

PORTUGAL IN THE EURO: THE ROOTS OF STAGNATION

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Doctoral Thesis in Economics

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Para a Zé e os nossos netos, Matilda e António

Biography

José Sá Carneiro was born on 7 April 1955, in Angola. He married Maria José Carneiro. They are parents of four and grandparents of two. He started the undergraduate degree in Economics at the University of Luanda, in 1972, and completed it at FEP, in 1977. He spent most of his professional life working on managerial and investment management activities across multiple sectors and companies (Amorim Group, Banco Privado Português, and Fundação Luso-Americana para o Desenvolvimento). Currently, he teaches Political Economy and Microeconomics at the Universidade Portucalense in Porto. He received a master's degree in Economics from FEP in 2002. The dissertation, supervised by Professor Mário Rui Silva, was entitled "Os Factores não Económicos do Desenvolvimento Económico: um Teste à Hipótese de Weber" ("The Non-economic Determinants of Economic Development: A Test to the Max Weber's Hypothesis").

Occasionally, he published opinion articles in the Portuguese press (Expresso) and collaborated as an economic commentator on TV (SIC Notícias).

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The School of Economics and Management of the University of Porto (FEP) has provided the right incentives to pursue my interests in economics. Those incentives stem from the high standards of the education delivered and are grounded in the qualifications of the FEP's teachers and the exceptional contribution of the invited professors during the PhD program.

For sure, those standards have been built after decades of hard work. Therefore, my first expression of gratitude goes to Professor José da Silva Costa. He was the Director of FEP when I undertook the Master's degree in Economics in 1997-2002, and an unforgettable teacher of regional economics. (I never forgot his lecture on von Thünen and the discussion of the Samuelsson's paper on the spatial equilibrium model).

The next word is for Professor António Brandão, the Director of the PhD program. He taught Industrial Economics when I took the Master's degree (I still remember his so brilliant introductory lecture on market structures) and Microeconomics in the PhD coursework.

I move now to the thesis work. I was fortunate to face truly critical examiners along the successive stages of research and writing. Namely, Professors Anabela Carneiro and Manuel Mota Freitas at the Thesis Project Defense Examination; and Professors João Loureiro and again Manuel Mota Freitas at the Interim Defense. Their careful and strict evaluation of the work in progress allowed me to attain – as now I expect to have reached – the requirements of academic work.

My interest in human interactions and its connection with the advance of the common good – is not that the purpose of economics as we have seen in Alfred Marshall? – led me to other fields in social sciences. Namely, to sociology, for which I have had the support of a special teacher, my old colleague from the Faculty of Economics of Luanda (Angola), Rui Pena Pires. He is a distinguished professor of sociology in ISCTE, and I owe this old friend the introduction to the work of Anthony Giddens. The insight for the concept of "institutional endowment" presented in the second Essay of this thesis came from the Giddens approach to Modernity and, more specifically, the property of "reflexivity" that characterizes modern societies.

Last but not least, my gratitude to the supervisors Professors Álvaro Aguiar and Luís Aguiar-Conraria. Without their guidance, I would have material for a thesis, but certainly

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Abstract

An intriguing question motivated this thesis: Why did the Portuguese economy stagnate after the euro adoption? Economic growth is expected when moving towards more advanced institutions. Furthermore, a stable monetary policy is not supposed to harm resources development and allocation.

I tackled this problem with a Marshallian flavor, starting by identifying what had changed, and after that seeking how might it have hindered economic growth. I found empirical evidence on a regime change in relative prices. Namely, the price of future to present consumption (i.e., the real interest rate) and the nominal exchange rate. By accessing the euro area, Portugal moved up in financial integration. A demand shock and overvaluation, driven by a credit boom, are typical outcomes of a shift in financial integration. Although, this time, the capital inflows were drawn from a "common pool" of savings, and the compression of the interest rates differentials turned structural.

Overvaluation impacting institutions that are biased against larger and more efficient enterprises not only hampers economic growth at the "frontier" but leads to misallocation of resources, both between sectors and within-industry. When the institutional framework is less endowed with the *reflexivity* property – a concept borrowed from the field of sociology – the persistent overvaluation episode articulates with hard to change institutional frictions. That mechanism solves the problem of the long-lasting impact of a regime change in relative prices on economic growth.

The thesis is composed of three essays. The first is more specific to the stagnation of the Portuguese economy. The second addresses the euro area experiment as a whole, the cleavages between the Core and the Periphery, and the productivity slowdown observed for selected Peripheral countries (Italy, Portugal and Spain). Finally, the third resumes the analysis of the euro experiment, but now in the short-run time frame, by entertaining oil shocks on the output and inflation.

Resumo

Uma questão intrigante motivou esta tese: Por que estagnou a economia portuguesa após a adoção do euro? O crescimento económico é esperado quando um país se move em direção a um quadro institucional mais evoluído. Para além disso, não é suposto que a prevalência de uma política monetária seja adversa ao desenvolvimento e alocação dos recursos.

É com um "sabor" Marshalliano que eu abordo este problema, começando por identificar o que mudou, e em seguida explorando a forma pela qual as alterações observadas possam ter afetado o crescimento económico. Encontrei evidência empírica sobre uma mudança no regime dos preços relativos. Nomeadamente, no preço do consumo presente em termos do consumo futuro (i.e., a taxa real de juro) e na taxa nominal de câmbio. Com a integração na área do euro, Portugal subiu no nível de integração financeira. Um choque da procura e um episódio de sobrevalorização, determinados por um *boom* de crédito, são consequências típicas de um salto em integração financeira. Contudo, desta vez, o afluxo de capitais teve origem em uma *common pool* de poupanças, e assim a compressão do diferencial nas taxas de juro tornouse estrutural.

Uma sobrevalorização, impactando em instituições enviesadas contra as grandes e mais eficientes empresas, não apenas atinge o crescimento económico na "fronteira" como ainda conduz à má-alocação de recursos, entre setores e intra-sectorial. Quando um quadro institucional é menos dotado na propriedade da *reflexividade* — um conceito tomado da sociologia — então um episódio de sobrevalorização articula-se com "fricções institucionais" resistentes à mudança. Este mecanismo explica os efeitos de longo prazo de uma mudança no regime de preços relativos sobre o crescimento económico.

A presente tese compõe-se de três ensaios. O primeiro é mais específico sobre a estagnação da economia portuguesa. O segundo aborda a experiência da área do euro no seu conjunto, incluindo as clivagens entre o *Core* e a Periferia, e o abrandamento da produtividade observado em três países selecionados (Itália, Portugal e Espanha). Finalmente, o terceiro retoma a análise da experiência do erro, porém desta feita no horizonte de curto prazo, utilizando choques do petróleo sobre o produto (PIB) e a inflação.

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INTRODUCTION

The Portuguese economy has stagnated for 17 years since the euro adoption, that is between 1989 and 2016, which is the period under analysis here. Why? This a challenging question, because we expect less-developed economies to catch up with the frontier, whenever supported by good institutions. And by accessing the European monetary union, Portugal moved up into a more advanced institutional setting.

To the best of our knowledge, the main explanations point to (i) competitiveness impairments (Blanchard 2007) and (ii) resources misallocation, either between-sector (Reis 2013) or within-industry (Dias et al. 2016). Financial integration led both to an overvaluation episode underlying the competitiveness issue and a boom of capital inflows allocated to less efficient entrepreneurs. Financial frictions, related to the lack of capital deepening, were at the root of the misallocation story of Reis (2013). The more efficient entrepreneurs, mostly in the tradables sector, were credit constrained. While "firm sized-contingent" regulations were the possible source of within-industry loss of allocative efficiency in Dias et al. (2016), by reducing the costs of capital and labor for the smaller firms.

The thesis presented in the first essay builds on those approaches but argues for a more comprehensive explanation. Neither macroeconomic factors alone, nor institutional distortions, are enough to account for the dismal performance of the Portuguese economy. We must take both and its interaction to find a sound explanation. The bias against larger and more efficient enterprises was not born with the introduction of the euro. And we should not be restricted to financial frictions when acknowledging the role of financial integration. Claiming that more efficient enterpreneurs were credit constrained might even imply some myopia from the financial system. This thesis argues that a change in relative prices was the channel through which financial integration guided the resources to a poor allocation, given some sort of *institutional frictions*.

I submitted the hypothesis of a regime change in relative prices (i.e., the real interest rates and the nominal exchange rate) to an econometric evaluation. The global VAR (GVAR) was the methodology employed. I showed that the referred hypothesis, which

implies a shift in the real exchange rate, was subsumable in the relative Purchase Parity Power (PPP) condition. The relative PPP holds when tested over the period 1979(Q2)-1998(Q4) but is rejected when the data include the euro time span, that is when the econometric test is run over 1979(Q2)-2016(Q4).

An episode of real appreciation does not necessarily imply stagnation. It might even come as a result of increasing productivity (the Balassa-Samuelson effect). But an adverse impact on economic growth is expected when the relative price of nontradables to tradables rise despite a productivity slowdown. Hence, two questions follow. First, may we find distortions in the Portuguese framework that might hinder economic growth after an overvaluation episode? Such being the case, which is the channel whereby institutions and the real exchange rate interacted to generate the misallocation of resources?

Figure 1, portrayed in Essay No. 1, shows a breakpoint in the Portuguese output growth rate in 1974. That was the year of the Carnation Revolution, followed by a severe episode of property rights violation in 1975. Poor economic performance succeeded over the next ten years. Are there still longer-lasting effects to be considered? We should examine the constitutional regime then established to address this question. In Essay No. 1 (subsection 2.1), I argue that an antimarket ideology¹ became entrenched in the "programmatic" style² of Constitution approved in 1976. The high degree of employment protection and the bias against larger enterprises turned out to be deeply rooted in the Portuguese institutional framework. It should be noticed that this country ranked as number one in the OECD indicator for employment protection up to the reforms implemented in 2012, driven by the Troika bailout agreement.

Overvaluation means the rise in the price of nontradables to tradables. Given that the tradables sector (e.g., manufacturing) is more efficient than the nontradables (mostly, services), an adverse effect on aggregate productivity is expected. To anticipate the impact of overvaluation within-industry is more difficult. But it becomes essential to understand the dismal performance of the Portuguese economy in the euro, because

¹ Antimarket ideology is defined as a "collectively sustained reality distortions about the merits of state versus market" (Bénabou 2008, p. 324).

² The Portuguese Constitution of 1976 is a "programmatic constitution" (Canotilho 2002, pp. 217-18) in the sense of determining the upcoming economic and social political choices. Thus, its economic effects transcend those usually discussed when evaluating the economic implications of policy choices made at the constitutional level, such as the trade-off between government effectiveness and representation implied by the electoral system adopted.

within-industry was the primary locus of resources misallocation over the 1996-2011 (see Dias et al. 2016).

How did overvaluation impinge misallocation of resources within-industry, moreover in the services sector? I found the answer for this tricky issue in a model built by Braguinsky et al. (2011). A framework based on the celebrated span-of-control model of Lucas (1978) and motivated by the "incredible shrinking of Portuguese firm" observed for more than 20 years. For a given level of productivity, the optimal size of a firm is inversely related to the real wage³. A higher degree of employment protection, modeled as "tax on labor", further dampens the firm size. Moreover, the effects are non-linear, meaning that the impact of the "tax on labor" is more than proportional on the larger and more efficient firms operating in a given sector⁴. Now, note that overvaluation raises the price of labor without the support of increased productivity. Therefore, it shifts the firm size distribution to the left, harming aggregate productivity. Besides, a heightened gross labor tax increases the self-employment incentive. This specific channel likely gains more traction in the services sector, where other sorts of institutional dysfunctionalities (e.g., informal work) is pervasive.

This thesis might have finished here, the same is to say, with the conclusions presented in Essay No. 1. That is, the dismal performance of the Portuguese economy in the euro stemmed from the interaction of a regime change in relative prices with domestic "institutional frictions". But thereby it will be exposed to pertinent criticism. Did you pretend the ill performance of the Portuguese economy has no link with the European monetary union foundations and its architecture? And has no connection with the interrelated cleavages between the Core and the Periphery turned apparent after the European financial crisis of 2010-12? Is there nothing in the experiences of the remaining Peripheral countries, like Italy and Spain, that might shed light to the stagnation of the Portuguese economy in the euro?

Those questions lead us to Essay No. 2, where I examine the euro area experiment as a whole, in the long-run perspective, but restraining the use of quantitative methods to stylized facts extracted with the Hodrick–Prescott (HP) filter. And, after that, to Essay No. 3, where the employment of more advanced econometric methods, namely the

³ See Equation 1 in Braguinsky et al. (2011).

⁴ See Section 4.1.2 in Braguinsky et al. (2011).

GVAR, is resumed to study the behavior of euro area economies, but now in a short-run horizon.

In Essay No. 2, I trace the overvaluation episode in the Periphery by eliciting the trends of the unit labor costs throughout 1995-2016. Figure 2 shows an ascending pattern of the unit labor costs of Italy, Spain and Portugal, since the mid-1990s and up to the European sovereign debt crisis of 2010. The connection with the financial integration of the Peripherals is suggested by the overlapping enlargement of their current account deficits (Figure 1). Figure 3 gives an account of the rising trajectory of nominal euro-dollar exchange rate up to the global financial crisis of 2008. Therefore, the appreciation of the real exchange rate stemmed from the change in the price of nontradables to tradables, after a demand shock, and the ascending course of the nominal exchange rate. In turn, the demand shock was rooted in an atypical episode of financial integration, where the debt-financing was ensured in a shared currency and the capital inflows drawn from a common pool of savings.

The trends extracted from Total Factor Productivity (TFP) data made clear that the story of Spain in the euro resembles that of the underperformance observed in Italy and Portugal (Figure 4), despite a different pattern in the behavior of the real output per capita. The literature reviewed made clear a common source for the observed technological shock across the three Peripheral economies: the loss in allocative efficiency (Calligaris et al. 2016; Dias et al. 2016; García-Santana et al. 2016; Gopinath et al. 2015; Reis 2013). Furthermore, and like the evidence found for Portugal (Essay No. 1), within-industry was the primary locus of misallocation.

A pertinent question follows. What kind of distortions led to the allocation of the credit boom to less efficient entrepreneurs? Gopinath et al. 2015 argued that the distortions stemmed from the underdevelopment of financial markets in the Periphery. I diverged from the financial friction argument. Financial development in Spain and Italy are assessed even higher than in Germany (see the FD Index published by the IMF in Figure 6). And I advanced another source of distortions, the institutional frictions, namely at the labor market institutions level, which I put in evidence after reviewing the *institutional endowments* of a selected group of Western European countries. The institutional endowment concept is built by adding an ingredient – reflexivity – to the standard definition of the institutional framework. In turn, reflexivity is borrowed from

sociology and means the ability of a (modern) society to change its rules by rationalizing the course of its own experience (Giddens 1990).

I concluded Essay No. 2 in the following terms. "Overvaluation interplaying with institutional frictions in less-reflexive institutional endowments diverted the allocation of resources from larger to smaller and less productive enterprises. This mechanism and its the deep foundations solve the intriguing problem of the long-lasting real impacts of a change in a "mere" monetary framework. In case, the connection of the euro introduction and the correlated underperformance in the Periphery."

Finally, Essay No. 3 addresses the fundamentals of the European currency union from a business cycle perspective. Oil shocks are entertained within a Global VAR framework to seek patterns of convergence between the Core and the Periphery as the euro experiments went on. Based on the impulse response analysis, the main findings are as follows. The inflation adjustment is sluggish in the Peripheral countries, and not showing improvement as the euro experiment went on. This result is consistent with a lessreflexive institutional endowment highlighted in Essay No. 2, concerning Italy, Spain and Portugal. Output responses to oil shocks are milder in the Core than in the Periphery but showing a convergence pattern, most noticeable in the case of Portugal. A robustness test conducted by using a global shock on the price of equity corroborate the output responses convergence of Portugal towards the Core's median, even though that evolution is not evidenced for the Periphery as a whole.

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ESSAY NO. 1

PORTUGAL IN THE EURO: THE ROOTS OF STAGNATION

Abstract

The Portuguese economy has almost stagnated over the 17 years of participation in the euro area, between 1999 and 2016, whereas it had thrived in the preceding EFTA and EEC stages of international integration. What happened fundamentally different when going from the EFTA and EEC experiments to the euro? The relinquishment of monetary policy autonomy, and therefore the endogenous setting of the real exchange rate, arises as the most distinctive feature. Has this had a significant impact on relative prices? Could it possibly misguide the resources allocation? In this paper, I make use of the relative purchasing power parity (PPP) condition to formulate the hypothesis of a relative prices disturbance stemming from the adoption of the euro by Portugal, and I submit that hypothesis to an econometric evaluation by making use of the Global VAR technique. The implication of relative prices disturbances on economic performance rests, I suggest, on their interaction with the domestic institutional framework, in particular the labor market institutions.

Keywords: Portugal, Euro area, Global VAR, Economic growth, Institutional framework.

JEL Codes: C32, E02, E17, F43, F45, J08, O43

1. INTRODUCTION

The Portuguese economy has almost stagnated for 17 years, since the introduction of the euro. In 2016Q4 the real GDP per capita was only 9.7% above the level of 1999Q1. The contrast with the previous stage of the Portuguese integration into the European Union is impressive. Between the accession to the European Economic Community (EEC) in 1986 and adoption of the euro, the Portuguese real GDP per capita increased at an average of 3.4% per year. The experience within the European Free Trade Association (EFTA) was even more striking: annual average growth of 6.5% over the period 1960–1974.

Let us designate those three regimes of international integration, although interrupted in 1974 by the so-called "Carnation Revolution" and its rather long aftermath, by the EFTA (1960–1974), the EEC (1986–1998) and the Euro (1999–2016) experiments. I begin this paper with one simple question. What happened in the third experiment that may account for such a striking change in the Portuguese output growth pace? In particular, given that this change occurred while the country was raising its participation in a more advanced institutional context, instead of divergence one would expect a faster catching up in the light of the Solow (1956) model; or to be more specific, under the "conditional convergence" hypothesis as presented by Barro and Sala-i-Martin (1995, p. 28). Indeed, this came at a time when Portugal was integrating into the more "inclusive economic institutions" that according to Acemoglu and Robinson (2012, pp. 69-71) provide the right incentives to foster economic growth.

At first glance the immediate explanation would be relinquishment of its currency and, more broadly, the surrender of monetary policy, implying the loss of (i) autonomy over the nominal exchange rate and (ii) the ability to set the inflation rate by controlling the money supply. It is worth noting that those price adjustment mechanisms were relevant for Portugal, considering, among other factors, the high rigidity of its labor market, deeply entrenched in the constitutional regime established after the "Carnation Revolution" of 1974.

Portugal's participation in the European currency union implied an impressive advance in financial integration. Large current account imbalances emerged, reflecting a structural change in the home savings pattern and debt financing. The price of future consumption in terms of present consumption (i.e., the real interest rate) changed; so too did the price of nontradables to tradables.

Hence, the first research question: May we find empirical evidence of a significant impact of the euro adoption on relative prices in Portugal? Elicited stylized facts point in that direction, but one should move from the univariate time series analysis into a more advanced framework to pursue the investigation.

The Global Vector Autoregressive (GVAR) modeling was the methodology chosen to evaluate the hypothesis of a disruptive impact of the euro regime on relative prices in Portugal, while subsumable under the relative purchasing power parity (PPP) condition. Chudik and Pesaran (2016) offer an updated review of the theoretical foundations and empirical applications of the GVAR. Of particular interest for the present work are the scope of GVAR, whereby the interconnections in the world economy are grasped; and its time dimension, by which the cointegrating long-run relations among the macroeconomic variables of interest are accounted for, and their "structural" properties (Garratt et al. 1998) can be evaluated. Those features are relevant when we test for the long-run relationships between inflation and the nominal interest rate (the Fisher Inflation Parity) and between the domestic and the foreign interest rates (the Uncovered Interest Parity), and by implication the relative PPP. Furthermore, the GVAR offers a good account of the short-run dynamics as being the main subject of interest in the seminal work of Pesaran et al. (2004). The impulse response analysis is thus undertaken and reported for Portugal and a selected group of countries/regions, namely the United States, the euro area Core, the euro area Periphery, the UK and Sweden (EU member states, but non-euro adopters).

The empirical results pointed to the rejection of the PPP condition when tested over a period that includes the euro regime. Which leads to the second research question: Where can one find the connection between the observed change in relative prices and the economic growth slowdown? This paper suggests that the answer rests in the interaction of the new relative prices regime with the old domestic institutions. That is the interplay with the institutional framework prevalent at the euro inception, in particular, the labor market and the capital market institutions. As far as I know, this is the first time in the literature that a tentative explanation for the dismal performance of a Peripheral country in the euro area is not restricted to a single dimension. Namely, confined to the strict macroeconomic domain, or to government failures, or to dysfunctional institutions leading to the misallocation of resources. Such as a competitiveness issue, as early pointed out by Blanchard (2007); the result of a bias towards nontradables driven by a demand shock (Bento 2010, Chapter III); or the outcome of an adverse financial integration episode related with the lack of "financial deepening" (Reis 2013). In the class of government failures, Alexandre et al. (2016) argued that the causes of the Portuguese economic stagnation were developed prior to the euro regime, and were not even related to its adoption (pp. 26-7); instead, it was ascribed to the buildup of a Leviathan State (Chapter 5). Finally, a misallocation story, driven by institutional dysfunctionalities and the consequent loss in allocative efficiency, as sustained by Dias et al. (2016).

This paper does not contradict any specific point in the explanations mentioned above. On the contrary: In the absence of those insights, I would not be able to grasp the roots of the Portuguese economy stagnation under the euro. I argue however that one must go further and examine the interplay between the macroeconomic and the institutional factors. Otherwise, it will be difficult to explain the shift from the successful EEC experiment into the gloomy performance of the Portuguese economy after the euro adoption.

There are other insights to be acknowledged. First, and because we are addressing long-run economic issues – 17 years of stagnation –, the role of institutions must be taken into account. That is the "incentive structure" embodied in the formal and informal rules that constrain human interaction (North 1994). Second, sometimes, the real exchange rate is used to ensure competitiveness, in particular when institutions are weak, as shown by Rodrik (2008). Third, political history matters to understand the functioning of the Portuguese institutions, namely the transition process from the old authoritarian to the parliamentary system – notably, the Carnation Revolution of 1974 and the constitutional regime established thereafter. This process was dominated by segments, at the far left of the political spectrum, not "tainted" by connections with the overthrown dictatorship, as noted by Braguinsky et al. (2011, p. 4). Fourth, the inspiring work of Blanchard (2006) on the persistent increase in the unemployment rate among the European countries in the 1980s. The explanation advanced for the differentiated cross-countries patterns rested precisely on the *interaction* between two supply shocks (the oil prices surge and the total

factor productivity slowdown) observed in the preceding decade and the labor market institutions prevailing across the European countries. That is, macroeconomic factors interacting with the institutional framework.

This paper is organized as follows. Section 2 describes the basic facts of the Portuguese convergence–divergence story across the EFTA, the CEE and the Euro experiments, between 1960 and 2016; examines the impact of the "Carnation Revolution" on the institutional framework and explores the connection of the poor Portuguese economic performance in the euro with the observed change in relative price and the institutional setting. Section 3 presents the specification of the adopted version of the GVAR model, the data sources and preliminary tests implemented. Section 4 reports and discusses the empirical results, focusing on Portugal and where relevant against the backdrop of a selected group of countries and regions, namely the euro area Core (EA-Core) and the Periphery (EA-Periphery). Section 5 concludes.

2. BASIC FACTS AND AN HISTORICAL ACCOUNT

I suggest starting the examination of the Portuguese contemporaneous economic history from 1960 when Portugal became a founding member of the EFTA association. To grasp the relevance of this moment while defining a turning point towards the outside world, we should bear in mind that the political system then prevailing in this country was still authoritarian, inwardly driven, imposed in 1926 by a military coup, and which would persist up to the "Carnation Revolution" of 1974.

Let us make the first quantitative approach to the behavior of the Portuguese economy between 1960 and 2016. Figure 1 displays the Portuguese real GDP per capita annual growth rate from 1961Q1 to 2016Q4 as well as the average across four distinct periods, defined by three structural breaks identified with the Bai (1997) and Bai and Perron (1998) procedures. Each break fits the institutional regime changes well: 1974Q2, precisely when occurred the so-called Carnation Revolution; 1985Q2, at the onset of the integration into the EEC; and 2001Q1, two years after the euro adoption. The average annual growth rate of the real GDP per capita computed between those break dates shows interesting distinctive patterns: 6.5% in the first spell, 1961Q1-1974Q1, corresponding to

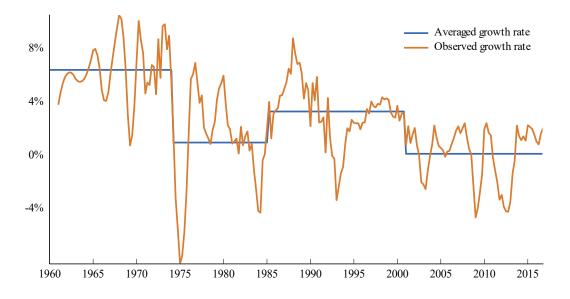


FIGURE 1. PORTUGUESE REAL GDP PER CAPITA, ANNUAL GROWTH RATE AVERAGED BETWEEN THE BAI-PERRON IDENTIFIED BREAK DATES (Sample: 1961Q1-2016Q4)

Sources: Computed by the author. Data: GDP from the OECD.Stat; population from the United Nations (Department of Economic and Social Affairs). Break dates identification output: Table A. 1 (Appendix A).

the EFTA experiment; 1.1% in the second spell, 1974Q2-1985Q1, after the "Carnation Revolution" and its long aftermath; 3.4% in the third spell, 1985Q2-2000Q4, overlapping the EEC experiment; and finally 0.2% after 2001Q1, that is across the Euro experiment.

Next, I give an historical account of the evolution of the institutional framework, highlighting the events with possible long-lasting effects.

2.1 The "Carnation Revolution"

The so-called Carnation Revolution took place on April 25, 1974, a military coup that overthrew the authoritarian government prevailing in Portugal since 1926. The purpose was the restoration of democracy and the withdrawal from the wars the country was fighting in three of its former African colonies.

A short time after the coup, however, social turmoil and exacerbated political disputes erupted, evolving into a revolutionary process – the so-called "PREC"¹ – which culminated, between March and June of 1975, in the "nationalization" of the leading privately-owned companies across all sectors, from finance to utilities, including public

¹ The acronym for "Processo Revolucionário em Curso" (Ongoing Revolutionary Process).

transports and the heavy industry. Furthermore, and according to Barreto (2017, pp. 10-11, 107, 228), about 1 million hectares of land were occupied by workers acting under the direction of unions and other collective organizations controlled by the Portuguese Communist Party and subsequently expropriated by law. All confiscated rural properties have been later returned to their original owners, but not the "nationalized" enterprises in manufacturing and the services sectors.

The immediate impact on the Portuguese economy was dramatic: between 1974Q2 and 1975Q2 the real output dropped by almost 8%. Yet the medium and long-run effects are those to be considered more carefully, for which we should examine the structural changes imposed at the highest level of the political system.

A new Constitution was promulgated on 10 April 1976, putting an end to the "revolutionary period" turmoil, but at the same time institutionalizing the perceptions of the more radical strands over the economic structure, the social organization and the role of government. To understand how it happened it is worth noting with Braguinsky et al. (2011, p. 4) that the "only segment of the political spectrum that had not become heavily tainted by associated with the dictator[ship] was the far left". On the other hand, the stance of moderate political forces – reflecting the preferences of the majority of the voters – prevailed in the political domain. Therefore, the plain safeguard of civil and political rights and the democratic form of the political system were ensured. This apparent contradictory evolution represents the outcome of a trade-off struck between the conflicting parties in the Parliament at the time the new Constitution was written and voted.

New perceptions of the social life and the economy have been formed across this process, grounded on the radical ideas of the far-left activists and the constraints of the non-opponents to the deposed right-wing dictatorship. Thereby, an "anti-market ideology" gained traction, that is the prevalence of a "collectively sustained reality distortions about the merits of state versus market" (Bénabou 2008, p. 324)².

Nevertheless, the majority of constituents, and their representatives in the Parliament, strongly supported the will to join the European Community.

²To be noted that the distortions in the opposite direction, that is overemphasizing the merits of the market, also fill the definition of ideology proposed by Bénabou (2008), namely, the *laissez-faire* ideology versus the *statist ideology*.

Both views, the anti-market ideology and the aspiration for European Community membership, were reflected in the new constitutional regime and determined its evolution, which I will now summarize.

The nationalizations carried out in the "hot summer" of 1975 were made "irreversible conquests of the labor classes", under article 83 of the new Constitution. This provision remained in full force until the second amendment introduced on 8 July 1989, which enabled the government to reprivatize the enterprises confiscated after 1974, rather than a reversion to the original owners.

As such, the 1975 nationalizations represent a typical episode of property rights violation. The consequences for the economic performance of a country subjected to such experiences are projected over a long period, as widely discussed in the literature after the seminal contribution of North (1981).

To be more specific, the Lisbon Stock Exchange was "suspended" in the same day of the Revolution eruption and did not reopen for trading until 28 February 1977. The investment loss, evaluated by comparing the market capitalizations in between, was estimated by Mata et al. (2017, p. 144) at 98.8%, a small part of which was compensated through symbolic indemnities paid by the government.

