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How Did the Fiscal Multipliers Respond to the Change in Policy in Accordance with the Memoranda of Understanding?

by
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DEDICATION

I dedicate this dissertation to my parents, Georgios and Evangelia,

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ABSTRACT

During the financial crisis that started in 2007-2008 many economies adopted fiscal consolidation programs, which caused economic activity to decline. Because of growth disappointments, however, there has been an intense debate about the size of fiscal multipliers. A natural question, therefore, is whether forecasters had underestimated the actual values of the impact fiscal multipliers, which measure the short-term effects of cuts in government purchases of goods and services and/or tax hikes on economic activity.

A number of studies based on pre-crisis data for advanced economies indicate actual multipliers of roughly 0.5 at the start of the crisis. There is evidence, however, that this figure underestimated the true values of the fiscal multipliers during the crisis. As a result, in the countries that adopted the IMF programs, called "memoranda of understanding" (MOU), which were based on these biased estimates of the fiscal multipliers, the negative effect of fiscal consolidation on economic activity was greater than expected.

To my knowledge, this dissertation contributes to the literature by investigating empirically the question of whether and to what extent and direction the MOU signed by a number of countries since 2010 might have changed the fiscal multipliers in these countries. Using a panel of annual aggregate data, 1995-2020, from the eight countries that had adopted MOU (Cyprus, Greece, Hungary, Ireland, Latvia, Portugal, Romania, and Spain), I provide evidence that supports the hypothesis that in these eight countries the imposition of the MOU caused the fiscal multipliers to increase. More specifically, I construct and estimate a macroeconomic model of 17 simultaneous equations, whose parameters may change in response to a major policy change, such as the imposition of the MOU, thus changing the values of fiscal multipliers, the essence of the famous Lucas critique.

Πώς η αλλαγή στην πολιτική μετά την επιβολή των μνημονίων επηρέασε τους δημοσιονομικούς πολλαπλασιαστές;

ΠΕΡΙΛΗΨΗ

Κατά τη διάρκεια της χρηματοπιστωτικής κρίσης που ξεκίνησε το 2007-2008 πολλές οικονομίες υιοθέτησαν προγράμματα δημοσιονομικής εξυγίανσης, τα οποία προκάλεσαν πτώση της οικονομικής δραστηριότητας. Λόγω των υποεκτιμήσεων του ρυθμού οικονομικής μεγεθύνσεως, ωστόσο, υπήρξε έντονη συζήτηση σχετικά με το μέγεθος των δημοσιονομικών πολλαπλασιαστών. Ως εκ τούτου, ένα φυσικό ερώτημα είναι εάν οι προβλέψεις είχαν υποεκτιμήσει τις αληθινές τιμές των άμεσων δημοσιονομικών πολλαπλασιαστών, οι οποίοι μετρούν τις βραχυπρόθεσμες επιπτώσεις των περικοπών των κρατικών δαπανών για την αγορά αγαθών και υπηρεσιών ή/και των αυξήσεων φόρων στην οικονομική δραστηριότητα.

Ορισμένες μελέτες που βασίζονται σε δεδομένα πριν από την κρίση για τις προηγμένες οικονομίες δείχνουν τους πραγματικούς πολλαπλασιαστές να κυμαίνονται περίπου στο 0,5 στην αρχή της κρίσης. Υπάρχουν ενδείξεις, ωστόσο, ότι ο αριθμός αυτός αποτελεί υποεκτίμηση των πραγματικών τιμών των δημοσιονομικών πολλαπλασιαστών κατά τη διάρκεια της κρίσης. Ως αποτέλεσμα, στις χώρες που υιοθέτησαν τα προγράμματα του ΔΝΤ, γνωστά ως «μνημόνια κατανόησης» (memoranda of understanding, MOU), τα οποία βασίστηκαν στις μεροληπτικές αυτές εκτιμήσεις των δημοσιονομικών πολλαπλασιαστών, η αρνητική επίδραση της δημοσιονομικής εξυγίανσης στην οικονομική δραστηριότητα ήταν μεγαλύτερη από την αναμενόμενη.

Εξ όσων γνωρίζω, αυτή η διατριβή συνεισφέρει στη βιβλιογραφία διερευνώντας εμπειρικά το ερώτημα εάν και σε ποιο βαθμό και κατεύθυνση τα MOU που υπέγραψαν ορισμένες χώρες από το 2010 και μετά θα μπορούσαν να έχουν επηρεάσει τους δημοσιονομικούς πολλαπλασιαστές σε αυτές τις χώρες. Χρησιμοποιώντας ένα πάνελ ετήσιων συνολικών δεδομένων, 1995-2020, από τις οκτώ χώρες που είχαν υιοθετήσει τα MOU (Κύπρος, Ελλάδα, Ουγγαρία, Ιρλανδία, Λετονία, Πορτογαλία, Ρουμανία και Ισπανία), βρίσκω ενδείξεις που υποστηρίζουν την υπόθεση ότι σε αυτές τις οκτώ χώρες η επιβολή των MOU προκάλεσε αύξηση των δημοσιονομικών πολλαπλασιαστών. Πιο συγκεκριμένα, κατασκευάζω και εκτιμώ ένα μακροοικονομικό μοντέλο 17 ταυτόχρονων εξισώσεων, των οποίων οι παράμετροι ενδέχεται να έχουν αλλάξει μετά από μια σημαντική αλλαγή της πολιτικής, όπως η επιβολή των MOU, αλλάζοντας έτσι τις τιμές των δημοσιονομικών πολλαπλασιαστών, που είναι η πεμπτουσία της περίφημης κριτικής του Lucas.

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CHAPTER 1: INTRODUCTION

1.1. Thesis Background

Following the outbreak of the international financial crisis in 2007, the worldwide economy slipped into a serious recession. After the initial consensus in favor of measures to support the economy in 2008-2009, several fierce controversies were developed since 2010 over economic policy recommendations. One of the most highly-mediatised dispute concerns the possible existence of a maximum debt-to GDP ratio that countries should not exceed if they are to continue growing and servicing their debt. In a famous article published in 2010, C. Reinhart and K. Rogoff (henceforth R&R) concluded that a public debt–to–GDP ratio of more than 90% causes negative growth. This conclusion had extremely important practical implications, as it was considered essential to reduce public debt if it rose above this threshold. Among other examples, the European Commissioner for Economic and Monetary Affairs O. Rehn and the British Chancellor of the Exchequer G. Osborne had no hesitation in using the results of R&R to justify the fiscal consolidation they considered to be necessary in Europe. Since then, however, the conclusions of R&R have been largely refuted.

A second controversy also burst when Blanchard and Leigh (2013) acknowledged that the International Monetary Fund (IMF) had underestimated the values of fiscal multipliers, thus underestimating the negative effect of fiscal consolidation on growth. More specifically, using cross-sectional data on forecasts made in 2010 in 26 European countries, including five countries that had adopted IMF's programs, known as "memoranda of understanding" (MOU), Blanchard and Leigh (2013) estimated the following relationship:

Forecast error in growth of real GDP (actual growth rate – expected growth rate) in country *i*

$= \alpha + \beta$(Forecast of fiscal consolidation in country *i*) + disturbance$_i$.

Under the assumptions of rational expectations and of a correct model that generates the forecasts, if the values of fiscal multipliers used for forecasting growth loss (because of fiscal consolidation) were accurate, the regression coefficient β should be zero. Blanchard and Leigh's (2013) "baseline" estimate of β is, however, -1.095 (*t*-statistic = -4.294). The interpretation of this negative coefficient is as follows: for every additional unit of fiscal consolidation, actual growth loss was greater than expected, implying that the forecasters were "too optimistic" in using lower than the actual values of the fiscal multipliers to generate their forecasts of output growth. In other words, the actual values of the fiscal multipliers were greater than those the forecasters assumed and, consequently, fiscal consolidation caused real GDP to fall by more than was expected.

Blanchard and Leigh (2013, p. 19) find plausible the assumption made by forecasters at the start of the crisis, that the actual values of fiscal multipliers during the crisis averaged about 0.5, an estimate based on pre-crisis data from advanced economies. Their conclusion is surprising, however, since multipliers are likely to be higher during periods of economic slack. In addition, and this is the central point of this thesis, for the countries that adopted the MOU the values of the multipliers during the crisis are likely to be different from their pre-crisis sizes, because the MOU involved a significant change in policy and, consequently, a change in the values of the parameters that determine the values of the multipliers (the Lucas Critique). The IMF failed to consider this possibility, however, thus generating "too optimistic" forecasts for the loss of output due to fiscal consolidation. Blanchard and Leigh (2013) also failed to consider this possibility. First, they stated (on p. 19) that they believed that the multiplier estimates of 0.5, which were based on *pre-crisis* data, were plausible, thus neglecting the Lucas

Critique. Second, when they removed from their baseline sample the five countries that had adopted MOU and, as a result, the estimate of β fell (in absolute value) from -1.095 to -0.812 (t-statistic = -2.89), they concluded that the new estimate "is not statistically distinguishable" from their baseline estimate. In the spirit of this thesis, however, the higher (in absolute value) estimate of β by -0.283 in their baseline results could have been attributed to the presence of these five countries. Because of these failures, the MOU turned out to be "catastrophic" for countries like Greece, as Blanchard (2015) admitted.

To my knowledge, this dissertation contributes to the literature by investigating empirically the question of whether and to what extent and direction the MOU signed by a number of countries since 2010 might have changed the fiscal multipliers in these countries. Using data from eight countries that had adopted MOU, Chapters 3 and 4 provide evidence, which is relevant for these eight countries, that supports the conclusion that the MOU caused the fiscal multipliers to increase. More specifically, I construct and estimate a structural macroeconomic model of small-to-medium size, whose parameters may change in response to a major change in policy, such as the imposition of the MOU, thus changing the values of the fiscal multipliers. This is the essence of the famous Lucas critique. In the context of this model, I address two questions. First, which parameters might change in response to a major policy change, such as the imposition of the MOU? Second, do these parameters determine the sizes of the fiscal multipliers, and how?

In an attempt to answer these questions, I focus on some parameters that are known to determine the values of the fiscal multipliers, namely, the marginal propensities to consume (MPC), to invest, and to import. Consider, for example, the possibility of an increase in MPC after the adoption of the MOU, as consumers might increase their spending (C) out of an additional euro of their disposable income (Y_d). This can occur if C is not a linear function of

Y_d, but Y_d has a diminishing marginal effect on C; so, as Y_d decreases (because of the MOU), *MPC* increases. In addition, assuming that the average consumer after the imposition of the MOU feels poorer (as the MOU implies higher current and future taxes, "haircuts" of the value of bonds, etc.), he/she might spend more out of an additional euro of disposable income to satisfy a need that remained unsatisfied because of his/her impoverishment. To clarify these conjectures, consider the consumption function $C_t = \alpha + \beta Y_{dt} + \gamma Y_{dt}^2 + \delta W_t$, where W = wealth, $\beta > 0$ (standard assumption), $\gamma < 0$ (the diminishing marginal effect of Y_d on C), and $\delta > 0$ (as $\partial C/\partial W > 0$). Thus, $MPC_t = \partial C_t/\partial Y_{dt} = \beta + 2\gamma Y_{dt}$. As W falls (the "impoverishment" due to MOU), other things equal, the level of C falls (so some needs remain unsatisfied), but *MPC* stays the same. Since $\gamma < 0$, *MPC* increases as Y_d decreases (due to MOU), however.

Next, consider a change in the marginal propensity to invest. If the adoption of the MOU induced investors to expect a more stable and more productive economic environment in the longer run, they would want to invest more now for every level of economic activity in the current period. Under these circumstances, we would expect an increase in the marginal propensity to invest.

Finally, consider a decrease in the marginal propensity to import after the imposition of the MOU, as people might have reduced the amount of imported goods out of a given increase in income due to the debt problem, thus increasing the value of the fiscal multiplier.

Blanchard and Leigh (2013) offer additional reasons for these possible changes in the parameters. Note, however, that they focus on the slackness of the economy during the crisis, not on the change in policy implied by the imposition of MOU, which is the central point of this thesis. Consider an increase in MPC and in the marginal propensity to invest. Blanchard and Leigh (2013, pp, 3-4) note the following:

> Because of the binding zero lower bound on nominal interest rates, central banks could not cut interest rates to offset the negative short-term effects of a fiscal consolidation on economic activity ... consumption may have depended more on current than on future income, and that investment may have depend more on current than on future profits, with both effects leading to larger multipliers ... a number of empirical studies have found that fiscal multipliers are likely to be larger when there is a great deal of slack in the economy.

Note that, although the theoretical model used here is of a Keynesian type, it nevertheless incorporates the rational expectations hypothesis (REH), the dominant theory of expectations formation, which says that people make intelligent use of available information in forecasting variables that affect their economic decisions, in that they collect and process information until the marginal benefit from doing so equals marginal cost. The expectations so formed are unbiased, i.e., they do not systematically over- or under-predict the actual values of the forecasted variables.

In the empirical part (Chapter 4), I use panel data from the countries that signed MOU. The panel consists of annual aggregate data, 1995-2020, for the following countries: Cyprus, Greece, Hungary, Ireland, Latvia, Portugal, Romania, and Spain. Note that the MOUs were not imposed at the same time to all of the eight countries in the sample. In the case of Greece, the MOU was imposed in 2010 and lasted formally until 2018. In the case of Spain, it started in July 2012 and ended in 2013. In the case of Ireland, it started in December 2010 and ended in 2013. For Portugal, it started in 2011 and ended in 2013. For Cyprus, the MOU was imposed in April 2013 until March 2016. For Latvia and Hungary, it was imposed from 2008 to 2011, and for Romania it was imposed from 2009 to 2011.

In the light of the fact that Greece's debt as a share of GDP has been increasing since the early 1980's (see Figure 1), and hence there is a need for fiscal contraction, an important question arises concerning the effectiveness of fiscal consolidation and whether a fiscal contraction can be self-defeating, in that a reduction in government expenditure or a tax increase might cause such a strong fall in economic activity that the budget deficit and hence the debt-to-GDP ratio might actually increase. Figure 1 shows the evolution of the Greek general government debt-to-GDP ratio over the period 1980-2020. As it is evidently clear, this ratio started to rise in the 1980s, and skyrocketed in the 1990s. During the 1965-1973 period, this ratio was about 17% on average (not shown in the figure), whereas during the 1981-1990 period, it rose to 50%, and during the period 1991-1999 it climbed to about 94%.

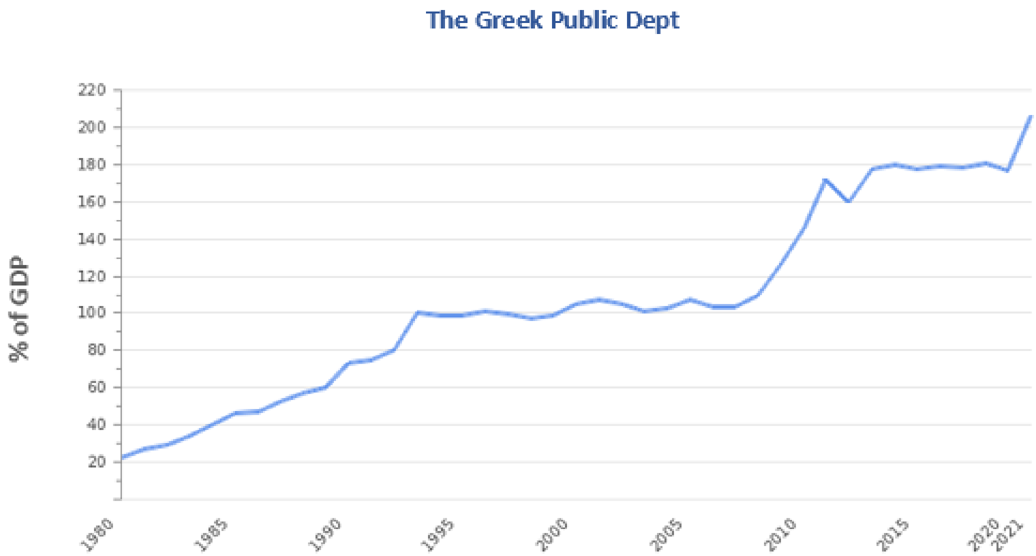

Figure 1.1 General Government's Debt-to-GDP ratio in Greece, 1980-2020 (Source: IMF)

1.2. What is the fiscal multiplier?

The fiscal multiplier is a measure of how the level of domestic production changes in response to a *ceteris paribus* change in government purchases of goods and services or in autonomous taxes. The macroeconomic mechanism of the fiscal multipliers is based on the idea that additional spending in the economy generates income which in turn provokes further spending. Since 1936, it has been associated with the British economist J.M. Keynes and his famous book entitled *The General Theory of Employment, Interest, and Money*. The higher the value of the multiplier, the greater the impact of government intervention on economic activity. However, this virtuous circle is limited by three factors, which prevent the income generated from being spent entirely on domestically produced goods and services: saving, imports, and taxes. The practical interpretation of the idea of the multiplier, that an increase in public spending could be considered an effective instrument against recessions, was soon called into question, however, initially by the monetarists and later by the new classical economists.

During the 1990s, a new generation of research developed the idea that cutting public spending (fiscal consolidation) is a means to sustain economic growth. This was a complete turnaround: the multiplier was thought of being negative, see Perotti, 2002, Favero and Giavazzi, 2009. These theoretical developments have had undeniable consequences on the economic policy recommendations made by international financial institutions since the 1980s. The multiplier has been considered negligible or illusory. Only supply-side policies are effective, and over the short-term, only monetary policy should be used.

1.3. Rediscovery of the multiplier and observation of its variation over the economic cycle

In a now famous article, Blanchard and Leigh (2013) indicated that they had underestimated the value of fiscal multipliers. Auerbach and Gorodnichenko (2012) had already published results showing that the fiscal multipliers were higher than had generally been assumed. In a recent article, Riera-Crichton et al. (2014) showed that multiplier effects are stronger when the economic slowdown is more pronounced and when public spending is used counter-cyclically. In other words, the multiplier effect is strongest during a deep recession, reaching as much as 3.20 in some OECD countries. In such cases, the value of the multiplier is far from being negligible.

1.4. Is the multiplier higher during recessions?

The question of whether the value of the fiscal multiplier is higher during recessions has not yet received a fully satisfactory answer. In their simple methodology, Charles et al. (2014a, 2014b) note that the value of the multiplier depends positively on the marginal propensity to consume (MPC) and negatively on the marginal propensity to import (MPI). Anything that changes the MPC influences the multiplier directly. For example, the level of income may affect the MPC of the average consumer. Generally, lower-income individuals are less able to save, and a windfall income is likely to be spent entirely on medical help, repairing a vehicle, purchasing new clothes, and the like, i.e., all expenditures that may have delayed prior to the increase in income. In contrast, high-income consumers are more likely to save extra income. Thus, tax policies that benefit high-income consumers may have a smaller effect on economic activity than those that benefit low-income consumers. For example, Zandi (2012) estimated that if Congress reduced permanently dividend and capital-gains taxes, then in the first year the multiplier would be only 0.39, whereas a temporary increase in food stamps would be associated with a multiplier of 1.71. The reason for the difference in the estimated value of the multiplier is that recipients of food stamps are more likely to spend the additional income immediately than the wealthier individuals, who would spend the savings accrued from the tax reduction on capital gains and dividends. Zandi (2012) concluded that tax policies favoring consumers with a higher MPC should be used to help the economy recover from a recession.

Government purchases increase aggregate demand more than an equivalent amount of transfer payment or a tax cut. In subsequent steps, consumers spend a portion of the income thus generated, in accordance with their MPC, and save the rest.

1.5. The size of fiscal multipliers

Simulations based on dynamic stochastic general equilibrium (DSGE) and structural vector autoregression (SVAR) models, developed since the early 1990s, suggest that first-year multipliers generally lie between 0 and 1 in "normal times." This literature also finds that spending multipliers tend to be larger than revenue multipliers;[1] see Mineshima, et al. 2014.

[1] This has often been explained with basic Keynesian theory, which argues that tax cuts are less potent than spending increases in stimulating the economy, since households may save a significant portion of the additional after-tax income.

Based on a survey of 41 studies, Mineshima, et al. (2014) report that the average first-year multiplier is 0.75 for government spending and 0.25 for government revenues in advanced economies.[2] Blanchard and Leigh (2013) argue that fiscal multipliers associated with planned fiscal consolidations during the Great Recession are larger than those used by policy institutions. In the opposite direction, authors find no evidence of systematic forecast errors related to planned fiscal policy changes in the pre-crisis period. See Romer, C.D., and D.H. Romer, 2010 and Hall, R. E., 2009. This evidence suggests that fiscal multipliers may be substantially larger during severe downturns. Second, some papers, Alesina, A., and R. Perotti, 1996, Kraay, A., 2012 and Mertens, R. and M. O Ravn, 2012, use a new "narrative" approach to identify exogenous fiscal shocks, find larger tax multipliers than conventional VAR models do.

These results have been challenged by more recent studies, however. Tagkalakis (2008) finds that, in the OECD, fiscal policy has a larger effect on consumption in recessions than in expansions; and that this effect is more pronounced in countries that have a less developed consumer credit market. Similarly, Auerbach and Gorodnichenko (2012), Bachmann and Sims (2012) and Riera-Crichton, Vegh and Vuletin (2014) find state dependent multipliers[3] that are larger during recessions.

[2] The survey, based on linear VAR and DSGE models, excludes results from narrative approach studies. The list of 41 papers is provided in Mineshima, et al. (2014).

[3] That is, multipliers whose values depend on the state of the economy.

The "narrative" approach[4] constitutes a methodological improvement upon the traditional measurement of fiscal shocks. The structural VAR methodology, which employs output elasticities of expenditure and revenue to filter out automatic stabilizers, may fail to capture exogenous policy changes correctly, because, for example, changes in revenues are not only due to output developments and discretionary policy, but also to asset and commodity price movements (IMF, 2010). It seeks to identify exogenous fiscal shocks directly. On the spending side, some studies have used news about future military spending as a measure of exogenous shocks (e.g., Ramey, 2011). The idea is that military spending is determined by wars and foreign policy developments and not by concerns about the state of the economy (Romer, 2011).

Two types of determinants of the size of fiscal multipliers are identified in the literature: (i) structural country characteristics that influence the economy's response to fiscal shocks in "normal times," and (ii) temporary factors, notably cyclical or policy-related phenomena, which make multipliers deviate from their "normal" levels. I discuss these in turn.

Structural characteristics

Some structural characteristics influence the economy's response to fiscal shocks in "normal" times.[5] Empirical estimates of fiscal multipliers vary accordingly, although the

[4] Narrative theory is based on the concept that people are essentially storytellers. Storytelling is one of the oldest and most universal forms of communication and so individuals approach their social world in a narrative mode and make decisions and act within this narrative framework (Fisher 1984).

[5] "Structural" refers to characteristics that are intrinsic to the way the economy operates over longer time periods.

incremental effect of structural factors on multipliers is, to a large extent, unknown. Key structural characteristics include:

• **Trade openness**. Countries with a lower propensity to import (i.e., large countries and/ or countries only partially open to trade) tend to have higher fiscal multipliers because the demand leakage through imports is less pronounced (Barrell, et al., 2012; Ilzetzki, et al., 2013; IMF, 2008).

• **Labor market rigidity**. Countries with more rigid labor markets (i.e., with stronger unions, and/or with stronger labor market regulation) have larger fiscal multipliers if such rigidity implies reduced wage flexibility, since rigid wages tend to amplify the response of output to demand shocks (Cole and Ohanian, 2004; Gorodnichenko, et al., 2012).

• **The size of automatic stabilizers**. Stronger automatic stabilizers reduce fiscal multipliers, since mechanically the automatic response of transfers and taxes offsets part of the initial fiscal shock, thus lowering its effect on GDP (Dolls, et al., 2012).

• **The exchange rate regime**. Countries with flexible exchange rate regimes tend to have smaller multipliers, because exchange rate movements can offset the impact of discretionary fiscal policy on the economy (Born, et al., 2013; Ilzetzki, et al., 2013).

• **The debt level**. Highly indebted countries generally have lower multipliers, as fiscal consolidation (stimulus) is likely to have positive (negative) credibility and confidence effects on private demand and the interest rate risk premium (Ilzetzki, et al., 2013, Kirchner, et al., 2010).

