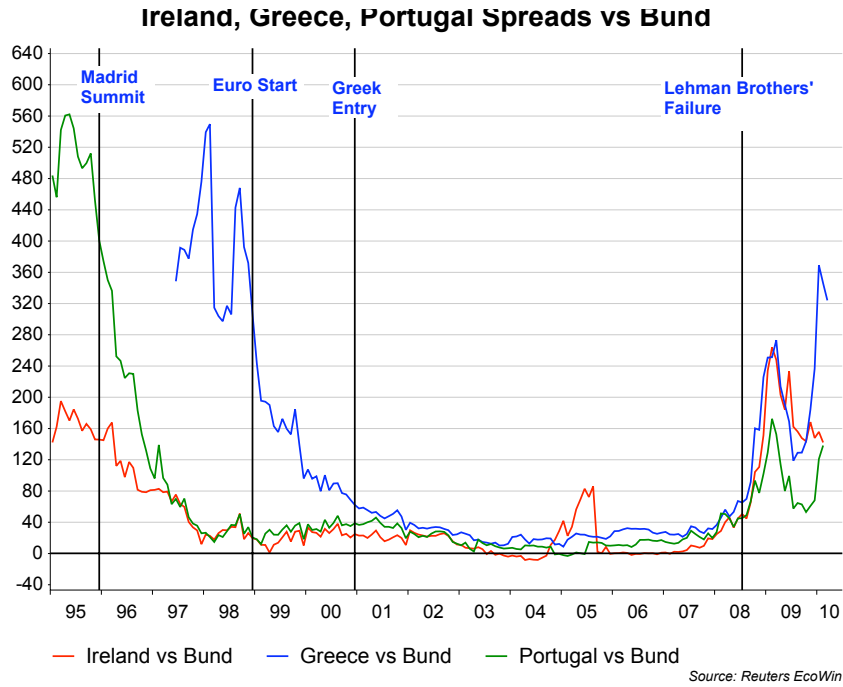
Ireland, Greece, Portugal Spreads vs Bund

Figure 1 Interest rate spreads versus the Bund

Table 4. United States Municipal Rating Distribution 1970-2000

AAA	3.15%
Aa	11.5
A	54.42
Baa	29.9
Ba	0.8
B	0.13
Caa-C	0.02

Special Comment. Moody's US Municipal Bond Rating Scale, Nov. 2002

Evaluation of the Excess debt, actual less optimum, of the private sector

Neither the markets nor the Central Banks anticipated the crises until it was too late. The basic question is: What is an "excessive" private sector debt ratio that is likely to lead to a crisis? The collapse of the housing market led to bank failures that led to bailouts. I now explain theoretically based, not empirical ad hoc, Early Warning Signals (EWS) of debt crises. The crucial variable is leverage or the debt/net worth ratio. Leverage = assets/net worth = 1 + debt/net worth.

Net worth is assets less debt. The growth of net worth is affected by leverage. An increase in debt to finance the purchase of assets increases the growth of net worth by the return on investment, but decreases the growth of net worth by the associated interest payments. The *return on investment* has two components. The first is the *productivity of assets* and the second is the *capital gain* on the assets. An increase in leverage will increase expected growth of net worth if the return on investment exceeds the interest rate. The productivity of assets is observed, but the future capital gain and the interest rates are unknown when the investment decision is made.

The basic equation for the growth of net worth is crucial to understanding the excesses of the private sector and evaluation of desirable policy. A rise in the ratio of debt/net worth, say by banks, is used to purchase assets, say investments in housing. The increase in debt raises the growth of net worth if the anticipated capital gain on the assets plus the rate of return on the assets exceed the interest rate.

Growth of net worth = (debt ratio)[capital gain + return on assets – interest rate]

The capital gains are described in Table 3 and the interest rates in figure 1. The huge capital gains in housing for Spain and Ireland, and low interest rates, during the period 2002-2006 led to a rise in the debt ratio of the private sector. That is, the term in brackets was large so the private housing sector increased its debt directly to banks and indirectly to foreign investors. The investment in housing seemed to be profitable because the debt could be refinanced/repaid from the recent capital gains – not from the marginal product of capital. But these capital gains – housing price appreciation in table 3

- were not sustainable. The reason is that insofar as the capital gain exceeds the appropriate interest rate, the present vale of the asset diverges to infinity.