Therefore, capital markets were abruptly suppressed in Portugal under the revolutionary process that laid the foundations of the new political regime. It is worth noting the contrast with the Spanish transition from the Francisco Franco dictatorship to a modern constitutional monarchy. It happened at about the same time, between 1975 and 1978, peacefully and without damaging property rights. We can find still today a gap between the degree of development of capital markets in Portugal and Spain. There is no domestic equity controlling the banking sector in Portugal nowadays, despite Portuguese investors entirely owned the banks operating in this country before the Carnation Revolution. We may still trace back to the noted contrasts in the transition processes the difference in "financial deepening" between the two Iberian countries. According to Reis (2013), the discrepant outcomes of the financial integration of the Spanish and the Portuguese economies in the euro area, the former booming up to 2008 while the latter stagnated, was rooted precisely in the low degree of the "financial deepening" prevailing in Portugal.

A second long-lasting implication from the Carnation Revolution refers to the labor market institutions. The high degree of employment protection prevails across the Southern European countries, including France (Tirole 2017, Chapter 9). But to the best of our knowledge, Portugal is the sole case where the respective legal norms are inscribed in the Constitutional Law³. Hence, it is without surprise to see Portugal scoring the highest mark among the developed countries "strictness of employment protection" OECD indicator, from the earlier data available (1985) and up to the reforms introduced in 2012. Furthermore, the softening of employment protection delivered in 2012 was not inwardly driven but imposed by the conditionality program managed by the Troika (IMF, the European Commission and the European Central Bank) under the financial assistance provided upon a request made by the Portuguese government on 6 April 2011⁴.

It is worth noting two significant economic developments observed in the aftermath of the Carnation Revolution. First, macroeconomic instability, leading to the request of financial assistance from the IMF in 1977-78 and again in 1983. Second, the overuse of inflation to compensate for the loss of competitiveness: The net real wage in 1985 was lower than in 1973 (OECD 1986), in spite of the nominal labor income having been increased by 21% per year on average in that the same period⁵.

2.2 The "EEC Experiment"

On 12 June 1985, the Portuguese government signed the treaty of accession of Portugal to the European Economic Community (EEC) to enter into force on 1 January 1986. Major institutional innovations were commanded by this new step towards the integration in a more advanced framework, as summarized below.

The process of participation in the European Union dates back to 28 March 1977 when a formal application was submitted. The fulfillment of the EU rules, at the time the European Economic Community (EEC), dictated the first amendment to the Portuguese

³ See Article 53, (Job security):"Workers are guaranteed job security, and dismissal without fair cause or for political or ideological reasons is prohibited", <u>http://www.tribunalconstitucional.pt/tc/en/crpen.html</u>. Corresponds to Article 52 in the original text of the Portuguese Constitution, approved in 1976.
⁴ See <u>http://www.oecd.org/els/emp/oecdindicatorsofemploymentprotection.htm</u>, namely the EPRC V1

indicator (concerning regulations for individual dismissal, available since 1985 and the EPRC V3 (concerning both individual and collective dismissals) available since 2008.

⁵Computed from Banco de Portugal, <u>www.bportugal.pt/en/publicacao/historical-series-about-portuguese-</u> <u>economy-after-world-war-ii</u>, "RENDIMENTO E POUPANÇA DAS FAMÍLIAS E ADMINISTRAÇÕES PRIVADAS", downloaded on January 2018.

Constitution, approved in 1982, whereby its "political fabric" was modified in order to "alleviate from the pertaining ideological component" ⁶, as in the words of Canotilho (2002, p. 209). In 1989, a second amendment was passed to change the "economic fabric", by replacing the original "unequivocal socialist orientation" with the "common market" principle Canotilho (2002, p. 210). Finally, the third amendment was approved in 1992, motivated by the Maastricht Treaty.

Under the new institutional framework, the Portuguese economy progressed well. The real GDP per capita grew at the average annual rate of 3.4%, and the inflation rate dropped from two digits down to 2%, spurred by the price stability criteria adopted by the Maastricht Treaty. The enterprises confiscated in the aftermath of the Carnation Revolution were reprivatized, but, at the same time, new distortions were being laid down, driven by the persistent anti-market ideology, and the aversion to larger firms.

Hence, according to the employment protection legislation, in the version approved in 1989, a firm with more than 20 workers was already considered big, and subject to stringent requirements for the effect of individual dismissals ("dismissal for cause"); and with more than 50 workers for the effect of collective dismissals (Martins 2009). On top of that, union contracts introduced additional protections over those already established by law. The result was "the incredible shrinking" of the Portuguese firms as formal and empirically analyzed by Braguinsky et al. (2011)⁷.

To sum up, Portugal entered the next experiment – EMU membership – burdened by high rigidities in the labor market, and an incentive structure biased against the larger and more productive firms. Moreover, hampered by an underdeveloped domestic capital market.

2.3 The "Euro Experiment"

Portugal adopted the euro on 1 January 1999. I give next a summary account of the impact on the relative prices of interest, that is, the interest rate, the tradables to nontradables, and the nominal exchange rate⁸. After that, I examine the impacts on productivity.

⁷ For sure, labor legislation adversarial to larger and more productive enterprises is not a Portuguese specific issue. See, for example, the French case in Garicano et al. (2016).

⁶ This paper translation to English.

⁸ Because of data limitation, we leave the EFTA period from now on.

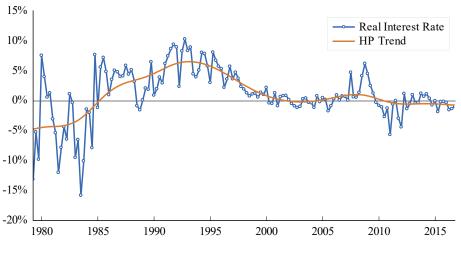


FIGURE 2. REAL SHORT-TERM INTEREST RATE (Sample: 1979Q2-2016Q4)

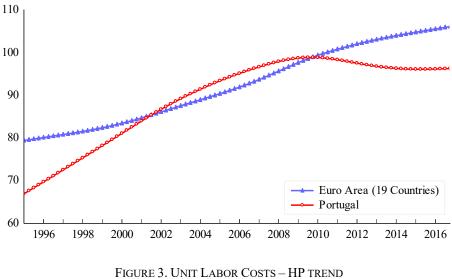
Note: The real annual short-term real interest rate is plotted along with its Hodrick-Prescott (HP) trend. Data is taken from the "JSC-2016 dataset" and annualized through the standard compounding formula.

2.3.1 Relative Prices

Figure 2 shows the real short-term interest rate evolution between 1979Q2 and 2016Q4. By plotting both the raw data and the Hodrick-Prescott (HP) filtered trend, a remarkable change is apparently brought about by the euro: a sharp drop in the real interest rate volatility. A fall in the real interest rate level is also a salient feature. However, this is true only by comparison with the antecedent period, the EEC experiment (i.e., 1985-1998). But not when moving back to the Carnation Revolution aftermath (here traced from 1979 through 1984), when the real interest rate trend went even below zero.

Thus, we must consider the effects of lower and more predictable interest rates. It was the combination of both that made the anticipation of future consumption more attractive for the Portuguese families. The elimination of the exchange risk, the capital flows originated from the Northern Europeans countries, and the additional funds extended to domestic banks by the ECB, ensured and provided for the debt financing. Financial integration jumped, grounded in a currency union membership. Large and persistent current account deficits took place up to the sovereign debt crisis of 2010, likewise in other Peripheral countries (Hale and Obstfeld 2016).

Figure 3 displays the evolution of the unit labor costs of Portugal and the euro area



(*Sample*: 1995Q1-2016Q4)

Source: Raw data from OECD.Stat⁹. HP trends extracted by the author, by running the EViews application.

from 1995 to 2016. An upward trend is noticeable up to the 2008 global financial crisis, reflecting increasing wages and anemic productivity growth – a process that has taken its course since the second half of the 1990s, as pointed out by Blanchard (2007). Between 2000 and the European sovereign debt crisis of 2010-12, the Portuguese unit labor costs went even above the euro area average. A sharp downward correction followed the "sudden stop"¹⁰ of capital inflows and the subsequent fiscal and macroeconomic adjustment program led by the Troika (i.e., the FMI, the ECB, and the European Commission).

At the origin of wage growth disconnected from improving labor productivity, there was a change in the relative prices of nontradables to tradables, in turn, motivated by a demand shift driven by the already mentioned fall in the interest rate and stepping up in financial integration. With Schmitt-Groh and Uribe (2013), I would emphasize that, because the law of one price hold for traded goods in a common market, the price effect of the demand shift translated to the nontradables. Meanwhile, the impact on

⁹ Data extracted on 02 Feb 2018 20:00 UTC (GMT) from OECD.Stat; <u>http://stats.oecd.org/index.aspx?DatasetCode=ULC_EEQ.</u>

¹⁰ A financial crisis originated by a "sudden stop" of foreign capital inflows as typified by Calvo (1998).

competitiveness might have been softened or intensified by the course of the nominal exchange rate.

Hence, I address now the relative price of the home to foreign currencies averaged by the pertinent trade weights, that is the nominal effective exchange rate (NEER). To elicit possible effects from the euro adoption, one must still consider the comovements of domestic inflation with the foreign counterparts, otherwise the mere evolution of the nominal exchange rate would be meaningless. Thus, the pertinent question is the following: Can we find evidence of a regime change in the NEER related with the euro adoption while having at the backdrop the path of inflation differentials between Portugal and its foreign counterparts?

A first tentative answer is pursued by plotting the relative purchasing power parity relation for Portugal across an extended period. Moreover, the per capita output gap¹¹ behavior is also exhibited, bearing in mind the possible Balassa-Samuelson effect¹².

This paper "2016 dataset", spanning from 1979Q2 to 2016Q4, and described in Appendix C, offers that possibility. To represent the relative purchasing power parity, I used the same criteria, the trade weights, to compute (i) the inflation differential between Portugal and its foreign counterparts and (ii) the change in the NEER. To control for the output gap, I followed an identical procedure, that is making the (log) difference between the real Portuguese output per capita and its foreign counterparts averaged on the same basis. Next, I applied the HP filter to extract the trend from the three series, because, and again, the primary interest is in long-run behavior rather than in high-frequency movements.

Figure 4 depicts the HP trends for the inflation differential, the change in the effective exchange rate (NEER), and the output gap. We can see periods where the inflation differential and the variation in the NEER are tied, suggesting that the relative purchasing power holds; and periods where they are falling apart, thus hinting relative prices disturbances. There are two periods when the inflation differential and the change in the NEER noticeably diverge: between 1987-1997, roughly overlapping the EEC experiment, and again throughout 1998-2007, that is in the course of the Euro experiment up to the global financial crisis. However, there is a sharp distinction in what concerns

¹¹ In this context, output gap means the log difference of the home to the foreign the real GDP counterpart. See, for ex., Pesaran (2007).

¹² See, for ex., Froot and Rogoff (1995, Section 3) for a discussion on the Balassa-Samuelson effect.

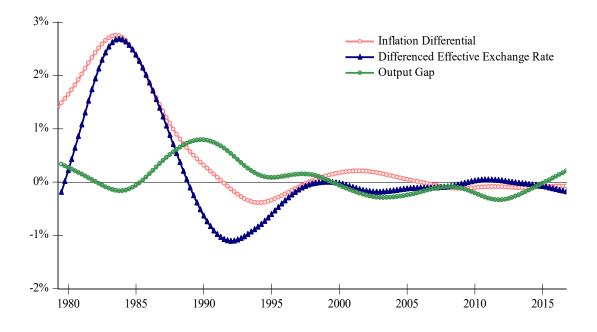


FIGURE 4. THE RELATIVE PURCHASING POWER PARITY FOR PORTUGAL AND THE OUTPUT GAP (Sample: 1979Q2-2016Q4)

Notes: The differenced effective exchange rate is the log difference of the quarterly nominal effective exchange rate; a positive variation means depreciation as the exchange rate is quoted as the price of a unit of foreign currency in terms of domestic currency. Inflation differential is the Portuguese inflation rate minus its weighted foreign counterparts, in logs. The output gap is the difference between the Portuguese real output per capita and the foreigners' real output per capita averaged by the trade weights. The trends obtained from the HP-filtered quarterly data of the three-time series are portrayed. Data Source: Raw data from this paper "2016 dataset". Data transformation are in the files "gvarJSC_PRT_estar" and "relative PPP" available in the supplemental link.

the output gap evolution. The Portuguese real output per capita was growing faster than the foreign counterparts across the EEC experiment, thus giving the Balassa-Samuelson effect support for an appreciation in the real exchange rate. But the reverse happened during the Euro experiment up to 2007 when the Portuguese real output per capita grew less than the foreign counterparts.

Hence, the data suggest that the relative price of the domestic to the foreign currency was disturbed after the euro adoption up to the global financial crisis of 2008, while diverging from the inflation differential, and at odds with the real output performance. The appreciation in the nominal exchange rate – the euro reached its maximum value against the U.S. dollar on 15 July 2008, viz. 1.599 USD per 1 EUR – was exogenously

determined, given the negligible size of the Portuguese economy in the euro area (about 2% in GDP terms), and evolved irrespectively of the current account which reached a negative balance of -12.1% in 2008¹³. Finally, the rise in the inflation differential reflects the increase in the price of nontradables, driven by the already mentioned demand shock.

2.3.2 The Impact on Productivity

How has the relative prices disturbing course impacted on the Portuguese GDP growth across the Euro Experiment? I suggest that the answer lies in its interaction with the Portuguese institutional framework, leading to misallocation of the capital inflows¹⁴. More specifically, the labor market institutions and capital markets development; and where misallocation is referred both to between-sectors (from tradables to nontradables) and within-industry. The same mechanism likely impaired foreign direct investment in the tradables sector, thus hindering GDP growth driven by (efficient) factors accumulation and productivity improvement. However, this paper does not explore that possibility, and as such, I restrict the discussion to the twofold misallocation story, that is the allocative inefficiency between and within sectors.

As pointed out by Rodrik (2008), whereas addressing "countries with low to medium incomes"¹⁵, tradables "suffer disproportionately (that is, compared with nontradables) from the institutional weakness"; and the "increase in the relative price of tradables [i.e. currency undervaluation] acts as a second-best mechanism to partly alleviate the relevant distortion" (p. 6). The argument follows in the opposite direction: an increase in the relative price of nontradables (i.e. the real exchange rate overvaluation) hits output growth in case of weak institutions. What makes Portugal different from the "medium income" countries considered by Rodrik (2008) is the nature of the prevailing institutional dysfunctionalities. Property rights and the enforcement of contracts are secure in any euro area member state. Thus, one must look at other sorts of distortions potentially leading to misallocation of resources.

¹³ Data from the AMECO, downloaded on 8 May 2018, < http://ec.europa.eu/economy_finance/ameco/ user/serie/ResultSerie.cfmv>.

¹⁴Where I put "institutional frictions", Reis (2013) has put "financial frictions", after undertaken an advanced theoretical and empirical approach to the "dismal performance" of the Portuguese economy in the euro. I leave the discussion of that alternative (possible complemental) to the essay "Puzzling Around the Euro Experiment".

¹⁵ There is no evidence found for a relationship between currency valuation and economic growth for richer countries (Rodrik 2008).

Earlier works on the dismal performance of the Portuguese performance contain the answer. After building a model based on the celebrated span-of-control model of Lucas (1978), Braguinsky et al. (2011) showed that larger and more efficient firms were hit harder by the high level of employment protection prevailing in Portugal. The so-called "tax on labor" led to the "incredible shrinking" of the Portuguese firms observed since the mid-1980s (pp. 1-6). It is worth noting that the effect of the "gross labor tax rate" on the firm size is non-linear¹⁶. As such, overvaluation, meaning increased wages disconnect from productivity improvement, has an adverse impact on the larger and more efficient firms.

Therefore, the appreciation of the real exchange rate observed during the Euro experiment up to the 2010-12 financial crisis hit the tradables through two operative channels. First by imposing augmented efficiency-adjusted labor costs whereas the price of traded goods was kept unchanged by the "law of one price". Second, by amplifying the "gross labor tax" and as such weighing more on larger enterprises. It should be noted too that the tradable sector was the one that exhibited catching-up productivity along the process of structural transformation analyzed between 1956-1995 (Duarte and Restuccia 2007).

Concerning the nontradables, a reference is due to empirical analysis undertaken by Dias et al. (2016). The within-industry allocative inefficiency was found to go even further in the nontradables rather than in the tradables¹⁷. Over the period 1996–2011, five industries in the service sector accounted for "72% of the total increase in resource misallocation" (Dias et al. 2016, p. 48). That might have happened not only due to the already mentioned non-linear effect of the "labor tax" – I suggest – while impacting on the firm optimal size, but also throughout the "self-employment" channel. An increase in the "gross labor tax" increases "the fraction of labor force that chooses to be self-employed" (Braguinsky et al. 2011, p. 19), further shifting the firm size distribution to the left and hence lowering aggregate productivity.

¹⁶ In the model built by Braguinsky et al. (2011) the effect of the distortionary "tax wage" is non-linear – meaning that an increase in the "tax results in a disproportional decrease in the sizes of the largest, that is, the most efficient firms" (p.17) – in spite of having been specified like a linear tax.

¹⁷ I suggest an explanation. The demand shock driven by financial integration has been directed to the nontradables. In the tradable sector, production costs increased whereas selling prices were pinned down by the "law of one price". Thus, the shock was harmful all across the firm size distribution for the tradable sector.

Up to now, changes in relative prices have been approached by eliciting stylized facts as portrayed in Figure 2, for the interest rate; in Figure 3 for the price of nontradables and tradables while reflected by the evolution of unit labor costs; and finally in Figure 4 for the real exchange rate, while implied by the course of the relative PPP.

It is now time to submit that same hypothesis – a significant intertwined change in relative prices in Portugal over the Euro experiment – to an empirical test in a more advanced framework, the GVAR.

3. The Empirical Model

A formal description of the GVAR modeling approach is offered in Appendix B, but it seems appropriate to summarize here its basic structure while informing the empiric model specified in the present work.

3.1 Methodology

The GVAR is defined and implemented in two steps as follows.

First, individual countries VARX* models are built and estimated. A VARX* is a vector autoregressive model augmented with the foreign variables, the "star variables". Hence, the right-hand side of each equation contains not only the lagged values of the domestic (endogenous) variables but also the current and lagged values of the foreign variables and a country-specific error term. The foreign variables are treated as weak exogenous, given that we are dealing with small open economies and are computed as per the relative weight of each foreign country to the home economy. More formally, let x_{it}^* denote the vector of k_i^* of foreign variables respecting to country *i*, where *i* = 0, 1, 2, ..., N, with 0 indexing the numeraire country (i.e., the United States). Each country-specific foreign variable, x_{it}^* , is defined by the weighted average of that same domestic variable for all remaining countries in the sample; hence $x_{it}^* =$ $\sum_{j=0}^{N} w_{ij} x_{jt}$, with $w_{ii} = 0$. The weights, w_{ij} , j = 0, 1, ..., N, are chosen by using a proxy for the interdependences in one specific variable, like the trade shares for the real output, and not necessarily the same for all variables; however the trade shares are the most commonly adopted and even for averaging financial indicators (e.g., the foreign countries price of equity). The VARX* coefficients are estimated each country at a time. Given the presence of integrated variables, the estimation is made through a vector error-correcting model, the VECMX*, and by applying the reduced rank regression method.

Second, the estimated country-specific VARX* models (36 in this paper) are stacked and after that combined by using a *link matrix* formed by the weights used to compute the foreign variables. Thus, the link matrix is the tool for mapping the individual VARX* coefficients into the coefficients of the global system, and thereby to reexpress all exogenous foreign variables in the global model in terms of domestic endogenous variables. Thereby, the GVAR model is identified and can be solved recursively to undertake the dynamic analysis: impulse response functions, persistence profiles, and forecasting. Finally, empirical distributions are derived by bootstrapping the GVAR and are used to statistically evaluate the results obtained from the dynamic analysis and to test for overidentifying restrictions and structural breaks.

3.2 The Model Specification

In the spirit of Sims (1980), the specification of the empirical global model turns into the choice of the variables to include in the VARX* individual country models. A choice to be made in light of the questions addressed, and with parsimony.

The present empirical work is foremost interested in possible relative prices disturbances after the euro adoption although without disregarding the potential of the GVAR methodology to undertake the dynamic analysis. Therefore, the choice of variables includes those entering in the baseline IS/LM model: the output, inflation and the short-term interest rate¹⁸. The justification for the short-term interest rate is reinforced because its behavior reflects structural interrelationships in a long-run horizon, subsumable in the relative purchasing power parity (PPP). Section 4.3 below provides a detailed explanation. The list of variables still includes the exchange rate given that we are dealing with a currency union and interested in its interlinkages with the rest of the world. Bearing in mind the role of capital markets as (i) a source of financial shocks and (ii) a transmission channel of real and nominal macroeconomic disturbances, tracking its behavior also looks relevant; therefore, the price of equity is included. Finally, the long-term interest rate completes the list of six endogenous variables.

The inclusion of the IS/LM set of variables looks still justified despite the interest in the

¹⁸ See, for ex., Clarida et al. (1999).

Variables	U.S. model		Other countries model	
	Domestic	Foreign	Domestic	Foreign
Real output per capita	${\cal Y}_{US,t}$	$\mathcal{Y}_{US,t}^{*}$	${\cal Y}_{it}$	${\cal Y}_{it}^{*}$
Inflation	$\pi_{_{U\!S,t}}$	$\pi^*_{_{U\!S,t}}$	$\pi_{_{it}}$	$\pi^*_{_{it}}$
Real equity price	$eq_{US,t}$	_	eq_{it}	eq_{it}^*
Real exchange rate	_	$e_{US,t}^* - p_{US,t}^*$	$e_{it}-p_{it}$	_
Short-term interest rate	$r_{US,t}$	_	<i>r</i> _{it}	r_{it}^{*}
Long-term interest rate	$lr_{US,t}$	_	<i>lr</i> _{it}	lr_{it}^*
Oil prices (DU)	-	p_t^o	_	p_t^o

TABLE 1-VARX* MODEL SPECIFICATION

Note: "Other countries model": A domestic variable will not enter a specific country model in case of missing observations. Example: The price of equity is not included in the Portuguese model because the first data value available from the MSCI Country Index is from 1988Q1.

long-run aggregates behavior because both high and low frequencies movements are intertwined in the data and possibly linked by cointegrating relations.

The six mentioned variables – the real output, the inflation rate, the real price of equity, the real exchange rate, the short- and the long-term interest rates – are the same as in Dees et al. (2007a), DdPS hereafter. But for the real output, I used the respective per capita value¹⁹. Likewise, those were the variables selected in the seminal work of Pesaran et al. (2004). The exception is the long-term interest rate, as the "real money balances" entered in its place in the original formulation. More formally, the country-specific variables in this paper GVAR model are defined as follows:

- Real output per capita, $y_{it} = ln(GDP_{it}/CPI_{it}) - ln(Pop_{it})$, where GDP_{it} stands for the nominal Gross Domestic Product, CPI_{it} is the consumer price index, and

 Pop_{it} the population resident in country i^{20} ;

¹⁹ I suggest that using per capita values for the GDP is beneficial for the identification of the short-run multipliers in case of a lengthy estimation period, as in this paper whose sample extends over 38 years, 1979(1)-2016(4). For that time span one may find significant differences in population variation even across developed economies. For example, the cumulative growth of the U.S. population was 45 % over 1979-2016, while only 7% for the UK and 10% for Japan.

²⁰ As detailed in Appendix C, data on country-specific population are normalized by the respective mean.

- The inflation rate, $\pi_{it} = \ln(CPI_{it} / CPI_{i,t-1});$
- The real equity prices, $eq_{it} = \ln(EQ_{it} / CPI_{it})$, where EQ_{it} is the nominal equity price index;
- The real exchange rate, $e_{it} p_{it} = \ln(E_{it} / CPI_{it})$, where E_{it} is the exchange rate in terms of U.S. dollars;
- The nominal short-term interest rate, $r_{it} = 0.25 \times \ln(1 + R_{it}^S / 100)$, where R_{it}^S is the nominal short-term rate of interest per annum, in percent;
- The nominal long-term interest rate, $lr_{it} = 0.25 \times \ln(1 + R_{it}^L/100)$, where R_{it}^L is the nominal short-term rate of interest per annum, in percent.

The common variable is:

- Oil prices, $p_t^o = \ln(POIL_t)$, where $POIL_t$ is the price of oil in USD.

Table 1 shows the country-specific VARX models defined by the stated choice of variables. The models are the same for all countries with exception to the United States, assumed as the numeraire or "reference country" (Pesaran et al. 2004, p. 130). As such the exchange rate is included as a domestic variable in all the other countries, but not the foreign exchange rate (i.e., the "star" variable); the opposite happens with the U.S. model. Because of its leading role in capital markets, the foreign counterparts of the price of equity and of the interest rates are not expected to be exogenous in the U.S. model. Although, and to take due account of second-round effects, the real output and the inflation rate foreign counterparts are included in the U.S. model.

I chose the dominant unit (DU) option to model oil prices, thus assumed as exogenous for all economies, including the United States. In the earlier stages of the GVAR methodology, the oil prices were treated as an endogenous variable within the U.S. model (Pesaran et al. 2004), (Dees et al. 2007a) and DdPS. It remains as an option still today (see, for ex., Dees 2016). But the choice here was for the dominant unit formulation (Chudik and Pesaran 2013), given the growing share of oil consumption outside the United States.

The lag-length of each VARX* model is selected by applying the Akaike Information Criterion (AIK). However, and due to data limitations, the maximum order of two is

U.S.	Euro Area–Core	Euro Area–Periphery	Rest of Asia
China	Germany	Italy	Indonesia
Japan	France	Spain	Korea
UK	Netherlands	Ireland	Thailand
	Belgium	Portugal	Malaysia
	Austria	Greece	Philippines
	Denmark	Finland	Singapore
Other dev. countries	Rest of W. Europe	Latin America	Rest of the World
Canada	Switzerland	Brazil	India
Australia	Sweden	Mexico	Turkey
New Zealand	Norway	Chile	Saudi Arabia
		Peru	South Africa

TABLE 2 - COUNTRIES AND REGIONS IN THE GVAR MODEL

imposed on the domestic variables, p_i , and one on the foreign counterparts, q_i . The selected lag-lengths are reported in Table A. 2. in Appendix A along with the number of the identified cointegration relations.

3.3 Data, Sample and Computation Program

This paper version of the GVAR model covers 90% of the world economy as in DdPS. The main difference rests on treating each euro area member states individually whereas in the latter the euro area is taken as a whole, that is as a single country/region. "Exploring the international linkages of the Euro Area" was the object of study in DdPS, while the focus of the present investigation is disentangling each member state (Portugal, in particular) from the euro economy.

The GVAR methodology and the respective Toolbox 2.0 (Smith and Galesi 2014) allows for proceeding with regional aggregations either before or after estimating the individual countries models. Therefore, the impulse response analysis is entertained in this paper at the country level for every euro area member; and again for the euro area Core (EA-Core, hereafter) and the euro area Periphery (EA-Periphery, hereafter) as separate regions.

The results of the investigation of Bayoumi and Eichengreen (1992) on the response to supply and demand shocks across the former European Community member states provided the base to divide the euro area between the Core and the Periphery. That division was already strikingly apparent in the quoted work, and premonitory of the cleavage revealed by the 2008 global financial crisis and the subsequent European sovereign debt crisis of 2010-12. Austria and Finland, which acceded to the European Community only in 1995, were not included in the Bayoumi and Eichengreen (1992) study. However, a more recent investigation in business cycle synchronization across the European Union presented by Aguiar-Conraria and Joana Soares (2011) provides the support to ascribe Austria to the EA-Core and Finland to the EA-Periphery.

Finally, and because *de facto* rather than *de jure* exchange rates regimes is the relevant criterion for the present work, I included Denmark in the EA-Core. It should be noted that the Danish krone is pegged to the euro since the inception of the latter, and according to the quoted study of Aguiar-Conraria and Joana Soares (2011), Denmark is the second most synchronized country with the EA-12 members (i.e., the first twelve countries that joined the European currency union). By using the same methodology, while investigating the impact of European Monetary Union on business cycle synchronization across its member states and other European economies, Aguiar-Conraria et al. (2013) arrived at the same conclusion about the fit of Denmark with the euro area.

Table 2 shows the list of the 36 countries covered in this paper sample and its distribution through specific regions.

The data is described in Appendix C. The sample spans over 1979Q2-2016Q4, while in the DdPS was over 1979Q2-2003Q4, later on extended by Mauro and Smith (2013) to 1979Q2-2011Q2 and to 1979Q2-2013Q1 by Smith and Galesi (2014).

Three different time frames were defined for estimating the model: the full sample, 1979Q2-2016Q4; the observation window W1 corresponding to the period 1979Q2-1998Q4 and the observation window W2 corresponding to the period 1997Q2-2016Q4. Recall that the euro was launched on 1 January 1999, when the conversation rates of the founding members' currencies were fixed. Observation window W1 matches precisely to the period before the euro introduction, 1979Q2-1998Q4. Regarding window W2, the endpoint corresponds naturally to the final observation in the full sample, 2016Q4. But for the starting observation, I chose 1997Q2 instead to the first quarter in the euro life,

1999Q1, to assemble the same number of data points as in W1 (i.e., 79 observations), without loss of consistency considering that the process of nominal convergence was already on course since the mid-1990s.

For the construction of the foreign variables (the "star" variables), I made use of the trade shares (exports plus imports) to build the weight matrices, given the role of trade relations on business cycles linkages. However, while in DdPS the weights were based on the average trade flows computed over the last three years, I used the average over the full sample.