• **Public expenditure management and revenue administration**. Multipliers are expected to be smaller when difficulties to collect taxes and expenditure inefficiencies limit the impact of fiscal policy on output.[6]

Temporary factors

Temporary (non-structural) factors tend to increase or decrease multipliers from their "normal" level. The recent literature has identified two such factors:

• **The state of the business cycle**

Fiscal multipliers are generally found to be larger in downturns than in expansions. This is true both for fiscal consolidation and stimulus. A stimulus is less effective in an expansion, because, at full capacity, an increase in public demand crowds out private demand, leaving output unchanged (with higher prices). A consolidation is costlier in terms of output in a downturn, because credit-constrained agents cannot borrow to maintain their consumption. Multipliers increase more in a recession than they decrease in an expansion. Jorda and Taylor (2013) examine how fiscal consolidation affects output distinguishing between slumps and upturns. Their measure of fiscal consolidation is based on the narrative approach proposed by IMF (2010). They show that the cumulative impact of a 1 percent of GDP fiscal consolidation

[6] This argument implicitly assumes that fiscal multipliers measure the effect of planned fiscal measures on output (as in papers using a narrative approach), rather than the effect of actual changes in revenue or spending.

on real GDP is about −2.5 percent after four years in a slump compared to about 0.9 percent in a boom.

• **Degree of monetary accommodation to fiscal shocks**.

Fiscal multipliers can potentially be larger when the transmission mechanism of monetary policy is impaired—as is the case at the zero interest lower bound (ZLB) (Erceg and Lindé, 2010; Woodford, 2011). Most of the literature focuses on the effect of temporary increases in government purchases and finds that the multiplier at the ZLB exceeds the "normal times" multiplier by a large margin.[7] Christiano, et al., (2011) find that implementation lags reduce the multiplier at the ZLB. See Table 1.1.

[7] Results on taxes are less conclusive. Eggertson (2010) investigates the impact of labor and capital tax *cuts* at the zero lower bound and finds that they have *contractionary* effects on output, in contrast to normal timesm when they are expansionary. He argues that this is due to their deflationary effects, which, at the ZLB, raise real interest rates.

Table 1.1 Government Spending Multipliers and the Zero Lower Bound

	No ZLB	**ZLB**	**Notes**
Christiano, et al. (2011)	1.1	3.7	Impact multiplier for a temporary increase in government spending in the United States. Multiplier at ZLB assumes policy implemented at time t when ZLB begins to bind. If there are implementation lags of fiscal stimulus, the multiplier declines. For instance, an implementation lag of 1 period reduces the multiplier from 3.7 to 1.5.
Eggertson (2010)	0.5	2.3	Impact multiplier for a temporary increase in government spending in the United States.
Erceg and Linde (2014)	1	4	ZLB multiplier of 4 is based on a temporary spending increase of 1 percent of GDP in the United States, and ZLB duration of 8 quarters. Erceg and Linde consider the government spending multiplier when the nominal interest rate is determined according to price-level targeting (PLT). They find that the government spending multiplier is smaller under PLT than under a Taylor rule.

1.6. Types of models economists use to estimate fiscal multipliers

Three types of models are often used to generate estimates of the fiscal multiplier: macroeconometric forecasting models, time-sseries models, and DSGE models. Each type has strengths and limitations.

- **Macroeconometric forecasting models**

Macroeconometric forecasting models, which underlie most of the forecasts offered to the clients of economic consulting firms, are the basis for many estimates of multipliers. The details of these models are based largely on historical relationships among aggregate economic variables and are informed by theories of how those variables are determined. Because macroeconometric forecasting models emphasize the influence of the overall demand for goods and services, they tend to estimate greater economic effects from policies that bolster demand than time-series and DSGE models do, see Chinn (2013).

The reliability of macroeconometric projections depends heavily on the validity of the specific economic assumptions used. For example, because the models are grounded on observed historical relationships, their estimates rely on the assumption that individuals will, on average, continue to react to changes in fiscal policies in the same way that they reacted in the past. Consequently, estimates projected by such models might be unreliable when policies or economic conditions differ substantially from those of the past; see Parker (2011) and Auerbach et al. (2010) for more details of limitations that arise from the use of historical data in order to estimate how output responds to new and untested fiscal policies.

- **Times-series models**

Time-series models offer an alternative to macroeconometric forecasting models. In their most basic form, time-series models, such as vector autoregression (VAR) models, summarize correlations between economic variables, such as government spending and gross domestic product (GDP), over time.[8] Because time-series models contain little economic theory, they can be particularly useful when there is reason to believe that existing theories may be inaccurate or based on particularly unrealistic assumptions.

However, the lack of theoretical grounding makes it difficult to use time-series models to assess the direction of causation between policies and the economy, see Parker (2011). For example, while poor economic conditions can spur the government to enact policies aimed at stimulating economic activity, a statistical correlation between the policies and economic performance could be interpreted as indicating that policies caused the weak performance.

Two approaches are often used to identify economic causation as distinct from mere correlation. One approach – called "structural vector autoregression" (SVAR) – relies on making assumptions about the interaction of the economic variables of interest. That approach is easy to implement (because it does not require specification of many behavioral relationships or extensive data gathering) and is useful when the statistical assumptions are correct. However, if the assumptions are incorrect, then the approach may lead to less reliable multiplier estimates than the most basic form of time-series models; see Blanchard and Perotti (2002).

[8] The main difference between time-series and macro models is that the latter impose *a priori* restrictions on the parameters, while time-series models do not impose such restrictions.

- **DSGE models**

DSGE models are also used to estimate fiscal multipliers. DSGE models are "dynamic" because they focus on how an economy evolves over time, "stochastic" because they take into account that the economy is affected by random shocks (owing to technological changes, for example), and "general equilibrium" because they assume that people make decisions in response to prices in the economy (such as wages and rates of return on saving) and that prices change in response to those decisions. In DSGE models, people are assumed to make decisions about how much to work, spend, and save on the basis of current and expected future values of wage rates, interest rates, taxes, and government purchases, among other things. As a result of these and other assumptions about individuals' and businesses' behavior, such models offer a clear perspective on the causal relationships among economic variables. DSGE models differ from traditional macro models in that they include micro foundations describing the optimal behavior of economic agents.

A thorough grounding on economic theory allows DSGE models to avoid the difficulties of interpretation that arise with purely statistical approaches to analyzing data. In addition, the explicit assumptions about economic decisions in DSGE models are less dependent on historical data than in macroeconometric models.[9] Therefore, DSGE models can be particularly useful when analyzing the effects of changes in fiscal policies that have not been observed previously.

[9] See Fernández-Villaverde and Rubio-Ramírez (2006) of how DSGE models are estimated. See Coenen, et al., (2012) for a comparison of significant model features and parameters of several DSGE models used by policy-making institutions in Canada, Europe, and the United States.

DSGE models often include assumptions that seem to be at odds with important features of the real–world economy. For example, see Parker (2011) and Fair (2012), who criticize several modeling choices made in many DSGE models. In addition, Leeper, et al., (2011) observe that a tight range for estimates of the multiplier is imposed by the assumptions and choices made by researchers when using DSGE models. See also Chari, et al., (2009), who argue that DSGE models rely on so many improvised modeling assumptions that their conclusions are unavoidably ambiguous for policy analysis.

DSGE models also are typically built on the assumptions that people have full information about the current economy and future economic developments and base their decisions on a full lifetime plan. In extreme form, these assumptions imply that people anticipate that increases in government spending or decreases in taxes will eventually lead to lower spending or higher taxes, thus raising their current saving in an attempt to offset the expected future burden. Therefore, in such models, tax cuts usually have little or no effect on current consumer spending.

CHAPTER 2: REVIEW OF THE LITERATURE

2.1. State dependent short – term fiscal multipliers

Most of the empirical models employed before the recent financial crisis to measure the output effects of fiscal policy focused on linear dynamics: vector autoregressions (VARs) and linearized (or close-to-linear) dynamic stochastic general equilibrium (DSGE) models. Several authors – see Parker (2011) for a review – point out that such models ignore the state of the economy and implicitly assume that there is a time-invariant fiscal multiplier. A recent strand of the empirical literature extends the analysis to allow for non-linearities or state-dependent fiscal multipliers. Such studies try to identify the economic conditions most closely related to the recent great recession and provide estimates for the output response in different regimes. While they will be the focus of this section, relevant results with DSGE models are also discussed.

Estimates of fiscal multipliers[10] are found to differ across countries, periods of analysis and methodologies employed. The range of estimates varies broadly across studies. See Figure 2.1 below for a distribution of the value of fiscal multiplier found in various studies reviewed by Spilimbergo et al. (2009) and Gechert and Will (2012). In Spilimbergo et al. (2009), the average multiplier is 0.5, while the most frequent values are positive but below average. In the Gechert and Will (2012), the average multiplier is between 0.5 and 1.0 depending on which

[10] The definition of fiscal multipliers varies across studies. Some studies consider the impact of fiscal shocks on the level of output while others consider the impact on output growth. This dissertation reviews studies that adopt both approaches.

fiscal instrument is used to achieve consolidation and the estimation method; see Andrés and Doménech (2013).

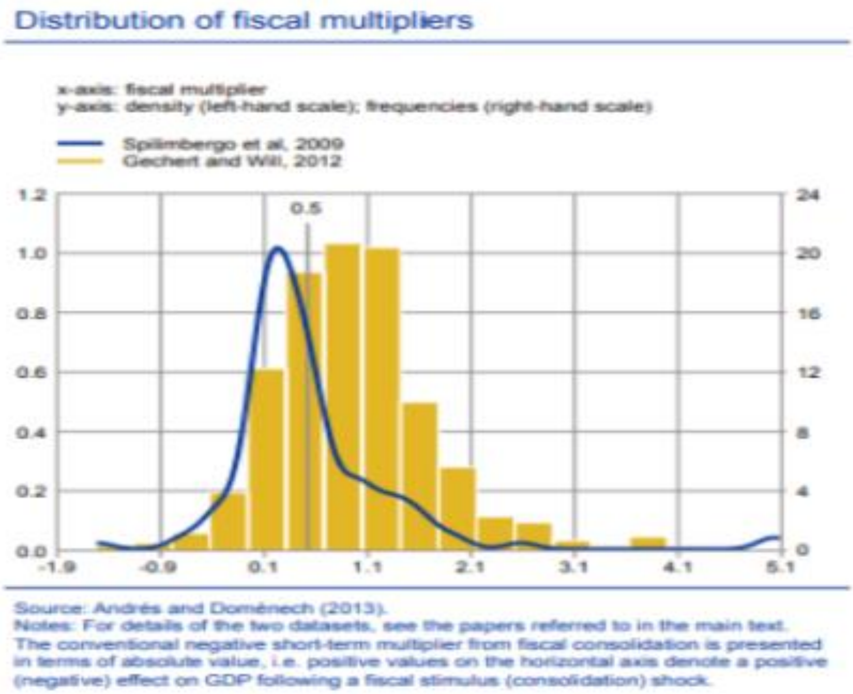

Figure 2.1 Distribution of fiscal multipliers

2.2. Fiscal multipliers in DSGE models

Studies conducted in a DSGE framework (see, inter alia, Coenen et al. (2012) for a review[11]) have investigated the factors affecting the size of fiscal multipliers, with a focus on

[11] This article also documents the findings of a comparative study analysing the effects of a variety of fiscal stimulus measures using seven structural policy models developed at the European Central Bank (ECB), the

(i) the structural features of the economy (degree of openness, the presence of nominal or real rigidities, liquidity constraints); (ii) the type of macroeconomic policy in place (degree of monetary policy accommodation and the exchange rate regime); and (iii) the composition and nature of the fiscal shock (expenditure versus taxes, temporary versus permanent, shocks under full versus imperfect credibility of fiscal policy, etc.), as I already noted in Section 1.1.5.

Although the effects of fiscal policy are evaluated linearly[12] at the steady state, DSGE models can also be calibrated to mimic conditions alongside the business cycle. For instance, a recessionary environment may be reflected by a higher share of liquidity constrained households. Moreover, the situation of constrained monetary policy (i.e. the zero lower bound, ZLB, on the policy interest rate), generally characterising deep recessions, is an important feature of some DSGE models. As pointed out in the meta analysis of DSGE studies on fiscal multipliers conducted by Leeper et al. (2011), the monetary policy regime and, to a slightly lesser extent, the fraction of liquidity-constrained households are the most important factors for the size of short-term multipliers.

As regards the ZLB, for US-calibrated models, Christiano et al. (2011), Woodford (2011) and Erceg and Lindé (2010), among others, find that the size of the government spending multiplier is substantially larger than 1 when the nominal interest rate is zero. Some authors (Braun et al. (2012)) have challenged the DSGE results at the ZLB for the United States on methodological grounds. More specifically, in a replication of Christiano et al. (2011), the critique refers to the use of log-linearized equations for all of the equilibrium conditions except

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Federal Reserve Bank, the International Monetary Fund (IMF), the European Commission, the Organisation for Economic Co-operation and Development (OECD) and the Bank of Canada.

[12] A few exceptions to linearity in a DSGE framework are represented by the modelling of the zero lower bound. See attempts to model the duration of the liquidity trap endogenously (i.e. making it dependent on the size of the fiscal shock, as in Erceg and Lindé (2010) and Gomes et al. (2010)).

the Taylor rule (which embeds the non-linearity created by the ZLB on the nominal interest rate).

Braun et al. (2012) claim that there are two types of time-invariant ZLB equilibria that can have very different properties in terms of their implications for the response of the economy to fiscal policy (in one, the spending multiplier is much lower, below 1, and, contrary to the results of the other study, labour supply behaves as expected, i.e. it drops following an increase in labour tax). A different strand of models (with no fiscal focus) has tackled the ZLB from a financial perspective, such as analysing the central bank balance sheet, e.g. Jeanne and Svensson (2007), Auerbach and Obstfeld (2005); or fighting the ZLB through the purchase of illiquid assets, e.g. Goodfriend (2000). See Gomes et al. (2010) for a review and analysis.

Very recent DSGE models integrating the channels of financial intermediation and sovereign default find substantially lower fiscal multipliers. By modelling adverse sovereign-financial risk loops through the balance sheet channel, van der Kwaak and van Wijnbergen (2013) find that the effectiveness of fiscal stimuli in raising output is sizeably reduced (to the point of being negative) in an environment characterised by financial fragility, weakly capitalised banks and sovereign debt discounts, in the face of poor fiscal positions. The introduction of the sovereign default channel in such models is the main factor behind the low multipliers.

In general, the evidence from DSGE models points to lower fiscal multipliers compared with other empirical models, though the treatment of fiscal shocks (transitory versus permanent) may not necessarily be similar across all studies. For the euro area, simulations conducted with the ECB’s New Area-Wide Model (NAWM) largely point to short-term fiscal multipliers considerably smaller (in absolute value) than 1. For a mixed-composition fiscal consolidation package (half revenue, half expenditure), the short-term multiplier is around 0.57

in situations of imperfect policy credibility, which implies that markets initially disbelieve the government's commitment to fully implement the announced consolidation measures. Only when the fiscal consolidation is based purely on reductions in government investment and/or government consumption, and markets initially exhibit doubts about their implementation, does the fiscal multiplier rise above 1 in the simulations.[13] Short-run output costs of fiscal consolidation have been identified in, among others, Almeida et al. (2011) under a DSGE model of a small, open economy in a monetary union, calibrated for Portugal; in Stähler and Thomas (2012) for a two-country DSGE model calibrated for Spain and the rest of the euro area; and in Hernández de Cos and Thomas (2012) for a DSGE model calibrated for the Spanish economy.

The fiscal multiplier increases to 0.67 if monetary policy is constrained at the ZLB. Considering in addition that the share of non – Ricardian liquidity – constrained[14] households is 50% (instead of 25% as assumed in the baseline), the multiplier increases to 0.75. On the other hand, the short-term multiplier can be much smaller in the case of full government credibility (when markets believe that the consolidation efforts will be fully implemented and lasting), or when the decline in the public debt-to-GDP ratio is associated with a reduction in the sovereign risk premium; see ECB (2012b, 2014).

[13] Short-run output costs of fiscal consolidation have been identified in, among others, Almeida et al. (2011) under a DSGE model of a small, open economy in a monetary union, calibrated for Portugal; in Stähler and Thomas (2012) for a two-country DSGE model calibrated for Spain and the rest of the euro area; and in Hernández de Cos and Thomas (2012) for a DSGE model calibrated for the Spanish economy.

[14] Liquidity constraints considered do not rule out the intertemporal smoothing of consumption through the adjustment of households' savings. This might explain the relatively modest effect on the multiplier.

2.3. Fiscal multipliers in recessions

In line with the traditional Keynesian theory, given slack resources in the economy, fiscal expansions may be more effective at increasing output in recessions than during normal times; see Section 1.1.4. Conversely, it has been claimed that fiscal consolidation can have a deeper negative impact on output during recessions. For instance, the effect of nominal price and wage rigidities may be greater during recessions than during boom periods, as prices and wages tend to adjust downwards more slowly on account of institutional factors, among other things. Greater nominal rigidities generally lead to larger fiscal multipliers, as adjustment to weaker demand occurs through output and employment instead. Finally, particularly after a financial crisis, the simultaneous private and public sector weakening could further reinforce the short – term negative impact on output. By lowering aggregate demand in the short term, fiscal consolidation can temporarily reinforce some negative feedback loops with the financial sector (e.g. increase the likelihood of non-performing loans).[15]

Several studies distinguish between fiscal multipliers in recessions and expansions using various econometric techniques, among others (i) time-varying parameter VAR models with stochastic volatility (Kirchner et al. (2010)); (ii) threshold VAR (Baum and Koester

[15] On the other hand, fiscal consolidation can remove pressures from private sector borrowing needs and have positive effects on bank balance sheets. For instance, Cimadomo et al. (2013) find that standard capital adequacy ratios, such as the Tier 1 ratio (is the ratio of a bank's core tier 1 capital-that is, its equity capital and disclosed reserves-to its total risk-weighted assets), tend to improve following episodes of fiscal consolidation. This improvement appears to result from a portfolio re-balancing from private to public debt securities, which reduces the risk-weighted value of assets. That is particularly the case when fiscal consolidation efforts are perceived as structural policy changes that improve the sustainability of public finances and, therefore, reduce overall credit risk

(2011) for Germany; Batini et al. (2012) for the euro area aggregate, France, Italy, the United States and Japan; and Baum et al. (2012) for the G7 economies except Italy); (iii) Markov switching (smooth transition) VAR (Auerbach and Gorodnichenko (2012a) for the United States; and Hernández de Cos and MoralBenito (2013) for Spain); and (iv) panel regression and VAR techniques conducted on sub-groups of countries according to pre-determined thresholds (Corsetti et al. (2012) for a sample of 17 OECD economies; Ilzetzki et al. (2012) for a panel of 44 economies; and Auerbach and Gorodnichenko (2012b) for an unbalanced panel of OECD countries). Most of these studies find much larger (one-year) spending multipliers in recessions compared with expansions, but the difference between the two regimes varies widely.

Such studies are subject to several drawbacks. First, as pointed out in Parker (2011), there is a "lack of data" – deep recessions are few in most studies and related non-linearities hard to measure using macroeconomic data.[16] Most VAR studies use only non-adjusted fiscal shocks (total spending and net taxes) and output. By omitting the channel of government debt accumulation, for instance, such studies may find over-estimated multipliers in recessions, in particular in highly indebted countries. Moreover, looking only at exogenous government spending in an extension of Ramey's (2011) military news series for a period covering the 20th century in the United States, Owyang et al. (2013) do not find evidence that multipliers are greater during periods of high unemployment in the United States. The estimated multipliers are also below unity. Second, results are subject to sizeable uncertainty, particularly in studies using threshold VAR in which the threshold variable (e.g. potential output) is in itself subject

[16] Parker (2011) argues that the lack of statistical power in the estimation of these non-linear models can be addressed by exploiting estimates of partial equilibrium responses in disaggregated data.

to uncertainty and data revisions. This can add significant noise to the regime switching and complicate the already difficult task of computing non-linear impulse reaction functions after a fiscal shock.

2.4. Fiscal multipliers in bad times of financial crises

Many advanced economies, including the euro area countries, were hit by the financial crisis that started in late 2007. Feedback effects between the banking and the government sector propagated throughout the economy, and risks shifted to government balance sheets (see Attinasi et al. (2009)), limiting their room for fiscal maneuvers. In turn, the sovereign debt crisis has further weakened the balance sheets of banks holding large portfolios of (vulnerable) euro area government bonds and limited their capacity to provide credit to the economy. Overall, given that binding liquidity constraints are thought to reinforce the impact of a fiscal shock (see also the results with DSGE models), another potential determinant of the size of fiscal multipliers is the health of the financial system.

In this respect, Corsetti et al. (2012) find that short-term spending multipliers are higher (broadly in the order of 2) in OECD countries suffering from a financial crisis (as defined in Reinhart and Rogoff (2008) and in Reinhart (2010)). Afonso et al. (2011) also provide evidence consistent with higher multipliers during periods of financial stress in a threshold-VAR framework for Germany, Italy, the United States and the United Kingdom. In the latter study, however, the multipliers in the high-stress regime remain well below 1. Finally, Hernández de Cos and Moral-Benito (2013) conclude that the spending multiplier is slightly larger in Spain during times of a banking crisis.

There is a general consensus that in bad fiscal times the short-term costs of fiscal consolidation are lower where the starting fiscal positions are precarious and/or the consolidation measures are implemented during periods of stress when the budget balance is rapidly deteriorating and public debt levels are high and unsustainable. In line with Blanchard (1990) and Sutherland (1997), the expectation channel may even induce non-Keynesian effects of fiscal consolidation at high levels of government indebtedness. If fiscal consolidation appears to the public as a credible attempt to reduce public sector borrowing requirements, consumers with finite horizons would expect an increase in their permanent income, leading to an increase in private consumption today. Furthermore, if the government raises (decreases) taxes today it will have to cut (increase) them even more tomorrow to compensate for the saved (accrued) interest payments.

Moreover, lower multipliers can be the result of confidence effects, which materialize via reduced sovereign spreads.[17] Determined action by governments can restore fiscal sustainability and thus contribute to macroeconomic stability. The credibility of government announcements can also influence the size of fiscal multipliers through direct supply-side effects. For instance, fiscal consolidation is generally associated with smaller short-term multipliers if markets are convinced that the measures announced will be implemented in full and remain in place. In the presence of full credibility, the markets' anticipation of tax cuts in the longer term following consolidation measures today may result in favorable supply-side effects, including an increase in labor supply even in the short term; see ECB (2012b). On the

[17] In an analysis of the impact of fiscal consolidation on economic growth in the European Union countries between 2004 and 2013, Cugnasca and Rother (2015) find evidence of confidence effects when consolidation is made under stressed credit markets. In a small number of episodes, involving open economies benefitting from confidence effects, the paper finds some evidence for expansionary fiscal consolidation.

other hand, when several countries facing fiscal problems consolidate simultaneously, the overall negative impact on the domestic economy may be compounded.

Based on the research of how fiscal multipliers change in bad fiscal times we have the following recent studies which find evidence that short-term multipliers are lower the higher the public debt ratio (Kirchner et al. (2010) for the euro area aggregate) or even turn negative at high debt ratios (Nickel and Tudyka (2013) for 17 European countries; Corsetti et al. (2012) for a public debt ratio above 100% of GDP and/or government net borrowing above 6% of GDP in their panel of OECD economies; Ilzetzki et al. (2012) and Hernández de Cos and Moral-Benito (2013) for regimes in which the public debt ratio is above 60% of GDP).[18]

2.5. Keynesian multipliers

Trying to classify econometric studies on the size of fiscal multipliers is not an obvious task, especially if we think about the recent controversies raised by the IMF (see World Economic Outlook, 2012, pp. 41-43) and, among others, the director of its research department, Olivier Blanchard (see Blanchard and Leigh, 2013). In consequence, there exist four sorts of studies according to which: i) the multiplier is greater than unity, ii) the multiplier is smaller than unity or, in some cases, negative, iii) the multiplier depends on particular conditions (the

[18] Ilzetski et al (2012) and Hernández de Cos, assessing the determinants of the value of fiscal multipliers, both in high-income and developing countries, realized that the value depends on the level of development of each country, where developing countries use to have higher multipliers than high-income ones, although negative at first moment and with a less persistent effect. About their debt level, the result showed that with a range of sovereign debts over 60 % GDP, the multipliers became no statistically different from zero, and the fiscal stimulus may have a negative impact on the long-run output.

chosen sample, the difference between transitory and permanent fiscal shocks) and iv) the multiplier depends on the economic context.

