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The eurozone debt crisis: A structural VAR approach☆

Simon Neaime*, Isabelle Gaysset, Nasser Badra

Institute of Financial Economics, American University of Beirut, P.O. Box 11-0236, Beirut-Lebanon

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ABSTRACT

This paper examines empirically the causes of the 2010 Eurozone debt crisis. We use a battery of econometric models with quarterly data from 2004 to 2014 to identify domestic and external nominal shocks and their transmission mechanisms through impulse response functions and granger causality tests derived from a structural VAR (SVAR) specification. It is shown that shocks to Germany's macroeconomic fundamentals have a significant impact on Greece's inflation rates, industrial production, and interest rates. Our empirical results indicate that the root cause of the Greek debt crisis emanates from imbalances in its balance of payment, mainly in its current account, losses in competitiveness vis-à-vis Germany, and the lack of nominal adjustment measures through monetary policy due to Greece's membership in the Eurozone. We argue, in the absence of nominal adjustment mechanisms, Greece will probably have to go through prolonged deflationary episodes in order to enhance its competitiveness, produce a positive current account, reduce its budget deficits and public debt, and reverse capital outflows. We also argue, in the absence of an effective monetary policy, countries members in a monetary union running large budget and current account deficits maybe more prone to a Greek debt type crisis.

1. Introduction

The Eurozone debt crisis has spawned a large amount of literature on its causes, consequences and the policies adopted to deal with it. It is time to take stock of the literature available on the subject, review it and identify the common and differing strands of analysis with particular emphasis on the changes made in the economic policy paradigms. If traditional macroeconomic policies and their modification in the context of the Greek crisis have not helped, are there any new directions that one can think of that will not only solve the current debt crisis but also prevent future ones from developing? It is well known that Greece has been running permanent current account deficits for the past decade, resulting in an external debt that became close to 195% of Gross Domestic Product (GDP) in 2015 (Eurostats, 2016). With the accumulation of a sizeable public debt, macroeconomic stabilization policies became ineffective in dealing with nominal economic and financial shocks. Subsequently, Greece's fiscal space started to narrow, at a time when monetary policy was conducted by the European Central Bank (ECB) on behalf of all Eurozone member countries and with one goal; price stability and no consideration to growth and unemployment.

After becoming a member of the Eurozone in 2001, Greece had to relinquish its monetary policy to the ECB, losing therefore an effective tool that constituted an effective mechanism to neutralize monetary and macroeconomic imbalances, as well as, external

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* Corresponding author.
E-mail addresses: sn01@aub.edu.lb (S. Neaime), ig07@aub.edu.lb (I. Gaysset), nbb03@mail.aub.edu (N. Badra).

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nominal shocks.[1] However, and due to the lack of a political European union, Greece retained its fiscal policy independence. In 2009, Greece's budget deficit reached 13% of GDP. By 2012, Greece's debt to GDP ratio hovered at 175% which is nearly three times the 60% EU's debt to GDP limit permissible by the Maastricht Treaty (Eurostats, 2015). Moreover, the literature on debt and financial crises argues that going beyond the 90% debt to GDP cliff renders the occurrence of debt and currency crises more probable. Although Greece's public debt became unsustainable in the years following the 2008 US financial crisis, it's largely believed that the current crisis is a balance of payment crisis rather than a sovereign debt crisis. It is well known that a balance of payment crisis coupled with lack of exchange rate adjustment mechanisms to restore macroeconomic imbalances has rendered it difficult for Greece to roll over its public debt. Moreover, high debt ratios and low GDP growth rates are putting further strains on Greece's macro economy.

Several suggested solution have been put forward in order to contain the Greek debt crisis. First, it was suggested that Greece would need to improve its competitiveness through an internal devaluation. If domestic prices decline through aggressive wage and income cuts, the real exchange rate will depreciate, rendering domestic goods more competitive vis-à-vis Germany. While this policy may improve the current account deficit, it will prove to be painful domestically, as a significant number of firms will likely go bankrupt, and unemployment will further deteriorate. Another suggested solution is for Germany's inflation rate to increase; i.e., allow prices to increase by more accommodative macroeconomic policies. In this case, German goods and services will become less competitive internationally, (export fewer goods to Greece), which will subsequently help Greece reduce its trade deficit relative to Germany. This is, however, unlikely to transpire, since Germany would not opt to inflate its economy to help European countries in the periphery of the euro zone, jeopardizing subsequently its comparative advantage relative to the rest of the world.

A third proposed solution is through short term borrowing to fund Greece's deficit/debt payments, coupled with the introduction of austerity measures. Greece obtained a bailout loan of €110 billion in May 2010, negotiated a €109 billion in July 2011, which was updated to €130 billion in October 2011. In return, Greece agreed to cut wages, freeze pensions, privatize public enterprises and public property worth €50 billion, and undertake structural and fiscal reforms. However, will the introduction of austerity measures help the Greek economy recover from its deep recession, and subsequently, help it grow out of debt? A forth solution is to have the ECB issue bonds at lower interest rates. There were, however, political and economic issues associated with the issuance of Eurobonds. Despite the lack of a European political union which poses a serious constraint on the issuance of Eurobonds, the ECB engaged in 2015 in an active Quantitative Easing (QE) Program designed to help EU governments in their liquidity and debt crises and fight deflation.[2]

A fifth proposed solution is debt haircut[3] which could alleviate the burden of the €360 billion accumulated national debt, by paying back only a fraction of the debt to lenders. However, questions remained on how to implement a debt haircut and its subsequent effects on the Greek and global economies. Rumors in June 2013 about a debt haircut with private investors absorbing some of the losses, led Standard & Poor to downgrade Greek bonds by two notches from BB+ to BB-. The Eurozone averted a banking crisis and subsequent bank runs. In 2010, there was already an estimated €50 billion deposit loss from Greek banks to foreign ones. The effects of an uncoordinated haircut will be severe: Greece's rate of unemployment, which is currently at 18.4%, will further deteriorate and the country will be shut out of financial markets for a long time. Moreover, a deep enough debt haircut, say 50% or higher, will put at risk major European and Greek banks, as well as pension funds. Finally, there was also a proposal by the German Finance Minister to exchange existing Greek bonds with new ones with longer maturity and lower interest rates.[4] This entails convincing the private sector to participate voluntarily in the bond exchange, and accept some losses. This option, if implemented, will reduce the burden of the debt and improve its sustainability. However, a Debt swap may cause a credit event: credit rating institutions further downgrading Greece's credit worthiness. Standard & Poor has already downgraded Greek bonds to CCC.