All routines since the computation of the foreign variables and going through the range of the preliminary tests have been undertaken by running the "GVAR Toolbox 2.0"(Smith and Galesi 2014)²¹, as well as the estimation of the country-specific models and the global VAR; and the subsequent dynamic analysis, and tests for the selected restrictions.

When reporting the results, the following criteria are adopted:

- The "focus group" comprehend the United States, the EA-Core and the EA-Periphery regions plus Portugal, the UK and Sweden. The interest in the UK and Sweden rest on being members of the European Union but not euro adopters (see: Aguiar-Conraria and Joana Soares 2011; Hashem Pesaran et al. 2007). The results for the "focus group" are reported in the main text.
- The "extended focus group" comprehend the United States, Japan, the UK, the 12 initial members of the euro area, except Luxembourg, plus Denmark, and the Rest of Western Europe countries (Switzerland, Sweden and Norway). The results for the "extended focus group" are reported in Appendix A.
- The remaining countries are reported in the supplemental material.

3.4 Testing for Unit Roots and Weak Exogeneity

The domestic and the foreign counterparts time series, as well as oil prices, were tested for unit roots, based on the "weighted symmetric estimation" test of the ADF type, as advocated by DdPS. The full results are available at the "Output" sheet in the supplemental material. In the case of Portugal, the unit root hypothesis is not rejected at

²¹ Available at <u>https://sites.google.com/site/gvarmodelling/gvar-toolbox.</u>

5% significance level, either for the endogenous variables or for the foreign counterparts (the "star" variables).

The weak exogeneity of country-specific foreign variables and the common variable (oil prices) is a fundamental assumption for GVAR modeling. Table A. 3 in Appendix A shows the results of the of the appropriate test implementation for the "extended focus group". The weak exogeneity is not rejected at 5% significance level in most cases. The exceptions are the output for Spain (borderline) and Finland; and inflation for Belgium, Austria and Finland; and the price of equity for Austria. It is worth noting that the oil prices weak exogeneity is not rejected for any country, a result that favors the option of assuming this variable also as exogenous for the United States.

3.5 Specification Tests and Break Dates

The "GVAR Toolbox 2.0" (Smith and Galesi 2014) include the routines to undertake the tests for checking the stability of short-run coefficients, including the full set referred in DdPS (Section 3.5). They were implemented, and the results and critical values are available at the "Output" file in the supplemental material (see the sheets "str_stab-stats" and "str stab cvals").

Here it seems of interest to address more specifically the tests designed to identify a one-time structural change, namely the *QLR* test for break dates, whereby suggesting inflection points in the variables of the model. Moreover, testing for break dates in the context of the GVAR entails an advantage when compared with single-equation models because of the cobreaking events (Hendry and Mizon 1998), which are accounted for in the former but not in the latter, as also highlighted by Dees (2016).

Table A. 4, inserted in Appendix A, reports the *QLR* break dates for the "extended focus group". The following breaks were identified for the Portuguese variables: 1985Q1 for the real output; 1985Q2 for the inflation rate; 2003Q3 for the real exchange rate; 1985Q2 for the nominal short-term interest rate; and 2010Q4 for the nominal long-term interest rate. The latter comes without surprise: it is related to the European sovereign debt crisis of 2010-12 (Shambaugh 2012). As does the break detected for "real exchange rate" while matching the currency regime change implied by the "Euro experiment". However, the results for the real output and the nominal variables, that is the inflation rate

and the nominal short-term interest rate, do not look as straightforward and deserve further examination.

Given 17 years of GDP stagnation observed after the euro adoption, a break date connected with the "Euro experiment" is expected rather than with the "EEC experiment". Recall that the "EEC experiment" went on through 1985-1998, and the real output break detected in this paper model is on 1985Q1. To interpret this result, one should bear in mind that in the GVAR framework the behavior of the foreign counterparts is accounted for when identifying a break date. By inspecting Table A. 4 again, we can see that there are also break dates identified for the U.S. real output in 1985 as well as for Netherlands and Italy. For Germany, a break is detected in 1991, thus one year after the Reunification. When plotting the real GDP behavior of those economies along with those of Portugal, as depicted in Figure A. 1 in Appendix A, we can see that, whereas 1985 is associated with an upward trend in the real GDP growth rate for Portugal, it stands for a turning point towards a decline for the other countries mentioned. We should now look to what happens around 2008-2010, that is after the eruption of the global financial crisis. Now the Portuguese GDP behavior grossly matches the downward trend observed in the other countries output, and there is no break date identified. Because the GVAR technique accommodates the cobreaking, it makes clear when international linkages or endogenous factors are responsible for regime changes in the macroeconomic variables.

4. EMPIRICAL RESULTS

I now present the main results obtained from the specified empirical model, starting with the short-term impacts, moving next to the impulse response functions and finally to the analysis in the long run.

4.1 Contemporaneous Effects

In the individual VARX* model, the domestic variables are regressed on their contemporaneous foreign counterparts averaged by the trade weights. Given that all variables enter in logs, the associated coefficients – the diagonal elements of matrix Λ_{i0} in equation (B.1), in Appendix B – can be interpreted as impact elasticities between the domestic and foreign variables, as highlighted by Dees et al. (2007b, p. 16); thus

providing insights on the degree of interlinkages across real, monetary and financial aggregates in the international setting.

Table A. 5 inserted in Appendix A reports the estimated contemporaneous coefficients over 1979Q2-2016Q4 for the "extended focus group". It is worth highlighting the main findings and to compare with the DdPS results; however, the latter referred to the period 1979Q2-2011Q2 as provided by Mauro and Smith (2013, Table 2.5).

- Real output coefficient. This paper estimates for the U.S., Japan, and the UK coefficients are close to those of Mauro and Smith (2013, Table 2.5). Respectively: 0.64 versus 0.61; 0.76 versus 0.79; and 0.69 versus 0.90. As already mentioned, the euro area is specified as a single VARX* model in the DdPS/Mauro and Smith (2013), whereas their member states are modeled individually in the present work. Hence, I suggest comparing the results of Mauro and Smith (2013) with those found here for the larger euro area economies. That means 0.60 shown in Mauro and Smith (2013, Table 2.5) for the euro area versus 0.96 shown here for Germany and 0.45 for France.
- Inflation rate coefficient. Again, this paper estimates compare fairly well with DdPS/Mauro and Smith (2013) for the United States, Japan and the UK. However, while the estimated coefficient for the euro area is 0.23 in Mauro and Smith (2013, Table 2.5), here it is 0.57 for Germany and 0.49 for France, the latter possibly reflecting the covariance across the euro area member states.
- Equity price coefficient. In this paper the estimated values are 1.13 for Germany and 0.99 for France, which compare with 1.04 for the euro area in Mauro and Smith (2013, Table 2.5). It should be noted that a value of one means that 1% change in the foreign equity prices translates in 1% change in domestic equity prices in the same quarter. Moreover, we can see high significant estimates across all countries as shown by the Newey-West *t*-ratio statistic also reported in Table A. 5. Overall this indicates that the GVAR model captures quite well the price of equity comovements; and thereby reflecting the close linkages in capital markets across the developed economies. The impulse response analysis in Section 4.2 points towards the same direction.

DOMESTIC VARIABLES							
Observation S	ample	Domestic '	Variables				
		У	π	eq	r	lr	
Full Sample:	1979Q2–2016Q4	0.30 [2.10]	0.54 [1.79]	-	0.06 [0.92]	0.84 [3.64]	
Window W1:	1979Q2-1998Q4	-0.02 [-0,10]	0.46 [0.66]	_	-0.03 [-0.28]	0.89 [3.23]	
Window W2:	1997Q2- 2016Q4	0.71 [3.70]	0.66 [7.54]	-	1.04 [51.46]	1.07 [4.58]	

TABLE 3-CONTEMPORANEOUS EFFECTS OF FOREIGN COUNTERPARTS ON THE PORTUGUESE

Note: Newey-West robust to autocorrelations and heteroskedasticity t-ratios are given in square brackets

- Short-term interest rate coefficient. The estimated coefficient for the euro area is as small as 0.04 in Mauro and Smith (2013, Table 2.5), while in this paper is 0.51 for Germany and 0.45 for France, possibly reflecting the covariance across the euro area countries.
- Long-term interest rate coefficient. The estimated values are high all over the sample, although and again higher across the euro area member states (1.07 for Germany, 1.18 for France, 1.00 for Spain). For Japan, the value is 0.53, and for the UK it is 0.83. But for Sweden, the estimated value is again high (1.01). It should be noted that the impact elasticities for all variables in the Sweden model are high, thus making this country an interesting case of tight inter-relationship with the world economy.

To conclude, and before going to a more specific analysis of Portugal, it is worth noting that the equity and the bond markets show the closer linkages, while the shortterm interest rates reveals weaker interdependence across distinct monetary jurisdictions. Does it reflect the power of the modern central banks when conducting the monetary policy?

Table 3 reports the contemporaneous coefficients estimated again over 1979Q2-2016Q4 but now only for Portugal; plus the estimated values for observations windows W1, that is over 1979Q2-1998Q4, and W2, that is over 1997Q2-2016Q4. In the short run, the interlinkages of the Portuguese economy with the rest of the world economies changed after the euro adoption. Impact elasticities for the real output, inflation and the short-term interest became statistically significant only after the participation in the European

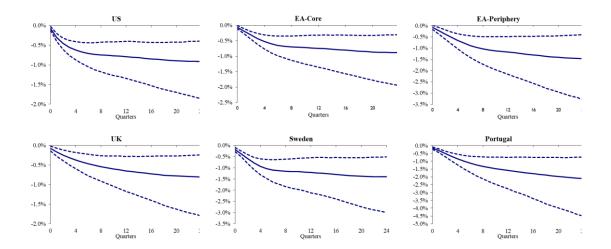


FIGURE 5. GENERALIZED IMPULSE RESPONSE OF A NEGATIVE UNIT (1 S.E.) SHOCK TO U.S. REAL EQUITY PRICES ON REAL OUTPUT PER CAPITA (BOOTSTRAP MEAN ESTIMATES WITH 90% BOOTSTRAP ERROR BOUNDS).

currency union. Furthermore, they were pretty aligned with the remaining member states estimated values (see Table A. 5, in Appendix A).

4.2 Impulse Response Analysis

Within the GVAR framework, the generalized impulse response function (GIRF), a technique summarized in Appendix B, traces the dynamic effects across all economies of a shock to one variable. The shocks can be originated in an individual country or simultaneously in all countries of a given region, or even at the global level. A shock to a common variable, like the oil prices, is also considered global.

This paper reports five shocks, implemented over the full sample 1979Q2-2016Q4, as follows: (i) a negative shock to U.S. real equity prices; (ii) a positive shock to oil prices (iii) a positive shock to U.S. short-term interest rate; (iv) a negative shock to EA-Core real equity prices; (v) a positive shock to U.S. real output. The first three shocks are the same as in DdPS, and the fourth is new; the fifth does not look as informative but is still reported. It is worth noting that a statistically non-significant impulse response function may either reflect an identification limitation or a feebler degree of international interactions across one particular variable (in case, the real output) or combination of both effects.

Figure 5 displays the GIRFs for a negative shock to U.S. equity prices on real output

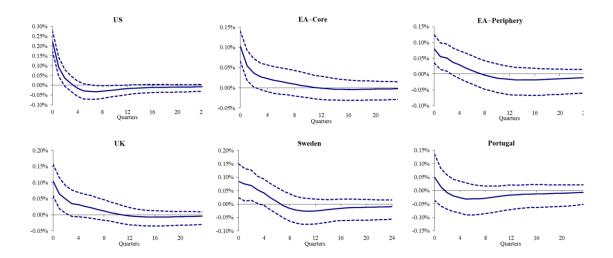


FIGURE 6. GENERALIZED IMPULSE RESPONSE OF A POSITIVE UNIT (1 S.E.) SHOCK TO OIL PRICES ON INFLATION (BOOTSTRAP MEAN ESTIMATES WITH 90% BOOTSTRAP ERROR BOUNDS).

across the "focus group" countries. The size of the shock is one standard error, which is equivalent to a fall of around 5-6% in the U.S. real equity prices per quarter. The impact is more pronounced in Portugal than in the EA-Periphery as a whole: the real output decline in the fourth quarter is by 0.9% in Portugal versus 0.7% in the EA-Periphery; and the average over the following quarters is 1.8% versus 1.3%, respectively. The same pattern is evidenced when entertaining shocks to the EA-Core equity prices and to oil prices (see the "Output" file in the supplemental material). Why is the (lag) sensitivity of Portuguese output to external shocks higher than the remaining countries in the euro area²²? This question deserves further investigation, but that behavior might be related with nominal and real rigidities in the labor market.

Figure 6 displays the GIRFs for a positive shock to oil prices on inflation across the "focus group" countries. The size of the shock is one standard error, which represents around 10-11% increase per quarter in the price of oil. On impact, the effects are stronger in the United States than in the euro area, likewise in DdPS. However, they are not statistically significant for Portugal. The inflation rate was much higher in Portugal than in the other developed countries before the euro adoption. More specifically, the mean of the rate of inflation over 1979Q2- 2016Q4 was1.7% per quarter for Portugal while being

²² See "Median Estimates" sheet in the Output file (\gvarJSC\GIRFs\UNITED STATES 1se neg shock to REAL EQUITY PRICES), available in the supplemental material, to check the persistence of the response of the shock across all euro area members and Denmark, and comparing with Portugal.

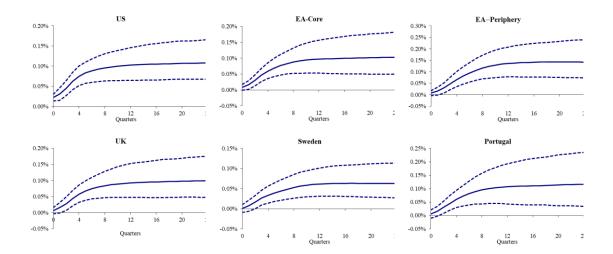


FIGURE 7. GENERALIZED IMPULSE RESPONSE OF A POSITIVE UNIT (1 S.E.) SHOCK TO U.S. SHORT-TERM INTEREST RATE ON LONG-TERM INTEREST RATES (BOOTSTRAP MEAN ESTIMATES WITH 90% BOOTSTRAP ERROR BOUNDS).

Note: Interest rates are measured on a quarterly basis.

0.5% for Germany and 0.8% for France; and around 1.2% for Italy and Spain. Hence, the estimation of the regression coefficients in the inflation equation turns more imprecise for Portugal.

Figure 7 displays the GIRFs for a positive shock to the U.S. short-term interest rate on long-term interest rates across the "focus group" countries. The size of the shock is one standard error, which is equivalent to an increase of 0.18% in the U.S. short-term rate measured on quarterly bases, that is a rise of 72 basis points. The effects on the long-term interest rate are statistically significant and are roughly the same for the United States, the UK, the EA-Core and EA-Periphery, including Portugal, and converging to 0.10% around the 12th quarter.

Figure 8 displays the GIRFs for a negative shock to the EA-Core real equity prices on the real exchange rate across the five countries of the "focus group" plus China²³. The size of the shock is one standard error, which is equivalent to a fall of around 4-5% per quarter in the average equity prices across the EA-Core member states. Although having implemented the model over the full sample, that is from 1979Q2 through 2016Q4, the

²³ Recall that the real exchange rate is not in the list of the U.S. endogenous variables. Thus, Figure 8 portrays the GIRF for China, the world's second largest economy, in place of the United States.

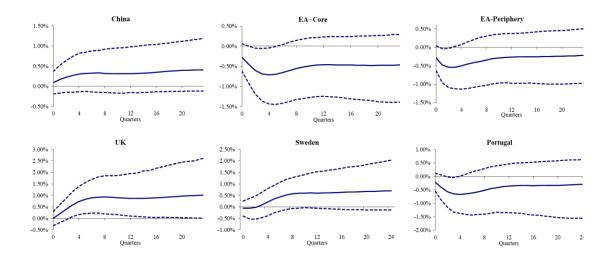


FIGURE 8. GENERALIZED IMPULSE RESPONSE OF A NEGATIVE UNIT (1 S.E.) SHOCK TO EA-CORE REAL EQUITY PRICES ON THE REAL EXCHANGE RATE (BOOTSTRAP MEAN ESTIMATES WITH 90% BOOTSTRAP ERROR BOUNDS).

GIRFs for the real exchange rate in the EA-Core and EA-Periphery, including Portugal, are quite similar. That behavior possible reflects the dynamics of the nominal convergence triggered by the Maastricht Treaty²⁴. It seems worth noting the contrasting profile of the real exchange rates of both Sweden and the UK. This differentiated pattern fits well the empirical evidence on their "diachronic business cycles" shown in Aguiar-Conraria and Joana Soares (2011) and in Aguiar-Conraria et al. (2013).

Figure 9 displays the GIRFs for a positive shock to the U.S. real output on the real output across the "focus group" countries. The size of the shock is one standard error, which is equivalent to an increase of around 0.5% per quarter in the U.S. real output. The responses are not statistically significant for the "focus group" countries other than the United States, thus contrasting with the results shown in Mauro and Smith (2013, p. 29). Even for the United States, they are different. While, in this paper, the estimated increase in the output is 0.36% over the first year, it amounts to 0.7% in Mauro and Smith (2013, p. 29). It should be noted that oil prices are a global variable in both model's specification. But, in this paper, it was defined as a dominant variable, while entered as an endogenous variable in the U.S. model, Mauro and Smith (2013). Furthermore, the real output is

²⁴ The Maastricht Treaty was signed in 1992, but the implied stabilization of the nominal exchange rates across the European Union member states started after 1994. As noted by Bayoumi and Eichengreen (2018), in 1992 and again in1993, the European Exchange Rate Mechanism (ERM) was hit by the crisis involving the UK and Italy, and finally France. Portugal joined the ERM in April 1992.

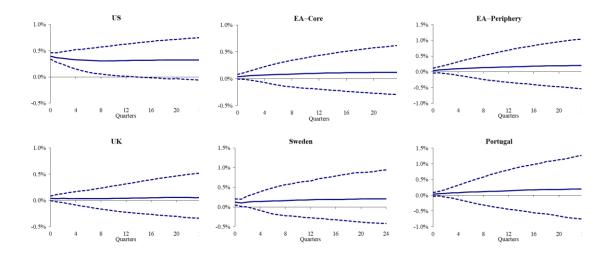


FIGURE 9. GENERALIZED IMPULSE RESPONSE OF A POSITIVE UNIT (1 S.E.) SHOCK TO U.S. REAL OUTPUT PER CAPITA ON REAL OUTPUT PER CAPITA (BOOTSTRAP MEAN ESTIMATES WITH 90% BOOTSTRAP ERROR BOUNDS).

measured differently, as I used the per capita units, as already mentioned. Finally, his paper sample spans over a lengthy period, namely 1979Q2-2016Q4 versus 1979Q2-2011Q2 in Mauro and Smith (2013).

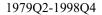
4.3 Analysis of Long Run

Within the GVAR framework, we may test for long-run equilibrium relationships, such as the purchasing power parity (PPP), by imposing the pertinent overidentifying restrictions on the cointegrating vectors²⁵.

Therefore, the strategy envisaged to test the impact of the euro adoption on the Portuguese relative prices was to impose the appropriated restriction successively over the sampling periods separated by the euro adoption 1999Q1. In this case, the observations windows W1, defined between 1979Q2 and 1998Q4 and W2, defined between 1997Q2 and 2016Q4, where the starting point in the latter is 1997Q2, instead of 1999Q1, to assemble the same number of observations.

However, after estimating and depicting the persistence profiles with regard to sample W1 (see Figure 10) and to sample W2 (see Figure 11), it became apparent the difficult adjustment to the long-run equilibrium when the model is implemented over to the

²⁵ See, for ex., Smith and Galesi (2014, pp. 130-32).



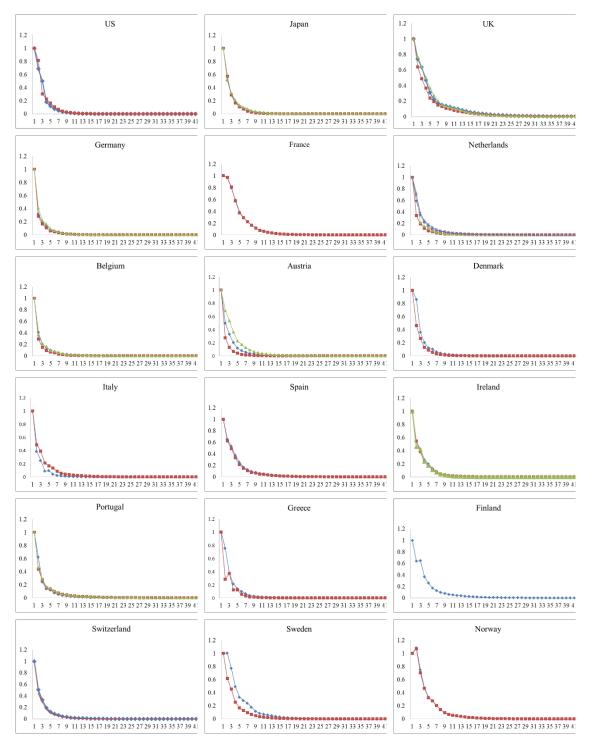


FIGURE 10. PERSISTENCE PROFILE OF THE EFFECT OF SYSTEM-WIDE SHOCKS TO THE COINTEGRATING RELATIONS. OBSERVATION WINDOW W1: 1979Q2-1998Q4.

Notes: Persistence profiles bootstrap median estimates portrayed for the "extended focus group", under the exact identification scheme of the cointegrating vectors. The number of cointegration relations for the individual country models was determined under the GVAR modeling standard routine (Case IV).

1997Q2-2016Q4

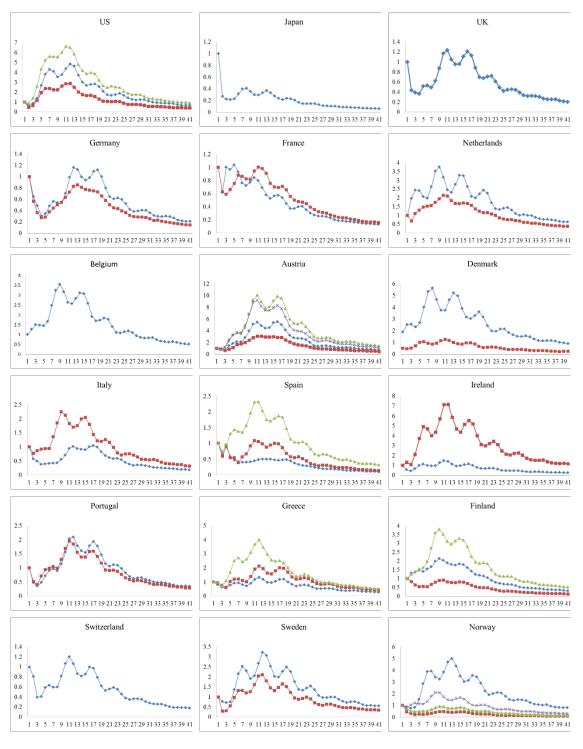


FIGURE 11. PERSISTENCE PROFILE OF THE EFFECT OF SYSTEM-WIDE SHOCKS TO THE COINTEGRATING RELATIONS. OBSERVATION WINDOW W2: 1997Q2-2016Q4.

Notes: Persistence profiles bootstrap median estimates portrayed for the "extended focus group", under the exact identification scheme of the cointegrating vectors. The number of cointegration relations for the individual country models was determined under the GVAR modeling standard routine (Case IV).

observation Window W2. Moreover, that disturbance is observed across all developed countries. I rechecked the cointegration ranks by changing the specified number of cointegration relations, but without any indication of improvement. And there was no evidence of eigenvalues greater than one. Finally, the empirical model run over the observation Window W2 was the same as the one run over observation Window W1. Therefore, I concluded that the instability was ingrained in the data, not the outcome of a misspecified empirical model²⁶.

All considered I made the following decision. To evaluate the long-run equilibrium relationships over the observation window W1, 1979Q2-1998Q4, that is the period preceding the euro adoption, and then again over the full sample, 1979Q2-2016Q4, that is now incorporating the "Euro experiment". This strategy was somewhat inspired by the Dees (2016) approach to the study of the impact of the 2008 global financial crises on the interrelation of financial variables with business cycles. Dees (2016) estimated a GVAR model over the full sample 1987-2013. After that, compared the results with those obtained from a restricted sample, where the post-financial crisis period was excluded, that is an observation window defined between 1987-2007.

The next step was to estimate, after imposing the restriction of interest, in case the PPP condition, the specified empirical model over the two selected periods and test whether the restriction is or is not rejected in any of those periods. And as such, gathering statistical evidence, related to the euro adoption, about possible deviations from the equilibrium level of the real exchange rate.

The current version of the GVAR Toolbox (Smith and Galesi 2014) does not allow to test the *absolute* PPP²⁷. However, the relative PPP can be tested using the well-known property that the relative PPP is implied by the uncovered interest parity (UIP) and by the Fisher inflation parity (FIP) relations combined. This paper pursues in that direction, without disregarding the sensitivity of the relative PPP measure to the base year (Rogoff

²⁶ The global financial crisis of 2008 likely accounts for the data instability turned apparent by the persistence profiles exhibited in Figure 11 (i.e., for the observation Window W2). Bayoumi and Eichengreen (2018), in a paper revisiting the conditions for the European countries to constitute an optimum currency area, made the choice to exclude the year of 2009 from the sample when analyzing the correlation shocks across U.S. regions and across the euro area countries (p. 7).

²⁷ The PPP long-run relation is testable within the GVAR framework after proper transformations as made by Dees et al. (2007a, pp. 7-9), even though not included in the current version of the GVAR Toolbox routines (Smith and Galesi 2014, p. 131).

1996)²⁸. But, at the same time, benefiting from including the interest rate into the test formulation, in addition to the inflation and the nominal exchange rates variables, that is the three relative prices of interest.

Recall that the relative PPP is defined by:

$$\pi_{it} = \Delta e e_{it} + \pi_{it}^* \tag{1}$$

where e_{it} is the (log) effective exchange rate, $e_{it} = \sum_{j=0}^{N} w_{ij} e_{ij}^{29}$, and where $e_{ij} = e_{it} - e_{jt}$ is the (log) bilateral exchange rate of country *i* with country *j*.

In a world of perfect foresight, equation (1) can be written for the expected variation on the nominal effective exchange rate as a function of country i expected inflation differential to its foreign counterparts

$$E\{\Delta e e_{i,t+1}\} = E\{\pi_{i,t+1} - \pi_{i,t+1}^*\} = E\{\pi_{i,t+1}\} - E\{\pi_{i,t+1}^*\}$$
(2)

Now notice that UIP relationship, which must hold by a simple arbitrage argument (Obstfeld and Rogoff 1996, p. 528), is given by

$$r_{i,t+1} = r_{i,t+1}^* + E\left\{\Delta e e_{i,t+1}\right\}$$
$$E\left\{\Delta e e_{i,t+1}\right\} = r_{i,t+1} - r_{i,t+1}^*$$
(3)

where $r_{i,t+1}$ is the nominal interest rate defined in period *t* for period *t* + 1. Now combining (2) and (3):

$$r_{i,t+1} - E\left\{\pi_{i,t+1}\right\} = r_{i,t+1}^* - E\left\{\pi_{i,t+1}^*\right\}$$
(4)

which imply the FIP relationship and that the real interest rate holds across countries.

Finally, and again with an arbitrage argument, we can see that once verified simultaneously the UIP and the FIP conditions the relative PPP necessarily holds.

The stochastic formulations³⁰ for the UIP and the FIP conditions are given by:

$$ee_{it} = \sum_{j=0}^{N} w_{ij}e_{ij} = \sum_{j=0}^{N} w_{ij}e_{it} - \sum_{j=0}^{N} w_{ij}e_{jt} = e_{it}\sum_{j=0}^{N} w_{ij} - e_{it}^{*} = e_{it} - e_{it}^{*}$$

²⁸ As the relative PPP compares the *rate of growth* of the variables of interest (the nominal exchange rate and inflation) it overcomes the problem of dealing with prices indexes possible based on different basket of goods across countries. See Rogoff (1996) for a discussion on this subject.
²⁹For computational purposes note that:

³⁰ See Garratt et al. (2006, Chapter 4).

$$r_{it} - r_{it}^* = a_{i1} + \zeta_{i1,t} \sim I(0)$$
(5)

$$r_{it} - \beta_{i,2}\pi_{it} = a_{i2} + \zeta_{i2,t} \sim I(0)$$
(6)

In practical terms, the implementation of the test depends on the number of cointegration relations identified. More commonly, the rank of order 2 is found, by which the FIP and the UIP conditions are simultaneous imposed and tested. When the rank order is of 1, we run one test at a time. For rank order of 3, we select a third possible structural relationship to run the overidentifying test. As noted by Smith and Galesi (2014, p. 132), "one cannot test for two long-run relations and simply exactly identify the remaining cointegration relation". The output gap non-divergent hypothesis stands as one possibility. In the terms formulated by Pesaran (2007), the cointegrating vector for the domestic and the foreign real output per capita – the *y* and *y** time series – take the form (1, -1). In a somewhat mild version, the coefficient respecting to the home country is left unrestricted, as such just subsuming a "common trends in output" (see Bernard and Durlauf 1995, p. 99). I have opted for the latter considering the diversity of countries in the sample. Thus, whenever having to impose a third overidentifying restrictions, the following econometric formulation is adopted ³¹:

$$\beta_{i,3}y_{it} - y_{it}^* = a_{i3} + \zeta_{i3,t} \sim I(0) \tag{7}$$

· -- >

where the intercept a_{i3} is restricted to lie in the cointegration space³² to allow for the joint evaluation of the three overidentifying restrictions implied in equations (5), (6) and (7).