In the first group the Keynesian multiplier is found to be greater than one. This is the case of the first macroeconometric models developed after World War II by Klein and Goldberger (1955) for the US economy. Following this well-established Keynesian tradition, Ball (1963), and Evans (1966, 1969) show that fiscal policy is efficient to fight recessions for large countries like the US and the United Kingdom. More recently, Bagnai and Carlucci (2003) find for the European Union a multiplier value of 1.62 after five years, assuming an increase in Government consumption. With French data on the period 1978-2003, Biau and Girard (2005) claim that an increase in public spending of 1€ quickly leads to an increase in GDP by 1.4€. Romer and Bernstein (2009), in a contested report for the Obama administration, find a fiscal multiplier of 1.44 for the first year. Focusing on the US economy, Fisher and Peters (2010) estimate a long-run spending multiplier, though based on military spending, which equals to 1.5. Turning our attention to small European countries, Pereira and Roca-Sagalés (2011) explain that a 1€ reduction in aggregate public spending reduces output in the long run by 1.21€. Finally, Pusch (2012) finds rather important multipliers for Germany and France and for a series of other European economies, based on the fact that some imports are used in the production of exported goods and others are just domestically absorbed, following the logic initiated by Palley (2009). Previous results are encompassed in Table 2.1 below.

Table 2.1 Keynesian multipliers higher than unity

	Country	Value*	Type of spending	Sample
Klein,Goldberger (1955)	US	2.26	Total spending	1929-1952
Ball (1963)	UK	1.44	Total spending	-
Evans (1966, 1969)	US	3.92	Total spending	1948-1962
Bagnai, Carlucci (2003)	Europe	1.62	Consumption	1960-1997
Biau, Girard (2005)	France	1.40	Total spending	1978-2003
Romer, Bernstein (2009	US	1.55	Total spending	-
Fisher, Peters (2010)	US	1.50	Military	1959-2007
Pereira et al. (2011	Portugal	1.21	Total spending	1980-2005
Pusch (2012)	France	1.72	Consumption	2000-2006
	Germany	1.76	Consumption	2000-2006

*Higher values of the multiplier

The second group of econometric works (see Table 2.2) contains Keynesian multipliers smaller than unity as in Barro (1981) for the US from 1942 to 1978 when he evaluates the efficiency of military spending. In the same vein, Mountford and Uhlig (2009) and Cogan et al. (2010) for the US economy find similar results for total public spending. The study of Burriel et al. (2010) also compares the Euro area and the US over the period 1981-2007, obtaining relatively small multipliers in the short-run. However, after five years they become close to zero, implying that fiscal policy is useless in the long-run. More radical studies, based on the principles of the Ricardian equivalence, are to be found in the studies of Perotti (2005) who shows anti-Keynesian results with negative multipliers for Canada and the United Kingdom in the short-run.[19] Cerda et al. (2006) follow the same logic for Chile by calculating

[19] This can be due to the large fiscal imbalances over this period that may have triggered Ricardian effects, before a fiscal surplus was achieved at the end of the 1990s.

a short-run multiplier (i.e. one year) of –0.2. For a sample of European countries, Marcellino (2006) obtains negative multipliers for Germany, Italy and Spain in the short-run and multipliers equal to zero in the long-run.

Table 2.2 Fiscal multipliers smaller than one and anti-Keynesian results

	Country	Value*	Type of spending	Sample
Barro (1981)	US	<1.00	Military	1942-1978
Mountford and Uhlig (2009)	US	<1.00	Total spending	1955-2000
Cogan et al. (2010)	US	0.65	Total spending	1966-2004
Burriel et al. (2010)	Euro area	0.87	Total spending	1981-2007
	US	0.91		
Perotti (2005)	Australia	0.21	Total spending	1960-2001
	Canada	-0.28		1961-2001
	UK	-0.22		1963-2001
	US	0.31		1960-2001
	Germany	0.40		1960-2001
Cerda et al. (2006)	Chile	-0.20	Total spending	1833-2000
Marcellino (2006)	France	>0	Total spending	1981-2001
	Germany	<0		
	Italy	<0		
	Spain	<0		

*Higher values of the multiplier

The third group contains studies in which fiscal policies depend on particular conditions; results are summarized in Table 2.3. Baxter and King (1993) evaluate different multipliers in the scope of a dynamic general equilibrium model based on US data. Their results strongly depend on the kind of fiscal shock (temporary or permanent) and on the financing of public spending (immediate new taxes or deficit). Blanchard and Perotti (2002) find, for the US, multipliers between 0.9 and 1.29, depending on assumptions about trends during the period 1947-1997. Next, Freedman et al. (2009) show how important is the cumulative World multiplier depending on the monetary policy adopted and on the level of interest rates. On a theoretical basis, Eggertson (2006) underlines the need for coordination between monetary and fiscal policies so as to increase the size of the multiplier. Finally, Ramey (2011) obtains fiscal multipliers between 0.6 and 1.2 also depending on the selected subsample.

Table 2.3 Multipliers depending on special conditions

	Country	**Range of estimates**	**Type of spending**	**Sample**
Baxter, King (1993)	US	-2.50 - 1.20	Total spending	-
Blanchard, Perotti (2002)	US	0.90 - 1.29	Total spending	1947-1997
Freedman et al. (2009)	World	1.60 - 3.90	Investment	-
Ramey (2011)	US	0.60 - 1.20	Total spending	1939-2008

A last influential group, dealing with Keynesian multipliers according to the state of the economy, brought new results. The basic idea consists in evaluating fiscal multipliers at different levels of capacity utilisation or in a recession (see Parker, 2011) and to show that they strongly increase during turbulent times. Some serious advances have been made by Auerbach and Gorodnichenko (2012), Gordon and Krenn (2010) and Fazzari et al. (2012) for the US or the OECD for total or military expenditures. Here, it should be noted that fiscal multipliers are always bigger for defense spending than for consumption or total expenditures. Candelon and

Lieb (2013) confirm the previous studies for the US economy by finding fiscal multipliers of 2.4 in bad times and around 0.5 in expansions. Besides, studies for single European countries also exist and indicate similar results for France and Spain (see Creel et al., 2011; Hernandez de Cos and Moral-Benito, 2013). For example, in the case of Spain, the authors obtain short-run multipliers between 0.6 and 1.4 depending on the state of the economy.

Table 2.4 State – dependent multipliers

	Country	Value*	Type of spending	Sample
Auerbach, Gorodnichenko (2012)	US	0.57 / 2.48	Total spending	1947-2008
		0.80 / 3.56	Military	
Creel et al. (2011)	France	0.50 / 1.10	Total spending	-
Gordon, Krenn (2010)	US	0.90 / 1.80	Total spending	1939-2008
Fazzari et al. (2012)	US	0.60 / 1.60	Total spending	1967-2011
Hernandez de Cos and Moral-Benito (2013)	Spain	0.60 / 1.40	Total spending	1986-2012
Candelon, Lieb (2013)	US	0.50 / 2.40	Total spending	1968-2010

*Right column for recessions, left column for expansions

From this last point of view, cutting public spending during a recession or a period of slow growth, with a fiscal multiplier above unity, is bad economic policy. Indeed, austerity policies adopted in countries like Greece, Spain, Portugal and Italy literally extended the negative impact of the 2008 financial crisis by ruining the economic recovery and ultimately deteriorating public finances.

2.6. Recent literature on fiscal multipliers

The empirical literature on the multiplier effect has grown significantly since 2007. A 2018 quantitative meta-study of 98 empirical studies that offer over 1800 estimates of the fiscal multiplier finds large differences amongst them (Gechert and Rannenberg, 2018). At the same time, it highlights a few key findings, namely, expenditure multipliers of 0.8 after 2 years on average, which tend to be higher than tax multipliers. Significantly higher than unity estimates are found for public investment and for other expenditure-side measures during a downturn, whereas the tax multipliers tend to be influenced only very little by the degree of capacity utilization and the business cycle, see, Figure 2.1.

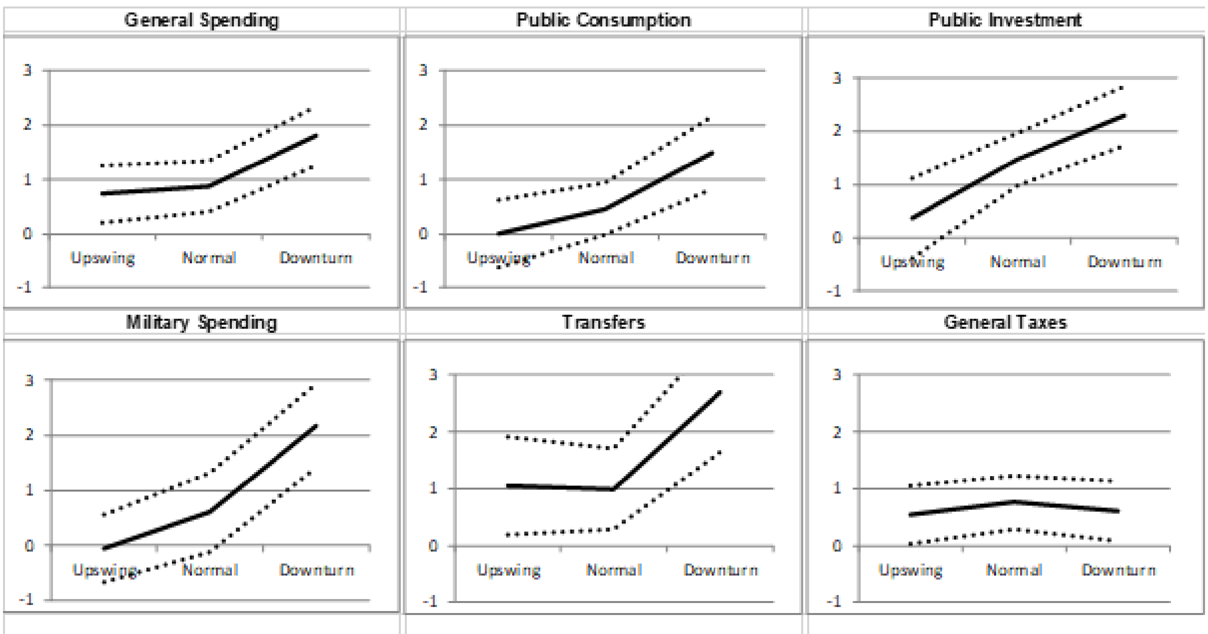

Figure 2. 1 Fiscal multipliers by type of impulse and depending on the business cycle.

Figure 2.1 shows fiscal multipliers by type of impulse and depending on the business cycle. Thick lines denote average values, dotted lines denote 95% confidence interval; a flat line signals independence from the business cycle, a steep line shows that the multiplier has increased because of the recession due to the business cycle.

That the expenditure multiplier is larger than the tax multiplier and that the multipliers are larger during a downturn is not uncontested in the economic literature: Ramey's literature survey (2019) concludes that expenditure multipliers lie between 0.6 and 1 – also during regular downturns – and in deep recessions they may turn out to be larger. On the other hand, she notes greater effects for tax cuts with multipliers from 2 to 3, but only refers to studies that use a specific method of estimation. The simulation study by Caldara and Kamps (2017) that compares different approaches, however, comes to the same conclusions as the meta-study just mentioned: expenditure multipliers tend to be higher than tax multipliers.

In a simulation study, Capek and Cuaresma (2019) find that results for the multiplier estimations very much depend on a few rather unsuspicious assumptions. The study has its own problems, because it is based on a comparatively short and volatile data set, which make the results more sensitive to changes in assumptions.

Furthermore, recent works on zero-lower-bound interest rates have also examined the monetary implication of a fiscal stimulus. In an environment where the nominal interest rates hit the zero lower bound, fiscal measures will be particularly effective since crowding out of investment from higher interest rates is largely absent, and the economy at this stage is likely to be operating at ample excess capacity (Woodford 2010; Christiano, Eichenbaum, and Rebelo 2011; Cloyne, Jorda, and Taylor 2020).

The empirical literature on fiscal multipliers is vast, and most studies focus on developed countries. A literature survey by Ramey (2019) finds that most estimates of general government spending multipliers range from 0.6 to 0.8 or up to 1.0, using either time series analysis (typically structural vector autoregression models of either a single country or panel of countries) or dynamic stochastic general equilibrium (DSGE) models. The survey also noted the evidence of multipliers greater than 1.0 during recessions or times of slack, although considered not sufficiently robust, and being higher at times when monetary policy accommodates fiscal measures (such as during wartime or the period at the zero-lower bound).

On the other hand, based on a survey of studies on the US, Whalen and Reichling (2015) reported that the multiplier of federal transfers to state and local governments for infrastructure investment can be as high as 2.5. Findings of public investment having higher fiscal multipliers than general government spending are also confirmed by Alloza, Burriel, and Pérez (2018), who reported that the multiplier of public investment in the euro area is 1.91 and the 8-quarter multiplier is 3.17.

Ramey (2019) also reported empirical estimates of the cumulative tax multipliers (the largest within the first 5 years) at least –2.0 to –3.0, much higher than the spending multipliers (in absolute value), opposite to what the theory predicts. But Ramey (2019) noted that the tax multipliers estimated from DSGE models are typically below 1.0 and never higher than 1.5 (in absolute value).

While most empirical studies on fiscal multipliers have focused on developed countries, a few studies have made attempts in the context of developing countries. Compared with developed countries, there are reasons to predict that fiscal multipliers for developing countries are larger, but there are also reasons to believe that they are smaller (Batini et al. 2014). The reasons for predicting larger fiscal multipliers for developing countries include greater liquidity constraints, less effective monetary policy responses and transmissions, less effective automatic stabilizers, lower levels of public debt, and greater slack in the economy (such as higher levels of unemployment). Batini et al. (2014) provided a survey of empirical studies on fiscal multipliers for developing countries, including those in Asia, Latin America and the Caribbean, the Middle East, Europe, and Africa. Most estimates of the first-year general government spending multipliers, including those of developing Asian economies, are in the range between 0.1 and 0.5, either from single country studies or panel estimations. These are much smaller than the spending multipliers for developed countries. Spending multipliers for oil-exporting countries were also found to be larger, i.e., close to 1.0. Similar to the findings for developed countries, the public investment multiplier was found to be greater than that of general government spending, as reported by Rafiq and Zeufack (2012) in the case of Malaysia: 2.7 during downturns and 2.0 during upturns.

Owyang et al. (2013) with data from the United States and Canada examined if the government expenditure multipliers are bigger during slowdown periods. They did not find larger multipliers in recession periods for the United States, but they did for Canada. Similarly, for the United States, Caggiano et al. (2015) used a non-linear VAR model with expectation revisions on fiscal expenses to control for the private agents' fiscal prevision. The anticipated fiscal shocks measurements turned out to be valuable information about the future public expenditure dynamics. With generalized impulse responses, the authors suggest that fiscal multipliers in recessions are larger than one, but are not statistically different from those in expansions.

For other countries, Baum et al. (2012) with a sample of G7 countries (excluding Italy) found that fiscal multipliers differ between countries, and also depend on the business cycle. They suggest that, on average, expenditure multipliers tend to be greater (in absolute value) in recessions than in expansions. For the case of Turkey, Cebi (2016) estimates the fiscal multiplier variation in high and low growth, given the potential output level. They found that fiscal policy is stronger in periods of low economic growth in comparison with times of high growth. While for France, Cleaud et al. (2017) found that the multiplier does not evolve significantly for any temporal horizon and that there is no evidence of a larger multiplier during recessions with a SVAR time-varying parameter model, emphasizing the government expenditure in goods and services.

Considering Latin America and the Caribbean, the IMF (2018) performed an impact analysis of the fiscal consolidation adopting the fiscal multipliers' approach. The multipliers were estimated with three methods: the narrative approach, forecast errors, and SVAR models for individual countries. Based on Jorda (2005) the impact multiplier was estimated with local projections[20] and found that the shock analyzed with the narrative approach was in a lower range and variability compared to shocks identified with the other two methods, the SVAR and forecast errors. The expenditure multipliers for the region were between 0.5 and 1.1, where the lower multipliers turned out to be from countries with a higher sovereign risk.

Estevao and Samake (2013) found that lower income countries experience a temporal negative effect on growth, while output increases in the medium run after a public expenditure shock. And Ilzetzki et al. (2013) found that key country characteristics, e.g., the level of development, the exchange rate regime, the trade openness degree, and the public debt level had a significant impact on the result for the multiplier. Hence, the economies' heterogeneity

[20] Jorda (2005) has introduced a novel methodology to estimate the impulse response functions, labelled model-free or local projection (LP) estimator. As the name suggests, the estimation employs nonparametric techniques. Also, the estimator is not constrained by the invertibility assumption, which allows the procedure to be computed when the VMA(∞) representation does not exist. Beside this crucial advantage, in the original paper, the author illustrates how the estimator accommodates nonlinearities, such as state and sign dependencies. Additionally, he shows how local projection can outperform a misspecified VAR model for estimating the impulse response functions.

plays an important role in the estimation of the fiscal multipliers. With information for 44 countries their estimations suggest that the effect on GDP is greater for developed economies than for developing ones, the multipliers are relatively higher for economies with predetermined exchange rates and turn out to be zero for the ones with flexible exchange regime. Also, they are lower for open economies, and even negative for countries with high public debt levels.

For open developing countries, Gualu (2013) used a SVAR with sign restrictions for the identification process. This framework intends to separate the impact of a government expenditure shock on GDP, deficit, and tax income. With data for nine countries, the author's results show that an increase in government expenditure leads to a short expansion of output and consumption, an immediate deterioration of net exports, and an appreciation or zero effect on the value of the domestic currency. All multipliers were larger than one, with the exception of one country for the impact effect.

Finally, Contreras and Battelle (2014) used the GMM with the lags of the dependent variable as instruments and found that a fiscal expansion has a larger impact in developing countries (including Costa Rica) than in developed countries. Additionally, Estevao and Samake (2013) state they are the first to estimate fiscal multipliers of short and medium run for Central American countries. Based on Blanchard and Perotti (2002), but considering the data limitations, they used cointegration techniques to define key inputs for the VAR's variance-covariance matrix; more specifically, they estimated a structural error correction model, and concluded that fiscal consolidation affects output in the short run (one year). Their estimates of the expenditure multipliers ranged from -0.01 for Nicaragua to -0.44 for Panama.

2.7. Three core schools of thought on fiscal policy decision making

1. Neoclassical perspective

The Neoclassical perspective assumes that economic agents will plan their consumption level over their life cycle, where fiscal deficits might change their projections, shifting costs to future generations. This theory is based on three central features: i) the consumption and saving level must be determined through an individual intertemporal optimization problem, thus determining the level of loanable funds and the market interest rate; ii) agents have finite lifespans; and iii) market clearing is assumed in all periods (Bernheim, 1989).

In this context, as argued in Bernheim (1989), a positive consumption shock is expected to lead to a decrease in saving, and possibly, to crowding out private capital accumulation. Moreover, according to Diamond (1965), the accumulation of public debt might depress the capital-labor ratio, since the rise of interest rates needed to attract additional saving will inhibit new investment.

Diamond (1965) also argues that the effect of temporary deficits on economic activity is expected to be small and perverse, changing the agents' decisions. Since households plan their consumption level in a long-term horizon, a marginal increment in their wealth level is supposed to generate a limited impact on current consumption. If the fiscal stimulus were generated through a tax decrease, the result is expected to be close to its counterfactual, where a decrease in capital tax level would stimulate saving (due to a higher after-tax rate of return), and an increase in labor income might induce an intertemporal substitution, leading to the same result (stimulates saving).

Also, Neoclassicists tend to focus on a cumulative deficit impact over a temporal interval rather than a year-to-year approach, arguing that with a lower permanent deficit, it is possible to achieve the same degree of stabilization of countercyclical fiscal policies (which intend to manipulate temporary shocks to stabilize fluctuations around the full employment equilibrium), gravitating toward an equilibrium without accumulating high levels of public debt (Bernheim, 1989).

2. Keynesian perspective

In the Keynesian perspective, it is assumed that a share of economic resources is unemployed, and that a certain fraction of the population is liquidity constrained or economically myopic. Then, since that kind of agents are expected to have a higher propensity to consume, a change on their income or taxes should have a significant impact on aggregate demand, leading consequently to second round effects: the so-called Keynesian multipliers. Following this perspective, the size of government spending should vary over the business cycle, being more needed and effective during recessions than expansions, enhancing the need for policy action to stimulate output during a deep recession (Auerbach and Gorodnichenko, 2012).

The Neoclassical economists appear to be critical about this perspective, neglecting the importance of fiscal policy to mitigate market failures. As argued in Lucas (1973), government policies are used to address macroeconomic problems, but the results may not always be the expected.

As argued by Blanchard and Perotti (2002), the neoclassical theory differs from the Keynesian one mainly in what concerns government spending, since on several occasions, private consumption and GDP increased simultaneously with a decrease in government spending (non-Keynesian effects of fiscal policy). Whilst in the neoclassical model, a positive shock in government spending can raise private investment only if the shock is sufficiently persistent and taxes are sufficiently non-distortionary (the investment may fall otherwise), in a Keynesian model, investment increases if the accelerator effect prevails (the crowding-in effect), and falls if the effect of a higher interest rate prevails (the crowding-out effect).

3. Ricardian perspective

Finally, as argued by Bernheim (1989), the Ricardian theory argues the existence of an inter-generational altruistic transfer system, where the consumption level is determined according to agent's resources as well as those of his/her descendants (dynastic resources function). This perspective predicts that fiscal deficits just shift their financing through taxation to future generations, and households will increase their savings, to match the present discounted value of future taxes and expenditures, avoiding effects on their children. Thus, a fiscal shock will have no real effects on economic activity.

2.7. Review of how fiscal multipliers respond to fiscal policy measures

In Brinca et al. (2016) it is shown that the level of liquidity-constrained agents is an important determinant of the value of fiscal multipliers. When the constraints are higher, the marginal propensity to consume will be higher, thus making the magnitude of the fiscal multiplier also higher. In addition, high interest rates, reduce the net present value of the fiscal shock, and may also be a liquidity factor that boosts the values of the multipliers.

Regarding the tax policy, Zubairy (2010) demonstrated that a decrease of one percentage point in labor taxes increases output, the number of hours worked, consumption and investment level. The response of consumption of this one percentage point decrease in labor taxes is explained through mechanisms generated by both substitution and wealth effects. This decrease in taxes leads to an increase in disposable income through both a higher output and a higher after-tax wage. This positive wealth effect generates an increase in consumption. On impact, this positive effect is weakened by the rise in the interest rate, however, which means a decrease in the discounted value of future consumption.

According to Barrel et al (2012), one of the most affective aspects related to fiscal multipliers is the role of expectations. For example, government spending shocks generate pure sentiment effects, providing a stimulus for future changes in output (Auerbach and Gorodnichenko, 2012). That kind of reactions affect the long-run interest rates, prices, exchange rates, salaries and inflation. Barrel's et al (2012) article points to a higher size of multipliers when the consumers are myopic. If consumers are forward looking, they will react to the expected values of future wealth.