The risk is that with the higher debt ratios, there would be a period when the capital gains fell below the interest rate – such as occurred in 2007 in Spain and Ireland. In fact the capital gain term and interest rate term are negatively correlated. When the growth of housing prices declined then the banks tried to deleverage and interest rates rose. *Then the large negative term in brackets is multiplied by a large debt ratio and the net worth of the housing industry vanishes.* The housing sector defaults on their loans. Bank failures followed the collapse of the housing market. The government then intervened to avert bank failures and purchased their bad debts in exchange for government debt. *In Ireland and Spain, the debt crisis was due to the private sector and not to the government cyclically adjusted budget deficits.*

Early Warning Signals of an Excessive Private debt ratio likely to lead to a debt crisis

The optimum debt ratio of the private sector, such as the housing sector, should maximize the expected logarithm of net worth at a terminal time. This is a risk averse strategy because losses are more heavily weighted than are gains. The future capital gains and interest rates are unknown when the debt is incurred. This is a problem of stochastic optimal control SOC discussed in Stein (2006)(2010)(2011). It is reasonable to assume that the capital gains consists of a trend/drift plus a stochastic (probabilistic) term, and the interest rate also has a trend/drift plus a stochastic (probabilistic) term, and that these two stochastic variables are negatively correlated.

On the basis of the SOC analysis, the optimal ratio of debt/net worth (in the box below) has the following form. It is equal to the trend of the capital gain less the trend of the interest rate plus the current return on assets less a risk premium, all of that multiplied by risk factors consisting of variances of the capital gains, interest rates and the correlation between these stochastic terms. *It is not the current or recent capital gains and interest rates that are relevant but their trends/drifts over a longer period.* The leverage, assets/net worth, is one plus the debt ratio.

Optimal debt/net worth = [drift capital gain – drift interest rate + current return on assets – risk premium](Risk factors).

Early Warning signal = excess debt = actual less optimal debt ratio.

Two important implications of the SOC analysis are as follows. (1) The expected growth of net worth is maximal when the optimal debt ratio – stated in the box - is selected. (2) As the actual debt ratio rises above the optimum, the expected growth declines and the risk rises. (3) The excess debt is an early warning signal of a crisis in the sector, such as housing/morgtages.

The housing sectors in Ireland and Spain selected debt ratios/leverage based upon recent capital gains 2003-2006. These rates far exceeded the interest rate and were unsustainable. They implied present values of assets that diverged to infinity. The correct approach would have been to use the drifts of the capital gains and interest rates, adjusted for risk.

This type of Warning Signal is clearly seen in the US mortgage crisis. Figure 2 plots a unit free measure of the actual debt ratio DEBTRATIO and a unit free measure of the optimal ratio RENTPRICE. In the US the drifts/trend of the capital gains and interest rate were approximately equal. RENTPRICE reflects the current return on assets. The variables are normalized/unit free, they are deviations from their long term means divided by the standard deviation The details of the calculation are in Stein (2010)(2011).

An excessive debt of the households is seen (figure 2) when the normalized debt ratio rises relative to the normalized value of the current return on assets, marginal product of capital. From 2002 to 2006, the return on assets declined more than one standard deviation below its long term mean while the debt ratio rose two standard deviations above its long term mean. This excessive debt, DEBTRATIO – RENTPRICE, signaled a situation where the debt can only be serviced from unsustainable capital gains.
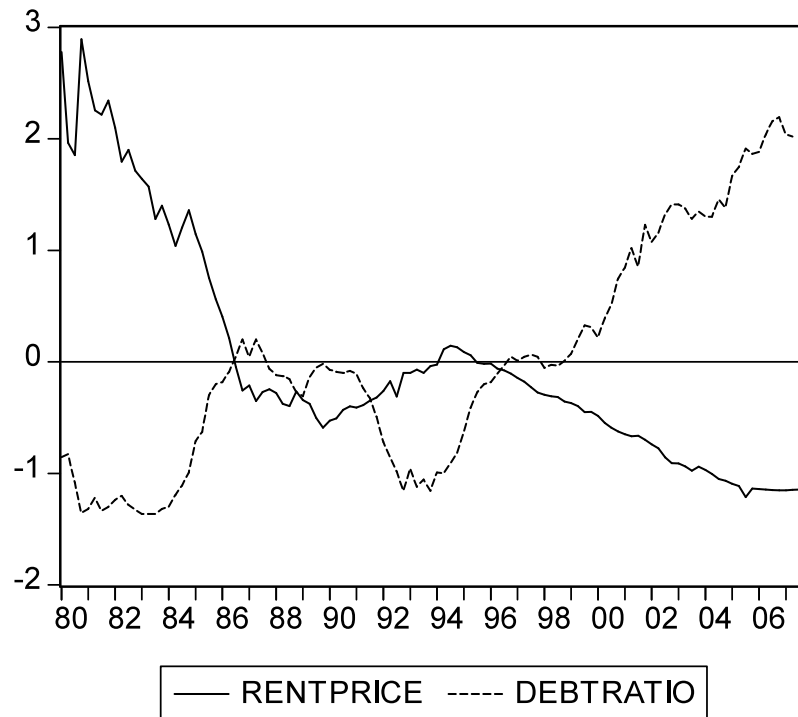
Figure 2. United States. RENTPRICE, normalized rental income/index of housing prices, reflects the marginal product of capital. DEBTRATIO is the normalized household debt/disposable income. A normalized variable is (Variable – mean)/standard deviation. Each curve is measured in standard deviations from its own mean. Excessive debt is DEBTRATIO – RENTPRICE, the difference between the two curves. This is an early warning signal of a crisis.