Perhaps the most painful solution which is still being debated is a potential default on the Greek debt and a GREXIT from the Euro area. A potential default on debt payments would mean dropping the euro and readopting the Drachma. However, Greece will have to be induced to finance future primary deficits by issuing its own currency, the new Drachma. This will create recurrent runs on Greek banks, as depositors try to avoid converting euro deposits into Drachmas. Similar to Argentina, at this point the Greek government will dictate drachma-fixation of all deposits at some official rate. The new drachma will most likely be devalued repeatedly leading to further bank runs, rising inflation, higher interest and unemployment rates, and falling real incomes. It should be also noted that a potential Greek default may spread the crisis to other Eurozone countries. The euro is not legal tender for the Eurozone because the Eurozone is not a political union. Instead, national laws of the member states make the euro legal tender. This fact makes the euro fragile in the case of national bankruptcies in the Eurozone.

With the above in mind and in this paper, we adopt a structural VAR approach to identify various exogenous shocks affecting

[1] See Also Neaime (2000, 2008, 2012, 2015a, 2016).

[2] Arguments against the QE program, delayed until 2015 at a time when the US's QE program was initiated in 2008, centered on the following: the EU is not a "transfer union" and none of the large EU countries would like to see the EU become one. For then it would mean that the more affluent EU states would subsidize the poorer EU countries of the periphery. Thus, the issuance of Eurobonds at this stage of European integration is politically not feasible. Eurobonds may also be economically distorting since they will involve the same interest rate for all members of the euro zone regardless of their macroeconomic conditions.

[3] European politicians have considered a controlled bankruptcy. The idea is to use the European Financial Stability Facility (EFSF) resources to either buy the country's debt in the secondary bond market or to loan Greece funds to buy a portion of its debt and retire it. The EFSF can issue bonds up to €440 billion and lend up to €250 billion to member states in difficulty. The EFSF's credit rating is a high AAA. In June 2013, the EFSF was supposed to be absorbed into a permanent European Stability Mechanism (ESM) with an effective real lending capacity of €500 billion.

[4] A similar solution is to rollover the Greek debt, inspired by the Vienna Initiative on rolling over the debt of 4 East European countries in 2009. This entailed a voluntary agreement with investors to exchange maturing Greek debt with new instruments of longer maturity, over the period 2012–2014, accompanied with a new program of Greek fiscal reforms and deep deficit cuts reminiscent of the Belgian experience of the early 1990s. In return, Greece will get more Troika funding for the period 2012–2016.

Greece's macro economy for the purpose of establishing the root cause of its 2010 debt crisis with the aim of establishing potential remedies and solutions. The SVAR approach permits to estimate the extent to which Greece can be resilient or vulnerable to exogenous nominal shocks, mainly shocks emanating from the German economy; Greece's main trading partner. Accordingly, this paper will bridge the gap in the literature on the Greek debt crisis by testing whether Greece's crisis is a balance of payment type crisis or rather a public debt sustainability problem emanating from recurrent budget deficits and the inefficient conduct of fiscal policy. Contrary to what is currently implemented in the traditional debt literature focusing on debt sustainability and default models to explain Greece's debt crisis, this paper will identify exogenous shocks that are the root cause of the crisis and come up with policy recommendations for improved fiscal sustainability in the future. Moreover, the structural VAR approach identifies various exogenous shocks that have led to the Greek crisis and indicates the extent to which Greece can be resilient to German shocks. Accordingly, this paper adds to existing literature, which has so far tackled the Greek crisis from a debt sustainability/default perspective,[5] by testing empirically using a SVAR model the many factors driving the crisis.

The remainder of the paper is divided as follows. Section 2 presents a macroeconomic overview and reviews related literature. Section 3 lays down the empirical methodology and the motivation of the empirical time series models to be estimated. The data set and empirical estimations and results are all summarized in Section 4. Finally, the last section offers some conclusions and policy recommendations.

2. Macroeconomic overview and related literature

In 2010, the Greek economy registered a large budget deficit amounting to 10.5% of GDP; a large trade deficit estimated at 10.6% of GDP; an unsustainable public debt reaching 143% of GDP; and a negative real GDP growth rate of −4.5%. These deteriorating macroeconomic fundamentals called for financial assistance from the European Union (EU), the ECB, and the International Monetary Fund (IMF) under the so-called Troika.[6] Three bailout agreements were signed. The first was signed on May 10, 2010 in the order of €110 billion in loans which would be accompanied by the introduction of Austerity Program 1.

On July 21, 2011, another agreement was reached in the order of €109 billion accompanied by the introduction of Austerity Program 2.[7] And on October 26, 2011, the last agreement was signed in the order of €130 billion coupled with the introduction of Austerity Program 3, to be accompanied by a deep haircut of the Greek debt by 50%.[8] The austerity measures introduced under Programs 1–3 led subsequently to the collapse of aggregate demand, to further deteriorations in unemployment rates, and to falling prices and renewed fears of deflation. Prime Minister Papandreou proposed then a national referendum on the October accord. Troika officials were angered and the Greek government subsequently collapsed. A new national unity government was formed with Prime Minister, Lukas Papademos, an ex-Vice President of the ECB. Its mandate was to approve the October 26 Accord, receive the next €8 billion loan instalment, pass a new budget for 2012, and call for national elections in early 2012.

It should be noted that the high accumulated Greek public national debt is not only the result of economic factors but is also due to political/institutional factors. Before we outline the major economic factors behind the Greek fiscal crisis, it would be instructive to highlight some of the political factors that triggered the crisis. To do that, we need to ask whether the successive Greek governments, and over the last 40 years have violated the no Ponzi condition by accumulating a €360 billion pile of debt. The response is yes since there was (1) a large expansion of the public sector with main motive to buy votes and get re-elected; (2) The generous salaries, pensions, and retirement packages of public employees, and the mismanagement of public enterprises; (3) Political corruption and the existence of rampant tax evasions with an estimated cost of €18 billion per year; (4) Frequent changes of the tax code which translated into an inherent weakness of the Greek taxation system; And (5) the Greek shadow economy estimated at about 30% of GDP.

Since 2002, right after the establishment of the European Monetary Union (EMU), the Greek government resorted to borrowing heavily from both domestic and international financial markets to finance its budget and current accounts deficits and to service its huge public debt. High government expenditure coupled with inadequate collection of taxes and corruption in the public sector have widened the gap between government revenues and expenditures. (Fig. 1(a)). A heavy debt service coupled with low revenues and uncontrolled government expenditures have subsequently led to the emergence of recurrent budget deficits (Fig. 2(b)). By July 2009, the year that ear marked Greece's debt crisis, the budget deficit reached 13% of GDP. By the end of 2015, total public debt stood at €341 billion (Fig. 3(c) and (g)), about 195% of GDP, and nearly three times the Eurozone debt-to-GDP limit set at 60%; surpassing the 90% debt cliff after which most debt and currency crises were registered. In between 2009 and 2010, Greece's credit ratings have been downgraded by Fitch, Standard & Poor, and Moody's respectively, driving the real interest rate up and exacerbating the public debt situation pushing the country to the brink of going Bankrupt-Insolvent (Fig. 1(d)).

[5] See for instance, Neaime (2015a); Mansoorian and Neaime (2003); Guerreiro (2012); Kosteletou, (2013); Shambaugh (2012); Lane (2012).