CHAPTER 3: THE THEORETICAL MODEL

3.1. THE SIMULTANEOUS-EQUATIONS MODEL

3.1.1. The structural equations of the model

The proposed model consists of the following 17 structural equations, which reflect different aspects of the economy:

$$C_t = \beta_{10} + \beta_{11}\mathrm{Yd}_t + \beta_{12}C_{t-1} + \beta_{13}r_t^e + \beta_{14}G_t + \delta_1 D_t \mathrm{Yd}_t + \epsilon_{1t} \tag{3.1}$$

$$I_t = \beta_{20} + \beta_{21}I_{t-1} + \beta_{22}Y_t + \beta_{23}r_t^e + \beta_{24}K_{t-1} + \beta_{25}K_{t-2} + \beta_{26}\left(Y_t - Y_p\right) + \delta_2 D_t Y_t + \epsilon_{2t} \tag{3.2}$$

$$X_t = \beta_{30} + \beta_{31}ln(R_t) + \beta_{32}Y_t^F + \beta_{33}l\,n(R_{t-1}) + \beta_{34}X_{t-1} + \epsilon_{3t} \tag{3.3}$$

$$M_t = \beta_{40} + \beta_{41}l\,n(R_t) + \beta_{42}Y_t + \beta_{43}l\,n(R_{t-1}) + \delta_3 D_t Y_t + \epsilon_{4t} \tag{3.4}$$

$$\pi_t = \beta_{50} + \beta_{51}g_{q_t} + \beta_{52}g_{w_t} + \beta_{53}g_{m_t} + \beta_{54}g_{m_{t-1}} + \beta_{55}u_t + \beta_{56}u_{t-1} + \beta_{57}\pi_{t-1} + \epsilon_{5t} \tag{3.5}$$

$$g_{w_t} = \beta_{60} + \beta_{61}\left(u_t - u_f\right) + \beta_{62}\pi_t^e + \beta_{63}g_{q_t} + \beta_{64}\mathrm{union}_t + \beta_{65}\mathrm{netimg}_t + \epsilon_{6t} \tag{3.6}$$

$$g_{q_t} = \beta_{70} + \beta_{71}\left(g_{w_t} - \pi_t\right) + \beta_{72}g_{K_{t-1}} + \beta_{73}g_{q_{t-1}} + \epsilon_{7t} \tag{3.7}$$

$$u_t = \beta_{80} + \beta_{81}(Y_t - Y_p) + \beta_{82}u_{t-1} + \beta_{83}u_{t-2} + \epsilon_{8t} \tag{3.8}$$

$$g_{m_t} = \beta_{90} + \beta_{91}(Y_t - Y_p) + \beta_{92}i_t + \epsilon_{9t} \tag{3.9}$$

$$i_t = \beta_{10,0} + \beta_{10,1}\left(Y_t - Y_p\right) + \beta_{10,2}(\pi_t - \pi^*) + \beta_{10,3}\pi_t^e + \beta_{10,4}i_{t-1} + \beta_{10,5}i_{t-2} + \varepsilon_{10,t} \tag{3.10}$$

$$T_t = \beta_{11,0} + \beta_{11,1} Y_t + \epsilon_{11t} \tag{3.11}$$

$$lnS_t = \beta_{12,0} + \beta_{12,1} lnS_{t-1} + \beta_{12,2}(i_t - i_F) + \epsilon_{12t} \tag{3.12}$$

$$Y_t = C_t + I_t + G_t + X_t - M_t \tag{3.13}$$

$$Yd_t = Y_t - T_t \tag{3.14}$$

$$ln(R_t) = ln(S_t) + ln\left(P_{t_{foreign}}\right) - ln(P_t) \tag{3.15}$$

$$ln(P_t) \approx ln(P_{t-1}) + \pi_t \tag{3.16}$$

$$r_t^e \approx i_t - \pi_t^e \tag{3.17}$$

where:

C_t: Real *per capita* private consumption.

I_t: Real *per capita* private gross domestic investment.

r_t^e: *Ex ante* real interest rate.

D_{it}: A dummy variable taking on the value of $D_{it} = 1$ for the years after the MOU was imposed on country *i*, and $D_{it} = 0$ before the imposition of the MOU on that country.

K_t: The level of the economy's real stock of capital *per capita*.

X_t: Real exports *per capita*.

M_t: Real imports *per capita*.

R_t: The real exchange rate, defined as the ratio of the foreign price level to the domestic price level, where the foreign price level is converted into domestic currency units via the current nominal exchange rate. This variable is important in macroeconomics, because it measures the competitiveness of a country's products in international markets. For the definition used here, if R_t increases, there is a real depreciation of the euro against the US dollar, so the tradable goods of the Eurozone countries become cheaper in international markets, thus improving their international competitiveness.

S_t: The nominal exchange rate, defined as the number of units of the domestic currency required to purchase a unit of a given foreign currency. A decrease in S_t implies a nominal appreciation of the domestic currency.

i_t: The market value of the nominal interest rate in period *t*.

i_F: Foreign interest rate in period *t*.

π_t: The rate of price inflation measured by the percentage change in the GDP deflator.

π_t^e: Expected inflation rate.

π^*: The target of the inflation rate.

Y_t^F: The level of foreign real GDP.

Y_t: The level of the domestic real GDP.

Y_p: The level of the domestic potential real GDP.

$Y\mathrm{d}_t$: The level of disposable income.

P_t: The domestic price level.

$P_{t_{foreign}}$: The foreign price level.

G_t: Government purchases of goods and services.

$union_t$: The strength of labor unions. Traditionally, union strength is measured simply by union density – typically, the proportion of employees in employment who are union members (occasionally, the proportion of the labor force who are union members). This indicator is used as the barometer of the strength of labor movements around the world, and is the most common comparator (e.g. Blanchflower and Freeman, 1992; OECD, 1994).

$netimg_t$: Net immigration.

T_t: Total taxes.

u_t: The actual rate of unemployment.

u_f: The natural rate of unemployment.

g_{m_t}: Growth rate of money supply.

g_{w_t}: Growth rate of the nominal wage in the private sector.

g_{q_t}: Growth rate of labor productivity.

$g_{K_{t-1}}$: Growth rate of the capital stock in period $t-1$.

Ω_{t-1}: Information set at the end of period $t-1$. The set includes not only observed values during period $t-1$, but also announcements made for imminent changes to take place during period t, such as an increase in the price of oil.

The model is complete in that the number of equations equals the number of current endogenous variables. Based on the relevant economic theory and the empirical findings documented in the literature, Table 3-1 presents the expected signs of the coefficients. The fiscal policy multipliers will be derived from the reduced form of the model.

Table 3.1 Expected Signs of Structural Coefficients

Variable	Expected Sign of Coefficient	Explanation
CONSUMPTION EQUATION		
Disposable income (Yd_t)	$\beta_{11} > 0$	Keynesian theory
Lagged consumption (C_{t-1})	$\beta_{12} > 0$	Hall (1978)
Ex ante real interest rate (r_t^e)	$\beta_{13} < 0$	Consumption theory
Government purchases (G_t)	$\beta_{14} = ?$	An empirical question
Interaction $\mathrm{Yd}_t \times D_t$	$\delta_1 = ?$	An empirical question
INVESTMENT EQUATION		
Lagged investment (I_{t-1})	$\beta_{21} > 0$	Hall (1978)
Real GDP (Y_t)	$\beta_{22} > 0$	Investment theory
Ex ante real interest rate (r_t^e)	$\beta_{23} < 0$	Investment theory [Summers 1981)]
Lagged capital stock (K_{t-1})	$\beta_{24} < 0$	Klein (1950)
Lagged capital stock (K_{t-2})	$\beta_{25} = ?$	An empirical question
Output gap ($Y_t - Y_p$)	$\beta_{26} > 0$	Economic Theory
Interaction $Y_t \times D_t$	$\delta_2 = ?$	An empirical question
EXPORT EQUATION		
Real exchange rate (R_t)	$\beta_{31} > 0$	Open-economy IS-LM-BP model
Foreign income (Y_t^F)	$\beta_{32} > 0$	Open-economy IS-LM-BP model
Lagged real exchange rate (R_{t-1})	$\beta_{33} > 0$	J – Curve Effect
Lagged exports (X_{t-1})	$\beta_{34} = ?$	An empirical question
IMPORTS EQUATION		
Real exchange rate (R_t)	$\beta_{41} < 0$	Open-economy IS-LM-BP model
Real GDP (Y_t)	$\beta_{42} > 0$	Open-economy IS-LM-BP model
Lagged real exchange rate (R_{t-1})	$\beta_{43} < 0$	J – Curve Effect

Interaction $Y_t \times D_t$	$\delta_3 = ?$	An empirical question

INFLATION RATE EQUATION

Productivity growth (g_{q_t})	$\beta_{51} < 0$	Lawrence Klein (1983)
Growth rate of nominal wage (g_{w_t})	$\beta_{52} > 0$	Zellner and Theil (1962)
Monetary growth (g_{m_t})	$\beta_{53} > 0$	Quantity Theory of Money
Lagged monetary growth ($g_{m_{t-1}}$)	$\beta_{54} > 0$	Quantity Theory of Money
Unemployment rate (u_t)	$\beta_{55} < 0$	Short-run Phillips curve
Lagged unemployment rate (u_{t-1})	$\beta_{56} = ?$	An empirical question
Lagged inflation rate (π_{t-1})	$\beta_{57} > 0$	Business Cycle

WAGE EQUATION

Unemployment gap $(u_t - u_f)$	$\beta_{61} < 0$	A. W. Phillips (1958)
Expected inflation rate (π_t^e)	$\beta_{62} > 0$	E. Phelps (1967) and M. Friedman (1968)
Productivity growth (g_{q_t})	$\beta_{63} > 0$	Samuelson and Solow (1960)
Strength of labor unions ($union_t$)	$\beta_{64} > 0$	Pantuosco Lou (2001)
Immigration (netimg_t)	$\beta_{65} < 0$	Bentolila Samuel (2007)

PRODUCTIVITY GROWTH RATE EQUATION

Growth rate of real wage ($g_{w_t} - \pi_t$)	$\beta_{71} > 0$	Efficiency Wage Theory
Growth of capital stock lagged ($g_{K_{t-1}}$)	$\beta_{72} > 0$	Zellner and Theil (1962)
Growth of productivity lagged ($g_{q_{t-1}}$)	$\beta_{73} = ?$	An empirical question

UNEMPLOYMENT RATE EQUATION

Output gap ($Y_t - Y_p$)	$\beta_{81} < 0$	Okun’s law
Lagged unemployment rate (u_{t-1})	$\beta_{82} > 0$	Business Cycles
Lagged unemployment rate (u_{t-2})	$\beta_{83} = ?$	An empirical question

MONEY SUPPLY EQUATION		
Output gap $(Y_t - Y_p)$	$\beta_{91} < 0$	Monetary Policy Rule
Nominal Interest Rate (i_t)	$\beta_{92} > 0$	Monetary Policy Rule

NOMINAL INTEREST RATE EQUATION		
Output gap $(Y_t - Y_p)$	$\beta_{10,1} > 0$	
$(\pi_t - \pi^*)$	$\beta_{10,2} > 0$	Taylor Rule
Expected inflation rate (π_t^e)	$\beta_{10,3} > 0$	The Fisher Effect
Lagged nominal interest rate (i_{t-1})	$\beta_{10,4} = ?$	An empirical question
Lagged nominal interest rate (i_{t-2})	$\beta_{10,5} = ?$	An empirical question

TAX EQUATION		
Real GDP (Y_t)	$\beta_{11,1} > 0$	Dornbusch and Fisher (1994:183)

NOMINAL EXCHANGE RATE EQUATION		
Lagged exchange rate (lnS_{t-1})	$\beta_{12,1} > 0$	Uncovered Interest Rate Parity
$(i_t - i_F)$	$\beta_{12,2} < 0$	

3.1.2. The demand side of the economy

The first four equations, (3.1) - (3.4), along with (3.9) - (3.17), model the demand side of the economy. We discuss these equations in turn.

In accordance with the Keynesian theory, Equation (3.1) is a consumption function, which says that current disposable income primarily determines consumption spending. If disposable income increases, consumers will increase their planned expenditures ($\beta_{11} > 0$). I include government purchases of goods and services (G_t) and lagged consumption (C_{t-1}). Based on the partial adjustment hypothesis or, alternatively, on Hall's (1978) famous random–walk model, I assume that $\beta_{12} > 0$. The latter is based on Friedman's permanent-income hypothesis combined with rational expectations. According to the random–walk model, at any moment in their lifetime, consumers choose consumption based on their current expectations about their lifetime income. They change their consumption if they receive news that causes them to change their expectations about their lifetime income. For example, a person getting a promotion would revise his/her expectations about lifetime income upwards and thus consume more. Last period's consumption contains all the important information about the representative consumer's lifetime income; he/she is surprised only by events that are entirely unpredictable. If Hall's (1978) theory is correct, C_{t-1} should be the only variable that belongs to the right-hand side of Equation (3.1), whereas disposable income and other variables should have zero coefficients.

On the other hand, I expect $\beta_{13} < 0$, as higher *ex ante* real interest rates increase the cost of borrowing, thus discouraging consumption expenditure (especially on durables) and encouraging saving. This assumes that the substitution effect of an increase in the real interest rate is stronger than the income effect.

What is the effect of government purchases on aggregate consumption? If government purchases are a complement to private consumption, e.g., government spending on highways that stimulates private spending on tourism, then $\beta_{14} > 0$. If, on the other hand, government purchases and private consumption are substitutes, e.g., government spending on teaching foreign languages in public schools, thus discouraging private spending on these services, then

$\beta_{14} < 0$. Finally, if both effects are approximately equally present, then $\beta_{14} = 0$.

The purpose for including the interaction term $D_t \times Yd_t$ in Equation (3.1) is to capture the change, if any, in MPC after the adoption of the MOU, and thus the change in the fiscal multipliers. Consider, for example, an increase in MPC after the adoption of the MOU. As I argued in the Introduction, this might occur if consumers increase their personal spending out of an additional euro of their disposable income, which can occur if consumption is not a linear function of disposable income, but the latter has a diminishing marginal effect on the former, so, as disposable income decreases (because of the austerity measures), MPC increases. As I also indicated in the Introduction, the average consumer might feel poorer after the imposition of the MOU and spend more out of an additional euro to satisfy a need that remained unsatisfied because of his/her impoverishment, so $\delta_1 > 0$, implying an increase in MPC. In contrast, if consumers have less confidence in the economy, they might increase their saving after the MOU, so $\delta_1 < 0$.

Turning to investment (I_t), equation (3.2), I expect $\beta_{21} > 0$, according to partial adjustment behavior. Also, I expect $\beta_{22} > 0$, since an increase in economic activity (measured by the level of real GDP, Y_t) is expected to encourage private investment, as firms will want to be able to respond to higher demand for their products. Furthermore, I expect $\beta_{23} < 0$, because higher interest rates render borrowing more expensive, so firms invest less.

Klein (1950) argues that there is a negative relationship between investment and lagged capital stock (K_{t-1}). He argues that when a firm decides to invest in order to increase its future profits, the more capital it has currently the less investment it will undertake. So, we expect $\beta_{24} < 0$. Concerning the sign of the coefficient of K_{t-2} it is an empirical question.

We expect the output gap, $(Y_t - Y_p)$, to have a positive coefficient, $\beta_{26} > 0$, because as output increases and reaches its potential level because, for example, total demand increases, the use of the productive possibilities of the economy tends to be complete. Therefore, the need to expand production capacity is increasing.

Next, consider the interaction term $Y_t{\times}D_t$ in Equation (3.2), which allows the marginal propensity to invest to change. If the adoption of the MOU induced investors to expect a more stable and more productive economic environment in the longer run, they would want to invest more now for every level of economic activity in the current period. Under these circumstances, we would expect $\delta_2 > 0$. This is only a possible scenario, however, so the sign of δ_2 is an empirical question.

According to the exports function, equation (3.3), exports depend positively on the real exchange rate (R_t), as a real depreciation improves the country's competitiveness in international markets. They also depend positively on foreign income (Y_t^F). So we expect $\beta_{31} > 0$ and $\beta_{32} > 0$. Analogously, in the imports function (3.4), we expect $\beta_{41} < 0$ and $\beta_{42} > 0$, since an increase in economic activity encourages imports. Finally, we expect $\beta_{33} > 0$ and $\beta_{43} < 0$ according to the J-curve effect,[21] and $\beta_{32} > 0$, as it is known that usually macroeconomic series are positively autocorrelated.

Next, consider the interaction term $Y_t{\times}D_t$ in equation (3.4), which allows the MPI (marginal propensity to import) to change. Consider the possibility that the MOU might have reduced the MPI as people might have reduced the amount of imported goods out of a given increase in income due to the debt problem, and consequently the value of the fiscal multiplier might have increased. This suggests that $\delta_3 < 0$. This is only a possible scenario, however, so

[21] The J-curve effect is often cited in economics to describe, for instance, the way that a country's balance of trade initially worsens following a devaluation of its currency, then recovers and finally surpasses its previous performance.

the sign of δ_3 is an empirical question.

We now turn to equation (3.9), which is a monetary policy rule with feedback. The more positive (negative) the value of the output gap, $Y_t - Y_p$, the stronger the signal to the monetary policy maker to implement contractionary (expansionary) monetary policy, i.e., $\beta_{91} < 0$. By the same token, $\beta_{92} > 0$, as higher interest rates can cause recession, thus leading the monetary authorities to react by raising the growth rate of money supply. This rule embodies the monetarist idea that the growth rate of money supply is a better intermediate target than the nominal interest rate.

Equation (3.10) is also a monetary policy rule, which embodies the Keynesian idea that the nominal interest rate is a better intermediate target than the growth rate of money supply.[22] The more positive (negative) the value of the output gap, the stronger the motive of the monetary authority to raise (reduce) the interest rate, so $\beta_{10,1} > 0$. Similarly, as the algebraic value of the deviation of the observed inflation rate (π_t) from its target (π^*), $\pi_t - \pi^*$, rises the monetary authority tends to raise the interest rate, i.e., $\beta_{10,2} > 0$.[23] A Taylor type rule requires that the interest rate be raised (cut) more than one-for-one with inflation in order to increase

[22] Countries have deployed different types of fiscal rules. I use two types of monetary policy rules in order to capture all the possible scenarios across the countries. For example, in the 1980s, several countries used an approach based on a constant growth rule in money supply. A good monetary policy rule specifies a plan of action which the central bank cannot later ignore, while discretion allows central bankers to react—and often overreact—to economic indicators as they see fit.

[23] In the United States (US), the Federal Open Market Committee (FOMC), in its meeting in January 2012, issued a statement in which the inflation target, as measured by the annual percentage change in the price index for personal consumption expenditures suggests that $\pi^* = 2\%$. Communicating this inflation goal clearly helps keep longer-term inflation expectations firmly anchored.

(decrease) the real policy interest rate so as to tighten (ease) monetary policy and thereby ensure price stability. The Taylor rule has been used by many central banks around the world since its inception in 1993. It has served not only as a gauge for interest rates, but also for the money supply. Also, $\beta_{10,3} > 0$, in accordance with the Fisher effect, given by equation (3.17), we treat π_t^e as exogenous. Finally, the signs of $\beta_{10,4}$ and $\beta_{10,5}$ are an empirical question.

As usual, taxes depend on the level of real GDP, so in equation (3.11), $\beta_{11,1} > 0$. Equation (3.13) is the equilibrium condition in the goods market, whereas equations (3.14), (3.15), and (3.16) are definitional equations.[24]

Equation (3.12) is based on the uncovered interest rate parity (UIP) condition, which says that, under perfect capital mobility, perfect substitutability between domestic and foreign assets, and flexible exchange rates, the nominal interest rate on a domestic bond should equal to the interest rate on a comparable foreign bond plus the expected percentage change in the nominal exchange rate, to compensate for possible losses owed to changes in the exchange rate. The UIP is a no-arbitrage condition without a forward contract to hedge against exposure to exchange rate risk. Risk-neutral investors will be indifferent among the available interest rates in two countries because the exchange rate between those countries is expected to adjust such that the dollar return on dollar deposits is equal to the dollar return on euro deposits, thereby eliminating the potential for uncovered interest arbitrage profits. The UIP helps explain the determination of the spot exchange rate.

According to the Uncovered Interest Parity theory, we have that $E_t(e_{12t+1}) - e_{12t} \approx i_{1t} - i_{2t}$ (see, e.g., Juselius, 1995), where E_t is the conditional expectation based on

[24] As is well known, for small changes in the price level, the first deference of the log price level is approximately equal to the rate of inflation.

information available at the beginning of the time period t. If we remove the expectations operator and add an expectational error on the right-hand side, the resulting equation is Equation (3.12). Note that in Chapter 4, I also contemplate the estimation of the following equation: $lnS_t = \beta_{12,0} + \beta_{12,1}(lnP_t - lnP_{t_{foreign}}) + \beta_{12,2}(i_t - i_F) + \epsilon_{12t}$, which combines the Uncovered Interest Parity with the Purchasing Power Parity theory, where the difference $lnP_t - lnP_{t_{foreign}}$ stands for the logarithm of the expected exchange rate (see, Juselius, 1995, Equation 3).[25]

3.1.3. The supply side

The supply side refers to all aspects of the economy up to and including the production and retail sale of goods and services in the economy. It is described by equations (3.5) to (3.8). First, equation (3.5), the equation for the inflation rate, is based on the mark-up pricing theory, the method of pricing by adding a certain percentage (mark-up) to the average cost of the product. As the Nobel Prize winner Lawrence Klein claims, equation (3.5) is a powerful equation, see L.R. Klein, 1983, because it shows that increases in nominal wages that do not reflect increases in labor productivity are inflationary.

First, in equation (3.5), we expect $\beta_{51} < 0$, as a higher rate of growth of labor productivity (g_{q_t}) leads to a lower inflation rate (π_t). As is well known, labor

[25] I thank Professor S. Fountas for suggesting that I include the expected exchange rate as an additional explanatory variable.

productivity gains lead to gains in income, lower inflation and increased profitability. A company that is increasing output with the same number of hours worked will likely be more profitable, which means that it can raise wages without passing that cost on to customers, which keeps inflation pressures down, while adding to GDP growth.

Futhermore, there is a positive relation between the growth rate of nominal wages (g_{w_t}) in the private sector and the inflation rate (π_t). This can be explained by wage push inflation, as businesses pass on to the consumer the higher cost of labor, so $\beta_{52} > 0$.

In the same equation (3.5), we assume that current and lagged monetary growth (g_{m_t} and $g_{m_{t-1}}$) cause inflation. According to the quantity theory of money, when the growth rate of money supply rises faster than real output the result is inflation. Therefore, $\beta_{53} > 0$ and $\beta_{54} > 0$. In addiction, according to the Phillips curve, $\beta_{55} < 0$. The sign of the coefficient of the lagged unemployment rate (u_{t-1}) is an empirical question. As for the sign of the coefficient of the lagged inflation rate (π_{t-1}), we assume that it is positive ($\beta_{57} > 0$), a business-cycle phenomenon.

Next, equation (3.6) is an expectations augmented Phillips Curve, in accordance with Phelps (1967) and Friedman (1968). Employees are interested in their real wages, so if they expect a higher inflation rate, they will demand higher nominal wages, to maintain their purchasing power, i.e., $\beta_{62} > 0$. The difference $u_t - u_f$ reflects the pressure on the labor market, implying that $\beta_{61} < 0$. As the unemployment rate decreases, workers demand higher nominal wages, i.e., A. W. Phillips, 1958.

The growth rate of labor productivity (g_{q_t}) influences the growth rate of nominal wages (g_{w_t}) positively, as improvements in labor productivity render work more valuable, i.e., $\beta_{63} > 0$. Furthermore, the stronger the labor unions ($union_t$) the higher the increases in nominal wages, implying that $\beta_{64} > 0$ (Lou, 2001). Finally, according to Samuel (2007), who presents evidence for Spain, (Bentolila Samuel, 2007), net immigration (netimg_t), which increases the supply of labor, reduces the growth rate of nominal wages, so $\beta_{65} < 0$.

In equation (3.7), in accordance with the efficiency wage theory (Michael E. Bradley, 2007), we assume that the growth rate of real wages $\left(g_{w_t} - \pi_t\right)$ influences positively the growth rate of labor productivity (g_{q_t}), i.e., $\beta_{71} > 0$. Higher wages boost employee morale and increase worker productivity. Firms that pay an efficiency wage attract skilled workers and reduce employee turnover. The lagged growth rate in the capital stock ($g_{K_{t-1}}$) is also assumed to influence g_{q_t} positively, i.e., $\beta_{72} > 0$. If a firm increases its capital stock in the previous period, it will increase labor productivity, since its workers will have more capital to work with. Finally, the sign of the coefficient, β_{73}, is an empirical question.

Finally, equation (3.8) is a version of Okun's law. It is an empirical relationship between the unemployment rate (u_t) and the output gap $\left(Y_t - Y_p\right)$, where $\beta_{81} < 0$. We also assume that $\beta_{82} > 0$ and $\beta_{83} > 0$ as the rate of unemployment is positively autocorrelated, a business-cycle phenomenon.