Table A. 6 presents the results of the tests undertaken over observation window W1 and the full sample. That is the log-likelihood ratio statistic (LR statistic) and the bootstrap critical values after imposing the UIP and the FIP conditions, and the output gap restriction in case of the rank order of 3. It should be noted that the cointegrating vectors are identified at each country VECMX models (see equation (B.8) in Appendix B).

For Portugal, the number of cointegrating vectors identified was of 3 for the observation window W1, 1979Q2-1998Q4, and 2 for the full sample, 1979Q2-2016Q4. Thus, three overidentifying restrictions (UIP, FIP and the output gap) were simultaneously imposed over the observation window W1. Those restrictions were not

³¹ The same specification can be seen in Assenmacher and Pesaran (2008, p. 13).

³² This means to choose Case II for the treatment of the deterministic component in the estimation of the VECMX* individual models (see Section B.4 in Appendix *B*).

rejected given that the LR statistics is of 66.9, which compares with the critical values of 82.8 (5% significance level) and of 98.6 (1% significance level). Conversely, when running the test over the full sample, thus including the Euro experiment, the FIP and the UIP conditions are rejected. In this case, the LR statistic is 76.7, whereas the critical values are 52.7 (5% significance level) and 62.1 (1% significance level).

To conclude, the relative PPP holds in the period prior to the introduction of the euro, 1979Q2-1998Q4, and is rejected when evaluated over an extended period that includes the Euro experiment, 1979Q2-2016Q4.

4.4 Robustness

Using the full sample instead of the observation window W2 to evaluate the FIP and the UIP long-term equilibrium entails a limitation that needs to be checked. I have considered two alternative approaches. First, to rerun the program over observation window W2 but excluding the year 2009 from the sample, given that the global financial crisis of 2008 is the likely source of the instability detected through the persistent profile analysis. Second, making a third observation window, say W3, by enlarging observation window W2 backwards.

The first approach rendered non-converging persistence profiles again. Thus, I moved to the second one. The period of the new observation window, W3, was defined between 1985Q3 and 2016Q4, considering the break date of 1985Q2 identified both for the Portuguese inflation and interest rates, as reported in Section 3.5. After running the overidentifying restriction test, the UIP and the FIP are again rejected. The LR statistics is of 84.5, which compares with the bootstrap critical values of 52.3 (5% significance level) and 62.8 (1% significance level).

To conclude, when including the Euro experiment in the period of test – both in the full sample, 1979Q2-2016Q4, as in the observation window W3, 1985Q3-2016Q4 – the relative PPP, subsumed in the UIP and the FIP relations, is rejected. The robustness of the evaluation benefits from changing the initial observation, here moved from 1979Q2 to 1985Q3, given the sensitivity of the relative PPP measure to the base year (Rogoff 1996), as already noted.

5. CONCLUSION

After comparing the stagnation of the Portuguese economy throughout 1999-2016 with the successful participation in the EFTA and the EEC, I raised, with a Marshallian flavor, a first hypothesis for the dismal performance in the euro: The change in relative prices after relinquishing monetary policy autonomy.

But there has been an intriguing issue since the beginning of this inquiry – the length of the stagnation (17 years). And we have learned with North (1994), and with Daron Acemoglu and co-authors (2005; 2001), that, in the long run, institutions play a decisive role in economic performance.

Therefore, I faced two research questions, requiring different methodologies, and ultimately, a connection, if it is the case. Looking for evidence on a regime change in relative prices requires a quantitative analysis. I started by eliciting stylized facts where a shift in the price of future to present consumption became evident; and a correlated episode of overvaluation. I moved then to a more advanced framework, the GVAR. I tested the relative PPP, which holds before the euro adoption, but is rejected when the data sample is extended to include the euro period. Turning now to the institutional framework. I noted that the Carnation Revolution of 1974 was followed by a severe incident of property rights violation in 1975 and an anti-market ideology grasped the new Constitution, approved in 1976. The accession to the European Community in 1986 led to the re-establishment of the basic free-market rules, including the plain safeguard of property rights. However, the bias against larger enterprises and the highest degree of labor protection among the developed countries remained as a legacy of the original Constitution.

How did those macroeconomic events, underpinned by the financial integration in the euro area, and the prevailing institutional framework interact? The augmented version of the celebrated span-of-control of Lucas (1978), proposed by Braguinsky et al. (2011), contains the answer. By modeling employment protection as a "gross-tax on labor", Braguinsky et al. (2011) showed that employment protection decreases the firm optimal size. I argued that the impact of overvaluation was higher the larger (and more efficient) the enterprises, on account of the "gross-tax on labor". Therefore, on top of the well-known between-sector adverse impacts, overvaluation leads to within-industry

misallocation of resources. The empirical evidence on declining allocative efficiency within-industry, between 1996 and 2011, has been found by Dias et al. (2016). This closes the explanation for the dismal performance of the Portuguese economy in the euro. In sum, it stemmed from the interaction of a regime change in relative prices with domestic "institutional frictions".

A note on policy implications. The short-run dynamics analysis conducted with the GVAR has shown that Sweden notably exhibits fast responses to external shocks, in sharp contrast with the sluggish Portuguese adjustments. Given that Sweden is widely recognized as equity prone, I suggest that economic development in Portugal would improve if equity and efficiency trade-offs were less conditioned by the old anti-market ideology. The fit with the European currency union would also improve by softening the labor market rigidities and the bias against larger enterprises.

APPENDIX A

Tables and Figures

TABLE A. 1– PORTUGUESE REAL GDP GROWTH BREAK DATES, 1961Q1-2016Q4

Dependent Variable: Real Output per Capita Annual Growth Rate for Portugal
Method: Least Squares with Breaks
Date: 01/19/18 Time: 20:45
Sample (adjusted): 1961Q1 2016Q4
Included observations: 224 after adjustments
Break type: Bai-Perron tests of L+1 vs. L sequentially determined breaks
Breaks: 1974Q2, 1985Q2, 2001Q1
Selection: Trimming 0.15, Sig. level 0.05

Variable	Coefficient	Std. Error t-Statist		Prob.			
	1961Q1 - 19′	74Q1 53 obs					
С	0.065402	0.003422	19.11277	0.0000			
1974Q2 - 1985Q1 44 obs							
С	0.010999	09 0.003756 2.928648		0.0038			
	1985Q2 - 20	00Q4 63 obs					
С	0.034259	0.003139 10.91542		0.0000			
	2001Q1 - 20	16Q4 64 obs					
С	0.002532	0.003114	0.813018	0.4171			
R-squared	0.489357	Mean depende	nt var	0.027994			
Adjusted R-squared	0.482394	S.D. dependent	var	0.034626			
S.E. of regression	0.024912	Akaike info cri	-4.529267				
Sum squared resid	0.136530	Schwarz criteri	-4.468345				
Log - likelihood	511.2779	Hannan-Quinn	-4.504676				
F-statistic	70.27658	Durbin-Watsor	0.351897				
Prob(F-statistic)	0.000000						

Notes: Structural change analysis of the Portuguese real GDP per capita annual growth rate by applying the Bai (1997) and Bai and Perron (1998) methods to identify break dates. EViews output.

Countries	Full S	Sample		Wind	low W1		Wind	low W2	
	p_i	q_i	# cnt	p_i	q_{i}	# cnt	p_i	q_i	# cnt
U.S.	2	1	2	2	1	2	2	1	3
Japan	2	1	2	2	1	3	1	1	1
UK	2	1	1	2	1	3	2	1	1
EA-Core									
Germany	2	1	2	1	1	3	1	1	2
France	2	1	2	2	1	2	2	1	2
Netherlands	2	1	2	1	1	4	2	1	2
Belgium	1	1	2	1	1	3	2	1	1
Austria	1	1	4	1	1	3	2	1	4
Denmark	2	1	1	2	1	2	2	1	2
EA-Periphery									
Italy	2	1	2	1	1	2	1	1	2
Spain	2	1	2	1	1	2	2	1	3
Ireland	2	1	2	2	1	3	2	1	2
Portugal	2	1	2	2	1	3	2	1	2
Greece	1	1	1	2	1	2	2	1	3
Finland	2	1	1	2	1	1	2	1	3
Other Europeans									
Switzerland	2	1	1	1	1	2	1	1	1
Sweden	2	1	2	2	1	2	1	1	2
Norway	2	1	4	2	1	2	1	1	4

Table A. 2–VARX* (p_i, q_i) Lag Length-order and Number of Cointegration Relations

Notes:

 The number of cointegration relations was identified by using the standard option – Case IV – as expressed in Equation (B.21) in Appendix B, by which the trend is restricted to lie in the cointegration space ³³.

2) Further to the full sample period, 1979Q2-2016Q4, the number of cointegration relations for Window W1, 1979Q2-1998Q4, and for Window W2, 1997Q2-2016Q4, are also reported for the sake of interpretation of the Persistence Profiles portrayed in the main text.

³³ For a discussion on the different options, see, for ex., Garratt et al. (2006, pp. 118-22).

Country			Fo	oreign Var	iables and t	he Oil Pric	es	
		<i>y</i> *	π^{*}	eq^*	$e^* - p^*$	r [*]	lr*	p^{o}
U.S.	F(2,136)	0.15	5.68	_	1.03	_	_	2.41
Japan	F(2,132)	0.36	0.19	0.03	_	2.20	0.88	0.63
UK	F(1,133)	0.00	2.51	1.06	-	1.12	1.48	2.66
EA-Core								
Germany	F(2,132)	0.10	1.26	0.35	-	0.42	0.40	0.50
France	F(2,132)	1.03	1.81	0.12	_	2.96	1.19	0.32
Netherlands	F(2,132)	0.09	0.57	0.92	_	0.28	1.16	0.79
Belgium	F(2,132)	0.94	5.47†	0.72	_	0.99	0.21	2.04
Austria	F(4,130)	0.56	2.95†	4.48†	_	1.89	0.64	1.35
Denmark	F(1,135)	1.20	0.70	0.07	_	0.11	3.55	2.63
EA-Periphery								
Italy	F(2,132)	0.45	1.39	0.23	_	1.95	0.78	0.37
Spain	F(2,132)	3.13†	1.48	0.06	_	1.71	0.76	0.80
Ireland	F(2,133)	1.94	0.80	0.46	_	1.19	1.62	0.16
Portugal	F(2,133)	0.81	0.14	3.29	_	0.23	0.14	0.94
Greece	F(1,135)	0.032	0.08	0.61	_	0.15	0.02	1.48
Finland	F(1,134)	4.00†	4.56†	0.44	_	2.61	0.53	2.86
Other Europeans								
Switzerland	F(1,133)	0.51	0.97	0.00	_	0.43	0.21	1.42
Sweden	F(2,132)	2.74	0.71	0.37	_	0.07	1.07	0.31
Norway	F(4,130)	2.12	2.42	0.92	_	0.14	0.30	1.39

 TABLE A. 3– F-STATISTICS FOR TESTING THE WEAK EXOGENEITY OF THE COUNTRY-SPECIFIC

 FOREIGN VARIABLES AND OIL PRICES, 1979Q2-2016Q4

Note: †denotes statistical significance at 5% level.

	у	π	eq	e-p	r	lr
U.S.	1985Q1	2002Q1	1998Q4	_	1985Q1	1987Q4
Japan	1989Q4	1986Q3	1992Q3	1998Q3	1986Q3	1996Q1
UK	1987Q1	1985Q4	1987Q1	1988Q4	1985Q3	1985Q1
EA-Core						
Germany	1991Q1	1990Q4	1987Q1	2002Q4	1985Q3	1985Q3
France	1991Q4	1986Q1	1985Q2	1986Q4	1985Q4	1985Q1
Netherlands	1985Q3	1993Q2	1989Q1	1988Q4	1985Q4	1985Q1
Belgium	1991Q4	1998Q3Q3	2008Q2	2003Q2	1985Q2	1987Q4
Austria	1988Q1	1985Q3	2003Q4	2006Q1	1986Q2	1988Q2
Denmark	1988Q3	1986Q3	1986Q3	1989Q3	-	-
EA-Periphery						
Italy	1985Q3	1985Q3	1986Q2	2003Q3	1987Q4	1986Q3
Spain	1991Q4	1988Q4	1986Q2	1988Q4	1988Q1	1987Q2
Ireland	2011Q2	1985Q2	-	2003Q3	1985Q1	2010Q1
Portugal	1985Q1	1985Q2	-	2003Q3	1985Q2	2010Q4
Greece	1986Q2	1985Q3		2003Q3	1994Q3	_
Finland	1987Q2	1985Q1	2000Q2	2003Q3	1986Q3	_
Rest of W. Europe						
Switzerland	1987Q2	1985Q1	1986Q4	1987Q1	1989Q2	1992Q1
Sweden	1986Q1	1990Q1	1985Q3	2004Q1	1992Q3	1987Q1
Norway	1985Q1	2002Q4	1990Q4	2006Q1	1995Q1	1990Q3

 $TABLE\ A.\ 4-Structural\ Stability\ Tests:\ Break\ Dates\ for\ QLR\ Tests,\ 1979Q2-2016Q4$

Note: The *QLR* test is the Wald form of the Quandt (1960) likelihood ratio statistics. See Dees et al. (2007b: Section 3.5) for its application in the GVAR context.

Country	Domestic Variables							
	У	π	eq	r	lr			
U.S.	0.64	0.15	_	_	-			
	[5.00]	[1.73]						
Japan	0.76	0.10	0.71	-0.05	0.53			
	[3.33]	[1.07]	[6.74]	[-1.02]	[7.11]			
UK	0.69	0.70	0.81	0.25	0.83			
	[4.02]	[6.42]	[17.04]	[2.04]	[9.16]			
EA-Core								
Germany	0.96	0.57	1.13	0.51	1.07			
	[4.12]	[4.76]	[19.44]	[3.46]	[15.64]			
France	0.45	0.49	0.99	0.45	1.18			
	[3.41]	[4.19]	[19.13]	[4.97]	[17.27]			
Netherlands	0.17	0.57	0.95	0.23	0.88			
	[1.26]	[7.42]	[15.18]	[3.88]	[24.18]			
Belgium	0.51	0.94	0.96	0.34	0.69			
	[4.04]	[8.32]	[8.60]	[3.45]	[10.21]			
Austria	0.22	0.49	0.92	0.50	0.90			
	[1.64]	[5.40]	[7.78]	[5.63]	[12.04]			
Denmark	0.66	0.29	0.79	-	-			
	[3.49]	[2.01]	[14.71]					
EA-Periphery								
Italy	0.68	0.04	1.09	0.25	0.69			
	[5.54]	[0.35]	[10.96]	[4.10]	[4.59]			
Spain	0.72	0.59	0.99	0.12	1.00			
	[4.11]	[3.36]	[13.41]	[1.38]	[4.71]			
reland	0.88	0.65	_	0.90	1.27			
	[2.05]	[2.90]		[3.50]	[7.06]			
Portugal	0.30	0.54	_	0.06	0.84			
	[2.10]	[1.79]		[0.92]	[3.64]			
Greece	1.61	0.55	_	0.10	_			
	[5.41]	[3.22]		[0.58]				
Finland	1.13	0.48	1.04	0.48	_			
	[5.41]	[4.54]	[7.94]	[3.87]				
Rest of W. Europe	L- J	L - J	L - J	L - 'J				
Switzerland	0.25	0.28	0.87	0.15	0.54			

 TABLE A. 5-CONTEMPORANEOUS EFFECTS OF FOREIGN VARIABLES ON THEIR DOMESTIC

	[3.81]	[2.83]	[16.12]	[2.16]	[8.48]
Sweden	1.30	1.03	1.13	0.51	1.01
	[4.96]	[5.66]	[14.76]	[3.38]	[6.25]
Norway	0.51	0.58	1.11	0.13	0.70
	[3.25]	[1.85]	[14.74]	[1.67]	[6.61]

37.	Newev–West robust to		1 . 1 1		• •	1 1 .
NOIP		ס מחוטכטודבומנוטווא מווט	HELEIUSKEUASHUHV	i-ratios are	PIVEN III S	MULATE DIALKER

Window W1: 1979Q2-1998Q4 Full Sample: 1979Q2-2016Q4 Country 95% 99% LR 95% 99% LR Rank Rank Statistic Crt.Values Crt.Values Statistic Crt.Values Crt.Values Germany 3 116.7 85.8 98.9 2 93.1 68.2 71.3 France 2 64.9 80.7 96.0 2 75.1 66.2 79.5 2 Italy 2 98.5 79.9 88.9 61.5 77.0 86.6 2 96.7 77.9 86.7 2 72.6 75.9 Spain 68.1 Portugal 2 66.9 98.6 76.7 3 82.8 52.7 62.1 UK 2 71.1 73.1 79.8 2 82.1 70.1 75.0 2 Sweden 2 45.9 77.1 84.1 63.3 54.8 67.0

TABLE A. 6–LR STATISTICS FOR TESTING OVERIDENTIFYING RESTRICTIONS

Notes: The "LR statistic" stands for the log-likelihood ratio statistic. "Crit. Values" are the bootstrap critical values. Cointegration relations: when the rank is of 2, the FIP and UIP conditions have been imposed; when the rank is of 3, the FIP the UIP and the output gap conditions have been imposed. Selected countries: the bigger economies in the EA-Core and in the EA-Periphery; plus Portugal, and the European countries non-members of the euro area but included in the "focus group" (the UK and Sweden).

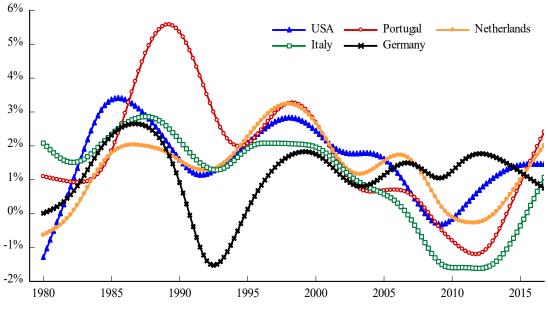


FIGURE A. 1. ANNUAL REAL GDP PER CAPITA GROWTH RATE (HP TREND)

Notes: Source: author computation using the EViews' Hodrick-Prescott filter routine. Raw data: quarterly data from *gvar*-JSC dataset.

APPENDIX B

THE GVAR METHODOLOGY

A formal description of the GVAR methodology is presented here. The purpose is to highlight the building blocks and the results further suited to the empirical model introduced in the main text. There will be nothing new in relation to the standard approach, as originally offered by Pesaran et al. (2004)³⁴, and more recently reviewed by Chudik and Pesaran (2016); but a more detailed approach to oil shocks, while treated as a dominant unit variable in the sense defined by Chudik and Pesaran (2013).

B. 1 The VARX* Country-specific Models

Given a set of N + 1 countries indexed by i = 0, 1, 2, ..., N and where 0 states for the numeraire country, the country i second order VAR model with weak exogenous variables³⁵, VARX* (2, 2), is written as

$$\mathbf{x}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \mathbf{\Phi}_{i1}\mathbf{x}_{i,t-1} + \mathbf{\Phi}_{i2}\mathbf{x}_{i,t-2} + \mathbf{\Lambda}_{i0}\mathbf{x}_{it}^* + \mathbf{\Lambda}_{i1}\mathbf{x}_{i,t-1}^* + \mathbf{\Lambda}_{i2}\mathbf{x}_{i,t-2}^* + \mathbf{u}_{it}$$
(B.1)

where \mathbf{x}_{it} is a $k_i \times 1$ vector of domestic variables, \mathbf{x}_{it}^* is a $k_i^* \times 1$ vector of foreign variables, and \mathbf{u}_{it} is a vector of idiosyncratic country-specific shocks, for t = 1, 2, ..., T.

The vector of foreign variables is defined as

$$\mathbf{x}_{it}^* = \sum_{j=0}^N w_{ij} \mathbf{x}_{jt}, \quad w_{ii} = 0$$
(B.2)

with w_{ij} , j = 0, 1, 2, ..., N, a set of weights such that $\sum_{j=0}^{N} w_{ij} = 1$. The weights are more commonly based on the trade share of country *j* in country *i* (imports plus exports) even when dealing with financial variables, e.g. in Dees (2016). Although, to capture more specific and time-varying financial interlinkages a more elaborated criterion might be

³⁴ See Mauro and Smith (2013) for a compact presentation or Smith and Galesi (2014) for a more detailed description.

³⁵ For a definition of I(1) weakly exogenous variables see, for ex., Garratt et al. (2006, pp. 56-59).

required, e.g. in Favero (2013)³⁶. More variations in weighting schemes are offered by Eickmeier and Ng (2013).

In matrix notation (B.1) is written as

$$\mathbf{x}_{it}^* = \widetilde{\mathbf{W}}_i' \mathbf{x} \tag{B.3}$$

 $(\mathbf{D}, \mathbf{2})$

where $\widetilde{\mathbf{W}}_i = \begin{bmatrix} w_{ji} \end{bmatrix}$ is the $k \times k_i^*$ matrix of country-specific weights and $\mathbf{x}_t = (\mathbf{x}'_{0t}, \mathbf{x}'_{1t}, ..., \mathbf{x}'_{Nt})'$ is $k \times 1$ vector collecting all endogenous variables in the global model; as such $k = \sum_{i=0}^{N} k_i$.

The idiosyncratic shocks \mathbf{u}_{it} are assumed to be serially uncorrelated with mean $\mathbf{0}$ and allowed "to be correlated across regions [countries] to a limited degree" (Pesaran et al. 2004; 131) – a feature to which we will revert later.

The vector autoregression expressed in (B.1) might be rewritten for the first difference of \mathbf{x}_{it} whenever containing at least one-unit root³⁷:

$$\Delta \mathbf{x}_{i,t} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t - \mathbf{\Phi}_i(1)\mathbf{x}_{i,t-1} + \mathbf{\Lambda}_i(1)\mathbf{x}_{i,t-1}^* + \mathbf{\Lambda}_{i0}\Delta \mathbf{x}_{it}^* - \mathbf{\Phi}_{i2}\Delta \mathbf{x}_{i,t-1} + \mathbf{\Lambda}_{i2}\Delta \mathbf{x}_{i,t-1}^* + \mathbf{u}_{it}$$
(B.4)

where

$$\mathbf{\Phi}_{i}(1) \equiv \mathbf{I}_{k_{i}} - \mathbf{\Phi}_{i1} - \mathbf{\Phi}_{i2}$$
$$\mathbf{\Lambda}_{i}(1) \equiv \mathbf{\Lambda}_{i0} + \mathbf{\Lambda}_{i1} + \mathbf{\Lambda}_{i2}$$

We now define $\mathbf{z}_{it} = (\mathbf{x}_{it}, \mathbf{x}_{it}^{*'})^{'}$, $\mathbf{\Pi}_{i} \equiv (\mathbf{\Phi}_{i}(1), -\mathbf{\Lambda}_{i}(1))$ and $\mathbf{\Gamma}_{i} \equiv -(\mathbf{\Phi}_{i2}, \mathbf{\Lambda}_{i2})$. Assuming that cointegration exists within \mathbf{x}_{it} and between \mathbf{x}_{it} and \mathbf{x}_{it}^{*} , $\mathbf{\Pi}_{i}$ is a rank deficient $k_{i} \times (k_{i} + k_{i}^{*})$ matrix, and the error correction representation of (B.1) is given by

$$\Delta \mathbf{x}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t - \mathbf{\Pi}_i \mathbf{z}_{i,t-1} + \mathbf{\Lambda}_{10} \Delta \mathbf{x}_{it}^* + \mathbf{\Gamma}_i \Delta \mathbf{z}_{i,t-1} + \mathbf{u}_{it}$$
(B.5)

To avoid quadratic trends in the level of variables (Pesaran et al. 2004: 137)³⁸, \mathbf{a}_{i1} must

³⁶ In Favero (2013) weights are based on the distance among fiscal fundamentals (expected deficit and debt ratios to GDP).

³⁷ See, for ex., Hamilton (1994, p. 549) for an alternative representation of a VAR (p) process.

³⁸ See the demonstration in Pesaran et al. (2000, pp. 295-98).

be restricted such that $\mathbf{a}_{i1} = \mathbf{\Pi}_i \boldsymbol{\gamma}_i$, where $\boldsymbol{\gamma}_i$ is a $(k_i + k_i^*) \times 1$ vector³⁹. Insofar, (B.5) is written as

$$\Delta \mathbf{x}_{it} = \mathbf{c}_{i0} - \mathbf{\Pi}_i \left(\mathbf{z}_{i,t-1} - \boldsymbol{\gamma}_i \left(t - 1 \right) \right) + \mathbf{\Lambda}_{10} \Delta \mathbf{x}_{it}^* + \mathbf{\Gamma}_i \Delta \mathbf{z}_{i,t-1} + \mathbf{u}_{it}$$
(B.6)

$$\mathbf{c}_{i0} = \mathbf{a}_{i0} + \mathbf{\Pi}_i \boldsymbol{\gamma} \tag{B.7}$$

Under the assumption that the long-run multiplier matrix Π_i is of rank $r_i < k_i$, we can write $\Pi_i = \alpha_i \beta'_i$, where α_i is the $k_i \times r_i$ loading matrix and β_i is the $(k_i + k_i^*) \times r_i$ matrix of cointegrating vectors, both of full column rank, and get the final form of the VECMX* model for each individual country

$$\Delta \mathbf{x}_{it} = \mathbf{c}_{i0} - \boldsymbol{\alpha}_i \boldsymbol{\beta}_i' (\mathbf{z}_{i,t-1} - \boldsymbol{\gamma}_i(t-1)) + \boldsymbol{\Lambda}_{10} \Delta \mathbf{x}_{it}^* + \boldsymbol{\Gamma}_i \Delta \mathbf{z}_{i,t-1} + \mathbf{u}_{it}$$
(B.8)

To see how cointegration is articulated both within \mathbf{x}_{it} and between \mathbf{x}_{it} and \mathbf{x}_{it}^* , and hence across \mathbf{x}_{it} and \mathbf{x}_{jt} for $i \neq j$, $\boldsymbol{\beta}_i$ can be partitioned into $(\boldsymbol{\beta}_{ix}, \boldsymbol{\beta}_{ix^*})^{'}$ conformable to \mathbf{z}_{it} (Smith and Galesi 2014: 127); as such the r_i error-correction terms can be written as

$$\boldsymbol{\beta}_{i}^{'}(\boldsymbol{z}_{it}-\boldsymbol{\gamma}_{i}t) = \boldsymbol{\beta}_{ix}^{'}\boldsymbol{x}_{it} + \boldsymbol{\beta}_{ix^{*}}^{'}\boldsymbol{x}_{it}^{*} - (\boldsymbol{\beta}_{i}^{'}\boldsymbol{\gamma}_{i})t$$
(B.9)

each country-specific VECMX* is estimated separately through the reduced- rank regression⁴⁰ procedure (Pesaran et al. 2004, pp. 137-38) taking in due account the stated cointegration structure and the weakly exogeneity of foreign and of global variables.

To recover each country VARX* model from the corresponding estimated VECMX* is straightforward: using (B.7) and the definitions of Π_i and Γ_i we reexpress (B.8) in levels

$$\mathbf{x}_{it} = \mathbf{a}_{i0} + \mathbf{\Pi}_i \boldsymbol{\gamma}_i + \mathbf{x}_{i,t-1} - \boldsymbol{\Phi}_i (1) \mathbf{x}_{i,t-1} + \mathbf{\Lambda}_1 (1) \mathbf{x}_{i,t-1}^* + \mathbf{\Pi}_i \boldsymbol{\gamma}_i t - \mathbf{\Pi}_i \boldsymbol{\gamma}_i + \mathbf{\Lambda}_{10} \Delta \mathbf{x}_{it}^* - \boldsymbol{\Phi}_{i2} \Delta \mathbf{x}_{i,t-1} - \mathbf{\Lambda}_{12} \Delta \mathbf{x}_{i,t-1}^* + \mathbf{u}_{it}$$

³⁹ Given the assumption that Π_i is rank deficient, γ_i can be estimated from the reduced form coefficients. See Garratt et al. (2006, p. 120).

⁴⁰ For a description of the reduced rank ML estimation method see, for ex., Lütkepohl and Krätzig (2004, pp. 96-103).

Finally, recalling the restriction $\mathbf{a}_{i1} = \mathbf{\Pi}_i \boldsymbol{\gamma}_i$ and after further simplifications we obtain equation (B.1).

B. 2 Solving for the GVAR

To build the global model all estimated individual countries VARX* models will be stacked in a single system which must be solved for k, $k = \sum_{i=1}^{N} k_i$, endogenous variables, \mathbf{x}_{ii} , making use of *link matrices* that will provide a mapping of the parameters estimated in the VARX* models into the GVAR coefficients.