[6] Reasons for the bailout agreements to Greece, Ireland, and Portugal were in order to save the EU, the euro currency, and insure financial stability in the euro zone and allow EU banks to recapitalize.

[7] The July 21, 2011 Accord stipulates: (1) The voluntary participation of the private sector in solving the debt problem through a 21% haircut of the Greek debt; (2) A potential 20 billion debt payback scheme using the secondary bond market; (3) A second €109 billion bailout loan with a 15 year maturity and 3.5% annual interest rate; And (4) another austerity stabilization program with deep deficit cuts, coupled with structural and fiscal reforms. All these measures were intended to make the debt sustainable until 2020.

[8] The October 26, 2011 Accord includes: (1) A 50% voluntary haircut to the national debt which will reduce the burden of the debt by about €100 billion. Details are to be worked out in consultation with private investors; (2) An improved bailout loan amounting to €130 billion; And (3) deep deficit cuts and an austerity program supported by all political parties with the Troika monitoring the implementation of the austerity measures.

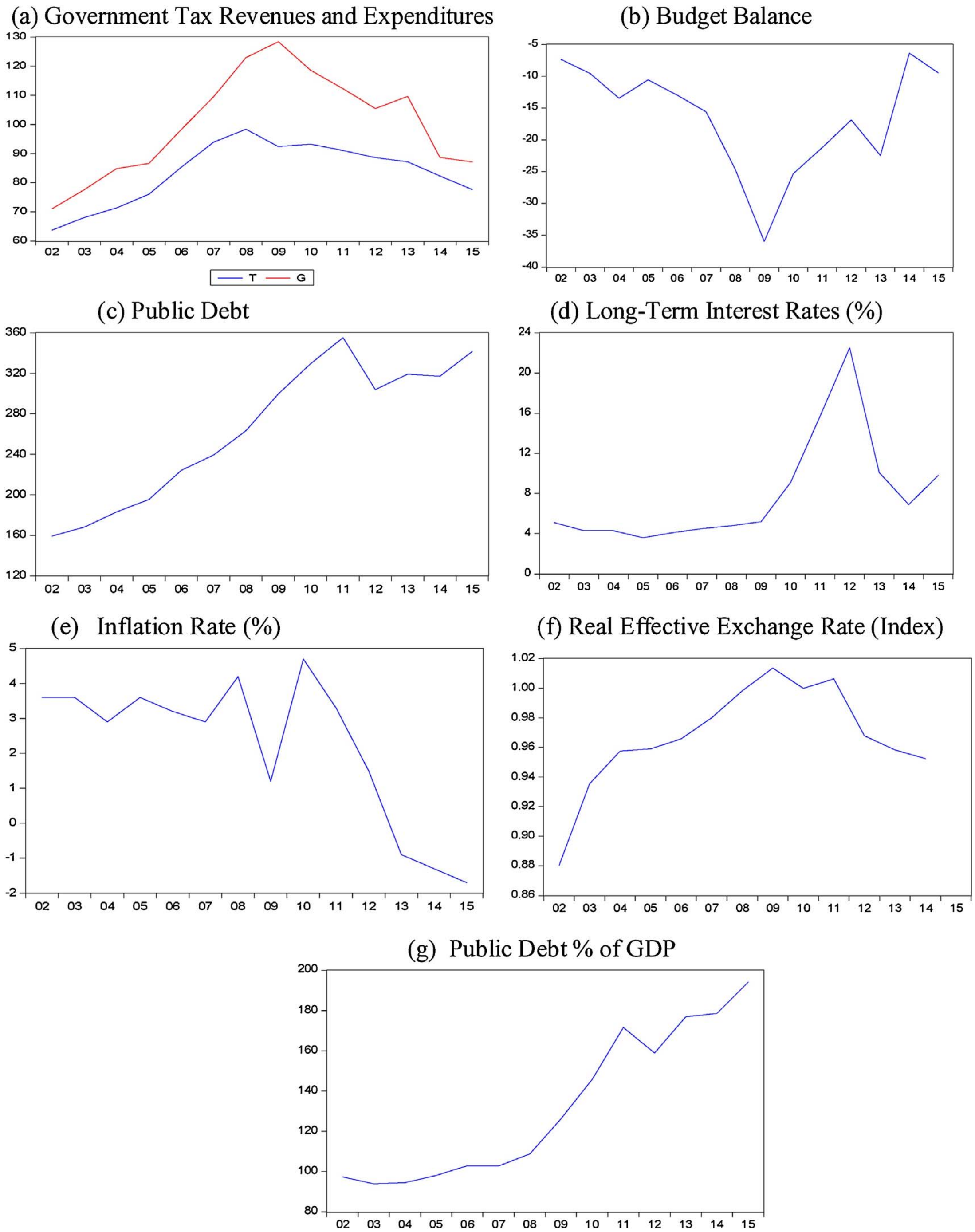

Fig. 1. Greece's Macroeconomic Indicators: 2001–2015 (Euro Billion and%).
Source: Euromonitor International from IMF, National Statistics, OECD, and World Economic Outlook.

Although inflation rates meandered around 3 percent in between 2002 and 2009 (Fig. 1(e)), the real exchange rate has been steadily appreciating over the same period pointing to a serious loss of Greece's competitiveness relative to the rest of the world in general and to its major European trade partner: Germany (Fig. 1(f)); worsening subsequently its current account and paving the way for a balance of payment crisis.

Developments in the external sector indicate that Greece's exports have never exceeded the €36 billion threshold in between 2002 and 2015, while Greece is a heavy importer of goods and services for a yearly average of €65 billion mainly from Germany (Fig. 2(a)). This has translated into a huge gap between exports and imports and has subsequently generated recurrent trade and current account