3.1.4. The model in matrix form

The simultaneous equation model consists of M = 17 equations, one for each of the M current endogenous variables**,** or jointly-determined variables, and K = 27 predetermined variables, including the constant term. Using matrix notation, the system may be written as follows:

$$(\mathbf{B} + \boldsymbol{\Delta} D_t)\mathbf{Y}_t + \boldsymbol{\Gamma}\mathbf{X}_t = \boldsymbol{\varepsilon}_t, \qquad t = 1,2,\ldots,T \tag{3.18}$$

where:

$\mathbf{Y}_t$ is a 17×1 column-vector of the $M = 17$ current endogenous variables, namely,

$$\mathbf{Y}_t = \begin{pmatrix} C_t \\ I_t \\ X_t \\ M_t \\ \pi_t \\ g_{w_t} \\ g_{q_t} \\ u_t \\ g_{m_t} \\ i_t \\ T_t \\ lnS_t \\ Y_t \\ Yd_t \\ lnR_t \\ lnP_t \\ r_t^e \end{pmatrix}$$

B is a 17×17 matrix of structural coefficients of the current endogenous variables, where the diagonal elements are $\beta_{i,i} = 1$, $i = 1, \dots, 17$, to wit,

$$
\mathbf{B} = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{11} & 0 & 0 & -\beta_{13} \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -(\beta_{22}+\beta_{26}) & 0 & 0 & 0 & -\beta_{23} \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{31} & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{42} & 0 & -\beta_{41} & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & -\beta_{52} & -\beta_{51} & -\beta_{55} & -\beta_{53} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & -\beta_{63} & -\beta_{61} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & \beta_{71} & -\beta_{71} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & -\beta_{81} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -\beta_{92} & 0 & 0 & -\beta_{91} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & -\beta_{10,2} & 0 & 0 & 0 & 0 & 1 & 0 & 0 & -\beta_{10,1} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -\beta_{11,1} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{12,2} & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
-1 & -1 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 1 & 1 & 0 \\
0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{pmatrix}
$$

$\boldsymbol{\Delta}$ is a 17×17 matrix of coefficients associated with the interaction effects, i.e.,

$$
\boldsymbol{\Delta} = \begin{pmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\delta_1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\delta_2 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\delta_3 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix}
$$

$\mathbf{X}_t$ is a 27×1 column vector of the $K = 27$ predetermined (current and lagged exogenous and lagged endogenous) variables, including the constant term, namely,

$$\mathbf{X}_t = \begin{pmatrix} 1 \\ C_{t-1} \\ I_{t-1} \\ G_t \\ K_{t-1} \\ Y_t^F \\ g_{m_{t-1}} \\ u_{t-1} \\ \pi_{t-1} \\ u_f \\ \pi_t^e \\ union_t \\ netimg_t \\ g_{K_{t-1}} \\ Y_p \\ \pi^* \\ lnS_{t-1} \\ i_F \\ lnP_{t_{foreign}} \\ lnP_{t-1} \\ K_{t-2} \\ lnR_{t-1} \\ X_{t-1} \\ g_{q_{t-1}} \\ u_{t-2} \\ i_{t-1} \\ i_{t-2} \end{pmatrix}$$

$\mathbf{\Gamma}$ is a 17×27 matrix of structural parameters of the 27 predetermined variables, including the constant terms, that is,

$$
\boldsymbol{\Gamma} = \begin{pmatrix}
-\beta_{10} & -\beta_{12} & 0 & -\beta_{14} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-\beta_{20} & 0 & -\beta_{21} & 0 & -\beta_{24} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \beta_{26} & 0 & 0 & 0 & 0 & 0 & -\beta_{25} & 0 & 0 & 0 & 0 & 0 & 0 \\
-\beta_{30} & 0 & 0 & 0 & 0 & -\beta_{32} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{33} & -\beta_{34} & 0 & 0 & 0 & 0 \\
-\beta_{40} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{43} & 0 & 0 & 0 & 0 & 0 \\
-\beta_{50} & 0 & 0 & 0 & 0 & 0 & -\beta_{54} & -\beta_{56} & -\beta_{57} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-\beta_{60} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \beta_{61} & -\beta_{62} & -\beta_{64} & -\beta_{65} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-\beta_{70} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{72} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{73} & 0 & 0 & 0 \\
-\beta_{80} & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{82} & 0 & 0 & 0 & 0 & 0 & 0 & \beta_{81} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{83} & 0 & 0 \\
-\beta_{90} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \beta_{91} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-\beta_{10.0} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{10.3} & 0 & 0 & 0 & \beta_{10.1} & \beta_{10.2} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{10,4} & -\beta_{10,5} \\
-\beta_{11,0} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-\beta_{12.0} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\beta_{12.1} & \beta_{12.2} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix}
$$

$\boldsymbol{\varepsilon_t}$ is a 17×1 column vector consisting of the 12 stochastic disturbances $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_{12}$, each one associated with a structural equation, and five zeroes that correspond to the equilibrium condition (3.13) and the four definitional equations.

$$\boldsymbol{\varepsilon_t} = \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \\ \epsilon_{4t} \\ \epsilon_{5t} \\ \epsilon_{6t} \\ \epsilon_{7t} \\ \epsilon_{8t} \\ \epsilon_{9t} \\ \epsilon_{10t} \\ \epsilon_{11t} \\ \epsilon_{12t} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

Now, we can derive the reduced – form equation of the system, that is,

$$\mathbf{Y}_t = -(\mathbf{B} + \boldsymbol{\Delta} D_t)^{-\mathbf{1}} \quad \boldsymbol{\Gamma}\mathbf{X}_t + \mathbf{v_t} \tag{3.19}$$

where:

$$\mathbf{v_t} = (\mathbf{B} + \boldsymbol{\Delta} D_t)^{-\mathbf{1}} \quad * \ \boldsymbol{\varepsilon}_t$$

3.1.1. The multipliers

The above reduced-form expressions allow us to derive closed-form expressions for the fiscal multipliers. Table 3.2 shows these multipliers. The fiscal variables are government purchases of goods and services (G_t) and taxes (T_t).

Table 3.2 Fiscal Multipliers for Government Purchases and Autonomous Taxes

Variable / Effect on $\mathrm{Y_t}$	Government Purchases of Goods and Services ($\boldsymbol{G_t}$)
$\frac{\partial Y_t}{\partial G_t}$	$\frac{\beta_{14}+1}{a-\delta_2 D_t+\delta_3 D_t+\delta_1 D_t(\beta_{11,1}-1)}$
Variable / Effect on $\mathrm{Y_t}$	**Autonomous Taxes ($\boldsymbol{\beta_{11,0}}$)**
$\frac{\partial Y_t}{\partial \beta_{11,0}}$	$\frac{-(\beta_{11}+\delta_1 D_t)}{a-\delta_2 D_t+\delta_3 D_t+\delta_1 D_t(\beta_{11,1}-1)}$

From the reduced-form equation for real GDP (Y_t), the multiplier for government purchases of goods and services is as follows:

$$\frac{\partial Y_t}{\partial G_t}=\frac{\beta_{14}+1}{a-\delta_2 D_t+\delta_3 D_t+\delta_1 D_t(\beta_{11,1}-1)}, \tag{3.20}$$

where

$$a = 1 + \beta_{42} - \beta_{22} - \beta_{26} - \beta_{13}\beta_{10,1} - \beta_{23}\beta_{10,1} + \beta_{11}(\beta_{11,1} - 1) - \beta_{31}\beta_{10,1}\beta_{12,2} + \beta_{41}\beta_{10,1}\beta_{12,2}. \quad (3.21)$$

Prior to the imposition of MOU ($D_t = 0$) the multiplier for government purchases of goods and services is

$$\left.\frac{\partial Y_t}{\partial G_t}\right]_{D_t=0} = \frac{(\beta_{14}+1)}{a}, \quad (3.22)$$

while after the imposition of the MOU ($D_t = 1$) it becomes

$$\left.\frac{\partial Y_t}{\partial G_t}\right]_{D_t=1} = \frac{(\beta_{14}+1)}{a-\delta_2+\delta_3+\delta_1(\beta_{11,1}-1)}. \quad (3.23)$$

Also, from the reduced-form equation for Y_t, the multiplier for autonomous taxes ($\beta_{11,0}$) is

$$\frac{\partial Y_t}{\partial \beta_{11,0}} = \frac{-(\beta_{11} + \delta_1 D_t)}{a - \delta_2 D_t + \delta_3 D_t + \delta_1 D_t \left(\beta_{11,1} - 1\right)} \tag{3.24}$$

Prior to the imposition of MOU ($D_t = 0$) the multiplier for autonomous taxes is

$$\left.\frac{\partial Y_t}{\partial \beta_{11,0}}\right]_{D_t=0} = \frac{-\beta_{11}}{a}, \tag{3.25}$$

while after the imposition of the MOU ($D_t = 1$) it becomes

$$\left.\frac{\partial Y_t}{\partial \beta_{11,0}}\right]_{D_t=1} = \frac{-(\beta_{11} + \delta_1)}{a - \delta_2 + \delta_3 + \delta_1 \left(\beta_{11,1} - 1\right)}. \tag{3.26}$$

CHAPTER 4: ECONOMETRIC ANALYSIS

4.1. ECONOMETRIC ANALYSIS OF THE MODEL

4.1.1. Introduction

This chapter investigates econometrically the theoretical results derived in Chapter 3, i.e., how fiscal multipliers responded to the imposition of the MOU. After describing the data sets, I employ various panel unit-root tests to examine the stationarity properties of the variables. Then I check the identification conditions to see whether each behavioral equation to be estimated is unidentified, exactly identified, or over-identified. Finally, I estimate the coefficients that enter the fiscal multipliers and assess how the estimates of the multipliers conform to reality.

4.1.2. Data description

The econometric analysis uses data from the following four sources: (1) AMECO, the annual macroeconomic database of the European Commission's directorate for economic and financial affairs;[26] (2) the Organization for Economic Co-operation and Development (OECD) database, an intergovernmental economic organization with 38-member countries founded in

[26] AMECO contains data from the European Union countries, candidates for entry, and other OECD countries.

1961 to stimulate economic progress and world trade; (3) Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts database (ICTWSS)[27] in 51 countries between 1960 and 2014; and (4) the European Central Bank, which is the central bank of the 19 European Union countries that have adopted the euro. The variables have already been defined in Chapter 3. In addition, I use three dummies to capture the changes in the fiscal multipliers in response to the imposition of MOU.

First, in equation (3.1) I use the interaction variable $D_t Yd_t$, and in equations (3.2) and (3.4) I use the interaction $D_t Y_t$, where D_t takes on the value 0 prior to the imposition of MOU and the value of 1 after the imposition of MOU in order to see the change that may occur after the imposition of MOU.

[27] The ICTWSS database covers four key elements of modern economies: trade unionism, wage setting, state intervention, and social pacts. The database contains annual data for all OECD and EU member states with some additional data for emerging economies, namely, Brazil, China, India, Indonesia, Russia, and South Africa, and it runs from 1960 to 2014.

4.2. ECONOMETRIC METHODOLOGY AND RESULTS

4.2.1. First Generation Panel unit – root tests

To begin with, in the case where the number of observations T in each cross – section, i.e., country, is small, the time series properties of the panel data are usually a side issue, but when T is growing, these properties become a central issue of the analysis (Greene, 2008, p. 767).

Before proceeding to estimation, I apply various panel unit-root tests to examine the stationarity properties of the variables. The estimated regressions and hypothesis tests can be distorted by nonstationarity in the data and the casual relationships can be spurious. So, the implementation of the unit-root tests is an important consideration (Greene, 2008, p. 767).

For testing the stationarity of the variables I used the following six panel unit-root tests: Levin, Lin, and Chu (2002), Breitung (2000), Im, Pesaran, and Shin (2003), Fisher-type tests using ADF and PP tests (Maddala and Wu (1999) and Choi (2001)), and Hadri (2000). I consider three tests based on the cross-sectional independence hypothesis. More specifically I apply the ADF and Phillips-Perron (PP) Fisher Chi-Square tests described by Maddala and Wu (1999), the Levin et al. (2002), and Im et al. (2003) tests.

The Levin–Lin–Chu (2002), Breitung (2000), Im–Pesaran–Shin (2003), and Fisher-type (Choi 2001) tests have as the null hypothesis that each cross section contains a unit root. The Hadri (2000) Lagrange multiplier (LM) test has as the null hypothesis that each cross section is stationary.

Breitung (2000) considers a model with heterogeneous trends and short-run dynamics. The testing procedure is one sided and develops a t-statistic (t^*), which follows a standard normal distribution. Breitung shows that the proposed statistic has low power in case of heterogeneous trend parameters across units. On the other hand, in the LLC test, under the null hypothesis, a modified t-statistic (t*) for the autoregressive coefficient is asymptotically normally distributed. In both tests the lag length of the difference terms may vary across cross-sections, while the autoregressive coefficient is assumed to be identical. The null hypothesis of a common unit-root test is tested against the alternative of stationarity.

All the tests we have discussed so far take as the null hypothesis that the series contains a unit root. Classical statistical methods are designed to reject the null hypothesis only when the evidence against the null is sufficiently overwhelming. However, because unit-root tests typically are not very powerful against alternative hypotheses of somewhat persistent but stationary processes, reversing roles and testing the null hypothesis of stationarity against the alternative of a unit root is appealing. For pure time series, the KPSS test of Kwiatkowski et al. (1992) is one such test. The Hadri (2000) LM test uses panel data to test the null hypothesis that the data are stationary versus the alternative that at least one cross section contains a unit root.

Two Langrance Multiplier (LM) statistics are formed, which are asymptotically distributed as N(0, 1). The Z_1-statistic is based on LM_1, which assumes homoscedastic errors, while the Z_2-statistic is based on LM_2, which is heteroscedasticity consistent. In the presence of autocorrelation, however, the Hadri test appears to over reject the null hypothesis of stationarity.

Furthermore, the Fisher tests and the IPS test are directly comparable. Note that the Fisher tests are non-parametric, whereas the IPS test is parametric. The distribution of the *t*-bar statistic involves the mean and variance of the individual *t*-statistics. IPS compute this for the ADF test statistic for different values of the number of lags used and different sample sizes.

The Fisher test is an exact test. The IPS test is an asymptotic test. Also, the Fisher-ADF and Fisher-PP tests combine the *p*-values from a unit-root test applied to each cross-section in the panel. The asymptotic distribution of the test statistics is chi-square (χ^2) with $2N$ degrees of freedom, where N is the number of cross-sections.

Table 4.1 reports the results from the unit-root tests from the 8-country unbalanced panel produced by the econometric program *EViews* 10. The tests are allowed to include individual constants or individual constants and time trends. In the Breitung test, both individual constants and time trends are included. In the Hadri test, Z_1 and Z_2-statistics give similar results, so I present the results from the Z_2-statistic only. The *p*-values are used to indicate the statistical significance of the tests.

The tests for stationarity are not in agreement. I take a variable to be I(0) if stationarity is supported by at least one test. The data are measured in per capita terms, so it is not unlikely that most series used here might be stationary. For example, the series for the level of consumption (C) is likely to be I(1), in accordance with Robert Hall's random-walk hypothesis. If the series for population (POP) is also I(1); and the logarithms of the two series are cointegrated with a cointegrating vector (1, -1); then, under these assumptions, the series for consumption *per capita* will be I(0), as $C/POP = \exp[\ln(C/POP)] = \exp(\ln C - \ln POP)$, where $\ln C - \ln POP \sim I(0)$.

Note that I consider the variables D_tYd_t and D_tY_t as stationary, I(0), since they are products of a stationary variable (Yd_tor Y_t) and a nonstochastic dummy. The tests confirm that these variables are I(0) indeed, despite the fact that they do not take into account the structural break; see Perron (1989).

Table 4.1 First Generation Panel Unit-Root Tests

Test Variable	LLC			Breitung	Hadri		IPS		Fisher ADF			Fisher PPP			Decision
	t^*_μ	t^*_t	t^*_n	t	$Z2_\mu$	$Z2_t$	W_μ	W_t	X^2_μ	X^2_t	X^2_n	X^2_μ	X^2_t	X^2_n	I(0) or I(1)
C_t	-4.62***	-7.11***	1.76	-1.26	4.80	5.11	-5.73***	-6.46***	61.84***	283.62***	12.61***	55.98***	122.02***	23.87***	I(0)
Yd_t	-1.63*	-1.36*	0.99	-1.51*	6.76	6.76	-0.13	-0.43	18.29	16.32	1.80	14.53	6.61	1.50	I(0)
r^e_t	-2.55***	-1.75**	-6.33***	-1.65**	5.18	6.95	-3.55***	-2.85***	44.59***	36.04***	83.34***	61.65***	57.29***	100.99***	I(0)
G_t	-4.38***	-5.69***	1.99	-1.92**	5.76	4.48	-6.53***	-6.24***	35.05***	277.23***	16.16	40.89***	276.59***	54.11***	I(0)
I_t	-0.72	-0.85	0.36	-2.54***	4.49	3.14	-0.25	-0.73	15.68	17.59	6.48	11.81	12.25	5.71	I(0)
Y_t	-6.52***	-13.96***	1.86	-1.93**	5.64	4.25	-7.43***	-9.54***	37.72***	277.22***	15.08	36.42***	273.60***	33.18***	I(0)
K_t	-2.05**	-12.43***	1.77	0.82	6.95	3.92	-2.83***	-8.91***	42.29***	271.18***	11.85	36.07***	271.36***	30.08**	I(0)
M_t	-1.03	-1.97**	2.74	-1.80**	7.88	3.13	0.40	-2.22**	13.48	33.20**	2.74	15.06	31.01**	5.50	I(0)
$ln(R_t)$	0.73	0.06	-0.09	-1.75**	1.98	2.93**	0.58	0.64	5.66	2.51	5.95	44.97***	27.28**	15.93	I(0)
D_tYd_t	-0.11	0.61	-4.03***	-3.24***	1.20**	2.07*	-1.90**	-0.43	26.05*	15.62	48.26***	22.88	12.49	46.33***	I(0)
D_tY_t	0.12	1.35	-4.78***	-2.86***	0.26*	2.16*	-2.35***	-0.13	28.66**	14.65	53.11***	26.32**	12.31	52.17***	I(0)

Notes: a) the subscripts μ, t and n indicate the presence of individual constant and individual constant and time trend or none of the above exogenous variables respectively; b) in the LLC, Breitung, IPS and Fisher ADF tests the lag length in each cross-section ADF regression is chosen by the Schwarz Info Criterion; c) in the LLC, Handri and Fisher-PP tests, a kernel-based consistent estimator of the residual covariance is obtained using the lag transaction parameter selection method of Newey and West (1994); d) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level respectively; e) I have also performed a unit root test for the remaining variables of the model as well, here I chose to present the unit-root tests for the variables which are included in equations (3.1), (3.2) and (3.4), the three important equations which incorporate the interaction effects.

4.2.2. Second Generation Panel Unit – Root Tests

Adding the cross-sectional dimension to the usual time dimension is very important in the context of nonstationary series. Indeed, it is well known that unit root tests generally have low power in small sample sizes to distinguish nonstationary series from stationary ones that are persistent. In order to increase the power of unit root tests, a solution is to increase the number of observations by including information relating to various individuals or countries. As noted by Baltagi and Kao (2000), the econometrics of nonstationary panel data aims at combining "the best of both worlds: the method of dealing with nonstationary data from the time series and the increased data and power from the cross-section" (emphasis in the original).

In the previous sub-section 4.1, we discuss the first generation panel unit root tests, which are based on the cross-sectional independency hypothesis. The cross-sectional independency hypothesis is rather restrictive and somewhat unrealistic in the majority of macroeconomic applications of unit root tests, like the study of convergence (Phillips and Sul, 2003b) or the analysis of purchasing power parity (O'Connell, 1998), where co-movements of economies are often observed. This is an important issue, since the application of tests belonging to the first generation to series that are characterized by cross-sectional dependencies leads to size distortions and low power (Banerjee, Marcellino and Osbat, 2000, Strauss and Yigit, 2003). In response to the need for panel unit root tests that allow for cross-sectional correlations, various tests have been proposed belonging to what we call second generation tests. As argued by Quah (1994), the modelling of cross-sectional dependencies is a difficult task, since no natural ordering exists in unit observations. This is why various tests have been proposed, including the works of Bai and Ng (2001), Phillips and Sul (2003a), Moon and

Perron (2004a), Choi (2002), Ploberger and Phillips (2002), Moon, Perron and Phillips (2003), and Chang (2002) and Pesaran (2003).

Regarding second generation tests, Pesaran (2007) proposes a test where the augmented Dickey-Fuller (ADF) regressions are augmented with the cross-sectional average of the lagged levels and the first differences of the individual time series. The Pesaran test uses the cross-sectional ADF statistics (CADF). In fact, Pesaran (2007) advances a modified IPS statistics based on the average of the individual CADF, which is denoted as a cross-sectional augmented IPS (CIPS).

The following Table 4.2 shows the tests of cross-sectional dependencies:

Table 4.2 Cross-sectional Dependencies Panel Unit-Root Tests

Second Generation	Cross-sectional dependencies
1. Factor structure[28]	Bai and Ng (2001, 2004)
	Moon and Perron (2004a)
	Phillips and Sul (2003a)
	Pesaran (2007)
	Choi (2002)
2. Other approaches	OíConnell (1998)
	Chang (2002, 2004)

Next, Tables 4.3, 4.4 and 4.5 report the results from the Pesaran (2007)–CIPS second generation cross dependent unit-root test from the 8-country panel produced by the econometric program *EViews* 12. The tests are allowed to include individual constants or

[28] A factor structure is the correlational relationship between a number of variables that are said to measure a particular construct.

individual constants and time trends. The *p*-values are used to indicate the statistical significance of the tests.

CADF denote the t-statistic associated with the traditional ADF null hypothesis (H0) for cross section *i*. Following Im, Pesaran, and Shin (2003), the panel unit root test of interest is a pooled version of individual CADF statistics, or the cross-sectionally augmented (CIPS) statistic. A truncated version of this test is proposed to counter the influence of extreme outcomes that may arise when the information set is sufficiently small.

Both individual and average statistics are given in the following Tables. CADF statistics represent individual country and CIPS statistics represent the whole panel. As we can see from the Tables below, all the variables are stationary, I(0).

Table 4.3 Pesaran - CIPS Cross-Sectionally Dependent Panel Unit Root Test

COUNTRY	C_t			r_t^e			G_t			I_t		
		CADF	TCADF		CADF	TCADF		CADF	TCADF		CADF	TCADF
GREECE		-2.923	-2.923		-1.219	-1.219		3.110	-6.190***		-2.241	-2.241
CYPRUS		-3.999***	-3.999***		-10.289***	-6.420***		-0.754	-0.754		-1.452	-1.452
HUNGARY		-2.502	-2.502		-0.774	-0.774		-2.775	-2.775		-7.227***	-7.227***
IRELAND		-4.188***	-4.188***		-14.274***	-6.420***		-1.284	-1.284		-2.239	-2.239
LATVIA		-1.771	-1.771		-24.888***	-6.420***		0.610	0.610		-2.588	-2.588
PORTUGAL		-4.421***	-4.421***		3.825	-6.420***		-0.925	-0.925		-4.945***	-4.945***
ROMANIA		-2.924	-2.924		-0.727	-0.727		-3.888**	-3.888**		-2.273	-2.273
SPAIN		-1.224	-1.224		4.936	4.936***		-2.844	-2.844		-1.825	-1.825
	CIPS	-2.994***		CIPS	-5.426***		CIPS	-1.094		CIPS	-3.010**	
		TCIPS	-2.994***		TCIPS	-4.352***		TCIPS	-2.256*		TCIPS	-2.998**
Decision	I(0)			I(0)			I(0)			I(0)		

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level respectively.