Following Smith and Galesi (2014, pp. 136-37), the country *i* VARX* model introduced in (B.1) is reexpressed as of order (p_i, q_i) ,

$$\mathbf{x}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \mathbf{\Phi}_{i1}\mathbf{x}_{i,t-1} + \dots + \mathbf{\Phi}_{ip_i}\mathbf{x}_{i,t-p_i} + \dots + \mathbf{\Lambda}_{i0}\mathbf{x}_{it}^* + \mathbf{\Lambda}_{i1}\mathbf{x}_{i,t-1}^*$$

$$+ \mathbf{\Lambda}_{iq_i}\mathbf{x}_{i,t-q_i}^* + \dots + \mathbf{u}_{i1}$$
(B.10)

It should be noted that in empirical applications lag length-orders of domestic and of foreign variables, p and q, are chosen using the Akaike Information Criterion (AIC) or the Schwarz Bayesian criteria (SBC).

Defining $\mathbf{z}_{it} = (\mathbf{x}_{it}, \mathbf{x}_{it}^{*})^{'}$, a vector with dimension $(k_i + k_i^{*}) \times 1$, and making $p_i = q_i$, (B.10) is rewritten as

$$\mathbf{A}_{i0}\mathbf{z}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \mathbf{A}_{i1}\mathbf{z}_{i,t-1} + \dots + \mathbf{A}_{ip_i}\mathbf{z}_{i,t-p_i} + \mathbf{u}_{i1}$$
(B.11)

with

$$\mathbf{A}_{i0} = \left(\mathbf{I}_{k_i}, -\mathbf{\Lambda}_{i0}\right), \quad \mathbf{A}_{ij} = \left(\mathbf{\Phi}_{ij}, \mathbf{\Lambda}_{ij}\right), \quad \text{for } j = 1, ..., p_i$$

and where \mathbf{A}_{i0} and \mathbf{A}_{ij} are $k_i \times (k_i + k_i^*)$ dimensional matrices; and \mathbf{A}_{i0} is non-singular. Define the $(k_i + k_i^*) \times k$ link matrices

$$\mathbf{W}_{i} = \left(\mathbf{E}_{i}^{'}, \widetilde{\mathbf{W}}_{i}^{'}\right), \tag{B.12}$$

where \mathbf{E}_i is the $k \times k_i$ dimensional selection matrix that select \mathbf{x}_{it} , namely $\mathbf{x}_{it} = \mathbf{E}'_i \mathbf{x}_t$ and $\widetilde{\mathbf{W}}_i$ is the weight matrix introduced in (B.3).

Consequently, we may substitute \mathbf{z}_{it} in (B.11) for $\mathbf{W}_i \mathbf{x}_t$ and get rid of the exogenous variables, \mathbf{x}_{it}^* , while preserving the VARX* coefficients already estimated. Meanwhile, I provide an illustration of a link matrix that might be useful.

Let \mathbf{W}_{1} be the *link matrix* for country i = 1, and assume a model with only three country-specific endogenous variables⁴¹, e.g. the real output per capita y_{it} , the inflation rate Dp_{it} , and the nominal short-run interest rate r_{it} ; as well as a weighting scheme based on constant weights, and a set of N + 1 countries:

$$\mathbf{W}_{1} = \begin{pmatrix} 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & \cdots & 0 \\ w_{10} & 0 & 0 & 0 & 0 & 0 & w_{12} & 0 & 0 & \cdots & 0 \\ 0 & w_{10} & 0 & 0 & 0 & 0 & 0 & w_{12} & \cdots & w_{1N} \end{pmatrix}, \\ \mathbf{x}_{t} = \begin{pmatrix} y_{0t} \\ Dp_{0t} \\ r_{0t} \\ y_{1t} \\ Dp_{1t} \\ r_{1t} \\ y_{2t} \\ Dp_{2t} \\ r_{2t} \\ \vdots \\ r_{1N} \end{pmatrix}$$

Let us use the definition $\mathbf{z}_{it} = \mathbf{W}_i \mathbf{x}_i$ and accordingly reexpress equation (B.11):

⁴¹ To be denoted as in Smith and Galesi (2014, p. 18) and as used in our empirical model in next section.

$$A_{i0}W_{i}x_{t} = a_{i0} + a_{i1}t + A_{i1}W_{i}x_{t-1} + \dots + A_{ip_{i}}W_{i}x_{t-p_{i}} + u_{it}$$
(B.13)

By which we have now the left and the right end sides of each country-specific equation written in terms of the global vector of endogenous variables, \mathbf{x}_{i} . Insofar, to build the global system we just need to stack all those equations, i.e. the expression given in (B.13) for the i = 0, 1, 2, ..., N countries,

$$\mathbf{G}_{0}\mathbf{x}_{t} = \mathbf{a}_{0} + \mathbf{a}_{1}t + \mathbf{G}_{1}\mathbf{x}_{t-1} + \dots + \mathbf{G}_{p}\mathbf{x}_{t-p} + \mathbf{u}_{t}$$
(B.14)

where \mathbf{G}_0 and \mathbf{G}_j , with $j_t = 1, ..., p$, are $k \times k$ matrices, and \mathbf{a}_0 , \mathbf{a}_1 and \mathbf{u}_t are $k \times 1$ vectors:

$$\mathbf{G}_{0} = \begin{pmatrix} \mathbf{A}_{00} \mathbf{W}_{0} \\ \mathbf{A}_{10} \mathbf{W}_{1} \\ \vdots \\ \mathbf{A}_{N0} \mathbf{W}_{N} \end{pmatrix}, \quad \mathbf{G}_{j} = \begin{pmatrix} \mathbf{A}_{0j} \mathbf{W}_{0} \\ \mathbf{A}_{1j} \mathbf{W}_{1} \\ \vdots \\ \mathbf{A}_{Nj} \mathbf{W}_{N} \end{pmatrix}, \quad \mathbf{a}_{0} = \begin{pmatrix} \mathbf{a}_{00} \\ \mathbf{a}_{10} \\ \vdots \\ \mathbf{a}_{N0} \end{pmatrix}, \quad \mathbf{a}_{1} = \begin{pmatrix} \mathbf{a}_{01} \\ \mathbf{a}_{11} \\ \vdots \\ \mathbf{a}_{N1} \end{pmatrix}, \quad \mathbf{u}_{t} = \begin{pmatrix} \mathbf{u}_{0t} \\ \mathbf{u}_{1t} \\ \vdots \\ \mathbf{u}_{Nt} \end{pmatrix},$$

and $p = \max(\max p_i; \max q_i)$.

By simple inspection of the illustration given above, we can see that the matrices \mathbf{W}_i are of full row rank as far as the weighs w_{ij} are nonzero. And "in general" \mathbf{G}_0 will be also of full rank (Pesaran et al. 2004, p. 133); as such we may premultiply (B.14) by for \mathbf{G}_0^{-1} and obtain a reduced-form for the global model, i.e. the GVAR (*p*) model:

$$\mathbf{x}_{t} = \mathbf{b}_{0} + \mathbf{b}_{1}t + \mathbf{F}_{1}\mathbf{x}_{t-1} + \dots + \mathbf{F}_{p}\mathbf{x}_{t-p} + \mathbf{\varepsilon}_{t}.$$
 (B.15)

where

$$b_0 = G_0^{-1} a_0, \quad b_1 = G_0^{-1} a_1,$$

$$F_j = G_0^{-1} G_j, \quad j = 1, ..., p, \quad \varepsilon_t = G_0^{-1} u_t$$

For which the moving average representation is given by:

$$\mathbf{x}_{t} = \mathbf{d}_{t} + \sum_{s=0}^{\infty} \mathbf{A}_{s} \boldsymbol{\varepsilon}_{t-s}$$
(B.16)

where \mathbf{d}_t represents the deterministic component of \mathbf{x}_t , and \mathbf{A}_s can be derived recursively as

$$\mathbf{A}_{s} = \mathbf{F}_{1}\mathbf{A}_{s-1} + \mathbf{F}_{2}\mathbf{A}_{s-2} + \dots + \mathbf{F}_{p}\mathbf{A}_{s-p}, \quad s = 1, 2, \dots$$
(B.17)

with $\mathbf{A}_0 = \mathbf{I}_k$, $\mathbf{A}_s = \mathbf{0}$, for s < 0

B. 3 Short-Run Dynamics

The high dimensionality of the GVAR model turns unpractical the identification of the structural innovations using the "structural VAR" methodology (Pesaran et al. 2004, pp. 135-36). I can exemplify with the empirical model presented in Section 3 of the main text, where there were 187 variables⁴². Now notice that the identification of the shocks requires k(k-1)/2 restrictions⁴³, thus amounting to 17,391 in this case. One may suggest that theoretical motivation to impose restrictions within each country can be replicable. Nevertheless, there would be still cross-countries interactions to consider. Thus, shock identification will always be a "problematic" task in the global VAR framework as emphasized by Chudik and Pesaran (2016, p. 176).

A slightly different story happens when employing the Orthogonalized Impulse Responses (OIR) of Sims (1980), although restricting the ordering of variables to a single country. To exemplify this procedure a reference is made to Dees et al. (2007b) where the OIR technique was employed to measure the effects of shocks to the short-term interest rates on inflation after ordering the U.S. variables.

All considered, the alternative method to undertake the impulse response analysis in the GVAR context⁴⁴ lays on the Generalized Impulse Response Functions (GIRF) originally proposed by Koop et al. (1996) and applied later on by Pesaran and Shin (1998) both to the unrestricted and to cointegrated VAR models. By moving in that direction, the need to identify the "structural innovations" is circumvented. The reduced form error

⁴² The panel data set comprehend 36 countries and six endogenous variables, but there was not data available for all variables in every country. To check the list of variables per each country a reference is made to the sheet "Specification & Estimation of Individual Models" in the file "gvarJSC", available at the supplemental link.

⁴³ See, for ex., Hamilton (1994, p. 332) for the identification of structural VARs.

⁴⁴ The forecast error variance decomposition (FEVD) is also suitable in the GVAR context, while conditioning on the non-orthogonalized shocks, see for ex. Smith and Galesi (2014, pp. 142-43). The method will not be reviewed here as it will not be employed in our empirical study.

terms are elected as the source of disturbances to the GVAR system, but after integrating out the effects of other shocks given the historically observed distribution of the errors (Pesaran and Shin 1998, p. 19).

Therefore the trigger of the "conceptual experiments" – as in the words of Koop et al. (1996, p. 121) when referring to the impulse response functions (IRF)s - will be the regression residuals u_{il} , where *l* states for the l^{th} equation in the i^{th} country. We can exemplify this with a shock to the U.S. short-term interest rate (an observable variable), indistinguishably of whether prompted by an "innovation" in the monetary policy domain or by a change in fiscal policy; or with a shock to the U.S. real output irrespectively of being originated by demand or supply (unobservable) shocks, which might even have occurred outside the U.S. economy; or still with a global shock to the equity markets, which might be entertained simultaneous hitting the price of equity equations error terms respecting to all countries included in the GVAR model. It remains clear now that while the GIRF approach does not elicit the original source of a macroeconomic or financial disturbance, it remains a suitable tool to reveal how those disturbances are transmitted (the intensity and time path) to the others aggregates within and across countries and regions. Summing up, the GIRFs are an appropriate technique to study empirically shortterm dynamics, eliciting how different countries react after having being hit by the same shock. For example, it illustrates how the Portuguese real output or the inflation rate responds to an equity price shock in the United States in comparison the EA-Core or to other Peripheral countries.

I present next the formal definition of the GIRF. Let us revert to the system expressed in (B.14) where the GVAR equations were still written in terms of the individual countries variables error terms, u_{il} . Then, the GIRFs are defined as:

$$GIRF(\mathbf{x}_{t};u_{ilt},n) = E(\mathbf{x}_{t+n}|u_{ilt} = \sqrt{\sigma_{ii,ll}}, \mathbf{T}_{t-1}) - E(\mathbf{x}_{t+n}|\mathbf{T}_{t-1}),$$

where T_{t-1} is the information set representing the history of the economy up to time t-1, $\sqrt{\sigma_{ii,ll}}$ is the size of the shock, and where " $\sigma_{ii,ll}$ is the diagonal element of the variancecovariance matrix Σ_u corresponding to the l^{th} equation in the i^{th} country, and n is the horizon" (Smith and Galesi 2014, p. 140). Assuming that \mathbf{u}_t have a multivariate normal distribution, the GIRF of a shock on the l^{th} equation at time *t* on the j^{th} variable at time t + n is given by the j^{th} element of

$$GIRF(\mathbf{x}_{t}; u_{ilt}, n) = \frac{e_{j}' \mathbf{A}_{n} G_{0}^{-1} \boldsymbol{\Sigma}_{u} e_{l}}{\sqrt{e_{l}' \boldsymbol{\Sigma}_{u} e_{l}}}, n = 0, 1, 2, ...; l, j = 1, 2, ..., k,$$
(B.18)

where $e_i = (0, 0, ..., 0, 1, 0, ..., 0)'$ is a selection vector with unity at the i^{th} element, with i = 1, 2, ..., k.

B. 4 Long-run Relationships

I move now to the long-run relations empirical analysis, which will be undertaken by (i) evaluating the speed for adjusting to the long-run equilibrium throughout the "persistence profiles" (PP); and (ii) testing for overidentifying restrictions on the cointegrating vectors.

It is noted that even if the *locus* for the investigation is the country-level VARX*-VECM* individual model – as it is the case when entertaining tests through the cointegration space – the distributions to evaluate the results, dealing as it is the case with small samples, are defined in the GVAR context, which is bootstrapped for that purpose⁴⁵.

Before moving on describing the long-run evaluation techniques, we have to address the deterministic components (intercepts and linear trends coefficients) when specifying the individual countries VECMX* models.

As proposed by Pesaran et al. (2000), there are five different cases to be considered: Case I (no intercepts, no trends) and Case V (unrestricted intercepts, unrestricted trends) are of no interest for our empirical research and also not included in the Smith and Galesi (2014) toolbox options; Case IV (unrestricted intercepts; restricted trends), has already been applied when specifying the equation (B.6) but will be described again for the clarity of exposition; to introduce now Cases II and III we revert to (B.5) and impose the following restrictions:

Case II: (Restricted intercepts; no trends) $\mathbf{a}_{i0} = \mathbf{\Pi}_i \boldsymbol{\mu}_i$ and $\mathbf{a}_{i1} = \mathbf{0}$, where $\boldsymbol{\mu}_i$ is a

 $(k_i + k_i^*) \times 1$ dimensional vector and $\gamma_i = 0$ was assumed. Substituting in (B.5):

⁴⁵ See Smith and Galesi (2014, pp. 147-49) for a detailed explanation on the GVAR bootstrapping.

$$\Delta \mathbf{x}_{it} = \mathbf{\Pi}_i \mathbf{\mu}_i - \mathbf{\Pi}_i \mathbf{z}_{i,t-1} + \mathbf{\Lambda}_{10} \Delta \mathbf{x}_{it}^* + \mathbf{\Gamma}_i \Delta \mathbf{z}_{i,t-1} + \mathbf{u}_{it}.$$
 (B.19)

Case III: (Unrestricted intercepts; no trends) $\mathbf{a}_{i0} \neq 0$ and $\mathbf{a}_{i1} = \mathbf{0}$; again $\gamma_i = \mathbf{0}$ is assumed. Substituting in (B.5)

$$\Delta \mathbf{x}_{it} = \mathbf{a}_{i0} - \mathbf{\Pi}_i \mathbf{z}_{i,t-1} + \mathbf{\Lambda}_{10} \Delta \mathbf{x}_{it}^* + \mathbf{\Gamma}_i \Delta \mathbf{z}_{i,t-1} + \mathbf{u}_{it}$$
(B.20)

Case IV: (Unrestricted intercepts; restricted trends) $\mathbf{a}_{i0} \neq 0$ and $\mathbf{a}_{i1} = \mathbf{\Pi}_i \boldsymbol{\gamma}_i$. Substituting in (B.5),

$$\Delta \mathbf{x}_{it} = \mathbf{a}_{i0} + \mathbf{\Pi}_i \boldsymbol{\gamma}_i t - \mathbf{\Pi}_i \mathbf{z}_{i,t-1} + \mathbf{\Lambda}_{10} \Delta \mathbf{x}_{it}^* + \mathbf{\Gamma}_i \Delta \mathbf{z}_{i,t-1} + \mathbf{u}_{it}$$
(B.21)

which will take the form already shown in (B.6) whenever making likewise $\mathbf{c}_{i0} = \mathbf{a}_{i0} + \mathbf{\Pi}_i \boldsymbol{\gamma}_i$:

$$\Delta \mathbf{x}_{it} = \mathbf{c}_{i0} - \mathbf{\Pi}_i \left(\mathbf{z}_{i,t-1} - \mathbf{\gamma}_i (t-1) \right) + \mathbf{\Lambda}_{10} \Delta \mathbf{x}_{it}^* + \mathbf{\Gamma}_i \Delta \mathbf{z}_{i,t-1} + \mathbf{u}_{it}$$

B. 4.1 Persistence Profiles

Persistence profiles (PPs) refer to the time path of a cointegrating relations adjustment to its long-term equilibrium after being hit by a system-wide or a variable-specific shock. Given a well-specified model, the persistence profiles analysis gives us insights on different aspects of the behavior of an economy. For example, Pesaran and Shin (1996) have found that the adjustment process in the purchasing power parity (PPP) is much slower than in the uncovered interest parity (UIP). Based on the results of the empirical model presented in the main text, when estimated for different while successive observation windows, W1 for 1979Q2-1998Q4 and W2 for 1997Q2-2016Q4, I suggest that persistence profiles can also offer evidence of structural changes or disturbing events occurring at a regional or even a global scope. While the adjustment to the equilibrium was smooth and fast in Window W1 it displays a rough pattern in Window W2 across all countries in the "extended focus group". I have made the conjecture that the global financial crisis of 2008 was the source of the detected instability.

A formal definition for the persistence profiles (PP) will be presented next. But before it is worth noting that the PPs are invariant to the error terms orthogonalization schemed (Pesaran and Shin 1996), which was not the case for the impulse response functions as above reviewed.

The aim now is to see the time path the j^{th} cointegration relation in the i^{th} country, $\mathbf{\beta}'_{ji}\mathbf{z}_{it}$, after having been hit by a system-wide shock in the GVAR framework. I start by highlighting that while the VECMX* model is written in terms of the country-specific vector of variables $\mathbf{z}_{it} = (\mathbf{x}'_{it}, \mathbf{x}^{*'}_{it})'$ as shown in (B.5), the GVAR is expressed in terms of the "global" vector of variables, $\mathbf{x}_t = (\mathbf{x}'_{0t}, \mathbf{x}'_{1t}, \dots, \mathbf{x}'_{Nt})'$, as shown in (B.15). Now making use of the definition $\mathbf{z}_{it} = \mathbf{W}_i \mathbf{x}_t$, we may also write the GVAR moving average representation given by (B.16) in terms of \mathbf{z}_{it} :

$$\mathbf{z}_{it} = \mathbf{W}_i \mathbf{d}_t + \mathbf{W}_i \mathbf{A}_0 \varepsilon_t + \mathbf{W}_i \sum_{s=1}^{\infty} \mathbf{A}_s \varepsilon_{t-s}$$
(B.22)

Then, the persistence profile of the $\beta_{ji} \mathbf{z}_{it}$ cointegration relation with respect to a system-wide shock to ε_t is given by

$$PP(\mathbf{\hat{\beta}}_{ji}\mathbf{z}_{it};\varepsilon_{t},n) = \frac{\mathbf{\hat{\beta}}_{ji}\mathbf{W}_{i}\mathbf{A}_{n}\Sigma_{\varepsilon}\mathbf{A}_{n}\mathbf{W}_{i}\mathbf{\hat{\beta}}_{ji}}{\mathbf{\hat{\beta}}_{ji}\mathbf{W}_{i}\mathbf{A}_{0}\Sigma_{\varepsilon}\mathbf{A}_{0}\mathbf{W}_{i}\mathbf{\hat{\beta}}_{ji}}, \quad n = 0, 1, 2, \dots$$
(B.23)

where *n* is the horizon and Σ_{ε} is the covariance matrix of ε_{t} .

B. 4.2 Testing for Overidentifying Restrictions

Long-run comovements among integrated macroeconomic variables may reflect both domestic interactions and relationships with foreign variables motivated by (i) technological factors, e.g. the diffusion of technical progress and (ii) arbitrage conditions in the goods and in the financial markets⁴⁶. The output gap convergence hypothesis is an example for the former; the Fisher Inflation Parity (FIP), the Uncovered Interest Parity (UIP), and the purchasing power parity (PPP)⁴⁷ are for the latter.

⁴⁶ See Garratt et al. (2006, Chapter 4) for a review on long run economic theory principles and on its econometric modeling.

⁴⁷ See, for ex., the definitions of FIP in Obstfeld and Rogoff (1996, pp. 516-17) ; of absolute and of relative PPP in Rogoff (1996); of the UIP in Obstfeld and Rogoff (1996, pp. 527-28).

Such being the case, the pertinent I(1) variables will be cointegrated, meaning that they share a structure that ties their behavior in an interrelated path. However, a myriad of disturbing events will originate deviations across time from the long-run equilibrium. But if that underlining structure exists, the changes on the levels of the cointegrated variables observed period after period will reflect both the short-term vanishing disturbances and the reversion to the path "dictated" by the underlining structure. As it is well known from the cointegration theory, after the seminal contributions of Granger (1983) and of Engle and Granger (1987), the distinction of the short-run dynamics from the long-run multipliers is attainable by including an error correction term, here denoted by $\Pi_i \mathbf{z}_{i,i-1}$, in the first-differenced vector autoregressive model, as expressed in (B.5)⁴⁸. Otherwise, the first-differenced representation would not be even a "compatible" with the cointegration hypothesis (Engle and Granger 1987)⁴⁹.

The question to be raised next is the following: How to identify in this framework the long-run relations among the variables of the model? Recall that Π_i is a $k_i \times (k_i + k_i^*)$ matrix of rank $r_i < k_i$, and that we can write $\Pi_i = \alpha_i \beta_i$, where α_i is the $k_i \times r_i$ loading matrix and β_i is the $r_i \times (k_i + k_i^*)$ matrix of cointegrating vectors, both of rank r_i . However α_i and β_i are not separately identified⁵⁰. Thus, to identify β_i we have to impose r_i restrictions per each r_i cointegrating vectors, thus amounting to r_i^2 restrictions. A "statistical" solution for this problem can be find through the orthogonalization of β_i , in line with Johansen (1988; 1991) approach, which provides an exactly identified

⁴⁸ In GVAR context, the left-hand side of the VEC model is written in terms of the vector \mathbf{x}_{it} , namely

 $[\]Delta \mathbf{x}_{it}$, while the error-correction term is defined in terms of vector $\mathbf{z}_{it} = (\mathbf{x}_{it}, \mathbf{x}_{it}^{*'})^{'}$, where $\mathbf{x}_{it}^{*'}$ are weakly exogenous. This is because only the so-called *conditional model*, i.e. the one written for the differenced data $\Delta \mathbf{x}_{it}$, is considered; while the *marginal model*, i.e. the one that would be written for the differenced data $\Delta \mathbf{x}_{it}^{*}$, is discarded. The conditional and the marginal models combined form the extend VECM for $\Delta \mathbf{z}_{it}$. As shown, for example, in Garratt et al. (2006, pp. 135-36) the splitting of the extended model into those above mentioned marginal and conditional models is based on the (testable) assumption that the country specific foreign variables $\{\mathbf{x}_{it}^*\}_{t=1}^{\infty}$ are *long-run forcing* for the endogenous variables

 $^{\{\}mathbf{X}_{it}\}_{t=1}^{\infty}$

⁴⁹ See Hamilton (1994, pp. 571-73) for a summary demonstration.

⁵⁰ See Garratt et al. (2006, pp. 36-7) for a detailed explanation.

system. Notice that this procedure – to be based on the identity matrix⁵¹ in the context of the GVAR estimation – does not reveal the "original" cointegrating vectors, for which it stands just as a linear combination. An alternative to identify β_i might be provided by the economic theory whereby $r_i^2 - r$ must be supplemented in addition to the *r* restrictions arising from normalization. Continuing in this direction, Pesaran and Shin (2002) described the methods for the identification of the cointegration coefficients based on information drawn from the economic theory, and for hypothesis testing, in particular testing for overidentifying restrictions on the cointegrating vectors. Previously and also in the context of non-stationary time series, Johansen and Juselius (1994, p. 10) had already addressed the "identification of economic identification" in a broader perspective, related to the "economic interpretability of the estimated coefficients"; and offered an empirical application to the Australian economy, where overidentifying restrictions have been used to investigate the conformity of long-rung macroeconomic theoretical relationships, in case drawn from the IS–LM model, with the observed data.

Testing for overidentifying restrictions is a procedure to be used in the present paper when addressing its fundamental questions related with the dismal path of the Portuguese economy after the euro adoption. There is statistical evidence of relative price disturbances in that same period as suggested in a preliminary quantitative approach presented in the main text

It seems convenient to summarize the "mechanics" of testing for overidentifying restriction the present context. I would suggest that it can be seen as combination of the "statistical" with the "economic" identification of the cointegrating vectors. The former by providing a "benchmark" – the maximum likelihood estimation, given the usual Gaussian assumptions – defined by the model estimated under the "exact identification" solution provided by the identity matrix; the latter by setting the framework to model the long-run relationships which are aimed to be verified empirically, and leading to the "overidentification" of matrix β_i .

⁵¹ To impose the identity matrix the $r_i \times (k_i + k_i^*)$ dimensional $\mathbf{\beta}'_i$ matrix is partitioned such that the first block is the identity matrix of order r_i , i.e. $\mathbf{\beta}'_i = [I_r : \mathbf{\beta}'_{iK}]$ where $\mathbf{\beta}'_{iK}$ is a $r_i \times (k_i + k_i^* - r_i)$ dimensional matrix of coefficients to be estimated.

A comparison between the results obtained from the "overidentified" versus the "exact identified" matrices was then undertaken, using the appropriate statistics (the Wald test) and the pertinent distributions. Accordingly, a judgment is made about the plausibility of the hypothetical long-run relationship prevalence in the observed period. To be clear, the point is not to identify the matrix β_i based on theoretical insights, but rather to test if certain theoretical properties hold in a certain period of time for a given economy.

I present next the formal description of testing for overidentifying restrictions ⁵² using as an illustration the VECM* model with the three endogenous variables, e.g. the real output per capita, the inflation rate and the short-term interest rate, and the respective country-specific foreign counterparts, $\mathbf{z}_{it} = (y_{it}, \pi_{it}, r_{it}, y_{it}^*, \pi_{it}^*, r_{it}^*)^T$. Suppose now that our aim is testing for the FIP and the UIP arbitrage conditions, and for the non-divergent output gap hypothesis in the sense defined by Pesaran (2007). Assuming that the FIP and the UIP conditions are not trended, and that y_{it} and y_{it}^* are cotrending, after duly testing for, the deterministic trend coefficient will be absent of the cointegration space. Suppose however that in the case of the FIP relation we choose to leave unrestricted the inflation rate coefficient. Translating into an econometric formulation those long-run relationships will be represented by the following reduced form⁵³ error correction terms, respectively for the UIP, the FIP and the *output gap* conditions:

$$r_{it} - r_{it}^* = a_{i1} + \zeta_{i1,t} \sim I(0)$$
(B.24)

$$r_{it} - \beta_{i,22} \pi_{it} = a_{i2} + \zeta_{i2,t} \sim I(0)$$
(B.25)

$$y_{it} - y_{it}^* = a_{i3} + \zeta_{i3,t} \sim I(0)$$
 (B.26)

To which corresponds the following (transposed) matrix of cointegrating vectors

⁵² The topic A.11 "Testing for overidentifying restrictions on the cointegrating vector" in Smith and Galesi (2014, pp. 130-32) and Chapter 9 in Garratt et al. (2006) provide the basic information to test for overidentifying restrictions.

⁵³ See in Garratt et al. (2006, Chapter 4) the derivation of the structural long-run equations.

$$\boldsymbol{\beta}_{i,OY}' = \begin{pmatrix} 0 & 0 & 1 & 0 & 0 & -1 \\ 0 & \beta_{i,22} & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & -1 & 0 & 0 \end{pmatrix}$$
B.27)

Now notice that we have imposed 17 restrictions in $\beta'_{i,OY}$ while nine would be enough to exactly identify β'_i . To make it more clear, let us write the exactly identified matrix based on the identity matrix

$$\boldsymbol{\beta}_{i,exat}^{'} = \begin{pmatrix} 1 & 0 & 0 & \beta_{i,14} & \beta_{i,15} & \beta_{i,16} \\ 0 & 1 & 0 & \beta_{i,24} & \beta_{i,25} & \beta_{i,26} \\ 0 & 0 & 1 & \beta_{i,34} & \beta_{i,35} & \beta_{i,36} \end{pmatrix}$$
(B.28)

We can now estimate the VECM* model using in alternative the $\boldsymbol{\beta}_{i,OY}$ and the $\boldsymbol{\beta}_{i,exat}$ options. We should expect that the more restricted version renders a "worse" result, i.e. a less likely estimation of the model. But if the data offers evidence in favor of the long-run relationships, then the result obtained with $\boldsymbol{\beta}_{i,OY}$ will not depart "too much" from the one obtained with $\boldsymbol{\beta}_{i,exat}$. A statistical evaluation is provided by the log-likelihood ratio statistics, LR, defined over $\boldsymbol{\theta}_i = vec(\boldsymbol{\beta}_i)$, where "vec" denotes the column stacking operator and $\boldsymbol{\beta}_i = (\boldsymbol{\beta}_{i1}, \boldsymbol{\beta}_{i2}, ..., \boldsymbol{\beta}_{ir_i})$,

$$LR = 2 \left\{ l_T \left(\hat{\boldsymbol{\theta}}_i; r_i \right) - l_T \left(\widetilde{\boldsymbol{\theta}}_i; r_i \right) \right\}$$
(B.29)

where $\hat{\boldsymbol{\theta}}_i$ and $\widetilde{\boldsymbol{\theta}}_i$ are the maximum likelihood (ML) estimators of $\boldsymbol{\theta}_i$, respectively obtained under the exact and the overidentifying restrictions; and $l_T(\hat{\boldsymbol{\theta}}_i)$ and $l_T(\widetilde{\boldsymbol{\theta}}_i)$ are the maximized values of the corresponding log-likelihood functions.