The situations in Ireland and Spain 2003-2006, seen particularly in Table 3, led to an excess debt – because the housing sector and the banks assumed that the recent capital gains – far above their trends – were sustainable. This was similar to the S&L crisis in the US in the 1980s and mortgage crises of 2007. The excess debt is an early warning signal of a crisis. In these countries, the decline in net worth, bankruptcy of the housing sector, led to the insolvency of the banking sector and then led to the bailout. The rise in government debt was simply an exchange of government debt for private debt.

Fiscal deficit and public debt

Unlike Ireland and Spain, the debt crises in Greece and Portugal were due to the government sector. Tables 1 and 2 showed these differences. The SGP rule had no value in predicting the Irish and Spanish crises, but clearly deficits and debt ratios are relevant in the cases of Greece and Portugal. It is instructive to consider specifically the case of Greece, though Portuguese case was similar.

Greece

Greece's large fiscal deficit and huge public debt are the cumulative result of chronic macroeconomic imbalances, and are at the origin of the debt crisis. I draw upon Annual Report of Bank of Greece. The global crisis simply aggravated Greece's fiscal performance and prospects, which had already begun to deteriorate in the second half of 2007 for reasons unassociated with the economic downturn. Indeed, the fiscal deficit has been above 3% of GDP almost every year for the past decade. According to revised data released by Eurostat on 22 April 2010, the deficit came to 5.1% in 2007, 7.7% in 2008 and 13.6% in 2009.

These adverse budgetary developments triggered the downgrading of Greece's credit rating and a sharp widening in the yield spread of Greek government bonds vis-à-vis German ones in late 2009 through to mid-April 2010 (fig. 1). The high public debt at 115.1% of GDP in 2009 was the highest in the euro area along with that of Italy, and is expected to keep rising at least through 2014, according to certain projections.

According to Bank of Greece staff projections, the debt dynamics is unfavorable, as it is estimated that the fiscal adjustment envisaged will only lead to a stabilization of the debt-to-GDP ratio in 2014, at very high levels (over 130%), on the basis of conservative assumptions regarding nominal GDP growth over the next few years and the nominal interest rate on public debt. It is estimated that reducing the debt ratio to below 100% of GDP will require a systematic fiscal effort over a number of years, at a time when it is essential to restart the growth process and ensure that strong economic performance is restored within a reasonable time frame. A social security

reform capable of successfully meeting future challenges, the strict implementation of the fiscal consolidation plan and the promotion of structural reforms and growth-enhancing initiatives constitute the only option.

General Principle evaluating the government debt ratio

Stability and Growth Pact (SGP)/Maastricht Treaty

The appropriate policies, to prevent a recurrence and/or to remedy the crisis, depend upon the origin of the "excessive debt". It seemed to the EU that adherence to the rules of the Stability and Growth Pact (SGP)/Maastricht Treaty would prevent debt crises. This hope was belied by recent events. Proposals for reform are still focused upon these rules limiting government budget deficits. The SGP rules are not based upon economic analysis but are arbitrary. They come from an identity linking the growth rate of the economy, the budget deficit/GDP and the debt/GDP. This identity will be satisfied if the debt ratio, budget deficit/GDP, stabilizes at any *arbitrary constant* level.

Budget deficit/GDP = (Growth rate)(Debt/GDP).