Table 4.4 Pesaran - CIPS Cross-Sectionally Dependent Panel Unit Root Test

CO UNTRY	K_{t-1}			$ln(R_t)$			Y_t			X_t			M_t		
		CADF	**TCADF**		**CADF**	**TCADF**		**CADF**	**TCADF**		**CADF**	**TCADF**		**CADF**	**TCADF**
GREECE		-3.858*	-3.858*		-3.385	-3.385		-3.464	-3.464		-1.814	-1.814		-1.999	-1.999
CYPRUS		-4.406**	-4.406**		-3.181	-3.181		-7.272***	-6.420***		-3.601*	-3.601*		-3.333	-3.333
HUNGARY		-0.307	-0.307		0.602	0.602		-0.487	-0.487		-0.751	-0.751		-0.560	-0.560
IRELAND		-3.921*	-3.921*		-2.814	-2.814		-2.516	-2.516		-3.105	-3.105		-2.115	-2.115
LATVIA		-2.471	-2.471		-4.275**	-4.275**		-3.039	-3.039		-3.153	-3.153		-4.392**	-4.392**
PORTUGAL		-5365***	-5365***		-1.678	-1.678		-0.271	-0.271		-3.431	-3.431		-3.259	-3.259
ROMANIA		-20.440***	-6.420***		-3.250	-3.250		-6.080***	-6.080***		-9.957***	-6.420***		-5.762***	-5.762***
SPAIN		-3.836*	-3.836*		-4.187**	-4.187**		-1.659	-1.659		-2.631	-2.631		-1.895	-1.895
	CIPS	-5.575***		**CIPS**	-2.921**		**CIPS**	-3.099**		**CIPS**	-3.556***		**CIPS**	-2.915**	
		TCIPS	-3.823***		**TCIPS**	-2.921**		**TCIPS**	-2.992**		**TCIPS**	-3.114**		**TCIPS**	-2.915**
Decision	**I(0)**			**I(0)**			**I(0)**			**I(0)**			**I(0)**		

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level respectively.

Table 4.5 Pesaran - CIPS Cross-Sectionally Dependent Panel Unit Root Test

COUNTRY	$D_t\mathrm{Yd}_t$			D_tY_t		
		CADF	TCADF		CADF	TCADF
GREECE		-2.417	-2.417		-2.471	-2.471
CYPRUS		-2.901	-2.901		-4.233**	-4.233**
HUNGARY		-5.883***	-5.883***		-6.062***	-6.062***
IRELAND		-4.025**	-4.025**		-3.393	-3.393
LATVIA		-4.980***	-4.980***		-6.477***	-6.420***
PORTUGAL		-2.510	-2.510		-1.974	-1.974
ROMANIA		-4.278**	-4.278**		-4.798***	-4.798***
SPAIN		-8.126***	-6.420***		-8.120***	-6.420***
	CIPS	-4.389***		CIPS	-4.691***	
		TCIPS	-4.177***		TCIPS	-4.471***
Decision	I(0)			I(0)		

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level respectively; b) I have also performed a second generation unit root test for the remaining variables that appear in the equations of the model, but here I chose to present the unit-root tests for the variables that are included in equations (3.1), (3.2) and (3.4), the three important equations which incorporate the interaction effects.

4.2.3. Unit-Root Tests with Structural Breaks

A number of different unit root tests have emerged from the research on structural breaks and unit roots. These tests vary depending on the number of breaks in the data, whether a trend is present or not, and the null hypothesis that is being tested. The most important difference is that in the first few tests that were developed, e.g. Perron (1989), the break was determined exogenously, by the researcher, by using a dummy variable at the break point, such as the Great Crash (1929), whereas in more recent tests the break is determined endogenously by the data, e.g., Lee and Strazicich (2003, 2013). The possible importance of structural breaks for the implementation and interpretation of unit root tests was first emphasised by Perron (1989) and Rappoport and Reichlin (1989).

Perron (1989) suggested that structural change in time series can influence the results of tests for unit roots. In particular, time series for which an uncritical application of ADF-type tests infers the existence of a unit root may often better be characterised by a single permanent break in a deterministic component of a stationary or trend-stationary process. However, as Perron (1989) points out, structural change and unit roots are closely related, and researchers should bear in mind that conventional unit root tests are biased toward a false unit root null when the data are trend stationary with a structural break. This observation has spurred development of a large literature outlining various unit root tests that remain valid in the presence of a break.

*EViews*12, offers support for several types of modified augmented Dickey-Fuller tests which allow for levels and trends that differ across a single break date. In this section we are going to conduct unit-root tests with a breakpoint. The test considered here tests the null hypothesis that the data follow a unit root process, possibly with a break, against a trend stationary with break alternative.

Tables 4.6 and 4.7 show the test results. The numbers in parenthesis represent the year in which the structural break has occurred. The last column shows that all variables for each country are stationary.

In the case of Greece, we can observe, from Table 4.6, that the structural break is around 2008 to 2010 for most series. Recall that 2008 was the year in which the crisis started and 2010 was the year in which the MOU was imposed. Also, in Appendix E, we can find some graphs especially for the case of Greece, which suggest year the break point occurred. I choose some variables, such as C_t, Y_t and G_t to show the year in which the structural break occurred. In that year the Dickey-Fuller t-statistic is minimized.

Table 4.6 Panel Unit Root Test with structural break

COUNTRIES	GREECE	CYPRUS	HUNGARY	IRELAND	RESULT FOR ALL COUNTRIES
Variables	ADF Statistic	ADF Statistic	ADF Statistic	ADF Statistic	
C_t	-5.581*** (2010)	-5.892***(2013)	-5.897***(2008)	-5.764***(2008)	I(0)
r_t^e	-3.465*(2010)	-5.345**(2013)	-4.910*(2009)	-5.387***(2008)	I(0)
Y_t	-4.842**(2008)	-6.342***(2013)	-5.183**(2008)	-4.604**(2013)	I(0)
G_t	-4.819**(2010)	-4.793**(2013)	-6.598***(2008)	-4.288*(2008)	I(0)
$ln(R_t)$	-7.516***(2008)	-5.199***(2013)	-5.492***(2009)	-4.288*(2008)	I(0)
I_t	-5.828***(2009)	-4.647**(2013)	-5.051***(2007)	-5.299***(2013)	I(0)
X_t	-5.724***(2009)	-4.202*(2014)	-6.788***(2009)	-5.251***(2014)	I(0)
M_t	-5.142**(2010)	-5.301**(2013)	-4.323*(2009)	-4.761**(2013)	I(0)
K_{t-1}	-5.641**(2010)	-4.861*(2011)	-5.211**(2009)	-5.188**(2009)	I(0)
$D_t\mathrm{Yd}_t$	-107.665***(2010)	-80.737***(2012)	-10.004***(2007)	-4.891**(2009)	I(0)
D_tY_t	-5.616**(2009)	-5.715**(2013)	-10.231***(2007)	-10.903***(2009)	I(0)

Table 4.7 Panel Unit Root Test with structural break

COUNTRIES	LATVIA	PORTUGAL	ROMANIA	SPAIN	RESULT FOR ALL COUNTRIES
Variables	ADF Statistic	ADF Statistic	ADF Statistic	ADF Statistic	
C_t	-3.961**(2008)	-4.922**(2011)	-19.173***(2008)	-5.189***(2011)	I(0)
r_t^e	-3.846*(2008)	-3.464*(2011)	-7.922***(2009)	-5.152***(2009)	I(0)
Y_t	-4.685**(2008)	-5.794***(2011)	-30.488***(2008)	-5.229**(2011)	I(0)
G_t	-4.586**(2008)	-3.920**(2011)	-12.246***(2008)	-4.763**(2010)	I(0)
$ln(R_t)$	-4.836***(2008)	-3.568*(2011)	-5.190**(2009)	-6.596***(2009)	I(0)
I_t	-3.828*(2008)	-5.367***(2011)	-5.740***(2008)	-5.125*(2009)	I(0)
X_t	-4.207*(2008)	-4.607*(2011)	-9.193***(2010)	-6.111***(2010)	I(0)
M_t	-4.153*(2008)	-4.397*(2011)	-5.184**(2010)	-4.260*(2010)	I(0)
K_{t-1}	-4.606**(2008)	-5.292***(2011)	-19.247***(2010)	-4.966**(2009)	I(0)
$D_t\mathrm{Yd}_t$	-12.966***(2008)	-6.039***(2011)	-8.505***(2008)	-4.894***(2011)	I(0)
D_tY_t	-6.758***(2008)	-11.941***(2011)	-10.954***(2008)	-4.403*(2011)	I(0)

4.2.4. Identification and GMM estimation of the structural equations

In this section, I estimate the structural equations presented in the previous chapter by the generalized method of moments (GMM). The equations I estimate are (3.1), (3.2), (3.3), (3.4), (3.10), (3.11) and (3.12), as their coefficients enter the fiscal multipliers of Table 3.2. Equations (3.1), (3.2) and (3.4) are the most important because they contain the interaction effects that allow for changes in the fiscal multipliers.

GMM requires that a certain number of moment conditions be satisfied for the model. These moment conditions are functions of the model parameters and the data, such that their expectation is zero at the parameters' true values. GMM minimizes an objective function that depends on these moment conditions. The GMM estimators are known to be consistent, asymptotically normal and efficient in the class of all estimators that do not use any extra information aside from that contained in the moment conditions. It has been introduced by Lars Peter Hansen in 1982 as a generalization of the method of moments, introduced by Karl Pearson in 1894. These estimators are mathematically equivalent to those based on "orthogonality conditions" (Sargan, 1958, 1959) or "unbiased estimating equations" (Huber, 1967; Wang et al., 1997).

The moment conditions are derived under the assumption that the error term is orthogonal to the 1xM row vector of the instrumental variables (IVs), $\boldsymbol{V}$, that is, $E[\boldsymbol{V}_t'u_t]=\mathbf{0}$, where $\mathbf{0}$ is a Mx1 column vector. The vector $\boldsymbol{V}$ contains a constant, the country dummy variables D_1, D_2, …, and D_7, the time dummies D_{t1}, D_{t2}, … and D_{t26}, the exogenous variables, current or lagged by one, two, or three periods, and lagged endogenous variables by two or three periods.[29] These IVs must be correlated with the variables employed in each equation, but uncorrelated with the error term. The values of R^2 from the regressions of each of the endogenous variables on the IVs are fairly high, thus suggesting that the weak-instrument problem is not present here. In each equation I use different IVs.

Note that the literature on dynamic panel-data models is concerned with the consequences of using too many moment conditions (Baltagi, 2008, pp. 164-166). Using time-series data (a sample of 50 or 75 observations), Tauchen (1986) demonstrates that there is a bias/efficiency trade-off as the number of moment conditions increases, and thus he recommends the use of suboptimal instrument sets in small samples. This problem, however, becomes more pronounced with panel data, because the number of moment conditions increases considerably as the number of predetermined variables increase. Note, however, Ziliak's (1997) finding that the bias in the GMM estimator may be quite severe as the number of moment conditions increases, outweighing the efficiency gain.

As well, in panel data with long time series the number of instruments can increase by including instruments dated far into the past. The quality of these instruments, however, is probably poor because they may be weakly correlated with the endogenous variables in the equation. This weak correlation between the instruments and the endogenous variables can lead to large standard errors and bias to GMM (Ziliak, 1997, pp. 419-20). Overall, there is no clear evidence in the literature regarding the number of instruments used in GMM in order to achieve the best empirical performance in terms of the bias/efficiency trade-off.

[29] To avoid the problem that occurs when the error term is a first-order moving average process and may thus be correlated with IVs lagged only once, I lag the IVs at least twice (Campbell and Mankiw, 1990, p. 268).

A strength of GMM estimation is that the econometrician can remain completely agnostic as to the distribution of the random variables in the data-generation process (DGP). For identification, the econometrician simply needs at least as many moment conditions as the parameters to estimate. See Davidson and MacKinnon (2004, ch. 9) for a detailed exposition of the GMM.

The estimates are produced by the econometric computer program *WinRats Pro* 9.2. We use the robust standard errors option in order to obtain consistent standard errors under heteroscedasticity and serial correlation. To evaluate further the results, I test the validity of the over-identifying restrictions (the moment conditions in excess of the number of parameters to be estimated) by using the well-known *J*-statistic, suggested by Hansen (1982). This statistic is computed by constructing a quadratic form based on the product of the residuals and the IVs. Under the null hypothesis that the over-identifying restrictions are valid, the statistic is asymptotically distributed as a chi-square variable with degrees of freedom equal to the number of IVs minus the number of parameters to be estimated.

In each equation separately I choose the IVs so as to achieve economic and empirical identification (i.e., correct signs and statistical significance of the coefficients) of as many parameters as possible. I also used fixed effects (country and time dummies) in every equation. Again, I have M = 17 current endogenous variables (equal to the number of equations in the system) and K = 20 predetermined variables, including the constant term.

I now turn to identification. In a complete system of M simultaneous equations, an equation is identified only if the number of predetermined variables excluded from the equation is at least as great as the number of endogenous variables included in that equation less 1. This is known as the order condition of identifiability. A mathematical formulation of the order condition is as follows (Gujarati, 2003 p. 748): Let K = the number of predetermined variables (including the constant term) in the model, k = number of predetermined variables in a given equation, M = the number of endogenous variables in the system, and m = the number of endogenous variables in a given equation. If K-k = m-1 the equation is just identified, and if K-k > m-1, the equation is over identified.

Koopmans (1949, p. 135) rephrased the order condition in the following way: A necessary condition for the identifiability of a structural equation within a given linear model is that the number of variables excluded from that equation (or more generally the number of linear restrictions on the parameters of that equation) be at least equal to the number M of structural equations less one. The order condition is not sufficient, however. It only states the minimal number of *a priori* restrictions on the parameters of an equation, in order for it to be identifiable (Holly, 2012).

Using the order condition helps us to check if sufficient variables have been omitted from the equation under examination, without checking the rest of the system. In this way, we may face the problem of identifying a specific equation by excluding a certain variable, which, however, does not belong to any other equation of the system.

A necessary and sufficient condition for the identifiability of a structural equation within a linear model, restricted only by the exclusion of certain variables from certain equations, is that we can form at least one non-vanishing determinant of order M-1 out of those coefficients, properly arranged, with which the variables excluded from that structural equation appear in the M-1 other structural equations. That is, in a system of M current endogenous variables in M equations, a specific equation is identified if and only if one nonzero determinant of order M-1 can be formed from the coefficients of the variables omitted from that equation but included in the other equations of the system. This is known as the *rank condition of identifiability* (Koopmans, 1949 p. 135; Gujarati, 2003).

A basic feature involved in the rank condition is the coefficient matrix $\mathbf{A}_i$ (one for every structural equation) constructed from the coefficients of the variables (both endogenous and predetermined) excluded from that particular equation but included in the other equations of the model. $\mathbf{A}_i$ has zero elements in the row of the i-th equation. For that reason, rank($\mathbf{A}_i$) ≤ M-1. In $\mathbf{A}_i$, the number of columns is equal to the number of variables excluded from the i-th equation.

The general principles of identifiability of a structural equation in an M simultaneous equations system are as follows (Gujarati, 2003 p. 753):

• if K-k > m-1 and the rank of the $\mathbf{A}_i$ matrix is M-1, the equation is over identified

• If K-k = m-1 and the rank of the $\mathbf{A}_i$ matrix is M-1, the equation is exactly identified

• If K-k ≥ m-1 and the rank of the $\mathbf{A}_i$ matrix is less than M-1, the equation is under identified

• If K-k < m-1 the equation is unidentified. The rank of the A matrix now is bound to be less than M-1.

Consider equation (3.1). Here, we have m = 4 and k = 3, so K-k > m-1, and the equation is over-identified, assuming that the rank condition is satisfied (see next paragraph). Similarly, it is easy to show that equations (3.2), (3.3), (3.4), (3.10), (3.11), and (3.12) are over-identified as well.

I now check the rank condition for equations (3.1), (3.2), and (3.4), which are central in our model, because they include the interaction terms, which allow the relevant marginal propensities (and hence the multipliers) to change after the memorandum of understanding. Consider equation (3.1). The matrix $\mathbf{A}_1$ of the coefficients of the variables not included in this equation is as follows:

$$
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -(b_{12}+b_{24}+\Delta_2 D_t) & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & b_{24} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -b_{23} \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -b_1 & 0 & 0 & 0 & -b_{32} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -(b_{42}+\Delta_3 D_t) & -b_{41} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & -b_{52} & -b_{51} & -b_{55} & -b_{53} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -b_{54} & -b_{56} & -b_{57} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & -b_{63} & -b_{61} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -b_{62} & 0 & 0 & 0 & 0 & b_{61} & 0 & -b_4 & -b_{65} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & b_{71} & -b_{71} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -b_{72} & 0 & 0 & 0 & 0 & 0 & -b_{72} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & -b_{81} & 0 & 0 & 0 & 0 & 0 & 0 & -b_{82} & 0 & 0 & b_{81} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -b_{92} & 0 & 0 & -b_{91} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & b_{91} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & -b_{10,2} & 0 & 0 & 0 & 0 & 1 & 0 & 0 & -b_{10,1} & 0 & 0 & 0 & -b_{10,3} & 0 & 0 & 0 & 0 & 0 & b_{10,1} & 0 & 0 & 0 & b_{10,2} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -b_{11,1} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -b_{12,2} & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -b_{12,1} & b_{12,2} & 0 & 0 \\
-1 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

We can see that the rank of this matrix is 16, as the square 16×16 sub-matrix consisting of the first 16 columns we have nonzero numbers in its main diagonal. Since rank($\mathbf{A}_1$) = 16 and K-k > m-1, equation (3.1) is over identified. I also calculated the determinant of this matrix by MATLAB, as long as this determinant differs from zero the rank of matrix $\mathbf{A}_1$ is 16. I also follow the same procedure for equations (3.2) and (3.4). Thus, I turn to estimation.

First, I estimate the consumption function, equation (3.1), using the following IVs:[30]

$\boldsymbol{V_1}$ = (Constant, Dum_1, Dum_2, …, Dum_7, $Dumt_1$, $Dumt_2$, …, $Dumt_{26}$, P_{t-2}, P_{t-3}, DYd_{t-2}, DC_{t-2}, DC_{t-3}, $union_{t-1}$, $(Y_t - Y_p)_{t-3}$, I_{t-3}, T_{t-3}, and G_{t-2}), where $DC = C_t - C_{t-1}$. From all the country and time dummies I use only Dum_2, $Dumt_{13}$, $Dumt_{15}$, $Dumt_{16}$, $Dumt_{17}$, $Dumt_{18}$ and $Dumt_{19}$, because all the other were statistically insignificant, so I dropped them. The results are reported in Table 4.8.

[30] The additional lags C_{t-2}, G_{t-1} and Yd_{t-1} in the consumption function turned out to be statistically insignificant.

Table 4.8 GMM estimation of the Consumption function

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	0.886***	0.131	6.722	0.000
Yd_t	0.521***	0.098	5.274	0.000
G_t	-0.136	0.088	-1.553	0.120
r_t^e	-2.695	2.030	-1.327	0.180
C_{t-1}	0.456***	0.094	4.819	0.000
D_tYd_t	0.039**	0.017	2.334	0.019
Usable obs. (n)	161			
J-statistic (p-value)	2.63 (0.76)			
Ho: No corr res. & IVs	χ^2_5=2.03 (0.84)			
Centered R^2 (Yd_t, r_t^e)	0.97 & 0.73			
Durbin Wu-Hausman test	χ^2_4= 84.19 (0.00)			
Ho: No serial corr	χ^2_1=0.48 (0.49)			
Ho: No break in 2008	F=8.16 (0.00)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

First, if $D_t = 0$, before the imposition of the MOU the MPC is 0.521, which is statistically significance at the 1% level. After the imposition of the MOU, $D_t = 1$, the MPC becomes 0.521 + 0.039 = 0.560, where $\delta_1 = 0.039$, which is statistically significant at the 5% level, so the MPC increased after the imposition of the MOU.

Second, the *J*-statistic does not reject the joint hypothesis that the equation is correctly specified and the IVs are valid at any of the usual levels of significance, as its *p*-value is 0.76.

Third, Table 4.8 reports another instrument validity test, which tests for correlation between the IVs and the residuals of the estimated equation. This test helps to choose the lag length of the IVs. For example, if u_t exhibits second order serial correlation, then second lags of variables may be correlated with u_t, thus being invalid instruments. The *p*-value of this test is 0.84, so the test does not reject the validity of the IVs (see Table 4.2).[31]

[31] See Davidson and MacKinnon (1993, p. 235).

Fourth, I have also tested if the instrumental variables are weak, in which case the distribution of the estimator would deviate considerably from a normal distribution even in large samples, thus rendering the tests unreliable. The “test” consists of simply looking at the centered R^2s obtained from the OLS regressions whose dependent variables are those explanatory variables of the consumption equation that we consider to be endogenous, namely, disposable income (Yd_t) and the *ex ante* real interest rate (r_t^e**)**, on the IVs. The values of these two R^2s are 0.97 and 0.73, respectively, so the IVs used here are not weak.

Fifth, to test the hypothesis that the OLS estimator would be consistent, I conduct the Durbin-Wu-Hausman test, which is described in Davidson and Mackinnon (1993, pp. 237-242). The value of the relevant statistic is $\chi_4^2 = 84.19$ with a p-value = 0.00, so the OLS estimator would not be consistent, hence the choice of GMM is correct.

Sixth, I test for first-order serial correlation based on Gauss–Newton regressions as described in Davidson and Mackinnon (1993, pp. 369-371). The value of the relevant statistic is $\chi_1^2 = 0.48$ with a p-value 0.49, so there is no evidence for the presence of first-order serial correlation. Note that I use the option of robust estimation. One could argue that there is no need to test for serial correlation because the choice “robust” yields consistent standard errors. I choose, however, to conduct the test because its presence could possibly reflect misspecification, e.g., omitted explanatory variables.

Seventh, I test for a structural break in 2008 using a Gauss–Newton regression (GNR), as described in Davidson and MacKinnon (1993, pp. 379-380, especially their equation (11.08)). Table 4.2 reports this test as F = 8.16 (p-value = 0.00), so I reject the null hypothesis that all the coefficients remained stable after 2008. This result reinforces the idea of this thesis that the MOU, which were imposed two years later, might have caused the coefficients to change, reflecting a change in behavior.

Next, I estimate the investment equation, (3.2) using the following vector of IVs:[32]

V_2 = (Constant, Dum_1, Dum_2, …, Dum_7, $Dumt_1$, $Dumt_2$, …, $Dumt_{26}$, Y_{t-2}, G_t, G_{t-1}, G_{t-2}, G_{t-3}, I_{t-2}, I_{t-3}, *union*, $union_{t-1}$, $union_{t-2}$, $uniont_{-3}$, r^e_{t-2}, r^e_{t-3}, DC_{t-2}, DC_{t-3}). From the country and time dummies the only survivors are Dum_5, Dum_7, $Dumt_{14}$ and $Dumt_{24}$; all the other ones turned out to be statistically insignificant and were dropped. Table 4.9 reports the results.

Table 4.9 GMM estimation of the Investment function

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	-0.441**	0.214	-2.059	0.039
Y_t	0.044*	0.029	1.516	0.065
K_{t-1}	-0.038	0.033	-1.138	0.255
K_{t-2}	0.042*	0.032	1.301	0.096
r_t^e	-4.086*	2.504	-1.632	0.051
D_tY_t	0.026	0.017	1.451	0.146
I_{t-1}	0.758***	0.077	10.018	0.000
$Y_t - Y_p$	0.547***	0.185	2.949	0.000
Usable obs. (n)	160			
J-statistic (p-value)	11.45 (0.18)			
Ho: No corr res. & IVs	22.80 (0.00)			
Centered R^2 (Y_t, r_t^e, D_tY_t)	0.98, 0.66, 0.45			
Durbin Wu-Hausman test	χ^2_4= 12.98 (0.01)			
Ho: No serial corr	χ^2_1=1.05 (0.31)			
Ho: No break in 2008	F=2.80 (0.01)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

First, when $D_t = 0$ (for the time period before the imposition of the MOU), the marginal propensity to invest is 0.044 and after the imposition of the MOU, $D_t = 1$, the marginal propensity to invest is 0.044 + 0.026 = 0.070. The *t*–statistic of the estimate of the coefficient

[32] The second lag I_{t-2} in the investment function turns out to be statistically insignificant.

δ_2 is 1.451, which is greater than one, so its presence improves the fit of the equation to the data, i.e., it increases the value of the adjusted R-squared (Haitovski, 1969). According to this, we can conclude that the marginal propensity to invest increases after the imposition of the MOU.

Second, the value of the *J*-statistic is 11.45 with a *p*-value = 0.18, so I do not reject the joint hypothesis that the equation for investment is correctly specified and the IVs are valid. Third, the alternative test of the same hypothesis rejects the null hypothesis (*p*-value = 0.00), so there is evidence that the IVs may not be valid.