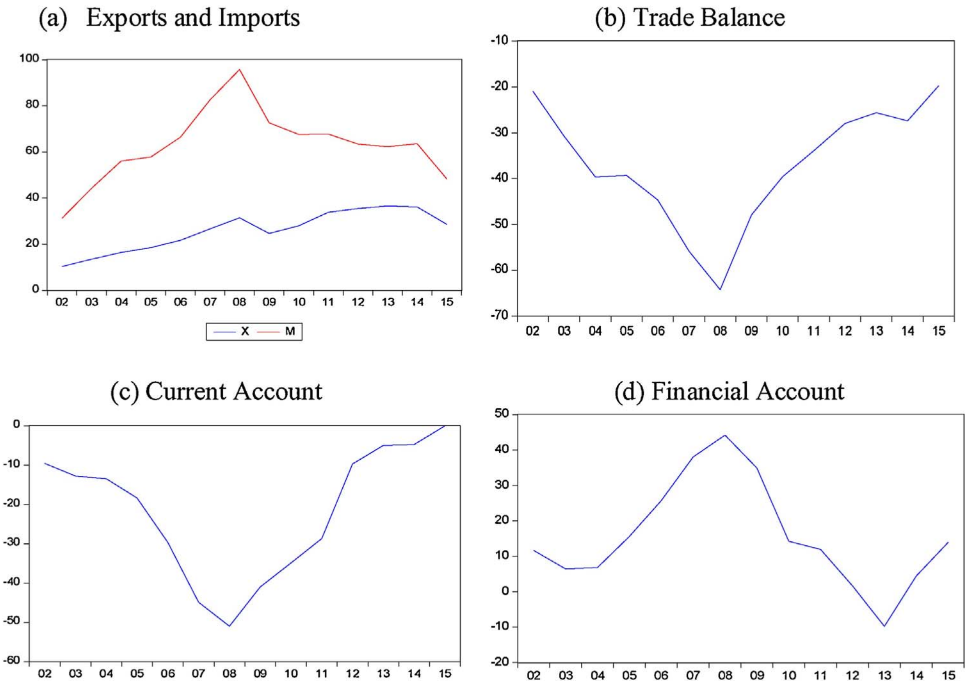

Fig. 2. Greece's Balance of Payment Components: 2002–2015 (Euros Billion).
Source: Euromonitor International from IMF, National Statistics, OECD, and World Economic Outlook.

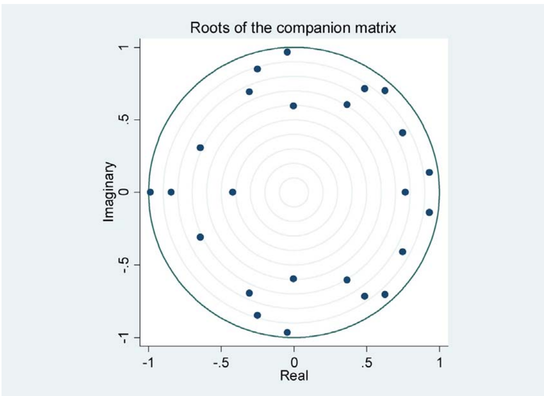

Fig. 3. SVAR Stability Condition, 2002–2014.
Notes: All the eigenvalues lie inside the unit circle.
Source: Authors' Estimates.

deficits (see Fig. 2(b) and (c)). Being at a comparative disadvantage relative to Germany, Greece registered persistent current account deficits since it joined the EU. This subsequently developed into the 2010 debt crisis. In order to run a persistent current account deficit, Greece has accumulated claims on its assets recorded in the capital account. The financial account registered a series of surpluses over the period 2002–2009, and subsequently a series of deficits in between 2009 and 2013 due to capital flights (Fig. 2(d)). This is because when a country runs persistent and permanent current account deficits, it is expected to experience a subsequent balance of payment crisis. The balance of payment will, therefore, swiftly move into a deficit due either to current account deficits or a capital flow reversals. Moreover, after Greece adopted the euro in 2002, any exchange rate adjustment mechanism became lacking in order to restore external dis-equilibria. Deflation and a decrease in real wages would therefore work as self-correction mechanisms to cover current account deficits following a capital flight crisis.

Krugman (1979) first generation balance of payment crisis models link a balance of payment crisis to inconsistency in a country's exchange rate regime and external sector's imbalances. This inconsistency, coupled with macroeconomic imbalances, may subsequently lead to a debt/currency crisis. It is well known that currency depreciation allows the current account balance to adjust, an option that is not available in a currency union like the EMU. Therefore, Greece must become more competitive to turn its current account deficit into a surplus, and subsequently use these surpluses to trim down public debt and regain investors' confidence and revert the flow of capital to the advantage of its domestic economy. Krugman (2013) argues that a sudden loss of investors' confidence accompanied by capital flights may translate into a sovereign debt crisis. This result is also obtained in speculative attacks on currencies type models which can be self-fulfilling. In the absence of a lender of last resort as is the case for the EU's member countries, a speculative attack could translate into a liquidity crisis. Krugman alluded to the two episodes of speculative attacks against the Eurozone peripheral countries of Italy and Spain in late 2011 and mid-2012, where dramatic reductions in spreads vis-a-vis Germany were observed following the ECB's market intervention. Finland and Denmark are two economies with relatively low debt levels. However, while Finland- who did not retain its central bank independence- experienced huge interest rates increases in late 2011, Denmark's interest rates did not increase despite the presence of an independent central bank, and the conduct of an independent monetary policy. Thus, currency regimes do matter in determining the likelihood of a crisis. This is in the spirit of the Mundell-Fleming model, stipulating that currency regimes have large impacts on the nature and probability of occurrence of financial/debt crises. Moreover, Krugman (2015) and in the same spirit of the above alluded that the Greek debt crisis is a balance of payment problem in the sense that capital flooded the south EU countries after the creation of euro, leading to currency overvaluation in southern Europe in general and Greece in particular. These surpluses in the financial account led to higher levels of budget deficits and accumulated public debt.

Within the context of the IS-LM framework, Kong (2012) argues that Greece's debt crisis is due to fiscal imbalances. In her paper, Greece is considered to be a small open economy, whereas Germany is assumed to be a large open economy. She assumes same interest rates and same monetary policy across both countries after joining the European Monetary System. However, because the size of the two economies is relatively different, initial output is assumed not to be the same given Germany's factor endowments, advanced technology, and a more developed and sophisticated manufacturing sector. Therefore, capital will be diverted to Germany as opposed to Greece which would be induced to increase domestic money supply to meet domestic money demand and prevent real interest rates from increasing in the absence of central bank interventions. This loop of capital outflows from Greece into Germany will continue until the real rate of return becomes equal again between the two countries. As capital flows out of Greece and into Germany, Greece is likely to experience a recession leading subsequently to fiscal imbalances. These dynamics were indeed observed in Greece prior to the crisis and since early 2000, as soon as it joined the Eurozone.

Guerreiro (2012) argues that the sovereign debt crisis in the EU is in fact a balance of payment crisis. Using the Capital Enhanced Equilibrium Exchange Rate approach coupled with cointegration and Granger causality tests for each EU member country relative to Germany, he showed that when a country is a member of a monetary union and faces external macroeconomic disequilibria, then interest rate differentials would be expected to increase. Further, if the disequilibrium persists, it may trigger a balance of payment crisis when real adjustments are hard to implement given the absence of monetary instruments to tackle the external disequilibrium. Accordingly, as the current account deficit widens so will the interest rate differential. This will subsequently worsen the deficit by raising the cost of debt. Likewise, Kosteletou (2013) found evidence in favor of the twin deficit hypothesis in Greece. Further, he found that it's not only Greece's fiscal policy that is worsening the current account but also the fiscal policy of other EU member countries that have current account surpluses; like for instance Germany.[9]

2.1. econometric methodology

It is well known that VAR models (Sims, 1980) have become an increasingly powerful macroeconomic tool to gauge the dynamic response of a set of endogenous variables to exogenous shocks, and to identify the particular shocks that dominate the intrinsic volatility in a set of endogenous variables. Within this context and following Kong (2012), Greece is assumed to be a small open economy which is subject to exogenous shocks originating in Germany, assumed to be a large open economy. The literature has argued that the Greek debt crisis is the result of successive current account deficits registered mainly against Germany's current account surpluses. Also, European economic and monetary integration and the lifting of obstacles to trade amongst European partner countries has put Greece at a disadvantage, losing its competitiveness mainly vis-à-vis Germany, its main trading partner. It is, therefore, indeed the case that nominal German shocks have adversely affected Greece's economy with devastating consequences on growth, unemployment, trade, balance of payment, public debt, and fiscal deficits. As noted above, it is not only domestic fiscal factors that are contributing factors behind the Greek debt crises, but also the fiscal and external macroeconomic policies of other EU member countries; namely Germany which has registered over the past decade successive current account surpluses, mainly relative to Greece.