Under the null hypothesis that the overidentifying restrictions hold, the LR ratio statistic expressed in (B.29) has an asymptotic χ^2 distribution with $m_i - r_i^2$ degrees of freedom, where m_i is the total number of restrictions, including those imposed on the deterministic variables if any. However, for small samples the critical values are computed by bootstrapping the GVAR using possibly 2000 replications (Dees et al. 2007a, p. [A.5]) or 3000 (Garratt et al. 2006, p. 208). The common practice is to check the bootstrapping with a smaller and a higher number of replications and then choose the

higher number in case of non-detected impact on the confidence intervals⁵⁴. In the present paper we have applied 2000 replications after observing that with a lower number (1000 replications) the decision of rejecting or not the null hypothesis was not affected at the same significance level.

⁵⁴ See, for ex., Lütkepohl and Krätzig (2004, p. 179).

APPENDIX C

Dataset Description and Sources

The most recent GVAR dataset version available is the "Vintage 2013" (1971Q1-2013Q1), built after successive extensions of the original GVAR dataset, namely the "2011 Vintage" (1979Q1-2011Q2), the "2009 Vintage" (1979Q1-2009Q4) and the "2006 Vintage" (1979Q1-2006Q4), as reported in the Global VAR Modeling website⁵⁵.

However, as the "GVAR Data 1979Q1-2013Q1 (2013 Vintage) link" was inactive at the time I was downloading the data, i.e. November 2017, I built the "2016 dataset" (1979Q1-2016Q4) using the "2011 Vintage" whenever needed.

That apparent limitation does not have practical consequences. Because, it has been already my option to build the "2016 dataset" not by extending by "forward extrapolation" a previous version, but by using of the most recent data available at the selected sources, and then link to the old data just in case of existing gaps needed to be backfilled.

It should be noted that "forward extrapolation" means in this context to update a preexisting time series by making use of the growth rate in identically defined and sourced time series or in a valid proxy.

By using the newest data instead of extending old data, the "2016 dataset" may benefit from what is expected to be the best available information. Moreover, I ensure cross-country consistency with the data gathered for the additional countries included in this paper version of the GVAR, namely Denmark, Greece, Ireland and Portugal. ⁵⁶

In any case, and to allow the best possible comparison with results exhibited by previous GVAR works, namely DdPS, I have resorted to the same data sources whenever feasible.

To fill missing observations, I adopted two slightly different methods depending on whether (i) "linking" to an available time series data or (ii) using growth rate data from

⁵⁵ A new dataset version, ranging from 1979(1)-2016(4), became available at GVAR site after the econometric work of the present paper having been finished. Anyway, as Portugal remains not include in the new dataset version, it would not dispense my work on data collection and treatment to ensure a consistency among all countries in the data sample. See https://sites.google.com/site/gvarmodelling/data. ⁵⁶ We have dropped Argentine due to data limitations and doubts arising about reliability of information publicly reported.

an appropriated variable. When linking to a pre-existing series, namely to the "2011 Vintage" dataset, I employed the recommended OECD method as described at http://www.oecd.org/std/methodology-linkingtimeseriesoecd.htm, by which the "linking factor" is built over the average of four successive (overlapping) quarters. When using growth rates data, the method employed was the so-called "backward extrapolation" by which the new (updated) series is back extended to fill the past missing observation simply based on the rate of change of available pertinent data.

Finally, a reference is made to acknowledge the detailed explanation provided by Smith and Galesi (2014, pp. 167-176) (Smith & Galesi hereafter) on structuring and compiling the GVAR database which has guided the buildup of this "2016 dataset".

Real GDP

Following the same procedure as in Smith & Galesi, countries were divided into two groups⁵⁷: those for which quarterly and seasonally adjusted data are available and those for which quarterly data are available, but not seasonally adjusted.

The first group comprises the following countries: (a) Australia, Canada, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Switzerland, UK, and United States, for which the International Financial Statistics (IFS)⁵⁸ data were used (Concept: Gross Domestic Product, Real, Seasonally adjusted, Index, 2010 = 100; Code: NGDP_R_SA_IX.Q); (b) Austria, Belgium, Denmark, Finland, Greece, Indonesia, Ireland, Korea, Saudi Arabia, Sweden, and Turkey for which the OECD data⁵⁹ were used (Concept: GDP, volume index, reference year 2010, seasonally adjusted; Code: VIXOBSA); (c) the Latin American countries: Brazil, Chile, Mexico and Peru, for which the Inter-Development American Bank (IDB) dataset⁶⁰ was used (Concept: GDP, Real Index, s.a.). Past missing observations were filled by: (i) linking to the "2011 Vintage" data as for Brazil (1979Q1-1995Q4), Chile (1979Q1-1989Q4), Indonesia (1979Q1-1989Q4), Italy (1979Q1-1989Q4), Saudi Arabia (1979Q1-1994Q4), and Turkey (1979Q1-1997Q4); (ii) extrapolating backward with recourse to the OECD

⁵⁷ There was a third group in Smith & Galesi, comprising the countries for which only annual data was then available, like Saudi Arabia, which is no more the case.

⁵⁸ IMF: <u>http://www.imf.org/en/Data,</u> downloaded on November 2017.

⁵⁹ OECD. Stat: <u>http://stats.oecd.org/</u>, downloaded on November 2017.

⁶⁰ Inter-Development American Bank: <u>https://data.iadb.org/.</u>

series "GPSA: Growth rate compared to previous quarter, seasonally adjusted", as for Austria (1979Q1-1987Q4), Belgium (1979Q1-1994Q4), Denmark (1979Q1-1994Q4), Finland (1979Q1-1989Q4), Greece (1979Q1-1994Q4) and Ireland (1979Q1-1996Q4).

The second group comprises the following countries: China, India⁶¹, Malaysia, Philippines, Singapore, and Thailand. For all of them the IFS data was used (Concept: Gross Domestic Product, Real, Index, 2010 = 100; Code: NGDP_R_IX.Q). To perform the seasonal adjustment, the EViews was employed, under the National Bureau's X12 additive option routine. Past missing observations were filled by linking to the "2011 Vintage". This was the case of China (1979Q1-1999Q4), India (1979Q1-1996Q3), Malaysia (1979Q1-1987Q4), Philippines (1979Q1-1980Q4), and Thailand (1979Q1-1992Q4). In regard to the more recent missing observations, the following procedures were adopted: (i) extrapolating forward with recourse to the OECD series "GPSA: Growth rate compared to previous quarter, seasonally adjusted", as for India (2016Q2-2016Q4); (ii) making use of data on quarterly real GDP sourced from respective Government Statistics' offices while having in due account being or not being already seasonally adjusted, as per China (2016Q2-2016Q4), Malaysia (2016Q2-2016Q4), Philippines (2016Q2-2016Q4), Singapore (2016Q2-2016Q4) and Thailand (2016Q2-2016Q4).

The real GDP per capita variable (in logs) is built by subtracting the log of each country population, normalized by the mean, from the log of the respective real GDP data, the latter collected as described above. The normalization of the country population was adopted to prevent discretionary alternating patterns of negative and positive figures for the real output per capita across distinct countries. The World Bank⁶² is the source for the population data (indicator: SP.POP.TOTL), which is reported yearly. The conversion to quarterly time series was undertaken by linear interpolation. In case of Germany, the population through 1990 refers to West Germany (as per the real GDP data series sourced from IFS), and the data obtained from the Eurostat⁶³.

Consumer Price Index

⁶¹ There are OECD Real GDP seasonally adjusted data for India however not as backwards as to link to the "2011 Vintage" series.

⁶² <u>https://data.worldbank.org/indicator/SP.POP.TOTL</u>, downloaded on 4 December 2017.

⁶³ <u>http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do</u> downloaded on December 2017.

For the CPI data I followed the same procedure as described above for GDP, i.e. making use of the updated data available from the IFS (Concept: Consumer Price Index, All Items, Index; code: PCPI_IX) and from OECD. Stat (Concept: Consumer Price Index, All Items, Index; Unit: Index, 2010=100), the latter in case of China and Germany after verifying that the data downloaded from the former source was incongruent with the reported indexation (2010=100), and also for the UK, as the IFS data was missing for the period 1979Q1-1987Q4.

For every series, I run the Eviews seasonal adjustment Census X12 procedure, under the additive option, i.e., the same as in Smith & Galesi, and having taken into account the respective results on seasonality tests. In accordance with the evidence found, the following countries CPI series were submitted to seasonal adjustment: Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Greece, India, Indonesia, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Peru, Philippines, Portugal, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, UK and United States.

Again missing observations have been filled by linking to the "2011 Vintage" dataset. That was the case of the following countries: Brazil (1979Q1-1979Q4), Chile (1979Q1-2008Q4), China (1979Q1-1985Q4), and Peru (1979Q1-1989Q4).

Equity Price Index

The price of equity is tracked by MSCI Country Index in local currency available from the Thomson Reuters Datastream. Data was collected in weekly frequencies and then quarterly averaged. Exceptionally the data source for Austria, India and Spain was the OECD. Stat (MEI: Share Prices, Index), as the data downloaded on November 2017 from the MSCI Country Index was not consistent with that reported in the "2011 Vintage" dataset as well as the observed in comparable economies, namely in the case of Austria (Germany, France or Belgium).

Missing observations were backfilled by linking to the "2011 Vintage" as for the following countries: Finland (1979Q1-1981Q4), India (1979Q1-1981Q4), Korea (1979Q1-1987Q4), Malaysia (1979Q1-1987Q4), New Zealand (1979Q1-1981Q4), Philippines (1979Q1-1987Q4), South Africa (1979Q1-1992Q4), Spain (1979Q1-1984Q4), and Thailand (1979Q1-1987Q4).

Exchange Rates

Our main source for exchange rates (units of foreign currency per U.S. dollar) was the Bank of England database (Concept: Quarterly average Spot exchange rate), because of its broader and historical coverage⁶⁴.

In regard to the euro area member states, the series were built by extrapolating backwards the euro exchange rate at its inception (1999Q1 for the 11 initial participants), or adoption (2001Q1 for Greece), using the respective national currencies exchange rates quarterly growth rate.

Missing observations were filled by linking to the "2011 Vintage", as for China (1979Q1-2005Q1), India (1979Q1-2005Q1), Korea (1979Q1-2005Q1), Malaysia (1979Q1-2005Q1), Singapore (1979Q1-1999Q4), Thailand (1979Q1-2005Q1), and Turkey (1979Q1-2005Q1).

When data was not available in the Bank of England database, I resorted to the IMF dataset (Exchange rate type: "Representative rates")⁶⁵, covering the period 2010Q3-2016Q4, back extended by linking to the "2011 Vintage" data. That was the case of the following countries: Brazil, Chile, Indonesia, Mexico, Peru and Philippines.

Short-term Interest Rates

The OECD MEI data (Concept: "Short-term interest rates, Percent per annum") was adopted for the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, New Zealand, Norway, Portugal, Spain, Switzerland, UK and the United States⁶⁶. When necessary, the backfilling of missing data was made by linking to the "2011 Vintage", as in the following cases: Austria (1979Q1-1989Q2), Finland (1979Q1-1986Q4), Netherlands (1979Q1-1981Q4); to IFF data (Concept: Interest Rate, Money Market Rate; Code: FIMM_PA.Q) for Ireland (1979Q1-1983Q4) and for Portugal (1983Q1-1985Q3)⁶⁷; and again to IFF data

⁶⁴ <u>https://www.bankofengland.co.uk/boeapps/database/</u>, downloaded on December 2017.

⁶⁵ <u>http://www.imf.org/en/data</u> downloaded on December 2017.

⁶⁶ By using the same data source for all euro area member states my aim is to ensure the best consistence on measuring comovements to identify proper insertion of each country into the Core or the Periphery delimitations. On the Denmark exchange rate regime, see:

http://www.nationalbanken.dk/en/monetarypolicy/implementation/Pages/Default.aspx On

⁶⁷ To avoid losing it entirely on the estimation of the Portuguese VARX* model, this series was completed backward through 1979Q1 based on the rate of change of the Portuguese long-term interest rate.

(Concept: Interest Rate, Deposit Rate; Code: FIDR_PA.Q), as for Greece (1979Q1-1994Q2).

For all other countries, I made use of the IFF dataset likewise in the "2011 Vintage". Therefore, IFF data were used for Chile, China and Peru (Concept: Interest Rate, Deposit Rate; Code: FIDR_PA.Q); for India and Turkey (Concept: Interest Rates, Discount Rate; Code: FID_PA.Q); for Mexico, Philippines, South Africa, Sweden, (Concept: Interest Rate, Treasury Bill Rate; Code: FITB_PA.Q); and for Brazil, Indonesia, Japan, Korea, Malaysia, Singapore, and Thailand (Concept: Interest Rates, Money Market Rate; Code: FIMM_PA.Q). When necessary, the backfill of missing data was ensured by linking to the "2011 Vintage", as in the following cases: Indonesia (1979Q1-1986Q2), Mexico (1979Q1-1987Q4), Peru (1979Q1-1987Q4), Philippines (1979Q1-2009Q1), and Thailand (1979Q1-1988Q4).

Long-term Interest Rates

Like in the 2011 Vintage, the IFS data (Concept: Interest Rates, Government Securities, Government Bonds; Code: FIGB_PA.Q) were used, namely for the following countries Australia, Austria, Belgium Canada, France, Germany, Ireland, Italy, Japan, Korea, Netherlands, Portugal, South Africa, Spain, Sweden, Switzerland, and the United States. When necessary, the backfill of missing data was made by linking to the "2011 Vintage", as in the following cases: Belgium (1979Q1-1979Q4), and Italy (1979Q1-1979Q4). For New Zealand, Norway, and the UK, the data is from OECD MEI (Concept: "Long-term interest rates, Percent per annum"). Missing data in Norway (1979Q1-1984Q4) was filled by linking to the "2011 Vintage".

Oil Price

The oil price is from the "Brent Crude | World series" (Code: POILBRE_USD.Q) sourced from the IMF's "Primary Commodity Prices" dataset. Missing observations (1979Q1-1979Q4) were filled by linking to the "2011 Vintage" database.

PPP – GDP Weights

The PPP-GDP country-specific weights are based on GDP data measured in Purchasing Parity Power in current international U.S. dollars, sourced from the World Development Indicators database. The data was downloaded from World Bank website (https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.CD), updated on 15

November 2017, and available for the period 1990-2016. To fill the gaps from 1989 back to 1980, I linked the new series to the "2011 Vintage data". In the case of the new countries, Denmark, Greece, Ireland and Portugal, the backward extrapolation was made using the OECD Dataset on GDP identically measured in U.S. dollars, current prices and current PPPs (<u>http://stats.oecd.org/#</u>), extracted on 23 November 2017.

Trade Matrix

Data source for construction of the trade matrices, the elements of which are defined by the average of imports and exports flows, were the same as in 2011 Vintage, i.e. the IMF Direction of Trade statistics (DOTs), available at <u>http://www.imf.org/en/Data</u>. Data on exports (code: TXG_FOB_USD.A) and imports (code: TMG_CIF_USD.A) for the period 1980-2016 was downloaded on November 2017.

To fill missing observations, the following sources and methods have been applied:

- a) The "2011 Vintage database" was used to fill the Belgium DOTs gaps (1980-1996).
- b) The missing observations in the Belgium DOTs data respecting to the new countries, i.e. Denmark, Greece, Ireland and Portugal, in the same period (1980-1996), were solved through backward extrapolation with recourse to the average of the rate of growth of trade flows of Belgium with its main partners (France, Germany and the Netherlands).
- c) The same method was applied to fill missing observations of Sweden DOTs with respect to Denmark, where the rate of growth of Sweden trade with its main partners (Germany, Norway and Finland) was assumed.
- d) In case of Turkey, in addition to the gap on flows with Belgium (1980-1986), there were observations missing in relation to Australia (1993), New Zealand (1980, 1993), South Africa (1993), Argentina (1984, 1992, 1993), Brazil (1992, 1993), Chile (1981, 1982, 1992, 1993), Mexico (1992, 1993), Indonesia (1993), Korea (1987, 1993), Malaysia (1992, 1993), Philippines (1980, 1981, 1992, 1993); those gaps were filled by simple extrapolation based on the rate of growth of Turkey with all the remaining countries in the data sample.
- e) The same criteria was applied to Saudi Arabia missing observations, namely with Belgium (1980-1986), Australia (1993), New Zealand (1980, 1993), South Africa (1993), Argentina (1984, 1992, 1993), Brazil (1992, 1993), Chile (1981, 1982, 1992,

1993), Mexico (1992, 1993), Indonesia (1993), Korea (1987, 1993), Malaysia (1992, 1993), Philippines (1980, 1981, 1992, 1993).

- f) The South Africa DOTs gaps, as spanning for all countries in the period 1980-1997, was filled with the "2011 Vintage" data; for the new countries, i.e., Denmark, Greece, Ireland and Portugal, that same gap was solved by backward extrapolation with recourse to the average rate of growth of all remaining countries.
- g) For Singapore, in addition to Belgium (1980-1996), the "2011 Vintage" data was used to fill the gap with Indonesia DOTs (1980-2002).

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ESSAY NO. 2

PUZZLING AROUND THE EURO EXPERIMENT^{*}

Abstract

This paper starts with the original but ever restated question: Is the European Monetary Union (EMU) feasible in the light of the optimum currency area (OCA) criteria? I move on to a comparative analysis of the impacts, between 1999 and 2016, of the euro experiment on the euro area members, clustered in the Core and in the Periphery. I find unexpected developments. A currency union feasible despite departing from the OCA assumptions. But adverse long-run effects on the less-developed members instead of catching up with the frontier. I suggest that the role of monetary policy might have been underestimated when assessing the EMU feasibility. I point to the interaction of a regime change in relative prices and institutional endowments to explain the divergence story in the Periphery.

KEYWORDS: Economic growth, Euro area, Institutional endowment, Labor market institutions, Optimum currency area. **JEL CODES:** B41, E65, F45, J48, N14, O43, O52.

^{*} An earlier attempt to understand the puzzling issues across the euro experiment had been undertaken when writing an essay in the coursework stage of the FEP PhD program. I would like to acknowledge the value of the critiques received from Professor Ana Paula Ribeiro, and the encouragement to pursue research in this field.

1. INTRODUCTION

A currency union in Europe, assembling a heterogeneous set of countries, has been taken, since the very beginning, a difficult project from a macroeconomic point of view. But it was advocated as a decisive step in the building up of the European Union $(EU)^1$. It was not without criticism, however, even at that level. Friedman (1997), for example, made a grim prognosis on the unity of the European countries by moving into a project arguably doomed to fail. The adjustment mechanisms to compensate for the loss of flexible exchange rates were non-existent among those countries. In the United States people "listen to the same television programs" across the fifty states – noted Friedman (1997) with his famous eloquence – while the Europeans were divided by different national cultures and jurisdictions. In the case of an asymmetric shock, the inter-regional movement of people and the "offsetting financial flows" from the federal to the state government jurisdictions will be inexistent in the European Monetary Union (EMU).

At the center of that discussion there was – and still is – a fundamental question: Did the EMU meet the optimal currency area (OCA) criteria such that would be wise for their participants to forgo the exchange rate adjustment mechanisms?

The global financial crisis of 2008 followed by the 2010-12 European sovereign debt crisis provided a test with unforeseeable intensity: A "sudden stop" crisis in the Periphery that led to the EU-IMF bailouts of Greece, Ireland, Portugal and Cyprus between May 2010 and March 2013; and which forced Spain to request financial assistance on July 2012 from the European Stability Mechanism (ESM). Nevertheless, the euro area did not break up. Conversely, we have seen a euro-outsider, the United Kingdom, taking the decision on 29 March 2017 to leave the European Union.

Is it the case that the EMU does not depart so much from the optimum currency area? Or does it depart and nevertheless the euro area arrangement is viable? This is the first question addressed in this paper. And I will argue that the EMU departure from the OCA assumptions

¹ The Maastricht agreement starts with the following statement: "This Treaty marks a new stage in the process of creating an ever closer union among the peoples of Europe".

might be even stronger than initially envisaged. Notwithstanding, the European currency union has been shown to be feasible, which might be better understood after acknowledging the role of the monetary policy as an adjustment mechanism.

The second question resumes the former but goes from the business cycle frame into the low-frequency domain and tackles the long-run impacts of the European Monetary Union. Disturbing cleavages in the economic performance of the euro area member states became apparent. Why did it happen?

Stylized facts elicited from the evolution of the macroeconomic variables and indicators of interest – the current account, unit labor costs, the euro-dollar nominal exchange rate, the total factor productivity (TFP), real output, and unemployment rate – put in evidence the cleavages among the euro area regions. Namely, between the Core, while divided by the Rhine River into the German-Core and the French-Core, and the Periphery. For the sake of conciseness, I will restrain the analysis to the major economies in each region. In the case of the Periphery, the focus countries are Italy, Spain and Portugal.

The rise of the unit labor cost in the Periphery, observed since the mid-1990s, in the runup to the euro adoption evidences an episode of overvaluation that lasted up to the European sovereign debt crisis of 2010. The overlapping enlargement of the current account deficits in Italy and, more pronounced, in Spain and Portugal suggest a connection of that episode with the credit boom triggered by financial integration. It should be noted that the relative price of the future to present consumption and inflation aversion in the Core lowered the real interest rate faced by the Peripherals. Furthermore, the elimination of the exchange risk and the financial strength of the European Central Bank (ECB) made way for the allocation of the high savings in the Core to the debt financing of the consumption in the Periphery.

The overvaluation in the Periphery is a well-known story, as well as the implied rise in the price of nontradables to tradables, and the likely impairments on output growth by diverting resources from a more efficient to a less productive sector (the nontradables).

However, the behavior of aggregate productivity and its different components in the Periphery make this story a more complex problem. Because there was not just a case of productivity slowdown: The variation of the TFP level became negative in the course of this lengthy episode (in Spain, for ex., from 1996 and up to 2014). Moreover, as the empirical

literature reviewed in this paper shows, the loss of allocative efficiency was much larger within-industry rather than between sectors.

Hence, looking for the ultimate explanations of the long-run cleavages across the euro area, in particular the underperformance of the Periphery, this investigation moves into two distinct domains and on their interplay. First, the institutional field because, as it is well known after the North-Acemoglu contributions, we need to uncover the structure of incentives embedded in the institutional frameworks to understand economic performance in the long run. Second, the study of the allocative efficiency evolution in the Periphery, by reviewing the pertinent empirical analysis (Calligaris et al. 2016; Dias et al. 2016; García-Santana et al. 2016; Gopinath et al. 2015; Reis 2013).

While pursuing the investigation in the institutional domain, I arrived at a new concept, the institutional endowment, built after adding an ingredient – reflexivity – to the standard definition of the institutional framework. Reflexivity is borrowed from the field of sociology and means the ability of a (modern) society to change its rules by rationalizing the course of its own experience (Giddens 1990). A summary review of Western Europe modern history and the examination of the labor market institutions across distinct European countries underpins the formulation of the institutional endowment concept. Furthermore, it made clear that the euro area participants that lost competitiveness are the ones characterized by less-reflexive institutional endowments.

The introducing of the institutional endowment concept opens a new perspective on the determinants of the long-run cleavages in the euro area and, more specifically, the channel that translated the euro-driven overvaluation episode into misallocation of resources. In the presence of labor market institutions, and correlated structures, biased against larger and more efficient enterprises, the over-priced wages (i.e., disconnected from productivity growth) leads to the allocation of resources to the smaller and less efficient enterprises. The technical explanation might be drawn from the celebrated span-of-control model of Lucas (1978), which shows that high wages imply a reduced optimal firm size for a given level of technology. Braguinsky et al. (2011) have developed an extended version of that framework, by modeling employment protection as a "gross tax on labor". From the latter, we can see that the impact of over-price wages on the firm size distribution are non-linear. Therefore, a

change in relative prices interacting with dysfunctional labor market and correlated distortions might have sizable effects in within-industries allocative efficiency.

Thus, the main contribution of this paper rests on placing *institutional frictions* at the center stage of the underperformance of the Peripheral countries after the euro and the implied regime change in relative prices.

The paper pursues as follows. Section 2 discusses the euro experiment from the business cycle perspective and, after reviewing the OCA assumptions, advances a possible explanation for the survival of an arguably non-optimal currency union. Section 3 uncovers the euro area fault lines from the long-run perspective, by eliciting stylized facts on the current account, unit labor costs, unemployment, output and the aggregate productivity growth; and examines the link with the changes in relative pieces. Section 4 introduces the concept of institutional endowment and reviews the evolution of labor market institutions in the European countries. Section 5 revisits the misallocation story in the Peripheral countries and suggests that the explanation for a fall in the observed aggregate productivity rests on the interaction of a regime change in relative prices with the institutional endowments. Section 5 concludes.

2. IS THE EURO AREA AN OCA?

The problem of an optimum currency area in its original formulation (Mundell 1961) arises when two distinct regions while specialized in different industries may or not have enough factor mobility to compensate for asymmetric shocks. When the answer to that question is affirmative, typically through the high degree of labor mobility, then those regions should adopt the same currency and profit from lower transactions costs, in particular by the elimination of currency risk.

Kenen (1969) has proposed a more stringent definition: a currency area would be optimum when the monetary and the fiscal domains overlap. Otherwise, the design of an appropriate policy mix will become impossible.

Thus, the Mundell criterion relies on the supply side of the economy – the ability to reallocate production factors across different regions. The Keenen criteria relies on the

aggregate demand and the implied fiscal integration, or, in the absence of it, business cycles synchronicity across the currency union participants.

Hence, when moving to empirical analysis, the feasibility of a single currency union is evaluated by examining (i) the correlation of supply and demand shocks across its member states and (ii) the existence of appropriated adjustment mechanisms to accommodate asymmetric shocks.

Unsurprisingly, the United States with its plurality of regions, more or less differentiated across states, but where free and easy movement of people and a high degree of fiscal integration provide a sound representation of a well-performing currency union. By that same reason, this natural experiment has served as a benchmark to evaluate the feasibility of setting up a currency union among the former member states of the European Economic Community (EEC), since its preliminary plans and discussions. An exercise that more often rendered critical assessments, even a "nightmare" (Krugman 2013), and which I summarize next by making a selective review of the pertinent empirical literature.

To start with, we should look at the possible asymmetric patterns at business cycle frequencies. Bayoumi and Eichengreen (1992) made a seminal contribution in this field, by applying a structural VAR analysis to the countries then integrating the European Economic Community and to the United States seven main regions, the latter used as a benchmark. After entertaining supply and demand shocks, the correlations between the anchor areas (Germany for the Europeans and the Mid-East for the United States) and the other regions in the respective continent were computed, as well as the impulse response functions. The results pointed to a clear distinction between the Core and the Periphery in the EEC strikingly throughout the same lines revealed many years later by the euro area cleavage in the sovereign debt crisis of 2010-12. Moreover, while the countries identified with the Core (Germany and its neighbors) showed a response to supply shocks quite similar to those of the United States regions, the countries then identified with the Periphery (the United Kingdom, Italy, Spain, Ireland, Portugal and Greece) exhibited a distinct pattern. It is worth noting that this exercise was redone 25 years later by Campos and Macchiarelli (2016), using the same methodology but now applied to the period 1989-2015, in order to see how the Core and Periphery distance had evolved after the euro adoption. The results corroborate the original findings of Bayoumi and Eichengreen (1992), although showing a smaller distance between the Core and the Periphery (Spain, Portugal, Ireland and Greece).

Using a wavelet analysis, which explores the spectral characteristics of time series, Aguiar-Conraria and Joana Soares (2011) also found distinctive patterns in business cycle synchronizations across the EU-15 countries – the first twelve euro area member states and the three countries that could have adopted the euro in 1999 (the United Kingdom, Sweden and Denmark) – which were very much in accordance with the results of Bayoumi and Eichengreen (1992). Looking at the countries present in both studies, we find the same closer synchronization between the Core members (Germany, France, Belgium, the Netherlands and Denmark), with the remaining countries falling apart (the United Kingdom, Italy, Spain, Portugal, Ireland and Greece), and even worse synchronized within themselves.

Those results are mutually reinforcing as the studies employed different methodologies, and track business cycles fluctuations through different macroeconomic variables, data frequencies and time windows. A structural VAR estimated over annual data on GDP and inflation for the period 1960-1988, in the case of Bayoumi and Eichengreen (1992); and the wavelet analyses undertaken over monthly data on the Industrial Production Index from July 1975 through May 2010, as for Aguiar-Conraria and Joana Soares (2011).

Furthermore, the idea of the endogenization of the currency union optimality has not gathered favorable evidence. In 2008, and after a critical review of empirical research, De Haan, Inklaar and Jong-A-Pin concluded that there was no clear evidence of convergence of the business cycles across the euro area. The results of more recent studies also go against the convergence towards a "European business cycle" (Ahlborn and Wortmann 2018; Bayoumi and Eichengreen 2018), even though changes were found in the euro area clustering after the financial crisis of 2018 and 2010-12. Namely, that the German business cycles moved apart from the previous delimitation of euro Core.