Fourth, the IVs are not weak, since they are fairly highly correlated with the endogenous variables employed in equation (3.2), namely, Y_t, r_t^e, and D_tY_t, as the values of R^2s from the OLS regressions of each of these endogenous variables on the IVs are 0.98, 0.66, and 0.45, respectively.

Fifth, the value of the Durbin-Wu-Hausman statistic is $\chi_4^2 = 12.98$ with *p*-value = 0.01, so I reject the hypothesis that the OLS estimator is consistent at the 5% level of significance, implying that the choice of GMM is correct.

Sixth, I test for first-order serial correlation based on a GNR. The value of the relevant statistic is $\chi_1^2 = 1.05$ with a *p*-value 0.31, so there is no evidence for the presence of first-order serial correlation.

Seventh, I test for a structural break in 2008 using a GNR. Table 4.9 reports this test as F = 2.80 (*p*-value = 0.01), so I reject the null hypothesis at the 5% level of significance that all the coefficients remained stable after 2008. Again, this result reinforces the idea of this thesis that the MOU, which were imposed two years later, might have caused the coefficients to change, reflecting a change in behavior.

Next, I estimate the exports equation, (3.3) using the following vector of IVs:[33]

V_3 = (Constant, Dum_1, Dum_2, …, Dum_7, $Dumt_1$, $Dumt_2$, …, $Dumt_{26}$, lnR_{t-2}, lnR_{t-3}, K_t, K_{t-1}, K_{t-2}, K_{t-3}, G_{t-2}, G_{t-3}, Y_{t-2}, Y_{t-3}). From the country and time dummies the only survivors are Dum_1, Dum_2, Dum_4, Dum_5, and Dum_7; all the other ones turned out to be statistically insignificant and were dropped. Table 4.10 reports the results.

Table 4.10 GMM estimation of the Exports function

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	-14.824*	8.367	1.771	0.076
$\boldsymbol{lnR_t}$	-7.030*	4.024	-1.747	0.081
$\boldsymbol{Y_t^F}$	0.172*	0.120	1.435	0.076
$\boldsymbol{lnR_{t-1}}$	2.894	2.323	1.245	0.213
$\boldsymbol{X_{t-1}}$	1.092***	0.025	42.926	0.000
Usable obs. (n)	168			
J-statistic (p-value)	6.45 (0.60)			
Ho: No corr res. & IVs	χ^2_1=17.19 (0.00)			
Centered R² $(ln(R_t))$	0.77			
Durbin Wu-Hausman test	χ^2_2= 13.45 (0.00)			
Ho: No serial corr	χ^2_1=1.38 (0.24)			
Ho: No break in 2008	F=0.75 (0.56)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

First, the *J*-statistic is 6.45 with a *p*-value = 0.60, so I do not reject the hypothesis that the equation for exports is correctly specified and the IVs are valid. Second, the alternative

[33] I thank Professors Apergis and Katrakilidis for suggesting that I include lagged variables in my equations to capture short-run effects. In response, I included X_{t-1}, $ln(R_{t-1})$, and $ln(R_{t-2})$ in the exports function. From these three variables I only kept only $ln(R_{t-1})$ and X_{t-1}, as $ln(R_{t-2})$ turned out to be statistically insignificant. Replacing the lags of the real exchange rate with lags of the nominal exchange rate also yields statistically insignificant results.

test of the same hypothesis shows that the IVs may not be the right choice, as its *p*-value is 0.00.

Third, the weak-instrument problem does not seem to be present here, as the value of R^2 from the OLS regression of $ln(R_t)$, the endogenous explanatory variable in equation (3.3), on the IVs is 0.77.

Fourth, the value of the Durbin-Wu-Hausman statistic is $\chi^2_2 = 13.45$ so I reject the hypothesis that the OLS estimator would be consistent as the *p*-value is 0.00.

Fifth, I test for first-order serial correlation based on a GNR. The value of the relevant statistic is $\chi^2_1 = 1.38$ with a *p*-value 0.24, so there is no evidence for the presence of first-order serial correlation.

Sixth, I test for a structural break in 2008 using a GNR. Table 4.10 reports this test as F = 0.75 (*p*-value = 0.56), so I do not reject the null hypothesis that all the coefficients remained stable after 2008.

Next, I estimate the imports equation, (3.4) using the following vector of IVs:[34]

$\boldsymbol{V_4}$ = (Constant, $Dum_1, Dum_2, \ldots, Dum_7, Dumt_1, Dumt_2, \ldots, Dumt_{26}, Y_{t-2}, Y_{t-3}, \pi_{t-2}, lnR_{t-3}, Union_{t-2}, Uniont_{-3}, r^e t_{-2}, r^e_{t-3}, (Y\text{-}Y_p)_{t-2}, (Y\text{-}Y_p)_{t-3}$). From the country and time dummies the only survivors are Dum_1, Dum_4, $Dumt_4$, $Dumt_5$ and $Dumt_{10}$; all the other ones turned out to be statistically insignificant and were dropped. Table 4.11 reports the results.

[34] Note that the positive sign of the coefficient of $ln(R_{t-1})$ in the imports function was not expected, in accordance with the J-curve effect. This variable was not present in the original version of the model, but was added in response to the criticism of the examiners. If, in addition, $ln(R_{t-2})$ is inserted, it is not statistically significant.

Table 4.11 GMM estimation of the Imports function

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	47.073***	17.154	2.744	0.006
lnR$_t$	-18.775***	6.351	-2.956	0.003
Y$_t$	0.783***	0.085	9.257	0.000
$\boldsymbol{D_t Y_t}$	-0.170**	0.076	-2.229	0.026
lnR$_{t-1}$	7.574**	3.849	1.967	0.049
Usable obs. (n)	176			
J-statistic (p-value)	9.08 (0.17)			
Ho: No corr res. & IVs	χ^2_6=4.59 (0.59)			
Centered R^2 $(\boldsymbol{ln(R_t), Y_t})$	0.67 & 0.98			
Durbin Wu-Hausman test	χ^2_4= 14.02(0.00)			
Ho: No serial corr	χ^2_1=5.04 (0.03)			
Ho: No break in 2008	F=17.89 (0.00)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

First, when $D_t = 0$ (for the time period before the imposition of the MOU), the marginal propensity to import (MPI), is 0.783 and after the imposition of the MOU, $D_t = 1$, the MPI is 0.783 + (-0.170) = 0.613. Here $\delta_3 = -0.170$, with t-statistic = -2.229, which is statistically significant at the 5% level of significance. Thus, the MPI decreased sharply after the imposition of the MOU.

Second, the *J*-statistic is 9.08 with a *p*-value = 0.17, so I do not reject the hypothesis that the equation for imports is correctly specified and the IVs are valid. Third, the alternative test of the same hypothesis also shows that the IVs are valid (*p*-value = 0.59).

Fourth, the weak- instrument problem does not seem to be present here, as the values of R^2s from the OLS regressions of each of the endogenous explanatory variables in equation (3.4), $ln(R_t)$ and $Y_t,$ on the IVs are 0.67, and 0.98, respectively.

Fifth, the value of the Durbin-Wu-Hausman statistic is $\chi_4^2 = 14.02$ with p-value = 0.00, so I reject null hypothesis that the OLS estimator would be consistent, implying that the choice of GMM is correct.

Sixth, I test for first-order serial correlation based on a GNR. The value of the relevant statistic is $\chi_1^2 = 5.04$ with a p-value = 0.03, so at the 5% level of significance there is evidence for the presence of first-order serial correlation.

Seventh, I test for a structural break in 2008 using a GNR. Table 4.11 reports this test as F = 17.89 (p-value = 0.00), so I reject the null hypothesis that all the coefficients remained stable after 2008.

Next, I estimate the interest rate equation, (3.10) using the following vector of IVs:[35] $\boldsymbol{V_5}$ = (Constant, Dum_1, Dum_2, …, Dum_7, $Dumt_1$, $Dumt_2$, …, $Dumt_{26}$, π^e_{t-2}, π^e_{t-3}, π_{t-2}, $(Y\text{-}Y_p)_{t-2}$, P_{t-2}, C_{t-2}, C_{t-3}, M_{t-2}, M_{t-3}). From the country and time dummies the only survivors are Dum_6, $Dumt_4$, $Dumt_5$ and $Dumt_{21}$; all the other ones turned out to be statistically insignificant and were dropped. Table 4.12 reports the results.

[35] Note that the lags i_{t-1} and i_{t-2} were not present in the original version of the model, but were added after the presentation, in response to the criticism of the examiners.

Table 4.12 GMM estimation of the Interest Rate function

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	-0.006	0.008	-0.765	0.444
$\boldsymbol{Y_t - Y_p}$	0.016*	0.012	2.938	0.085
$\boldsymbol{\pi_t - \pi^*}$	-0.380*	0.218	-1.743	0.081
$\boldsymbol{\pi_t^e}$	2.101***	0.618	3.398	0.000
$\boldsymbol{i_{t-1}}$	-1.152*	0.617	-1.868	0.061
$\boldsymbol{i_{t-2}}$	0.485*	0.279	1.734	0.082
Usable obs. (n)	176			
J-statistic (p-value)	1.37 (0.71)			
Ho: No corr res. & IVs	χ^2_3=5.00 (0.17)			
Centered R² (Y_t, π_t)	0.95 & 0.44			
Durbin Wu-Hausman test	χ^2_3= 41.37 (0.00)			
Ho: No serial corr	χ^2_1=0.13 (0.72)			
Ho: No break in 2008	F=3.16 (0.00)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

First, the *J*-statistic is 1.37 with a *p*-value = 0.71, so I do not reject the hypothesis that the equation for the interest rate is correctly specified and the IVs are valid. Second, the alternative test of the same hypothesis also shows that the IVs are valid (*p*-value = 0.17).

Third, the weak- instrument problem does not seem to be present here, as the values of R^2s from the OLS regressions of each of the endogenous explanatory variables in equation (3.10), Y_t and π_t, on the IVs are 0.95 and 0.44, respectively.

Fourth, the value of the Durbin-Wu-Hausman statistic is $\chi_3^2 = 41.37$ with *p*-value = 0.00, so I reject the hypothesis that the OLS estimator is consistent, implying that the choice of GMM is correct.

Fifth, I test for first-order serial correlation based on a GNR. The value of the relevant statistic is $\chi_1^2 = 0.13$ with a *p*-value 0.72, so there is no evidence for the presence of first-order serial correlation.

Sixth, I test for a structural break in 2008 using a GNR. Table 4.12 reports this test as F = 3.16 (*p*-value = 0.00), so I reject the null hypothesis that all the coefficients remained stable after 2008.

Next, I estimate the tax equation (3.11) using the following vector of IVs: $\boldsymbol{V_6}$ = (Constant, Dum_1, Dum_2, ..., Dum_7, $Dumt_1$, $Dumt_2$, ..., $Dumt_{26}$, Y_{t-2}, Y_{t-3}). From the country and time dummies the only survivors are Dum_4, Dum_5, Dum_6, Dum_7, $Dumt_4$, $Dumt_5$, $Dumt_6$, $Dumt_7$, $Dumt_8$, $Dumt_9$, $Dumt_{15}$ and $Dumt_{16}$; all the other ones turned out to be statistically insignificant and were dropped. Table 4.13 reports the results.

Table 4.13 GMM estimation of the Tax Equation

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	2.9733***	0.417	7.114	0.000
$\boldsymbol{Y_t}$	0.173***	0.022	7.858	0.000
Usable obs. (n)	192			
J-statistic (p-value)	0.99 (0.32)			
Ho: No corr res. & IVs	χ^2_1=1.48 (0.22)			
Centered R^2 (Y_t,)	0.98			
Durbin Wu-Hausman test	χ^2_2= 28.40 (0.00)			
Ho: No serial corr	χ^2_1=1.36 (0.24)			
Ho: No break in 2008	F=17.79 (0.00)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

First, the *J*-statistic is 0.99 with a *p*-value = 0.32, so I do not reject the hypothesis that the tax equation is correctly specified and the IVs are valid. Second, the alternative test of the same hypothesis also shows that the IVs are valid (*p*-value = 0.22).

Third, the IVs are fairly strong, since they are fairly strongly correlated with the endogenous explanatory variable in equation (3.11), namely, Y_t, as the value of R^2 from the OLS regression on the IVs is 0.98.

Fourth, the value of the Durbin-Wu-Hausman statistic is $\chi^2_2 = 28.40$ with p-value = 0.00, so I reject the hypothesis that the OLS estimator is consistent, implying that the choice of GMM is correct.

Fifth, I test for first-order serial correlation based on a GNR. The value of the relevant statistic is $\chi^2_1 = 1.36$ with a p-value 0.24, so there is no evidence for the presence of first-order serial correlation.

Sixth, I test for a structural break in 2008 using a GNR. Table 4.7 reports this test as F = 17.79 (p-value = 0.00), so I reject the null hypothesis that all the coefficients remained stable after 2008.

Finally, I estimate the nominal exchange rate equation (3.12) using the following vector of IVs:

$\boldsymbol{V_7}$ = (Constant, Dum_1, Dum_2, ..., Dum_7, $Dumt_1$, $Dumt_2$, ..., $Dumt_{26}$, lnS_{t-2}, lnS_{t-3}, i_{t-2}, i_{t-3}, i_{Ft-2}, i_{Ft-3}, P_{t-2}, P_{t-3}, $Union_{t-2}$, P_{t-2}, P_{t-3}). From the country and time dummies the only survivors is the $Dumt_5$; all the other ones turned out to be statistically insignificant and were dropped. Table 4.14 reports the results.

Table 4.14 GMM estimation of the Nominal Exchange Rate Equation

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	-0.614	0.664	-0.925	0.355
$\boldsymbol{lnS_{t-1}}$	1.134***	0.144	7.879	0.000
$\boldsymbol{i_t - i_F}$	-0.785***	0.259	-3.031	0.002
Usable obs. (n)	174			
J-statistic (p-value)	8.07 (0.33)			
Ho: No corr res. & IVs	χ^2_7=11.29 (0.13)			
Centered R² ($\boldsymbol{lnS}$, $\boldsymbol{i_t, r_t^e}$)	0.92, 0.95 & 0.91			
Durbin Wu-Hausman test	χ^2_2= 0.04 (0.98)			
Ho: No serial corr	χ^2_1=0.56 (0.46)			
Ho: No break in 2008	F=3.73 (0.03)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

First, the *J*-statistic is 8.07 with a *p*-value = 0.33, so I do not reject the hypothesis that the equation for the nominal exchange rate is correctly specified and the IVs are valid. Second, the alternative test of the same hypothesis shows that the IVs are valid (*p*-value = 0.13).

Third, the weak- instrument problem does not seem to be present here, as the values of R^2s from the OLS regressions of each of the endogenous explanatory variables in equation (3.12), namely, lnS, i_t, and r_t^e, on the IVs are 0.92, 0.95, and 0.91, respectively.

Fourth, the value of the Durbin-Wu-Hausman statistic is $\chi_2^2 = 0.04$ with *p*-value = 0.98, so I do not reject the hypothesis that the OLS estimator is consistent, implying that the choice of GMM might not be correct.

Fifth, I test for first-order serial correlation based on a GNR. The value of the relevant statistic is $\chi_1^2 = 0.56$ with a *p*-value 0.46, so there is no evidence for the presence of first-order serial correlation.

Sixth, I test for a structural break in 2008 using a GNR. Table 4.14 reports this test as F = 3.73 (p-value = 0.03), so I reject the null hypothesis at 5% level of significance that all the coefficients remained stable after 2008.

Finally, as I noted in Chapter 3, I have also contemplated estimating the following equation:

$$lnS_t = \beta_{12,0} + \beta_{12,1}(lnP_t - lnP_{t_{foreign}}) + \beta_{12,2}(i_t - i_F) + \epsilon_{12t},$$

which combines the Uncovered Interest Parity with the Purchasing Power Parity theory, where the difference $lnP_t - lnP_{t_{foreign}}$ stands for the logarithm of the expected exchange rate (see, Juselius, 1995, Equation 3).[36] The results were not encouraging, however, so I keep the original specification, Equation (3.12).

With the estimates reported in Tables 4.8 to 4.14, I can calculate the fiscal multipliers, which I derived in Chapter 3 and reproduce here for convenience, as follows:

$$\frac{\partial Y_t}{\partial G_t} = \frac{\beta_{14} + 1}{a - \delta_2 D_t + \delta_3 D_t + \delta_1 D_t(\beta_{11,1} - 1)}$$

where:

[36] Unfortunately, I have not been able to find a series for the expected exchange rate.

$$a = 1 + \beta_{42} - \beta_{22} - \beta_{26} - \beta_{13}\beta_{10,1} - \beta_{23}\beta_{10,1} + \beta_{11}(\beta_{11,1} - 1) - \beta_{31}\beta_{10,1}\beta_{12,2} + \beta_{41}\beta_{10,1}\beta_{12,2}$$

and:

$$\frac{\partial Y_t}{\partial \beta_{11,0}} = \frac{-(\beta_{11} + \delta_1 D_t)}{a - \delta_2 D_t + \delta_3 D_t + \delta_1 D_t(\beta_{11,1} - 1)}$$

The coefficient estimates needed for the calculation of the multipliers are reported in Table 4.15[37]:

Table 4.15 Coefficient estimates needed for the estimation of the multipliers

COEFFICIENTS	
β_{11}	0.521
β_{13}	-2.696
β_{14}	-0.137
β_{22}	0.044
β_{23}	-4.086
β_{26}	0.547
β_{31}	-7.030
β_{41}	-18.775
β_{42}	0.783
$\beta_{10,1}$	0.016
$\beta_{11,1}$	0.174
$\beta_{12,2}$	-0.785
δ_1	0.039
δ_2	0.025
δ_3	-0.170
D_t	0 or 1

[37] Appendix B contains the tables that report the results of the other equation estimates.

Substituting these coefficient estimates in the above formulas for the multipliers, I obtain the following estimates of the fiscal multipliers for the time period *after* the imposition of the MOU (D_t = 1):

$$\frac{\partial Y_t}{\partial G_t} = 1.12$$

and

$$\frac{\partial Y_t}{\partial \beta_{11,0}} = -0.72$$

For the period *before* the imposition of MOU (D_t = 0), I obtain:

$$\frac{\partial Y_t}{\partial G_t} = 0.86$$

and

$$\frac{\partial Y_t}{\partial \beta_{11,0}} = -0.52.$$

These estimates suggest that the fiscal multipliers have increased substantially after the imposition of the MOU, thus supporting the idea that motivated this thesis.

4.2.4. Assessing the values of the multipliers based on the sample averages

In the previous subsection, I estimated the multipliers for government purchases for goods and services (*G*) and for autonomous taxes ($\beta_{11,0}$) using the GMM estimates of the structural parameters (see Chapter 3). Here, I check if these estimates conform with reality.

First, note that, as is well known, underestimating the multipliers may lead countries to miscalculate the amount of adjustment necessary to curb their debt ratio (Eyraud and Weber, 2012, 2013), which could affect the credibility of fiscal consolidation programs. In addition, authorities may engage in repeated rounds of tightening in an effort to make fiscal variables converge to official targets, thus setting off a vicious circle of slow growth, deflation, and further tightening. For example, Blanchard and Leigh (2013) find that the under-estimation of fiscal multipliers early in the crisis contributed significantly to growth forecast errors.

Second, from first-year macroeconomics (see. e.g. Hatzinikolaou, 2011, pp. 187 -188), we know that the following equation can be taken to hold approximately:

$$\Delta Y \approx \Delta G \times M_G + \Delta T \times M_T \tag{4.1}$$

$$M_T = -MPC \times M_G \tag{4.2}$$

where:

M_G= government purchases multiplier,

M_T = autonomous tax multiplier,

ΔY_i = (Five-year average of real GDP in billions of euros before the MOU was imposed in country *i*) – (real GDP for the year right after the MOU was ended in country *i*).

ΔG_i = (Five-year average of G_i in billions of euros before the MOU was imposed in country *i*) – (G_i for the year right after the MOU was ended in country *i*).

$MPC_i = \Delta C_i/\Delta Y_{di}$, where ΔC_i = five-year average of C_i in billions of euros before the MOU was imposed in country *i*) – (C_i for the year right after the MOU was ended in country *i*), ΔY_{di} = five-year average of Y_{di} in billions of euros before the MOU was imposed in country *i*) – (Y_{di} for the year right after the MOU was ended in country *i*).

ΔT is calculated as follows. Using the data from the panel, I estimate the following equation: $T = to + \delta D_t + t_1 Y + u_t$ by GMM and I take the value of the coefficient δ ($\delta > 0$). Here, the per capita variables *T* and *Y* are measured in thousands of euros because the levels of taxes and of real GDP are expressed in billions of euros and the population is expressed in thousands of persons. Therefore, the estimate of δ reported in Table 4.16, 0.615, means that the yearly per capita autonomous tax paid by each individual in the panel of the eight countries is 615 euros.

Table 4.16 GMM Estimation of the change in autonomous taxes

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	1.309***	0.261	5.003	0.000
D_t	0.615*	0.354	1.736	0.082
Y_t	0.244***	0.012	19.153	0.000
Usable obs. (n)	192			
J-statistic (p-value)	3.903 (0.14)			

Next, I take the average population in the eight countries from 1995 to 2020, which is 13.078.058,65 persons (see Table D.1 in Appendix D) and multiply it by this $\delta = 0.615$. The result is $\Delta T = 8.043$ (billions of euros paid by the 13.078.058,65 persons).

In Table 4.17, I present the changes in *Y*, *G*, and *T*:

Table 4.17 Changes in *Y*, *G*, and *T*

COUNTRIES	ΔY	ΔG	ΔT
GREECE	-64.91	-14.78	2.65
CYPRUS	1.76	0.17	6.69
HUNGARY	-15.15	-2.28	27.14
IRELAND	16.30	-4.16	0.48
LATVIA	1.39	0.11	1.97
PORTUGAL	-7.57	-5.86	6.17
ROMANIA	-18.19	-2.62	6.38
SPAIN	-53.27	-30.18	12.87
SUM	-139.64	-59.61	64.34
AVERAGE	-17.45	-7.45	8.04

Substituting equation (3.28) to equation (3.27), we get $\Delta Y = \Delta G \times M_G + \Delta T \times (-MPC \times M_G)$ from which we get $\Delta Y = (\Delta G - MPC \times \Delta T) \times M_G$, hence $M_G = DY/(DG - MPC \times DT)$ and $M_T = -MPC \times M_G$. Thus,

$M_G =$	**1.27**

$M_T =$	**-0.99**

Table 4.18 reports the values of the multipliers allow compare them:

Table 4.18 Fiscal Multipliers by two different approaches

	M_G	M_T
GMM estimates used in (3.23) and (3.26)	1.12	-0.72
Calculation of the Multipliers as in (4.1) and (4.2)	1.27	-0.99

From Table 4.18 we can easily see that the values of the multipliers obtained from equations (3.23) and (3.26) are close to those obtained from the basic definitions using the sample averages. Thus, our GMM estimates can be taken to be reliable, and thus usable.

CHAPTER 5: CONCLUSION

The purpose of this thesis has been to investigate the question of whether the actual values of the fiscal multipliers during the crisis in the countries that had adopted MOU were in fact larger than forecasters assumed at the start of the crisis, thus causing actual growth of real GDP in these countries to be less than expected. In particular, based on pre-crisis data for advanced economies, IMF forecasters assumed that the actual values of the fiscal multipliers averaged about 0.5, and IMF officials thought that this assumption was plausible, implying that the imposition of MOU does not cause the values of the fiscal multipliers to increase. This dissertation provides both theoretical reasons and empirical evidence to the contrary. To my knowledge, the existing literature has failed to consider this possibility.

More specifically, I find empirical evidence that the marginal propensities to consume and to invest increased during the crisis, whereas the marginal propensity to import decreased. I argue that these parameter changes can be attributed to the change in policy implied by the imposition of the MOU, in accordance with the Lucas critique. All of these parameter changes, however, caused the values of the multipliers to be greater during the crisis. As I note in the Introduction, Blanchard and Leigh (2013) reported weak evidence supporting this conclusion, but considered it to be statistically insignificant, without applying a formal test, and avoided to attribute the difference to the imposition of the MOU.

Based on a panel of annual aggregate data from 1995 to 2020 for the eight countries that adopted MOU during the crisis, I estimate a simple macroeconomic model consisting of 17 equations and find that the government purchases multiplier increased from 0.72 before the imposition of MOU to 1.12 after the MOU, and the autonomous-tax multiplier increased (in absolute value) from -0.52 before the MOU to -0.72 after. In Chapter 4, I demonstrate that these estimates conform with reality and, broadly speaking, can be taken to be reliable and therefore usable.