It is well known that SVAR models embody an identification problem, where additional $(n^2–n)/2$ theory-derived restrictions need to be imposed in order to recover the SVAR specification. Following Sims (1986), Bernanki (1986), Blanchard and Quah (1989) the orthogonalization of structural disturbances, which is a common practice in applied macroeconomics, or the contemporaneous cross equation effects, manifest themselves through the matrix of contemporaneous effects between different variables. As a result, the cross-equation error variance-covariance matrix Σ of the structural shocks is necessary diagonal. However, and more generally, Lutkepohl (2005) representation of SVAR models, also referred to as AB systems, does not assume orthogonalization of structural shocks, and allows for a larger set of restrictions on both cross-equation error variance-covariance matrix, and the matrix of contemporaneous effects. In the context of AB systems, $2n^2–n\ (n + 1)/2$ restrictions are necessary to obtain a well identified SVAR model.

There are various ways to place restrictions within the process of identification. One must caution, however, that placing arbitrary

[9] For more discussion about the Greek debt crisis see also: Oltheten et al. (2013); Reinhart and Trebesch, (2015); Roubini, and Kim (2000), and Gibson et al. (2012).

restrictions like the Choleski decomposition distorts the estimated dynamic behavior of the system, and may lead to misguided results at best. Instead, restrictions must be guided by economic theory or by what is known in the literature as "a priori restrictions." These allow the data to capture the unknown dynamic relationships among various components of the system that are left unconstrained. A priori restrictions fall in one of three categories: (1) Sims (1986); Bernanke (1986)Sims (1986); Bernanke (1986) short-run restrictions, also referred to as contemporaneous restrictions; (2) Blanchard and Quah's (1989) long-run restrictions; And Gali (1992) type restrictions which are a combination of both short and long run restrictions.

A Structural VAR model for y_t, a vector of n observable variables, can be written as

$$A(L)y_t = A_0(I_n - B_1L - B_2L^2....B_pL^P)y_t = A_0e_t = B\epsilon_t \tag{1}$$

where ε_t is an nxn column vector of structural shocks; e_t is a n-column vector of reduced-form shocks; A_0 an nxn matrix of contemporaneous effects between variables; and $A(L)$is a matrix lag polynomials such that

$$A(L) = A_0 - \sum_{k=1}^{p} A_kL^k \tag{2}$$

The variance covariance matrix is

$$\Sigma e_t = E(e_te_t^T); \tag{3}$$

And

$$\Sigma\epsilon_t = P\Sigma_{et}P^T, \tag{4}$$

$$\text{where } P = B^{(-1)}A_{(0)}. \tag{5}$$

Following Sims-Bernanki's (1986) decomposition method, short run restrictions are imposed on matrix A_0, the matrix of contemporaneous effects and on matrix B. Restrictions on matrix B manifest themselves in Eq. (4) which is an additional set of equations to solve for the estimated parameters in Eq. (1).[10] An alternative set of restrictions that can be used relies on long-run relationships. Following Blanchard and Quah (1989), the widespread use of this type of restrictions is due to the existing consensus among economists in the long-run regarding macroeconomic theory and derived policy implications and results. Blanchard and Quah (1989) used the money neutrality hypothesis in the long-run to impose long run restrictions. Also, King et al. (1991) used economic theory implications to justify the inclusion of long-run restrictions as follows.

Assume that $A(L)$ in equation (1) is a 2 × 2 matrix with elements $y_t = A(L)^{-1}\epsilon_t$, and $A(L)^{-1}$ is a 2 × 2 matrix with entries Cij. If a variable has no permanent effect on another variable, then it must be the case that the cumulative effect of that variable's shock on the other variable is zero. This corresponds to restricting one of the off-diagonal entries of$A(L)^{-1}$, the $C_{ij,}$ to be zero. This restriction can be viewed as a restriction on the sum of the auto regressive coefficients of $A(L)^{-1}$ and, therefore, $A(L)$. Gali (1992) used a combination of long and short run restrictions as in Shapiro and Watson (1998). In his argument of the usefulness and predictive power of the IS-LM model, he used a set of restrictions that are believed to have no long term effects on GDP along with another set of short term shocks that are believed to have no contemporaneous effects on other variables in his paper. Gali restricted money demand, IS, and money supply shocks to have no long term effects on GDP. In addition to the restrictions on the absence of contemporaneous effects of monetary shocks on contemporaneous GDP, the price level is assumed not to affect the monetary policy rule due to information and decision lags, and the price level is assumed not to affect the demand for real money balances contemporaneously.

If the variables of interest are assumed to be integrated of order zero then the identification scheme will not include any cointegrating relationship. If, however, the variables of interest are found to be cointegrated, then the identification scheme must follow King's et al. (1991) approach. Our identification procedure for nominal shocks follows Blanchard and Watson (1986), Bernanki, and Sims (1986). As noted above, this identification approach invokes contemporaneous restrictions. As in Sims (1986); Bernanki (1986); Blanchard and Quah (1989)Sims (1986); Bernanki (1986); Blanchard and Quah (1989)Blanchard and Quah, 1989Sims (1986); Bernanki (1986); Blanchard and Quah (1989), and since we have orthogonalization of structural disturbances, matrix B in each of Eqs. (1)–(5) above is necessary diagonal. By normalizing n diagonal elements of matrix A_0 to 1′s, we are left with $(n^2–n)/2$ restrictions to be imposed on A_0, the matrix of contemporaneous effects between variables, to achieve proper identification. Recall that relationships between structural and reduced-forms follow Eq. (1). After imposing the appropriate orthogonalization of structural disturbance restrictions, Eq. (1) becomes:

[10] Note that Blanchard and Watson (1986) and King and Watson (1997) also followed this approach.