I address now the adjustments mechanisms. The role of labor mobility in the process of adjusting for asymmetric shocks grounds on the wage rigidities prevalent in all developed economies. Families hit by unemployment in a region disturbed by an idiosyncratic shock would not be forced to move out if a decrease in nominal wages could restore the labor market equilibrium. However, this is what happens – moving to other regions – in the United States

at a significant extent as shown by Blanchard and Katz (1992) after studying the labor market behavior across the U.S. states over the period 1970-1990. More specifically the authors found that while the rate of unemployment tended to converge to the national average, the employment in the regions hit by a downturn did not recover to the level showed before the slump.

However, the role of labor mobility on regional shocks absorption was put in second place to the *fiscal federalism* adjustment mechanism in the United States in an empirical study presented by Sala-i-Martin and Sachs (1991). The estimated size of the fiscal buffer was impressive: "one dollar reduction in a region's per capita income triggered a decrease in federal taxes in the neighborhood of 34 cents and an increase in federal transfers of about 6 cents" (Sala-i-Martin and Sachs 1991, 20). Moreover, when faced with a tail event like the Great Recession of 2008-09, the national buffer was even more impressive – estimated by Feyrer and Sacerdote (2013, 126) in the amount of "USD 0.83 for every dollar of GDP change". In 2013, Krugman compared the impacts of the real estate bubble bursting in Spain and Ireland in 2010 with a similar experience in the United States. When a downturn hit Florida in 2007, the automatic fiscal compensation received from other U.S. regions through Washington amounted to USD 40 billion considering tax payment reductions and increased benefits (unemployment insurance programs and food stamp payments), representing around 5% of Florida's GDP.

The bursting of the real estate bubbles in 2007-08 in the United States, followed by Spain and Ireland in 2010, put in evidence yet a third type of adjustment mechanism within a currency union: *bank flows* (Goodhart and Lee 2013). And again, the United States worked as a reference point, whereby (i) the nationwide banks provide the major banking services and (ii) the resolution mechanism and deposit insurance are federated². This means that when a region is hit by a crisis, like Arizona in 2007 in the study of Goodhart and Lee (2013), and

² The "Federal insurance of bank deposits" was first adopted by the Banking Act of 1933, became effective on 23 August 1935 and was considered by Friedman and Schwartz (1963, pp. 434-42) as one of the most important structural changes conducive to monetary stability by preventing the bank runs and the sequence of events leading to "drastic contractions in the money stock". It came as the response to the 1933 panic and in the context of landmark institutional changes made to the monetary system of the United States as a result of the Great Depression.

local banks, overburdened with non-performing loans, became unable to extend new credits, the financing of the regional economy is not interrupted. In that case, the local branches of national banks ensure the continuity of the credit flows. Moreover, when the bank resolution authority is ascribed to the federated level, the failure of a big regional bank does not impair the financial stability of the regional government. To illustrate the relevance of this point a reference is made to example offered by Shambaugh (2012) on the seizure by the Federal Deposit Insurance Corporation (FDIC), in September 2008, of the near collapsing Washington Mutual with almost \$200 billion in deposits. Furthermore, a process did not imply any fiscal cost even at the Federal Government level as the FDIC sold the failed bank to the JP Morgan Chase.

To sum up, and accordingly to the empirical studies reviewed, the euro area did not meet the OCA assumptions. Neither their participants exhibited business cycles aligned; nor the adjustment mechanisms required (labor mobility, fiscal integration and bank flows) were in place to compensate for relative prices disturbances and asymmetric shocks.

Nevertheless, the euro area survived the most stringent of the tests, the European sovereign debt crisis of 2010-12. Or, as in the words of Krugman (2013), "the mother of all asymmetric shocks – a shock that was, in a bitter irony, caused by the creation of the euro itself", p. 444.

As it is now well known, the intervention of the European Central Bank (ECB) was crucial and well succeeded in stabilizing the financial markets in the euro area; moreover, and as this paper also highlights in the next section, prompted an evolution in the nominal exchange rate of the euro aligned with the recovery of competitiveness in the Periphery.

Therefore, the role of the monetary policy, pursued by an independent and powerful central bank, as epitomized by the ECB, had possibly been missed when discussing the adjustment mechanisms in a currency union. But the "new-style central banking" as designated by Hall and Reis (2015) with large balance sheets is a recent phenomenon, which may explain the understatement of the monetary policy role in a currency union.

3. THE EURO AREA FAULT LINES

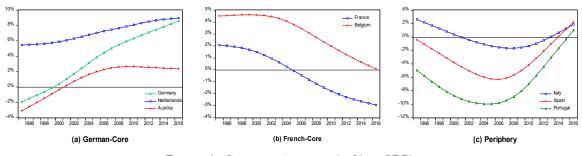


FIGURE 1. CURRENT ACCOUNT (IN % OF GDP): (a) GERMAN-CORE, (b) FRENCH-CORE AND (c) PERIPHERY. (Sample: 1995-2016)

Notes: Raw data sourced from AMECO, "Balance on current transactions with the rest of the world (UBCA)". Trend components: HP filtered annual time series data.

Some have argued, including Mundell (1998), that the setting up of the European Monetary Union would enhance labor mobility and capital markets inclusiveness by promoting integration among its member states. In terms of financial integration, the reality quickly surpassed the expectations: The elimination of the currency risk, the common monetary policy and the discount facilities provided by the ECB promptly closed the spreads between the German and the Peripheral sovereign bonds. But on the real side of the economy, the divergent paths on fundamental macroeconomic variables became apparent, namely those reflecting competitiveness and saving preferences (current account balances), labor market equilibrium (unemployment rate dispersion) and productivity growth (GDP per person employed and total factor productivity).

Those differentiate patterns, notably current account imbalances, have been commonly addressed, after the European sovereign debt crises of 2010-12, across a line dividing the euro area into the Core, anchored by German and including France, and the Periphery, clustering the Mediterranean members plus Ireland and Portugal. However, as Figure immediately suggests, when displaying the current account evolution throughout 1995-2016, a cleavage is still apparent inside the Core perimeter, between Germany and its closest neighbors (Netherlands and Austria), on the one hand, and France and Belgium, on the other hand. As such, I subdivided the Core into two clusters separated by the Rhine River (Brunnermeier et al. 2016, Introduction, loc. 155): the German-Core (Germany, the

Netherlands and Austria) and the French-Core (France and Belgium). Furthermore, I restrict the Periphery scope, for the sake of clarity, to its major countries: Italy, Spain and its Iberian neighbor, Portugal.

3.1 Current Account Asymmetries and Competitiveness Developments

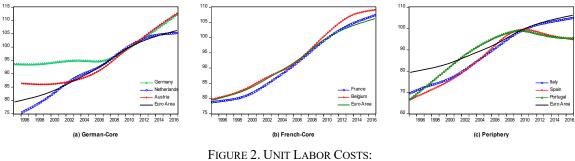
I return to Figure 1 which displays the evolution of the current account balance as a percentage of GDP for the German-Core, the French-Core and the Periphery from 1995 to 2016. Long-run behavior is the object of interest for the present work, rather than short-term fluctuations. Therefore, I removed the medium and high frequencies components by making use of the HP filter (Hodrick and Prescott 1997).

Three well-differentiated patterns emerge along with the euro adoption for the current account. For the German-Core, an ever increasing positive balance, reaching in the case of Netherlands and Germany a surplus between 8 and 9% of GDP in 2016. For the French-Core, a decreasing balance dropping to near -3% in 2016 in the case of France. For the three Peripheral countries, a fall into the negative range, more pronounced in Spain than in Italy, and even more in Portugal whose deficit dropped to -10% in 2005, however inflecting around 2010, and such that the three Peripheral countries show slightly positive balances after 2015.

Financial integration and the surge of capital inflows from the Core to the Periphery, in particular towards Spain and Portugal, associated with the misallocation of capital to less productive nontradables sector (Giavazzi and Spaventa 2010; Reis 2013) is the main explanation advanced for the current account imbalances observed in the Peripheral countries after the euro introduction.

The impact of that same "credit boom" (Lane 2012) on competitiveness is a correlated issue. The rise in the prices of nontradables, prompted by the jump in domestic demand(Kang and Shambaugh 2016; Shambaugh 2012), and the consequent increase in nominal wages led to the appreciation of the real exchange rate (Schmitt-Groh and Uribe 2013) and as such impinging a second-round impairment on the Peripheral countries external imbalances.

Figure 2 depicts the evolution of unit labor costs against a benchmark built as that same variable averaged across the euro members. By comparing the German-Core pattern, panel (a), with the Periphery, panel (c), we can see contrasted movements towards the average



(a) GERMAN-CORE, (b) FRENCH-CORE AND (c) PERIPHERY. (Sample: 1995-2016)

Notes: Raw data sourced from OECD, "Unit Labor Costs, Index, seasonally adjusted". Euro Area: 19 countries. Trend components from HP filtered quarterly time series data.

whereby the German-Core countries went upside down (decreasing unit labor costs), whereas the Peripheral countries described an ascending trajectory (increasing unit labor costs). In the case of Spain and Portugal, and more pronounced in the latter, the unit labor costs went expressively above the euro area average. After 2010 the diverging pattern changed signs: the Germany unit labor costs now getting higher than the euro area average while the Peripheral falling below the benchmark. More impressively still is the case of Spain and Portugal, for which we can see a sharp downward correction after a peak reached in 2009. It looks of interest to review and discuss what happened at the inflection point, which I will address next.

After 2008 the three Peripheral countries current account deficits started contracting along with the eruption of "sudden stop"³ successive episodes up to 2012 (Merler and Pisani-Ferry 2012; Reis 2013). Portugal was bailed out in April 2011 and submitted to the program managed by the *troika* (the European Commission, the IMF and the ECB)⁴, written under the IMF conditionality standards. Spain requested financial assistance in June 2012 from the European Financial Stability Facility (EFSF) to restructure its banking sector, which was granted again under specified conditioning, although with the structural reforms defined in the context of European semester recommendations, the so-called Macroeconomic

³ A "sudden stop" crisis (Calvo 1998) is characterised by an abrupt reversal of international credit flows occurring after a period of an extraordinary high volume of private-capital inflows.

⁴ Succeeding to the bailouts of Greece (May 2010) and of Ireland (November 2010).

Imbalance Procedures (MIP). Finally, Italy managed to avoid external assistance, given a lower net international investment position (-22.8% of GDP)⁵ in comparison to Spain (-85.6% of GDP) and Portugal (-100.1% of GDP)⁶, at the onset of the global financial crisis in 2007, and thus having time to benefit from the monetary policy changes adopted meanwhile by the ECB.

The most pervasive sign of the global financial crisis contagion to the euro area has been the widening of the sovereign spreads over the German Bund since 2008 and intensified after 2010 when the financial fragmentation of the monetary union became evident. Pressed by the deteriorating positions of the heavyweights Spain and Italy, the ECB adopted nonstandard measures, in particular the Securities Markets Programme (SMP), launched in May 2010 and the Outright Monetary Transactions (OMT), formally approved in September 2012 (Falagiarda and Reitz 2015; Szczerbowicz 2015). The latter was preceded, and implicitly announced, by Mario Draghi, the President of ECB, famous "whatever it takes" London remarks, delivered on 26 July 2012, which had a sizable and favorable impact on the Spanish and Italian spreads by neutralizing the looming concerns about the so-called redenomination risk, as highlighted by Altavilla et al. (2014).

The ECB's unconventional monetary measures have benefited all Peripheral countries, and ultimately ensuring financial stability to the euro area as a whole, as no other entity rather than the lender of the last resource would be able to do (De Grauwe 2013). But might also have spared Italy from an intervention in the style delivered to the other Peripheral countries. Thus, and even if an unintended consequence of the ECB non-standard measures, Italy avoided undertaking structural reforms, despite exhibiting a dysfunctional labor market⁷.

We should look again to Figure 1 and Figure 2 and compare the path described by the Italian trajectories after the 2008-12 financial crises (i.e., the global financial crisis of 2008 and the European sovereign debt crisis of 2010-12) against the ones exhibited by Spain and Portugal. The three Peripheral countries balanced their current accounts in around 2014,

⁵ Data: NIIP from the IMF, "International Investment Position by Indicator: Net International Investment Position (With Fund Record), US Dollars"; GDP from OECD, "CXC: Current prices, current exchange rates".

⁶ In 1998, the NIIP (% of GDP) was -14.6% for Italy, -21.2% for Spain and -24.0% for Portugal.

⁷ See, for example, Brunnermeier et al. (2016, Chapter 12, Loc. 4529) for a summary description of the "restrictive" Italian labor market.

however, while the unit labor costs of Italy kept going upwardly, the Spanish's and the Portuguese's sharply corrected after 2008. Moreover, whereas the unit labor costs correction in Portugal and Spain have been mainly the result of increased productivity at the cost of "large labor shedding" (Kang and Shambaugh 2016, p. 176), in Italy productivity kept falling in spite of higher unemployment.

Finally, it seems worth noting that Italian real output began to grow again in 2014. Hence, even if one could ascribe the Spanish and the Portuguese current account corrections to the domestic demand contractions, and labor market reforms, it would be more difficult to find an explanation for the Italian recovery without bringing into the stage a new actor. If productivity and nominal wages had not contributed, what made the Italian current account balance turn from a deficit into a surplus? The "price of foreign exchange" (Friedman 1953, p. 173), I suggest.

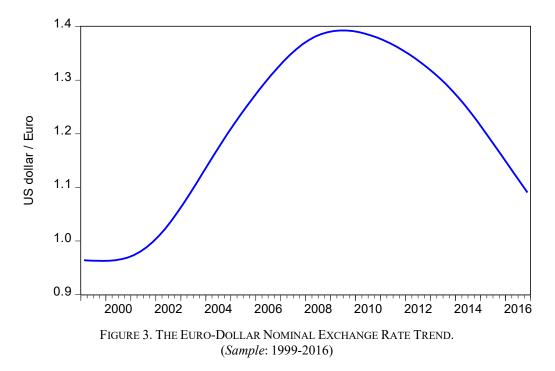
3.2 The Role of the Nominal Exchange Rate

The members of a monetary union where the common currency freely floats are not under the same regime as the one prevailing in the Bretton Woods system (1945-1973)⁸, whereby every country had its exchange rate fixed to the U.S. dollar, which in turn was convertible into gold.

When the euro nominal exchange rate declines (appreciates) the relative prices at every member state change over three different though interrelated channels. First, the price of nontradables to tradables decreases (rises). Second, the terms of trade with the rest of the world fall (increase) and exported goods become more (less) competitive. Third, across the monetary union (i.e., within the euro area internal market) home produced tradables become relatively cheaper (costly) than foreign tradables.

Competitiveness and the current account are improved (worsened) along those three ways. For example, and regarding the third channel, shoes produced in Italy and Portugal for German consumers tend to gain (loose) market share where competing with low-cost countries.

⁸ See Klein and Shambaugh (2012) for a comprehensive and updated review of exchange rate regimes in the Modern era.



Notes: Raw data sourced from ECB (ECB reference exchange rate, quarterly average). Trend component from HP filtered quarterly time series data.

Some relevant questions then follow: How is the "daylight saving time" switcher set ⁹, that is the euro exchange rate? Second, how might it lean towards the best direction given the external balances asymmetries between the euro area clusters? Third, despite all imperfections arising from the distance to the ideal conditions (the unmatched OCA assumption as suggested in section 2 above), does the euro exchange rate perform a relevant role on correcting for euro area member states' macroeconomic imbalances? Four, what might have been the role of nominal exchange rate on the run-up to the European sovereign debt crisis of 2010? I address here the third and fourth question and leave the others for future work.

Figure 3 depicts the euro-dollar exchange rate evolution since the monetary union inception in 1999 and up to 2016. As again we are more interested in persistent behaviors

⁹ The famous metaphor used by Friedman (1953, p. 173) to explain how quickly it becomes to coordinate a myriad of agents by changing a single price, the exchange rate. That is, like advancing the clocks in Summer time, instead of expecting that everybody adjusts their schedule to the longer daylight.

rather short-term fluctuations, high and medium frequencies components in the data were removed by applying the HP filter. We can see two distinctive spells: The euro rising until the 2008 global financial crises and afterwards falling against the U.S. dollar. In the second spell, the euro movement was aligned with the correction of Peripheral countries competitiveness imbalances. In the case of Italy, it has been the main adjustment instrument, as the unit labor costs were increasing even after the 2008-12 financial crisis as shown in Figure 2. Thus, the nominal exchange rate has worked as a proper "daylight saving time" switcher for the Peripheral economies. Having still in mind that their financial stress was putting at risk the survival of the European monetary union at risk, we may conclude that the depreciation of the euro has worked for the best interest of all member states.

It is more challenging to understand the underlying factors in the first spell (i.e., the euro appreciation path), but also more promising to explain the fault lines erupted between the Core and the Periphery along the euro experiment.

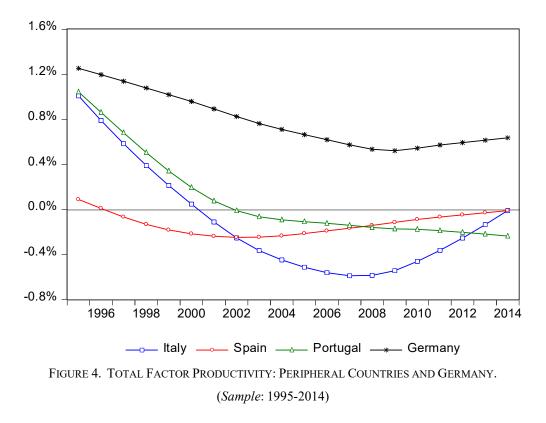
3.3 The Technological Shock

The deterioration observed in the Peripheral countries current account (Figure 1) in the runup to the European sovereign debt crisis of 2010-12 reflects a change in relative prices. Namely, the price of future consumption in terms of present consumption, as evidenced by a fall in the interest rates¹⁰; and the price of the home to the foreign currency, as shown by the sharp appreciation of the euro portrayed in Figure 3. The combination of both leading to the overvaluation of the price of nontradables to tradables, as discussed in section 3.1 above, and impairing competitiveness as evidenced in Figure 2.

The next question is the following: Did those changes in relative prices weaken the longrun economic growth in the Periphery?

Figure 4 displays the evolution of productivity in Germany and in the Peripheral countries (Italy, Spain and Portugal) from 1995 through 2014, measured by the annual change in the Total Factor Productivity (TFP) level. As before, the HP filter was applied to elicit trend movements. Overall, productivity growth was declining from 1995 and up to 2009. However,

¹⁰ See for ex. Shambaugh (2012) for an account on the downward path of Peripherals interest rates while converging to the German level, driven by the euro introduction.

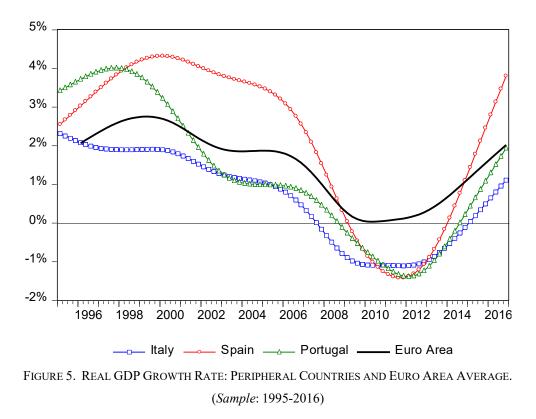


Notes: Raw data sourced from OECD: "Multifactor productivity, Measure: Annual growth/change". Trend components: HP filtered annual time series data.

while in the case of Germany the TFP growth rate remained positive all the way through, it turned negative for the three Peripheral countries since the euro inception (in the case of Spain, even earlier, as from 1997 onwards). Finally, the downward path was more accentuated in Italy and more persistent in Portugal.

Thus, empirical evidence points to a technological shock hitting the Peripheral countries in connection with the euro adoption. Conversely to the widely debated adjustment to asymmetric shocks at business cycle frequencies, the hypothesis of long-run diverging paths was never taken for discussion. Besides intriguing, that TFP evolution does not seem like a minor issue if one bears in mind that long-run income growth is mostly explained by the rise on productivity, rather than by factor accumulation (Caselli 2005; Hall and Jones 1999; Hsieh and Klenow 2010).

Hence it seems of interest to investigate the causes of the technological shock observed in



Notes: Raw data sourced from OECD: "Quarterly Growth Rates of real GDP, change over same quarter, previous year seasonally adjusted (GYSA)". Trend components: HP filtered quarterly time series data.

the Peripheral countries. To the best of our knowledge, the main explanations have pointed to the misallocation of the capital inflows surged after a regime change in financial integration (Gopinath et al. 2015; Reis 2013). The flood of cheap credit was beneficial to less efficient firms and brought into activity unproductive entrepreneurs, more extensively in the nontradables sector. Consequently, the expansion of low productive activities led to a fall in aggregate TFP.

The story of misallocation of capital is particularly evident in Spain, where we may observe an adverse shock in productivity, as shown in Figure 4, but the real output growth rising above the euro area average throughout the period 1999-2007, as depicted in Figure 5. The relation with a change in financial integration is suggested by the deterioration in the current account balances from 1996 to 2008 (Figure 1), reflecting a surge in capital current

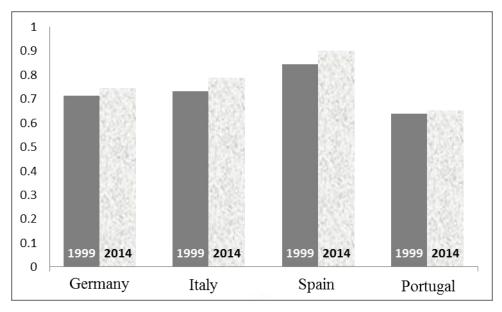


FIGURE 6. FINANCIAL DEVELOPMENT INDEX (FD INDEX). DATA: IMF

inflows¹¹. It should be noticed that the process of financial integration started in the mid-1990s when the advance towards the European Monetary Union gained traction, and shortand long-term interest rates for the Peripheral countries started converging to the low levels prevailing in Germany (see Fagan and Gaspar 2007).

The mechanism by which financial integration has translated into capital misallocation is a matter for an interesting discussion. From my point of view, it seems questionable the argument of less productive entrepreneurs crowding out the more productive entrepreneurs because the latter were credit constrained. In Aoki et al. (2010) it happens when the home economy financial system is less advanced. However, this was not the case of Spain, nor Italy, while there was another sort of credit frictions to consider and other channels by which the surge in capital inflows might have led to misallocation of resources and the consequent fall in average productivity. I address this subject pursuing different though interrelated directions. First, by reporting the level of financial development of the Peripheral countries. Second by exploring alternative sources of credit frictions. Third, by suggesting other drivers

¹¹ In 2007 the current account balance of Spain felt to -9.6% (AMECO); to be noticed that because of the HP filter smoothing effect the trough was depicted at -6.3% in 2006.

of misallocation related to the euro adoption, namely the change in relative prices. Forth, by making a selective review of the empirical studies on misallocation of capital across the Peripheral countries, both between sectors (tradables versus nontradables) and within-industry. Finally, by examining the interaction between the relative prices and the labor market institutions, after having introduced a new concept, the *institutional endowment*.

The financial markets of the Peripheral countries were not underdeveloped. According to the FD index (i.e., the new IMF financial development index¹²), Spain and Italy scored even above Germany at the time of the euro introduction in 1999, while Portugal was slightly below (see Figure 6). Therefore, one should look for other sources of financial constraints and incentive distortions possibly affecting the more productive entrepreneurs rather than to the level of the domestic financial development.

I suggest that asset specificity was at the root of the credit frictions, with asset specificity defined by the loss of productive value in case of redeployment (Williamson 1985, Chapter 2). As a general principle, the more advanced the technology employed by a firm, the more specific are their assets, including human capital; therefore, the lower its ability to leverage equity through asset collateralization¹³, and the more expensive debt financing will become. A Silicon Valley firm has been offered by Tirole (2006, Chapter 4) as an example of credit constrained by asset specificity. At the opposite pole are the real estate assets, both the residential and the commercial use, like the ones inflating the Spanish economy throughout the booming years of 1999-2007. Expanding in real estate development, property investment and consumption (home ownership¹⁴) is high leverageable through mortgage financing.

Those sort of financial constraints unambiguously favored the allocation of the flood of cheap capital to the sector of nontradables despite being less productive. But there was a second channel related to the same underlying factor – the financial integration into the monetary union – inflating the nontradables: a regime change in relative prices.

I have already reviewed in section 3.1 how a fall in the interest rate and the flood of capital originated in the Core led to a real overvaluation in the Periphery. This was not a singular

¹² See, for ex., Svirydzenka (2016) for a detailed explanation about this new index of financial development.

¹³ See, for ex., Tirole (2006, Chapter 4) on redeployability, asset specificity and collateralization worthiness.

¹⁴ Recall that in Europe and differently from the United States, in mortgage financing home buyers pledge their income to the lender in addition to the real collateral.

event or a new experience in the international macroeconomics domain¹⁵. The innovation rests on the recipients and the lenders sharing now the same currency and a common pool of savings, which provides for a long-lasting overvaluation episode. Therefore, we must examine the institutional environment to study the possible implications.

4. THE INSTITUTIONAL ENDOWMENT

In the long run the structure of incentives embedded in the social fabrics are determinants for the economic performance. I tackle now the euro area cleavages from an institutional perspective.

4.1 The Historical Legacy

I start by recalling the definition of a fundamental concept. The institutional framework or the social infrastructure, as designated by Hall and Jones (1999), means the institutions and government policies that shape the incentives faced by individuals and firms when accumulating human and physical capital. In the present context, the crucial questions are: How distinctive are the euro area countries institutions? Second, which are the relevant features in the social infrastructure when dealing with changes in relative prices?

This paper addresses those matters by advancing a new perspective on institutional change and proposes a new concept, the *institutional endowment*. To that end, an insight from the field of Sociology is pivotal, namely the dynamic property of *reflexivity* that characterizes modern societies. According to Giddens (1990, p. 38), "social practices are constantly examined and reformed in light of incoming information about those very practices", and that is the characteristic that mostly distinguishes modern from traditional societies. I suggest that the more (or less) a given society is endowed with that resource – reflexivity – the greater (smaller) will be its ability to rationalize adversarial experiences and overcome the burden of structural dysfunctionalities.

¹⁵ In a different context, Rebelo and Vegh (1995), for example, showed how financial integration might lead to a consumption boom, growing output and the appreciation of the real exchange rate.

Likewise in standard microeconomics, one does not need to explain how specific endowments have been achieved or accumulated. The point is recognizing when a given social infrastructure is more or less endowed with the reflexivity resource. In that sense, countries can be distinguished by their institutional endowments, which is defined as the social infrastructure augmented with the stock of the reflexivity resource. The more prevalent reflexivity is in a given society the more dynamical will be its institutional endowment, as for correcting incentive distortions. In other words, the richer the institutional endowment, the higher the proclivity of a given society to change its social infrastructure and making it better suited for human and physical capital accumulation. Finally, I advance two conjectures to be developed in future work. First, reflexivity is affine to human capital while not being subjected to diminishing returns; second, reflexivity and human capital are positively correlated.

Despite taking the institutional endowment as a legacy¹⁶, one should not be blind to its historical roots. Otherwise, it will be practically impossible to understand its features and implications. Hence, I will try to give a historical overview of the process that led to the social infrastructures prevailing in the countries of interest.

In a broader perspective, the Western European cultural heritage and its incentive structure have been built along a process that goes back at least to the high Middle Ages, between 1000-1300 (North and Thomas 1973). "With curious anticipatory precision", as observed by Judt (2011, p. 45), the Europe of the original six EEC member states – France, West Germany, the Benelux and Italy – corresponded, if excluded the Center and the South of Italy and included Catalonia, approximately to the Charlemagne's ninth century empire. One can still notice that the capital of the Charlemagne empire, Aachen (Aix-la-Chapelle), which lies on the tripoint of Germany, the Netherlands, and Belgium, is not far from Brussels, a mere 130 kms.

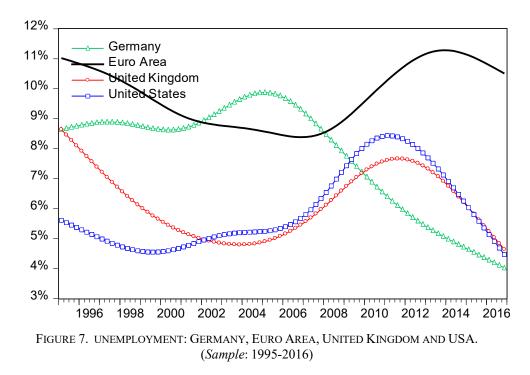
In the modern era, that is from the seventeenth century onwards, the evolution of the Western European common structures, driven by innovations mostly originated in the Netherlands and England (North and Thomas 1973, Chapters 11-12), underpinned the

¹⁶ The foundations of a dynamic institutional framework might be examined at the light of the determinants of institutional change, the latter as notably described by North (1990, Part II).

leading role taken by Western Europe in multiple fields. The fundamental conditions and incentives, with emphasis to secure property rights, have been laid down to ensure technical progress and economic growth. Ideas and institutions were the drivers of that process. Like "innovative betterments" (McCloskey 2016) or "accumulated beliefs" impacting on organized human activity (North 2006; Weber 1904-1905); or notable institutional changes as highlighted by North (1990) and Acemoglu and Robinson (2012).