Given an arbitrary growth rate, this identity only determines the *ratio* (budget deficit)/debt. If the growth rate is 5% pa, and the deficit is constant at 3% pa then the debt ratio would be constant at 60%. If the deficit is constant at 6% then the debt ratio will be 120%. The EU and IMF still use the 60% debt ratio as a target for policy. *These values have nothing to do with whether the debt is optimal or "excessive" and are irrelevant as early warning signals of a crisis such as Europe has experienced.*

It is not possible to establish an optimal debt ratio – and hence excess debt ratio - for the government, as it was for the private sector. However, the focus should be on the trend of debt burden, defined as interest payments on the debt/GDP. Budget deficits should be viewed in terms of their effects upon the GDP. Will the borrowing/increase in debt raise the productivity of the economy by more than the interest rate? If the marginal productivity exceeds the interest rate, the debt burden – interest payments/GDP – will decline. For example, in the CEEC countries tax rates can be lowered which increase the government debt. However, the decline in tax rates may lead to FDI which increases the

productivity of the economy. Similarly, the government may increase expenditures for education, health and infrastructure, which raise productivity. Alternatively, the government expenditures/tax reductions may simply stimulate consumption. For example, low rent housing, subsidies, wage increases will not raise the GDP. Since the interest payments exceed the marginal productivity of expenditure, the debt burden rises. Therefore the focus should be upon the *trend of the government debt*. Table 2 last row shows that the ratio of government debt/GDP from 1998 to 2007 was: Portugal 1.42, Greece 1.16 whereas in Spain it was 0.53 and in Ireland it was 0.43. This is a clear example of the origin of crises should be viewed.

Repercussions in financial markets

It is difficult to separate bank debt from government debt when the governments have bailed out banks. The government/taxpayer takes over the role of the debtor. There is reason to combine the two debtors. Table 4 displays the debts of the banks and governments.

Debtor is listed in row and creditor in column. Thus Spain owed $220 billion to the French and $238 billion to the Germans. The major creditors were the French and German banks. The major creditors for Ireland were Britain and Germany. Last column is total debt to all countries in addition to those in the table.

When the crises occurred in Greece, Portugal, Ireland and Spain, whether due to the government or the private sector, defaults occurred or were threatened. If Spain defaulted then assets of the British, French and German banks/government declined in value. If the Irish defaulted, the British and German banks/government were affected.

Table 4. Banks and governments. Debtor, Creditor by country, $billions.

Debtors	Greece	Ireland	Italy	Spain	Portugal	Britain	France	Germany	Total debt
Greece	-	8.5	6.9	1.3	9.7	15	75	45	236
Ireland	0.8	-	18	16	22	188	60	184	867
Italy	0.7	46	-	47	5.2	77	511	190	1,400
Spain	0.4	30	31	-	28	114	220	238	1,100
Portugal	0.1	5.4	6.7	86		24	45	47	286
Britain									
France									
Germany									
Total	2	89.9	62.6	150.3	64.9	418	911	704	

Source: Fidelity Investments, Strategic Advisers, 2010. *Row is debtor and column is creditor.*

Conclusions

The main causes of the debt crises in Europe varied by country. In Ireland and in Spain, they were mainly due to the private sector, particularly housing. These crises had great similarity to those in the US: the S&L crisis, the agricultural crisis in the 1980s and the mortgage crisis in 2007-08. In Greece and Portugal, the cyclically adjusted structural deficit was the major cause.

In Ireland and Spain, the domestic housing booms were financed from foreign borrowing. The creditors failed to require a risk premium related to the probability of default. The anticipated return was the sum of the marginal product of capital plus an anticipated capital gain or asset price appreciation. The marginal product of capital was below the rate of interest. The debt was anticipated to be refinanced from the capital

gains in excess of the interest rate, not from current earnings. The anticipated capital gains were based upon recent experience, which was unsustainable. The debts were excessive – the actual exceeded the optimal derived from stochastic optimal control. When the capital gain fell below the rate of interest, the borrowers in the housing industry defaulted. Their creditors were the banks who in turn were debtors to international lenders.

On the basis of the Stochastic Optimal Control analysis, the optimal ratio of debt/net worth of the private sector has the following form. It is equal to the trend of the capital gain less the trend of the interest rate plus the current return on assets less a risk premium, all of that multiplied by risk factors consisting of variances of the capital gains, interest rates and the correlation between these stochastic terms. *It is not the current or recent capital gains and interest rates that are relevant but their trends/drifts over a longer period.* An early warning signal EWS of a debt crisis is a significant excess debt – the actual less the optimal debt ratio.

A sensible EWS for the excess government debt is the trend of the debt burden – interest payments/GDP. Insofar as the government deficits have a marginal product above the interest rate, the debt burden will tend to decline. Insofar as the budget deficits have marginal productivities below the interest rate, the debt burden will rise. In the cases of Greece and Portugal the trend was highly positive, and in Spain and Ireland the trend was negative.

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