$$\begin{bmatrix} 1 & a_{12} & 0 & 0 & 0 & a_{16} & a_{17} & 0 \\ a_{21} & 1 & a_{23} & a_{24} & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & a_{34} & 0 & a_{36} & 0 & a_{38} \\ 0 & 0 & 0 & 1 & 0 & a_{46} & 0 & a_{48} \\ 0 & 0 & 0 & 0 & 1 & a_{56} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 & a_{78} \\ 0 & 0 & 0 & 0 & 0 & a_{86} & 0 & 1 \end{bmatrix} \begin{bmatrix} e_{IR} \\ e_{M} \\ e_{INF} \\ e_{IP} \\ e_{IRGER} \\ e_{OIL} \\ e_{EX} \\ e_{IPGER} \end{bmatrix} = \begin{bmatrix} b_{12} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & b_{88} \end{bmatrix} \begin{bmatrix} \epsilon_{IR} \\ \epsilon_{M} \\ \epsilon_{INF} \\ \epsilon_{IP} \\ \epsilon_{IRGER} \\ \epsilon_{OIL} \\ \epsilon_{EX} \\ \epsilon_{IPGER} \end{bmatrix}$$

where, e_{IR} is Greece's long-term government bond yield reduced form shock; e_{M} is a monetary aggregate reduced form shock; e_{INF} is the rate of inflation reduced form shock; e_{IP} is Greece's industrial production reduced form shock; e_{IRGER} is Germany's long-term government bond yield reduced form shock; e_{OIL} is the price of oil reduced form shock; e_{EX}: is the euro-dollar exchange rate reduced form shock; e_{IPGERL} is Germany's industrial production reduced form shock; is an n-column vector of structural shocks; and e_t an n-column vector of reduced-form shocks.

We impose the following restrictions on the contemporaneous structural parameters matrix $A_{0.}$ Monetary policy is assumed to be a rule with feedback. It, therefore, responds to changes in lag industrial production and the price level. The central bank observes changes in the latter variables and then acts accordingly. This is referred to in the literature as "information lag" and is an embodied virtue of the monetary policy practice. In addition, and in line with Kim and Roubini (2000); Sims and Zha (1995), the monetary authorities do not respond contemporaneously to changes in US federal funds rate; Germany's Bundesbank rate in our case. This is because the monetary authority cares more about unexpected changes in the exchange rate rather than unexpected changes in the Bundesbank rate, i.e., $a_{13} = a_{14} = a_{15} = a_{18} = 0$.

The real demand for money function depends on income and nominal interest rate. Therefore, the price of oil, the euro dollar exchange rate, Germany's industrial production, and both German and Greece's interest rates do not contemporaneously affect the real demand for money balances; i.e., $a_{25} = a_{26} = a_{27} = a_{28}$. Greece's interest rate and money supply, Germany's interest rate, and the exchange rate are assumed not to affect the price level and real economic activity (proxied by industrial production) contemporaneously. Instead, these variables affect the price level with a one-period lag.[11] Also, the price level is assumed to affect real economic activity with some lags, but not contemporaneously. Therefore, $a_{31} = a_{32} = a_{35} = a_{37} = 0$, and $a_{41} = a_{42} = a_{43} = a_{45} = a_{47} = 0$. Oil prices and German interest rate are not affected by any of Greece's macroeconomic variables, this follows from Greece's small open economy assumption. The price of oil is determined internationally by the law of supply and demand. The same is true for Germany's interest rate with the exception that the price of oil is allowed to affect the interest rate contemporaneously; the intuition behind this is that the ECB might react contemporaneously to an oil price shock. Thus, $a_{51} = a_{52} = a_{53} = a_{54} = a_{57} = a_{58} = 0$; and $a_{61} = a_{62} = a_{63} = a_{64} = a_{65} = a_{67} = a_{68} = 0$. Germany's industrial production is not affected by any of Greece's macroeconomic variables. Also, Germany's interest rate and the exchange rate do not affect its industrial production contemporaneously, that is: $a_{81} = a_{82} = a_{83} = a_{84} = a_{85} = a_{87} = 0$.

3. Data sample and empirical results

3.1. Data description and choice of variables

The choice of the variables included in the SVAR model is motivated by the fact that these variables must be classified as endogenous variables in the theoretical/textbook sense for them to be helpful in identifying structural disturbances. Modeling Greece's monetary policy must be conducted under the small open economy assumption. It is well known that small open economies are sensitive to external macroeconomic shocks, and therefore, a foreign set of variables-in our case German variables- must be included along with domestic variables to isolate the effect of exogenous monetary policy changes on Greece's small open economy. As in Kim and Roubini (2000); Cushman and Zha (1997); Fung (2002)[12] we include foreign (German) and domestic (Greek) macroeconomic variables. Our data vector is {IR, M, Inflation, IP, IRGR, OIL, EX, IPGER}, where OIL is the World price of oil denominated in US dollars; IRGER is Germany's long-term government bond yield; IPGERL is Germany's industrial production; and EX is the exchange rate expressed as units of foreign currency (euros) for one unit of the US dollar.[13] The domestic variables include IR, Greece's long-term government bond yield, M which is a monetary aggregate defined as $M_{1;}$ Inflation is the rate inflation; and IP is Greece's industrial production. All variables are taken in log difference except oil prices and inflation rates which are denominated in percentage change and percentage points respectively. The data set spans the period: Q1- 2002 through Q1- 2014, and has been retrieved from the Organization of Cooperation and Economic Development (OCED) and the Saint Louis federal reserve databases (Table 1).

[11] See Goldberg and Knetter (1997) for a more detailed discussion.

[12] Inclusion of foreign variables in Kim and Roubini (2000) and Cushman and Zha (1997) solved previous anomalies, such as liquidity, price, exchange rate, and forward discount rate bias puzzles.

[13] German variables were frequently used in the literature as proxies for world macroeconomic variables given the large size of the German economy.

Table 1
Descriptive Statistics, 2002–2014.
Source: Authors' Estimates.

	Exchange Rate	Germany IR	Germany IP	Greece IP	Greece IR	Greece Inflation	Greece M1	Oil Prices
Mean	0.79	3.29	1	1.09	7.76	0.64	103118	74.28
Median	0.77	3.48	1.01	1.13	4.96	0.6	107043	73.20
Maximum	1.14	5.11	1.13	1.29	25.40	3.6	124057	138.40
Minimum	0.64	1.34	0.86	0.81	3.41	−2.1	79210	25.33
Std. Dev.	0.10	1.05	0.08	0.15	5.79	1.42	13393	31.57
Skewness	1.66	−0.52	−0.28	−0.46	1.80	−0.19	0	−0.02
Kurtosis	6.02	2.19	1.60	1.89	5.31	1.89	2.0	1.82
Jarque-Bera	41.22	3.55	4.59	4.25	37.24	2.79	4.0	2.87
Probability	0.00	0.17	0.10	0.12	0.00	0.25	0	0.24
Sum	38.69	160.98	49.00	53.38	380.24	31.3	5052793	3639.78
Observations	49	49	49	49	49	49	49	49

Notes: All variables are in log difference except for inflation and oil prices which are in percentage change. The data frequency is Quarterly from 2002 to 2014.