Therefore, I conclude that in the countries that adopted the MOU the values of the fiscal multipliers increased during the crisis, and this increase was predictable, implying that the extent of the austerity measures imposed by the MOU was inappropriate, as they caused greater damage to the economy than was expected. I do not suggest that fiscal consolidation should not have taken place altogether in countries that faced debt problems, but instead that the erroneous assumptions regarding the actual values of the fiscal multipliers in these countries during the crisis could and should have been avoided, so that growth disappointments would be avoided.

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APPENDIX A: THE DATA

The sources of the data are as follows:

a. $\mathbf{C_t}$, private final consumption expenditure refers to the expenditure on consumption of goods and services of households and non-profit institutions serving households. Goods and services financed by the government and supplied to households as social transfers in kind are not included. The source is AMECO.

b. $\mathbf{I_t}$, gross domestic investment the source is AMECO. The way AMECO compute these series is, from gross fixed capital formation at current prices, total economy subtracts gross fixed capital formation at current prices, general government.

c. Ex ante real interest rate ($\mathbf{r^e{}_t}$), from the nominal interest rate in period t, ($\mathbf{i_t}$) we subtract expected inflation rate, ($\boldsymbol{\pi_t^e}$).

d. We use dummy variables in order to capture the changes in the years after the MOU was imposed on country, we used eight dummies as the countries that entered the memoranda. The source is from electronic magazine, https://bankingnews.gr/index.php?id=359611.

e. $\mathbf{K_t}$, net capital stock at constant prices. The source is AMECO.

f. $\mathbf{X_t}$, real exports per capita, the source is AMECO.

g. $\mathbf{M_t}$, real imports per capita, the source is AMECO.

h. $\mathbf{R_t}$, real effective exchange rates, relative to a competitor group, double export weights. The real effective exchange rate (RER) is the weighted average of a country's currency in relation to an index or basket of other major currencies. The weights are determined by comparing the relative trade balance of a country's currency against each country within the index. The source is AMECO.

i. **St,** nominal exchange rate, the nominal effective exchange rate (NEER) is an unadjusted weighted average rate at which one country's currency exchanges for a basket of multiple foreign currencies. The nominal exchange rate is the amount of domestic currency needed to purchase one unit of foreign currency. The source is AMECO.

j. $\mathbf{i_t}$, I used the nominal short term interest rate. Short-term interest rates are the rates at which short-term borrowings are effected between financial institutions or the rate at which short-term government paper is issued or traded in the market. Short-term interest rates are based on three-month money market rates where available. The source is AMECO.

k. $\mathbf{i_F}$, here we used the Germany’s interest rate because this country we can say that is the country leader. Germany is the country that forced the other countries we have discussed brevious to enter the memorandum of understanding (MoU) to keep their economies stable. The source is AMECO.

l. $\boldsymbol{\pi_t}$, the rate of price inflation measured by the percentage change in the GDP deflator. The source is AMECO.

m. $\boldsymbol{\pi_t^e}$, I derive the expected inflation rate from OECD and IMF data. Inflation forecast is measured in terms of the consumer price index (CPI) or harmonised index of consumer prices (HICP) for the euro area countries, the euro area aggregates and the United Kingdom. Inflation measures the general evolution of prices. It is defined as the change in the prices of a basket of goods and services that are typically purchased by households. (https://data.oecd.org/price/inflation-forecast.htm)

n. $\boldsymbol{\pi^*}$, the target of the inflation rate. When households and businesses can reasonably expect inflation to remain low and stable, they are able to make sound decisions regarding saving, borrowing, and investment, which contributes to a well-functioning economy. For many years, inflation in the United States has run below the Federal Reserve's 2 percent goal. The Federal Reserve manages inflation with an inflation targeting policy. This monetary tool seeks that sweet spot of inflation at 2%. When prices rise at this ideal pace, it drives consumer demand.

o. $\mathbf{Y_t^F}$, net primary income from the rest of the world. We use the average of European Union gross domestic product at constant prices and the average of European population in order to transform the series to per capita. The source is AMECO.

p. $\mathbf{Y_t}$, the level of domestic real gdp. The source is AMECO.

q. $\mathbf{Y_p}$, I derive the level of domestic potential real GDP from AMECO. Also here we used and the series of population across the years in order to transform the data in per capita terms.

r. $\mathbf{Yd_t}$, net disposable income is equal to gross disposable income minus consumption of fixed capital. In order to transform the data to constant prices we use the price deflator. The source is AMECO.

s. $\mathbf{P_t}$, for domestic price level we use the harmonised indices of consumer prices. (HICPs) are designed for international comparisons of consumer price inflation, in particular for the purpose of the Economic and Monetary Union (EMU), which requires among other things the assessment of inflation convergence. HICPs are calculated according to a harmonised approach and a regulated set of definitions, comprising a common classification, a common coverage of consumer goods and prices and a common index reference base (1996 = 100). The source is AMECO.

t. $\mathbf{P_{tforeign}}$, for foreign price level we use the average of harmonised indices of consumer prices in European Union. The source is AMECO.

u. $\mathbf{G_t}$, final consumption expenditure of general government is a variable which consists of individual consumption of general government plus collective consumption of general government. The source is AMECO.

v. $\mathbf{union_t}$, the strength of labor unions, source is a database named ICTWSS.

w. $\mathbf{netting_t}$, for net immigration we take the data from EUROSTAT.

x. $\mathbf{T_t}$, the source is AMECO. For this variable we use the total tax burden including imputed social security contributions which is the sum of: indirect taxes plus direct taxes plus capital taxes plus social security contributions (actual and imputed).

y. $\mathbf{u_t}$, from AMECO we use the unemployed as a percentage of active population.

z. $\mathbf{u_f}$, for natural rate of unemployment we take the non-accelerating wage rate of unemployment. Structural unemployment is the rate of unemployment consistent with constant wage inflation (NAWRU). The source is AMECO.

aa. $\mathbf{g_{mt}}$, monetary aggregate M3 vis-a-vis euro area non-MFI excl. central gov. reported by MFI & central gov. & post office giro Inst. in the euro area (index). The source is European Central Bank.

bb. $\mathbf{g_{wt}}$, from AMECO we take the average of five variables. These variables are: 1) nominal unit wage costs of agriculture, forestry and fishery products 2) nominal unit wage costs of industry excluding building and construction 3) nominal unit wage costs of building and construction 4) nominal unit wage costs of services and 5) nominal unit wage costs of manufacturing industry.

cc. $\mathbf{g_{qt}}$, the source is EUROSTAT.

dd. $\mathbf{i_t l}$, long term interest rate is the nominal long term interest rate minus the expected inflation rate. Long-term interest rates refer to government bonds maturing in ten years. Rates are mainly determined by the price charged by the lender, the risk from the borrower and the fall in the capital value. In all cases, they refer to bonds whose capital repayment is guaranteed by governments. The source is AMECO.

APPENDIX B: GMM ESTIMATION OF THE REST OF THE EQUATIONS

In Tables B.1 to B.5, I present the results of the rest of the equations the parameters of which do not enter the multiplier formulas (3.23) and (3.26). As we can see, according to Table 3.1, most of the signs of the coefficients are the expected ones, except the following four. In the inflation equation (3.5), the coefficient of monetary growth (g_{m_t}), β_{53}, and that of the unemployment rate (u_t), β_{55} (see Table B.1) are wrongly signed. In addition, in the nominal wage equation (3.6), the coefficient of $netimg_t$, β_{65}, is also wrongly signed (see Table B.2), and so is the coefficient of the output gap ($Y_t - Y_p$), β_{91}, in the money-supply equation (3.9); see Table B.5.

Table B.1 GMM estimation of the Inflation Equation[38]

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	0.029	0.051	0.561	0.575
g_{q_t}	-0.851	0.750	-1.135	0.128
g_{w_t}	0.321	0.298	1.075	0.141
g_{m_t}	-4.378*	2.819	-1.553	0.060
$g_{m_{t-1}}$	3.644*	2.333	1.562	0.059
u_t	1.467	1.384	1.060	0.144
u_{t-1}	-1.256	1.189	-1.056	0.145
π_{t-1}	1.153**	0.474	2.431	0.015
Usable obs. (n)	160			
J-statistic (p-value)	1.81 (0.61)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

[38] Inserting the additional lags $g_{q_{t-1}}$, u_{t-2}, and π_{t-2} results in insignificant results and in a rejecting value of the J – statistic, so I chose not to.

Table B.2 GMM results from Growth Rate of Nominal Wage Equation[39]

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	-0.049*	0.027	-1.830	0.067
$u_t - u_f$	-0.942*	0.685	-1.376	0.084
π_t^e	0.597*	0.362	1.647	0.091
g_{q_t}	2.602*	1.449	1.796	0.073
$union_t$	0.090*	0.055	1.651	0.099
$netimg_t$	0.000*	0.000	1.275	0.100
Usable obs. (n)	166			
J-statistic (p-value)	4.70 (0.19)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

Table B.3 GMM results from Growth Rate of Productivity Equation[40]

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	-0.059	0.036	-1.578	0.115
$g_{w_t} - \pi_t$	0.063*	0.040	1.560	0.060
$g_{K_{t-1}}$	1.931*	1.192	1.620	0.051
$g_{q_{t-1}}$	0.737*	0.384	1.922	0.054
Usable obs. (n)	160			
J-statistic (p-value)	4.86 (0.77)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

[39] Here, too, inserting the additional lags $g_{q_{t-1}}$, and $g_{w_{t-1}}$ results in insignificant results and in a rejecting value of the J – statistic, so I chose not to.

[40] In the original version of the model, the variable $g_{q_{t-1}}$ was not present in the equation for the growth rate of productivity. I have added it in response to the criticism of the examiners during the defence of the thesis. If, in addition, the variable $g_{K_{t-2}}$ is also inserted, it turns out to be statistically insignificant.

Table B.4 GMM results from Unemployment Equation[41]

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	0.021*	0.011	1.848	0.065
$\boldsymbol{Y_t - Y_p}$	-0.013***	0.004	-3.219	0.001
$\boldsymbol{u_{t-1}}$	0.867***	0.228	3.811	0.000
$\boldsymbol{u_{t-2}}$	-0.178	0.177	-1.001	0.314
Usable obs. (n)	184			
J-statistic (p-value)	2.23 (0.82)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

Table B.5 GMM results from Growth Rate of Money Supply Equation[42]

VARIABLE	COEFFICIENT	Std ERROR	T-STAT	SIGNIFICANCE
Constant	0.047***	0.000	112.466	0.000
$\boldsymbol{Y_t - Y_p}$	0.000*	0.000	1.382	0.088
$\boldsymbol{i_t}$	0.002***	0.001	2.517	0.010
Usable obs. (n)	176			
J-statistic (p-value)	2.02 (0.85)			

Notes: a) ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level, respectively.

[41] Note that in the original version of the model, the variable u_{t-2} was not present.

[42] Inserting the lag $g_{m_{t-1}}$ in the growth rate of money supply equation turns out to be statistically insignificant.

APPENDIX C: THE MATRICES B, Δ, AND Γ

$$
\mathbf{B} = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.52 & 0 & 0 & 2.69 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.59 & 0 & 0 & 0 & 4.09 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 7.03 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.78 & 0 & 18.77 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & -0.32 & 0.85 & -1.46 & 4.37 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & -2.60 & 0.94 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0.06 & -0.06 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0.01 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -0.01 & 0 & 0 & -0.00 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0.38 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & -0.02 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -0.17 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 24.06 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
-1 & -1 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 1 & 1 & 0 \\
0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{pmatrix}
$$

$$
\boldsymbol{\Delta} = \begin{pmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.04 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.03 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.17 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix}
$$

$$
\boldsymbol{\Gamma} = \begin{pmatrix}
-0.88 & -0.45 & 0 & 0.14 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.44 & 0 & -0.59 & 0 & 0.04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.55 & 0 & 0 & 0 & 0 & 0 & -0.04 & 0 & 0 & 0 & 0 & 0 & 0 \\
-14.82 & 0 & 0 & 0 & 0 & -0.17 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -2.89 & -1.09 & 0 & 0 & 0 & 0 \\
-47.07 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -7.57 & 0 & 0 & 0 & 0 & 0 \\
-0.03 & 0 & 0 & 0 & 0 & 0 & -3.64 & 1.25 & -1.15 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.94 & -0.60 & -0.09 & -0.00 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.06 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1.93 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.74 & 0 & 0 & 0 \\
-0.02 & 0 & 0 & 0 & 0 & 0 & 0 & -0.87 & 0 & 0 & 0 & 0 & 0 & 0 & -0.01 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.18 & 0 & 0 \\
-0.05 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.00 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.01 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -2.10 & 0 & 0 & 0 & 0.02 & -0.38 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.150 & -0.48 \\
-2.97 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-2.07 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1.56 & -24.06 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix}
$$

APPENDIX D: TABLE D.1 POPULATION AVERAGE

Table D.1 Average in millions of people in countries imposed in MOU

Country	SUM OF PEOPLE (1995 – 2020)	AVERAGE OF PEOPLE (1995 -2020)
Ireland	111.913.400,00	4.304.361,54
Greece	282.651.400,00	10.871.207,69
Spain	1.147.337.400,00	44.128.361,54
Cyprus	20.211.800,00	777.376,92
Latvia	83.265.000,00	3.202.500,00
Hungary	260.896.800,00	10.034.492,31
Portugal	269.655.000,00	10.371.346,15
Romania	544.305.400,00	20.934.823,08

SUM AVERAGE	104.624.469,23
AVERAGE	**13.078.058,65**

APPENDIX E: GRAPHS FOR THE STRUCTURAL BREAK: CASE OF GREECE

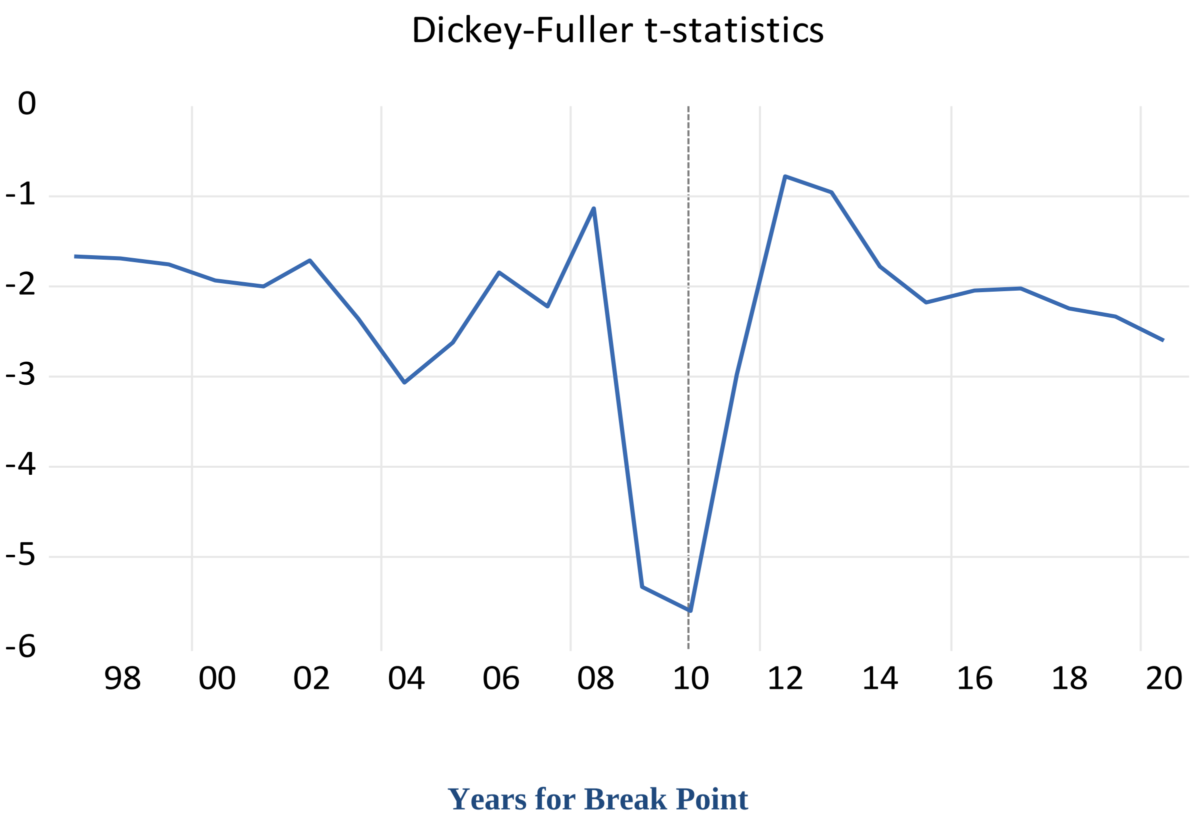

Figure E.1 Augmented Dickey-Fuller statistic for Consumption Variable, the case of Greece

The lower section of Figure E.1 reports the Augmented Dickey-Fuller *t*-statistic for the unit root test, along with Vogelsang's asymptotic *p*-values. Our test resulted in a statistic of -5.58, with a *p*-value less than 0.01, leading us to reject the null hypothesis of a unit root. The graph shows a large dip in 2010, leaving little doubt as to which date should be selected as the break point.

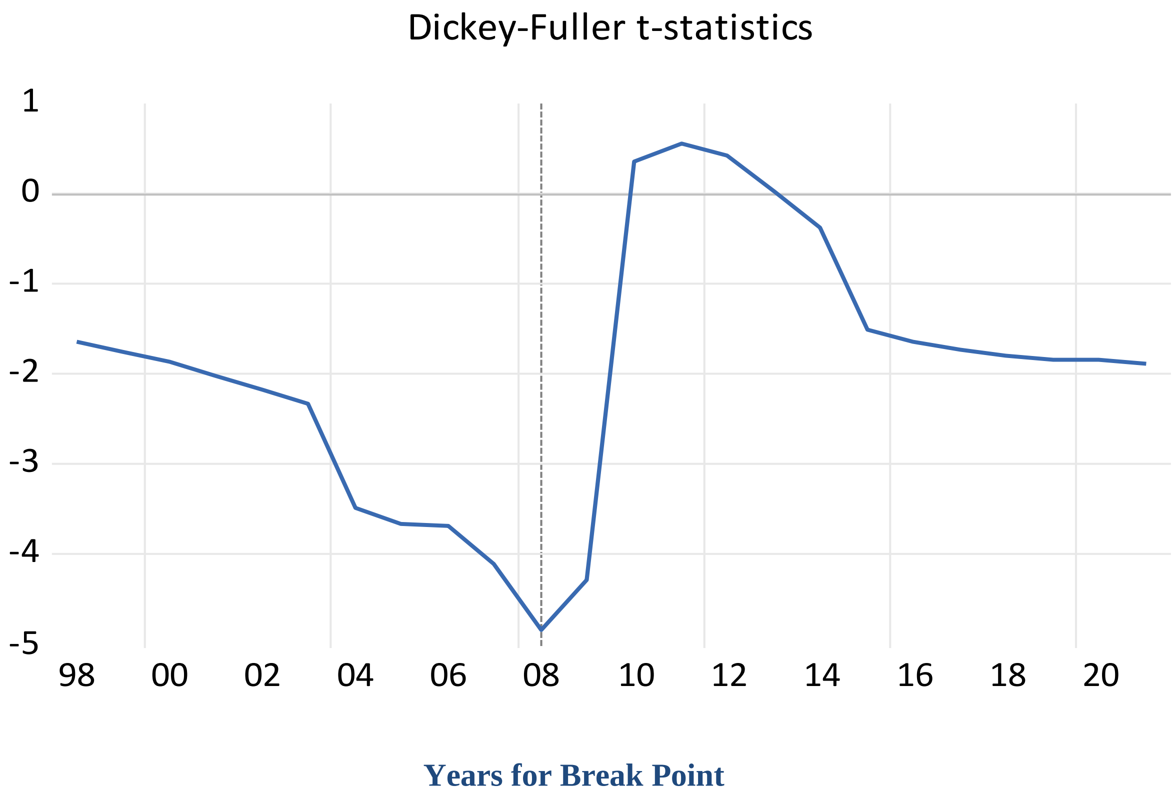

Figure E.2 Augmented Dickey-Fuller statistic for Real GDP Variable, the case of Greece

The lower section of Figure E.2 reports the Augmented Dickey-Fuller *t*-statistic for the unit root test, along with Vogelsang's asymptotic *p*-values. Our test resulted in a statistic of -4.84, with a *p*-value less than 0.05, leading us to reject the null hypothesis of a unit root. The graph shows a large dip in 2008, leaving little doubt as to which date should be selected as the break point.

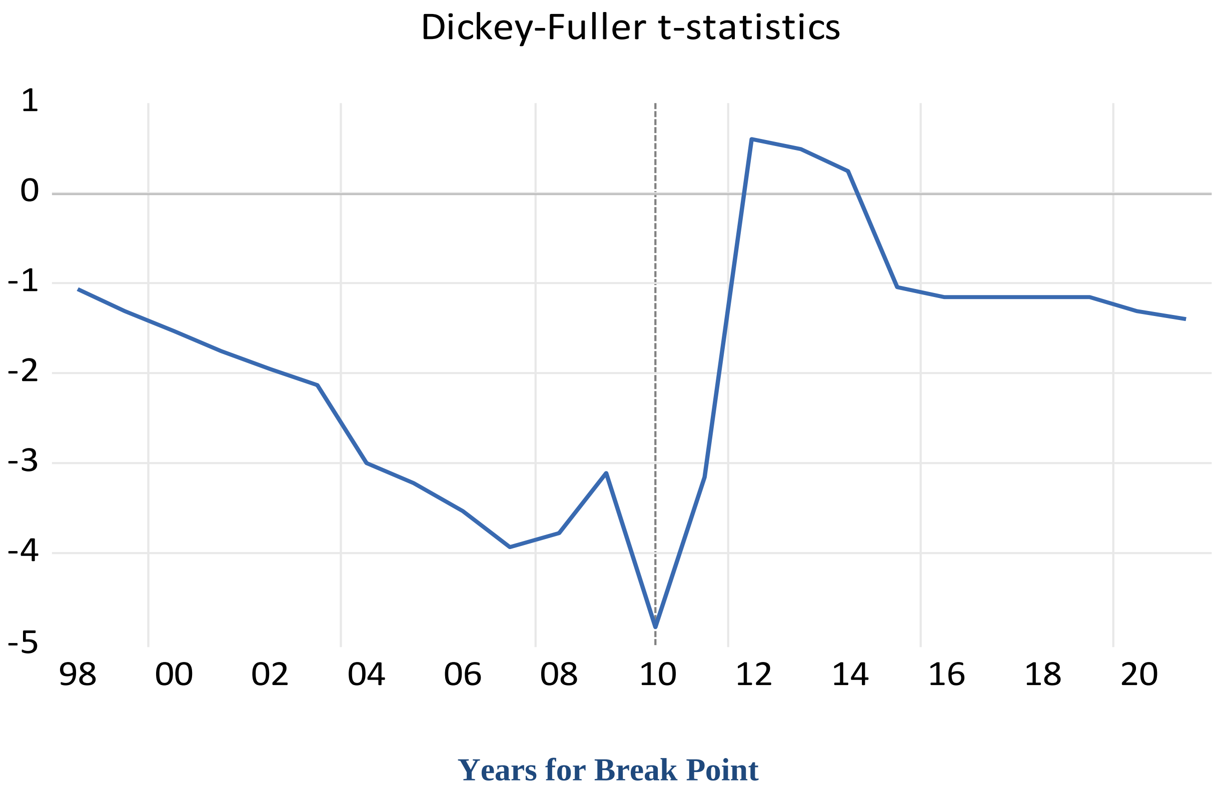

Figure E.3 Augmented Dickey-Fuller statistic for Government Purchases of Goods and Services Variable, the case of Greece

The lower section of Figure E.3 reports the Augmented Dickey-Fuller *t*-statistic for the unit root test, along with Vogelsang's asymptotic *p*-values. Our test resulted in a statistic of -4.82, with a *p*-value less than 0.05, leading us to reject the null hypothesis of a unit root. The graph shows a large dip in 2010, leaving little doubt as to which date should be selected as the break point.