3.2. Empirical results

We start our empirical analysis by checking the stability condition which is a necessary first step to establish stationarity of the variables of interest. In other words, we will first determine the lag length of the variables to be used in the SVAR model. Even though in previous studies the maximum lag length that is allowed is 4, we use a lag length of 3,[14] as indicated by the AIC, SBIC, and HQIC criteria. A lag length of 3 insures that the SVAR model is stable i.e.; all characteristic roots lie within the unit circle, as indicated in Fig. 3 below.

Moreover, our identification procedure to recover structural shocks and, therefore, impulse response functions uses restrictions on the contemporaneous structural parameters. The impulse response analysis is expected to generate an inference into the dynamic patterns and time path of reactions of Greece's macroeconomic variables to shocks originating in Germany. Additionally, the impulse response analysis will shed light on the duration of the effect of German shocks on the Greek economy.[15]

Fig. 4 indicates that all shocks appear to be transitory in nature over a period of 10 quarters and tend to vanish in the long run. None of Germany's industrial production and interest rate shocks has a permanent effect on Greece's industrial production, interest rate or inflation. However, shocks to Germany's industrial production and interest rate, as well as oil prices affect Greece's inflation rate significantly with either an alternating or pure positive effects, i.e.; Greece's rate of inflation responds positively to German shocks, like for instance, technological shocks, the growth rate of industrial output, and changes in German competitiveness. This has been indeed the case since Greece joined the Eurozone in 2002, whereby improved productivity in Germany and higher industrial production growth rates have been contributing factors in increasing Greece's inflation rates with devastating consequences on competitiveness and subsequent trade and current account deficits. Likewise, Greece's interest rate seems to respond positively to shocks in German interest rates. The significant impact of German interest rates on those of Greece is due to the fact Greece, which is a member of a monetary union, has been vulnerable to external macroeconomic disequilibria since it joined the Eurozone in 2002. This has further widened its interest rate differential with Germany. Since these disequilibria have been persistent over the last decade, they subsequently triggered a balance of payment crisis, because real adjustments have been hard to implement given the absence of monetary instruments to tackle Greece's external disequilibrium. Accordingly, Greece's current account deficit has been widening, so have the interest rate differential, further worsening the national debt and the government budget deficit via increases in the cost of debt (see also Neaime 2015b).

It is well known that Greece's real exchange rate vis-a-vis Germany has been appreciating over time, especially during the period 2000–2010, right before the crisis. Right after the establishment of the EMU, Greece experienced huge losses in international competitiveness, and its trade balance relative to Germany started registering recurrent deficits. If Germany agrees to inflate its economy either through the current ECB's quantitative easing, or through more accommodative domestic fiscal policy, then German goods will become less competitive internationally. Germany will run a current account deficit which will subsequently help Greece reduce its trade deficit relative to Germany. However, so far Germany has refused to inflate its economy in order to accommodate countries in the periphery of the Eurozone in general, and Greece in particular, since this will also jeopardize its comparative advantage relative to the rest of the world.

In order to further corroborate our impulse response functions results, we conduct next Granger-causality tests to trace the short run dynamics and direction of causality between both sets of endogenous and exogenous variables. We are mainly interested in identifying whether German interest rates and industrial production granger cause Greece's macroeconomic variables. Table 2 below

[14] At a lag length of 4, which is widely used in the empirical literature for quarterly data, the SVAR model does not satisfy the stability condition even though all variables turned out to exhibit stationarity. However, we believe this is due to the fact that statistical tests have probabilities of errors of certain types including unit root tests and, therefore, it is certainly possible that while finite sample variables are statistically stationary, the estimated VAR may turn out to be unstable.

[15] Convergence criterion of the maximum likelihood maximization/estimation was set to be less than or equal to 10ˆ-5. Moreover, the gradient vector of the underlying estimated system approached zero at convergence values. It is therefore safe to assume that our estimates are optimal and, thus, empirical results such as impulse response functions and confidence intervals are reliable.

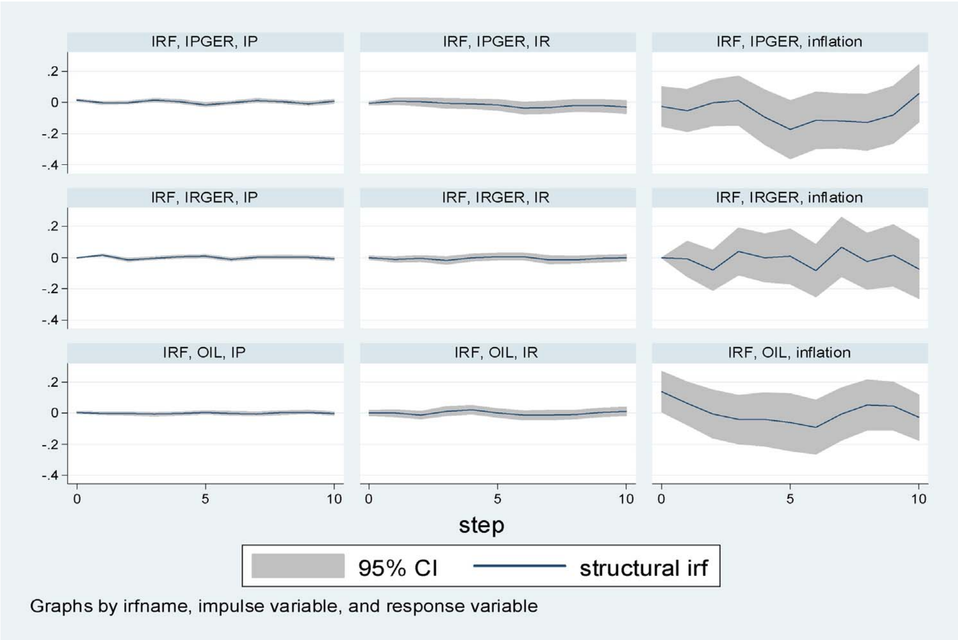

Fig. 4. Impulse Response Functions, 2002–2014.
Notes: Responses of Greece's industrial production (IP), interest rate (IR) and inflation rate to an Impulse in IRGER, OIL, and IPGER. All variables are in log difference percentage change. CI is the confidence interval, and irf refers to impulse response functions.

Table 2
Granger Causality Wald Tests.
Source: Authors' Estimates.

Equation		chi2	Probability
IRGER	IR	18.67**	0.000
IRGER	Money	0.26	0.966
IRGER	Inflation	7.56**	0.006
IRGER	IP	15.38**	0.002
IRGER	OIL	39.35**	0.000
IRGER	EX	18.89	0.000
IRGER	IPGER	10.86*	0.012
IRGER	ALL	109.19	0.000
IPGER	IR	6.99	0.072
IPGER	Money	10.71*	0.013
IPGER	Inflation	2.57**	0.003
IPGER	IP	15.38**	0.002
IPGER	IRGER	3.65	0.302
IPGER	OIL	17.67**	0.001
IPGER	EX	3.27	0.351
IPGER	ALL	102.74	0.000

Notes: A * and ** Corresponds to significance level at 5% and 1% respectively.

indicates that German interest rates are found to granger cause Greece's interest rates, inflation, and industrial production at the one percent level of significance. Moreover, Germany's industrial output affects significantly Greece's inflation rates, money supply, and industrial output.

Given Germany's factor endowments, advanced technology and sophisticated manufacturing sector, and after European monetary unification, domestic capital and foreign direct investment flows have been diverted away from Greece and into Germany. This has induced Greece to constantly increase domestic money supply to meet domestic money demand and prevent real interest rates from increasing in the absence of appropriate central bank intervention.[16] As capital has been flowing out of Greece and into Germany, Greece has been experiencing, higher inflation rates, losses in competitiveness, trade and current account deficits, recession, and

[16] Greece's money supply increased due to the capital inflows driven by the higher yields offered by Greek assets and the misperception among international investors about the existence of a bail-out clause for the member countries of the union.

fiscal imbalances. In short, one can safely assume that German nominal shocks appear to have a significant impact on Greece's macroeconomic fundamentals. The Granger causality results have reinforced the impulse response analysis above. Our empirical findings are in line with Krugman (2013) findings that Greece's crisis is in fact a balance of payment crisis coupled with alarming sovereign debt levels, and that self-fulfilling virtues are contributing factors to the problem.

4. Conclusion and policy recommendations

Using a structural VAR approach, this paper explored the root cause and triggering factors of the Greek debt crisis, as well as, whether EMU and the German macroeconomic policies have contributed negatively to the crisis. After recovering structural shocks using short-run theory derived restrictions, impulse response functions and Granger causality tests were constructed and estimated. It was shown that shocks to Germany's industrial production and interest rate, as well as oil prices affect Greece's inflation rate significantly, i.e.; Greece's inflation responds significantly to shocks originating in Germany, like for instance technological shocks, the growth rate of industrial output and changes in German competitiveness. Likewise, Greece's interest rate responds positively to shocks in German interest rates. Finally, German interest rates are found to granger cause Greece's interest rates, inflation, and industrial production. Moreover, industrial output in Germany affects significantly Greece's inflation rates, money supply, and industrial output. In short, one can safely assume that German nominal shocks appear to have a significant impact on Greece's macroeconomic fundamentals.

Our empirical results suggest that the root cause of the Greek debt crisis emanates from imbalances in its balance of payment, mainly in its current account, losses in Greece's competitiveness vis-à-vis Germany, and the lack of nominal adjustment measures through monetary policy due to Greece's membership in the EU. In the absence of nominal adjustment mechanisms, Greece will probably have to go through prolonged deflationary episodes in order to enhance its competitiveness relative to Germany, produce a positive current account, contain its recurrent budget deficits, reduce the pressure on its accumulated national debt, and reverse its capital outflows.

Since Greece is a member of a monetary union, a potential devaluation of the domestic currency is not a policy option in order to restore macroeconomic equilibrium following a balance of payment crisis. The crisis translated into a significant reduction in income, which is considered to be another form of currency devaluation. Lower income coupled with a decline in prices served as automatic stabilizers to correct or reduce the current account deficit − similar to a balance of payment adjustment mechanism due to a capital flight crisis. However, Greece needs not only to run a positive current account, but also to reduce its budget deficits in order to convince international investors to regain confidence in its domestic economic. Therefore, Greece has to go through prolonged deflationary episodes in order to correct for its current account deficits given that a small portion of its produced goods are tradable goods (30%), and subsequently correct its large budget deficits.

On the other hand, a proposed exit from the Eurozone and the Euro currency and a subsequent adoption of the Drachma is currently not an option for Greece. It is well known that one of the most important functions of money is that it is a store of value. Reintroducing the Drachma combined with the adoption of a flexible exchange rate system, will not convince Greece's economic agents to hold drachmas instead of holding Euros given the expectation that the Drachma will tend to depreciate which, in turn, might be self-fulfilling and lead to further depreciation of the domestic currency. A potential introduction of the Drachma should go along with a strong government commitment to internal price stability. Only after prolonged episodes of proven credibility would local economic agents start to use the Drachma again as a store of value.

Policy makers and portfolio managers have lessons to learn from the Greek debt crisis. The recent ECB's QE monetary policy will benefit Greece more than Germany. Germany, which has accumulated external current account surpluses and significant external assets has been opposing the ECB's policy. Since long term interest rates are expected to eventually fall, and Germany will subsequently lose in term of interest income. However, countries in southern Europe in general, and Greece in particular, with huge external account deficits will benefit. They will be able to finance their expenditures at low costs.

Germany has been charging Greece and other Eurozone countries for the Eurozone's debt crisis and has been requesting those countries to bear alone the economic cost of adjustment by implementing austerity measures. While the Eurozone countries in crisis have perhaps borrowed heavily to maintain consumption levels above their production capacities–budget deficits are the offspring of trade deficits–Germany still relies on those countries because its production capacity is higher than what its domestic population can consume. Therefore, german economic growth has always depended on EU countries' high consumption levels. Germany cannot maintain its trade surplus if countries in the periphery permanently restrict their consumption levels. Imposing harsh austerity measures on those Eurozone countries in crisis would eventually affect Germany's current account surplus and economic growth. In the current European debt crisis, macroeconomic imbalances should be shared between Germany and countries in the periphery. Germany should accept to implement accomodative economic policies, inflate its economy, and perhaps run a current account deficit, while the remaining EU countries would need to consolidate their finances.

Greece's newly introduced austerity measures will fail to reduce debt and will continue to have a negative impact on economic growth, causing further downgrading of the Greek economy and more hikes in interest rates. Austerity measures are creating a trap whereby recessionary budgets, high interest rates and high levels of debt are reinforcing each other. The ECB, however, will need to continue with its QE policy to reduce interest rates to close to zero and induce further depreciations of the Euro (FED monetary policy since 2008). Greece will need to improve private sector's expectations and encourage commercial banks to give out more loans. It also needs to become more competitive to turn its current account deficit into a surplus, and subsequently use these surpluses to trim down public debt and regain investor's confidence and revert the flow of capital to the advantage of its domestic economy. Once the above is achieved, austerity and structural adjustment measures may be introduced to consolidate fiscal spending and tax collection.

This will insure sustainable economic growth and will reduce the likelihood of a future debt and currency crisis from occurring. All the above would increase the growth rate of GDP and would render debt more sustainable.

It should be noted, finally, that the Greek debt crisis is the result not only of economic deficits but also of political and institutional deficits, which have been developing over the last few decades. Greece needs to reform the electoral process, adjust public sector wages and pension plans to public sector productivity, eliminate institutionalized corruption by abolishing the law about ministerial responsibility, create a credible tax system, without the negotiated settlement of tax arrears, and create a credible national accounting agency. Greece's best alternative is to remain in the euro zone by satisfying its agreements with the Troika; all the other alternatives are inferior and dangerous, not only for Greece but for the Eurozone itself. The proposed economic and political reforms will make the economy more efficient and competitive, and transform it into a modern EU state; and will give hope to the Facebook generation for a better future.

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