However, there were also distinctive features and individual experiences, and the subsequent path-dependent evolutions, forging the more specific social infrastructures at the national level. A reference has already been made to a separation defined by the Rhine River (Brunnermeier et al. 2016). Other sources of historical diversity and distinctive cultural patterns are well documented in the literature. As among the *Atlantic traders* that led the global expansion of Western Europe between 1500 and 1850: Absolutists monarchies prevailing in Spain and Portugal, while they were already relatively constrained in Britain and Netherlands (Acemoglu et al. 2005). The notable Glorious Revolution of 1688 in England (North and Weingast 1989), as precursor of the modern rule of law primacy. The subsequent leading role of England and Netherlands on building up the modern financial institutions (Neal 1993). Or more broadly, the distinction within Western Europe, already apparent in the XVII century, between the North (mostly Protestant, using German languages) and the South (Catholic, using Latin-based languages), as pointed out by Judt (2011, Chapter 2).

After reviewing the historical background, we turn now the contemporaneous institutional patterns of differentiation that might be relevant for the matters of concern. Recall that in a currency union the endogenous determination of the real exchange rate is foregone at the country level. Thereby, the incentives structure of the local labor market gains special importance. Put in general terms, we may say that the more flexible or inwardly coordinated a domestic labor market is the less pertinent would be the "daylight saving time" switcher (Friedman 1953, p. 173) to solve for loss of competitiveness; as well as the inflation



Notes: Raw data sourced from OECD, "Harmonized unemployment rate, all persons". Trend components: HP filtered quarterly time series data.

mechanism to set real wages and restore employment at the desired level¹⁷.

Thus, it is of interest to make a brief incursion on the history of relevant experiences on the labor market institutions across the euro area members and other countries sharing the Western European foundations (e.g., the UK and Denmark). Furthermore, it may offer the opportunity to identify differences in the institutional endowment across the European countries precisely where it becomes particularly relevant for the performance of a currency union.

4.2 Labor Market Institutions and the Institutional Endowment

Labor market institutions are commonly summarized by the degree of employment protection, the unemployment insurance specification and the wage setting process. The three

¹⁷ As highlighted by Blanchard (2006) an expansionary [and possibly inflationary] monetary policy plays two roles when limiting the decrease in employment: by lowering real wages and by decreasing the real interest rate, the latter limiting capital accumulation decline in particular when a technological shock hits the economy.

dimensions are taken into consideration, however not necessarily all in every country examined below.

At the top of the experiments of interest, a reference is due to the unemployment evolution observed in Germany in the last two decades. And not only because of the contrast with the remaining euro area countries, but also by the distinctive response exhibited by the German labor market to the Great Recession of 2008-09 when compared with the United Kingdom and the United States (Pissarides 2013). Recall that markets are supposed to be more flexible in the Anglo-Saxons countries and, as it is well known, the fiscal and the monetary responses to the global financial crisis of 2008 were bolder and more promptly taken in the United States and the United Kingdom than in the euro area.

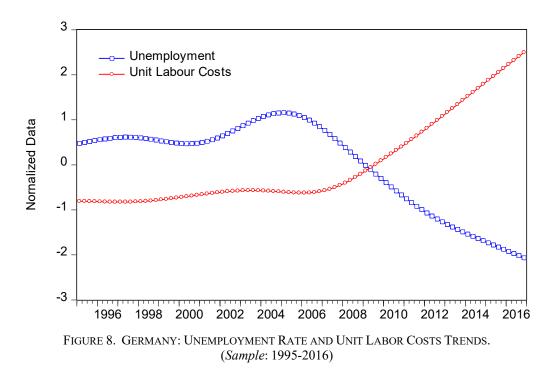
Figure 7 displays the trend of the unemployment rate, extracted with the HP filter from the respective quarterly data, for Germany, the euro area (19 countries), the United Kingdom and the United States throughout 1995(1)-2016(4). Four stylized facts become apparent: (i) the persistent and high unemployment in Germany up to 2005; (ii) a turning point in 2006 leading to downward sloping trajectory in spite of Great Recession (there was just a slight increase of less than 1% in 2009, here removed by the HP filter); (iii) a discrepant behavior in regard to the euro area average all over the observed period: the slope of the trajectories exhibiting opposite signs for most of the time, and unemployment rates falling quite apart at the end: 3.9% (Germany) versus 9.7% (euro area) in 2016; (iv) while the Great Recession strongly hit the United Kingdom (the unemployment rate reached 8.4% in 2011 versus 5.0% in 2007) and the United States (9.9% in 2009 versus 4.4% in 2007) it almost did not affect Germany.

We should still take into account that the correction observed in the German unemployment took place in the context of low and decreasing inflation, averaging 1.4% per annum from 2005 until 2016. Therefore, I suggest that the value of around 4% of unemployment rate observed at the end of this process may reflect not only that the German effective unemployment rate has become closer to the natural rate, but even that the latter had decreased along the way. Arguably, this view should be tempered by the output effect of the euro exchange rate depreciation after 2009. Recall that Germany is an export-oriented economy and as shown in Figure 1 its current account surplus reached almost to 9% in 2016.

But is worth noting that its unemployment correction had started when the euro exchange rate was at higher marks. Moreover, there are earlier microeconomic empirical evidence pointing to a change in the Germany labor market, namely the dynamics exhibited by the Beveridge curve, which shifted inwards and turned from almost flat shaped to downward sloping around 2007-08 (Pissarides 2013).

We must go back to the Germany unification process to find out the origins of such extraordinary evolution. In July 1990 East Germany was fully integrated into the Federal Republic of Germany and as such entitled to the generous West Germany social insurance system. But, on the other hand, becoming exposed to international competition despite inheriting a much less competitive economy from its former central planned system. In 1991 labor productivity in East Germany had near collapsed, while the West's level (Wunsch 2005). Thus, the economy of East Germany had near collapsed, while the West's was benefiting from a demand shock boom in the early 1990s, although of short duration given the burden of the vast transfers needed to sustain the Eastern side and the effects on German exports of global recession arising at that same time. As still noted by Wunsch (2005), unemployment that was already high in East Germany, 10% in 1991 (it would rise up to 20% in 2005), increased also in the West Germany, reaching 8% in 1993, after a drop of 2.8% in the output in that same year. After those shocks, and given labor market rigidities, unemployment in Germany became high and persistent, rising to 11% in 2005, notoriously above the level observed in the euro area, as we can see in Figure 7.

Meanwhile, Germany had started to reform its labor market institutions and policies. In 1998 the old legislation was replaced by the "Social Code III"; in 2002 the Job-AQTIV was launched to improve Active Labor Market Policy (ALMP) measures; and from 2003 to 2005 the impressive Hart programs (I-IV) were implemented in four waves across all relevant dimensions (Rinne and Zimmermann 2013; Wunsch 2005). More flexibility was introduced, by relaxing employment protection, softening regulation on fixed-term and on part-time contracts, and making working time more manageable (time accounts, labor hoarding, etc.). Incentives for job searching were improved by lowering replacement rates and benefit duration. Active labor market policies (ALMP measures) were redesigned to enhance job seekers qualifications and the matching process.

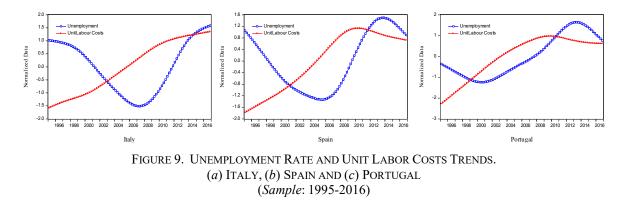


Notes: Raw data sourced from OECD: "Harmonized unemployment rate, all persons", "Unit Labor Costs, Index, seasonally adjusted". Trend components from HP filtered quarterly time series data; plotted after normalization.

Across that same period, or even earlier, that is since the mid-1990s, a wage moderation stance has been in place. Different while not contradictory explanations were advanced. Like changes in the waging setting process due to a decline in the labor unions power (Akyol et al. 2013). Or the restraint in the union's bargaining stance by taking into account the likely loss of jobs for the *insiders*. Anyway, the point is that the German unit labor costs were kept flat from 2000 and up to 2007, as we can see in panel (*a*) of Figure 2, while for the euro area they were ever increasing (likewise for the United Kingdom and the United States, even if not shown here).

Looking now at Figure 8, where German unit labor costs and unemployment rate trends are plotted together, after having been normalized, we can see that labor costs have been kept strictly controlled up to the point the unemployment had not started relieving. Moreover, that pattern was already apparent before the Hartz programs implementation.

Given the empirical evidence, I suggest that a combination of all mentioned factors - a



Notes: Raw data sourced from OECD: "Harmonized unemployment rate, all persons", "Unit Labor Costs, Index, seasonally adjusted". Trend components from HP filtered quarterly time series data; plotted after normalization.

cooperative prone culture, changes in labor market institutions, the design and implementation of new labor policy measures (ALMP) – led to the observed adjustment process in Germany employment, after the disturbances triggered by the unification and the world recession in the early 1990s. I further suggest that while being inwardly motivated – there was no external power imposing structural reforms – that process reflected a high reflexive institutional endowment.

I tackle now the responses of other euro area members hit by high unemployment episodes, such as the Peripheral countries. In Figure 9 their unemployment rate and unit labor costs trends are plotted together, after normalization, to provide a better perspective as depicted in Figure 8 for Germany. Thereby, we can see that (i) the unit labor costs of Spain and Portugal clearly adjusted downwards after the 2010-12 European sovereign debt crisis, but not Italy's, which kept rising; (ii) unemployment decreased in Spain and Portugal along with the downward adjustment of the unit labor costs, while was increasing in Italy.

The contrasting evolution of the labor market equilibria after 2010-12 between Portugal and Spain on the one hand, and Italy on the other hand, should be evaluated in the light of the conditionality imposed to the former by the financial assistance programs as mentioned in section 3.1, while Italy was spared from any external interference. A significant package

of measures in the adjustment programs focused on the reform of labor market institutions¹⁸. It is worth noting that labor markets were dysfunctional in both Iberian countries. The Spanish characterized by a high structural rate of unemployment: around 20% in 1995 and again in 2016, even if the effective rate adjusted downward (8% in 2007) during the booming years of the euro experiment, when cheap real estate financing inflated the nontradables output. The Portuguese showing increasing unemployment since the euro inception: from around 5% in 2000 to 9% in 2007. And both countries evidencing high labor market segmentation.

We should not ascribe all the credit for the relief in the labor costs to the reforms of the labor market institutions: Fiscal adjustment and the corresponding downward pressure on nontradables have for sure played a role. However, there is a remarkable feature in this process to highlight. As opposed to Germany, where high and persistent unemployment had led to an *endogenously* determined regime change in the labor market institutions and behaviors, the reforms in Spain and Portugal have been *exogenously* imposed. And in Italy, a country kept immune from external assistance and the implied structural changes, no reforms at all were implemented.

There are earlier experiences in Europe of endogenously determined reforms which have had a significant impact in structural unemployment. Namely, the pro-market transformation led by Margaret Thatcher in the United Kingdom (Card and Freeman 2004; Siebert 1997) and the "flexicurity" arrangement in Denmark (Bredgaard et al. 2005; Westergaard-Nielsen 2001). I will not discuss here the specificities of those reforms. They were diverse in scope, in deepness and in the informing principles, dependent as they were on each country's social

¹⁸ The Economic Adjustment Programme was prepared by the *troika* consisting of the European Commission, ECB and IMF, after a request of financial assistance made by Portugal on 7 April 2011. Regarding the labor market reforms, the stated objectives were to improve flexibility by reducing employment protection, e.g. excessive severance payments; making wage setting less rigid, e.g. limiting union coverage (in case, by reviewing the criteria for the extension of collective agreements); to promote job search effort by decreasing unemployment benefits, which were misaligned with the European averages; make working time arrangements more flexible and overtime payment less expensive. It should be noticed that employment protection for permanent contracts in Portugal was the highest among the developed countries in 2011, accordingly to OEDC classification criteria, "Strictness of employment protection – individual and collective dismissals (regular contracts), OECD.Stat.

infrastructure. High centralized collectively bargained systems work well in more cooperative society such in the Scandinavia countries¹⁹ and Netherlands (Nickell et al. 2000). Market-based wage setting arrangements are associated with higher employment rates in the post-Thatcher era in the United Kingdom, for example. What matters here is the reform proclivity, the reaction or the absence of it to past and ongoing adversarial experiences. In short, the degree of reflexivity in a given society, and the so-revealed institutional endowment.

5. THE MISALLOCATION STORY REVISITED

I return now back to the technological shock addressed in section 3.3. An episode of overvaluation driven by a shift in home demand, such as that one described in section 3.1, likely harms aggregate productivity growth by diverting resources from the tradables sector to the less efficient nontradables. However, empirical analysis in the field of growth accounting, or more specifically in allocative efficiency, has shown that the misallocation of resources in the Peripheral countries was highly significant within-industry and weighing much more in the observed TFP deterioration than the between-sector component. This pattern makes the identification of the mechanics behind the loss in aggregate productivity much more difficult. I summarize next the main findings on the allocative inefficiency literature for Italy, Spain and Portugal; and I discuss its possible sources, where the previously introduced concept of institutional endowment might become useful.

Calligaris et al. (2016) found a substantial increase in misallocation both in manufacturing and in services since 1995 and have shown that it accounted for a large fraction in the Italian aggregate TFP slowdown. By applying the Hsieh and Klenow (2009) methodology²⁰, they estimated that productivity in 2013 would be 18% higher in manufacturing and 67% higher

¹⁹ According to Olson (1982, Chapter 4), the fact that Scandinavian countries exhibit a high trade union density makes the respective unions internalize the impact of their bargaining stance on the overall course of the economy, including in a long-run perspective (economic growth). This follows from the logic of collective action theory by which "encompassing organizations" rather than narrow special-interest ones face incentives to account for the consequences of inefficient policies.

²⁰ In Hsieh and Klenow (2009) methodology, the misallocation of resources is estimated by computing the dispersion of marginal products of capital and labor across firms.

in non-manufacturing if the allocative efficiency prevailing in 1995 had not been degraded. The analysis was conducted across regions, firm sizes and industries; in any case, the between misallocation component was small when compared with the within component. It should be noted that the segment of big firms in the Northwest (i.e., the richest region in Italy) exhibited the more pronounced increase in misallocation. In 2018, Fadi et al. redid the same exercise, though being more specific on the more tainted segments, namely the "firms that have large share of workers under the Italian wage supplementation scheme, that are family owned, or financially constrained" (p. 4). Furthermore, the authors pointed to "the presence of sluggish reallocation of resources" as the source of heterogeneity in the ability to respond to "frontier shocks" (Fadi et al. 2018, p. 4).

In 2017, Pellegrino and Zingales had already taken "frontier shocks", namely the Information and Communication Technologies (ICT) revolution²¹, and its interaction with a dysfunctional management system, based on loyalty instead of on merit, to explain the productivity slowdown observed in Italy since the mid-1990. Ultimately, the "institutional environment" underlined the bias against meritocracy, the authors noted, because "familism and cronyism" were the most rewarding management attributes to deal with a patronage-based banking system, an inefficient legal system, the prevalence of tax avoidance and bribes.

Gopinath et al. (2015) analyzed productivity evolution in the manufacturing sector in Spain between 1999 and 2012 based on a model combining credit frictions and the framework developed by Hsieh and Klenow (2009). By using a calibrated model, the authors were able to show the relation between the real interest rate decline since the mid-1990s and dynamics of the marginal return on capital dispersion and its detrimental effect on the aggregate TFP evolution. Moreover, they showed a differentiated pattern between countries in the North and the South of Europe, the latter supposed to represent "less well-developed financial markets" (p. 4).

García-Santana et al. (2016) extended the misallocation analysis to all sectors in the Spanish economy, over the period 1995-2007. After employing several measures to compute allocative efficiency, including again the one proposed by Hsieh and Klenow (2009), they

²¹ Based on Bresnahan et al. (2002), the authors highlighted that "American firms were able to take advantage of the Information and Communication Technologies thanks to the meritocratic management practices", p. 2.

found that the within-industry component explained 89% of the decline in TFP over the 1995-2007 period. The losses in productivity driven by misallocation were more severe in constructions and services, but even lower also felt in the manufactory sector. However, differently from Gopinath et al. (2015), they did not found any significant connection with financial dependence; however, "the deterioration in allocative efficiency was 22.6 points larger in sectors influenced by regulations" García-Santana et al. (2016, p. 24). It is worth noting the evidence gathered on the firm size channel of misallocation: The estimate of the OP covariance term, which capture the relation between size and productivity (Olley and Pakes 1996), dropped from 0.30 in the observation window 1995-2000 down to 0.21 in observation window 2001-2007²².

Dias et al. (2016), employing the Hsieh and Klenow (2009) methodology, investigated the misallocation in Portugal over the period 1996-2011 and found that "within-industry misallocation almost doubled between 1996 and 2011" (p. 48). Moreover, deteriorating allocative efficiency, which was mostly driven by the service sector, might have "shaved around 1.3% of annual GDP growth" in that same period (p. 48). Regarding the source of distortions, a detailed description was presented on economic policies that overprotected and subsidized SMEs.

In 2011, Braguinsky, Branstetter and Regateiro had already provided a technical explanation for the bias towards SMEs in Portugal (i.e., against the larger and more efficient firms) and shown its implication on aggregate productivity. The shift of the firm size distribution to the left, observed for more than 20 years, was an old rooted problem, stemming from the prevailing labor market institutions. More specifically, employment protection, for which Portugal ranked the highest score among the Western European countries. The framework is based on the Murphy et al. (1991) variation of the seminal work of Lucas (1978) on firm size distribution. By modeling the costs induced by employment protection as a tax on labor, T, the so augmented span-of-control model shows that in equilibrium a higher T not

 $^{^{22}}$ For a benchmark, notice that OP covariance term for labour productivity averages 0.51 over 1993-2001 within the U.S. manufacturing industries. in the US is 0.51 versus 0.20-0.30 for Western European countries (Bartelsman et al. 2013, pp. 310-11).

only leads to smaller sizes of all existing firms but induces entry by entrepreneurs with relatively lower ability (self-employment included). Hence, the outcome of a leftward shift of the firm size distribution and the consequent fall in aggregate productivity.

Strict employment protection was also prevalent in Spain and Italy before the euro adoption. The Spanish labor market was high dysfunctional as revealed by the structural rate of unemployment (around 20% in 1995). Concerning Italy, the reforms undertaken in the mid-1990s were more or less restricted to the flexibilization of short-term contracts which led to a dual labor market and where the old jobs have been kept highly protected (Calligaris et al. 2016).

Therefore, the three Peripheral countries entered the monetary union exhibiting heavily taxed employment in the sense of the augmented span-of-control model. I have suggested in another work more strictly focused on the dismal performance of the Portuguese economy in the euro²³ that, because of the *non-linear effects* of the "gross tax on labor"²⁴, the impact of overvaluation on the larger and more efficient enterprises was more than proportional. I argue that this mechanism stands for the possible link of the euro adoption and the adverse technological shock observed since the mid-1990s, almost simultaneously, in the three Peripheral countries.

To sum up, aggregate productivity has taken a symmetric dismal course in Italy, Spain and Portugal along the process of the euro adoption, which started in the mid-1990s. The three countries were simultaneously hit by an overvaluation shock while sharing a nonreflexive "institutional endowment", where some remarkable features were common (e.g. at the labor market institutions level) and others more specific (e.g. corporate management and structure unfitted to the ICT revolution, in Italy). Under the augmented span-of-control model of Lucas (1978), over-priced wages imply a decrease in the firm optimal size. The empirical analysis conducted by García-Santana et al. (2016) on Spain offers a perfect illustration on this point, because, diversely from Italy and Portugal, the Spanish economy boomed in course of the euro-led financial integration episode. The shift in the demand has not been met by an

²³ "Portugal in the Euro, a GVAR approach".

²⁴ For the non-linear effects of the "gross tax on labor", see Braguinsky et al. (2011, Section 4.1.2).

increase in the production of larger and more efficient firms, but by the smaller and less efficient enterprises, as shown by the estimated fall in the OP covariance term.

It remains to be said that the explanation based on the interaction of the euro-driven overvaluation with the firm size distortions, embedded in the "institution endowment", does not preclude other shocks or channels. The interaction of the ICT shock with the management structure in Italy, for example, might have played an overlapping role. Although, two comments are offered in this respect. First, the ill adaptation to the ICT revolution likely explains a slower, but not a negative, productivity growth rate. Second, the underlying distortion is clearly embedded in the Italian institutional framework. Pellegrino and Zingales (2017), have already suggested that connection. Considering its persistence, this paper suggests an additional ingredient: the implied low-degree of reflexivity in that same institutional framework.

6. CONCLUSIONS

Puzzling developments in the euro experiment were the object of inquiry. First, the survival of the euro area despite not fulfilling the OCA assumptions. Second, the observed diverging path in the long run where catching up was expected from the integration of the less-developed economies in more inclusive and advanced institutions.

In what concerns the OCA issue, I suggest that monetary policy might have been underestimated by the earlier discussions on the adjustment mechanisms in a currency union, given the still unknown power of the "new-style central banking" (Hall and Reis 2015). For the gloomy long-run performance of the Peripheral countries addressed in this paper – Italy, Spain and Portugal –, I emphasize the role of relative prices and institutional frictions.

An episode of overvaluation was observed in the Peripheral countries, starting in the mid-1990s and going through the European sovereign debt crisis of 2010-12. Why so long? I suggested an explanation. Diversely from demand shocks propelled by typical financial integration, this time debt financing was ensured in a shared currency, and the capital inflows were drawn from a common pool of resources. Thus, the change in relative prices of future to present consumption facing the Periphery had deep foundations. But, how has that episode of overvaluation hindered economic growth?

Overvaluation, the increase in unit labor cost or the change in the relative price of nontradables to tradables are interrelated macroeconomic events. The implications over economic growth when resources are diverted from a more to a less efficient sector are straightforward. But the story of underperformance in the Periphery was trickier. First, there was not just the case of a slowdown in aggregate productivity evolution, but even a TFP negative growth over a long period. Second, the within-industry misallocation of resources was much higher than the one measured between sectors. Thus, this inquiry pursued with the following question: Which channel translated the observed overvaluation into the misallocation of resources within-sectors?

A comparative analysis of the evolution of the labor market institutions (e.g. labor protection) across a selected group of Western European countries revealed the diversity in their institutional frameworks. Furthermore, those institutional frameworks were endowed with different degrees of *reflexivity* (Giddens 1990) – that is the proclivity to change the rules after revealed dysfunctionalities.

Overvaluation interplaying with institutional frictions in less-reflexive institutional endowments diverted the allocation of resources from larger to smaller and less productive enterprises. This mechanism and its deep foundations solve the intriguing problem of the long-lasting real impacts of a change in a "mere" monetary framework. In this case, the connection of the euro introduction and the correlated underperformance in the Periphery.

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ESSAY NO. 3

Dynamical Analysis of the Euro Area Using Oil Shocks – A GVAR Approach*

Abstract

We return to oil shocks to study the evolution of the economic structures among the euro area member states as the euro experiment moves ahead. Are oil shocks still a meaningful conceptual experiment despite the Great Moderation and the prevalence of oil demand shocks in the last two decades? By modeling oil prices as a "dominant unit" in a GVAR framework, this paper restates its usefulness to conduct dynamic analysis. Both the positive initial impact of oil price surges driven by global demand and the lagged adverse effects on the output of net energy importers are captured. Noticeably for Germany, which output responses to global shocks further, and surprisingly, show to be more aligned with the Periphery rather than with the Core. Meanwhile, the Peripheral economies became less heterogeneous; although, the evidence for closer resemblance with the Core is mixed. Finally, the empirical results point to a persistent sluggish adjustment of inflation in the Periphery.

Keywords: Euro area, Germany, Global VAR, Oil shocks. **JEL Codes:** C51, E32, F45, F47

^{*}This is a joint work with my PhD co-supervisor, Professor Luís Aguiar-Conraria, who has suggested using oil shocks and the GVAR methodology to study the evolution of the euro area economic structure across its members.

1. INTRODUCTION

The euro area has completed 20 years since its inception, viz. the irrevocable fixing of the exchanges rates for the eleven initial members on 1 January 1999. For the Peripheral countries, the movement towards financial integration had started even earlier, in the mid-1990s. Thus, it seems pertinent to question if the fundamentals for the adoption of a common currency have strengthened in the meanwhile.

Measuring business cycle synchronization is a well-known method to address the problem, but the findings in that strand of the literature are ambiguous or even contradictory. In a critical review of the empirical research, De Haan et al. (2008), for example, concluded that there was no evidence of convergence of business cycles across the euro area countries. More recent studies present mixed results: either against the convergence towards a "European business cycle" (Ahlborn and Wortmann 2018) or "only a limited support" in that direction (Bayoumi and Eichengreen 2018); or showing increasing business cycle synchronization after the euro introduction (Aguiar-Conraria et al. 2013; Campos et al. 2019).

The matter of concern is the optimality of a single monetary policy, which imply the stabilization of both output fluctuations and inflation. Therefore, we restate the synchronicity problem in the following terms: Did the economic structures of the euro area countries converge as the euro experiment advanced?

We suggest that the economic structure must be taken in a broader sense when discussing the membership in a currency area. In common usage, it refers to "regional specialization" (Krugman 2001). We further consider the institutional framework. If the labor market institutions, for example, were similar across the members of a currency union, the effects of an adverse supply shock on employment, or the output gap, would fall apart less. The same might be said about the impact on inflation of a positive demand shock.

By using oil shocks – a common global variable – we can disturb both variables of interest, the real output and inflation and compare the country-specific responses. Hence, this paper employs oil shocks as the "conceptual experiment" ¹ to test the economic

¹ We borrowed the "conceptual experiment" expression from Koop et al. (1996) in the context of impulse response analysis.

structures of the euro area countries.

This is not new of course. In 2009, Peersman and Van Robays already employed oil shocks to investigate asymmetries across the euro area members. Although our contribution is distinctive in two fundamental aspects. First, using a different methodology, namely the global VAR (GVAR). Second, by seeking to evaluate the convergence in the behavior of the variables of interest as the euro experiment moves ahead.

But again, using the GVAR² to study the euro area is not new in the literature. The empirical model adopted in the present work is based on a version built by Dees et al. (2007) precisely for "Exploring the international linkages of the euro area". However, whereas the euro area was then taken as a single region, this paper addresses each member country individually, as well as the aggregates for the euro-area Core and the euro-area Periphery regions. Furthermore, the price of oil was included by Dees et al. (2007) in the list of the endogenous variables of the U.S. "conditional model"³. Here we make use of an alternative specification where oil prices are defined as a "dominant variable" in a sense later advanced by Chudik and Pesaran (2013). Accordingly, in this paper, the oil prices are framed in a "marginal model" and enter as weak exogenous in the U.S. model, likewise in all countries in the sample. This option entails a remarkable distinction when conducting the impulse response analysis. A positive shock to oil prices entertained in a "marginal model" means a rise in the price of oil. That same shock is a mere disturbance of the error term of the oil price equation in the U.S. model when oil prices are framed in a "conditional" model.

All euro area members are net energy importers. Therefore, as argued by Blanchard and Gali (2007), a rise in oil prices, even when driven by a shift in global demand, turns into an exogenous adverse shock to those economies. However, we should not disregard that an "oil demand shock" (Kilian 2009), whereby conveying the signal of an increase in global demand, might prompt different responses across the European economies. See, for example, the case of Germany and Portugal, where the former exports to the large emerging and transition economies, notably China, while the latter is exposed to its

² Chudik and Pesaran (2016) offer a concise description of the GVAR methodology and a review of the empirical work undertaken since its introduction by Pesaran et al. (2004).

³ See, for example, Garratt et al. (2006, pp. 58-9) for the definition of "conditional" and "marginal" models.

competition on less advanced manufactured products (e.g., textiles). By modeling the oil shocks as a "dominant unit" in the GVAR framework, the adverse impact of an increase in oil prices on energy-importing countries is captured without missing the possible favorable comovements between the domestic GDP and its foreign counterparts. On one hand, the adverse exogenous effects *a la* Blanchard and Gali (2007) are identified by the direct "causal nature of the common variable" (Chudik and Pesaran 2016, p. 170). On the other hand, the positive effects of an oil demand shock *a la* Kilian (2009) is "integrated out" throughout the properties of the generalized impulse response functions (GIRFs)⁴ adopted by the GVAR methodology. Subsection 3.2 and Appendix B provide the technical details.

That said, the evolution of the composition of oil shocks over our sample period, 1979Q2-2016Q4, become relevant to interpret the results of the empirical analysis. The same is true for the changing patterns on the interaction of oil shocks with the macroeconomic variables of interest since the mid-1980s, that is along the "Great Moderation". Therefore, when defining the observation windows to tackle the evolution of the economic structure of the euro area countries, we take into account those structural changes. Therefore, the year 1986, which was identified as a break date in the oil literature (Baumeister and Peersman 2013), was chosen as the splitting mark. Hence, we define the first observation window (W1) throughout 1979Q2-2010Q1 and the second observation window (W2) throughout 1986Q1-2016Q4. Each one assembles the same number of observations, 151 quarters. An overlapping time span was unavoidable for conducting meaningful impulse response analysis.

The second observation window offers the best context to evaluate the methodology adopted in this paper. As the basic facts reported in section 2 show, "oil demand shocks" episodes were prevalent in that period. Even though their impacts on the output of larger and open economies, including the euro area countries, are statistically significant, sizable and negative, around the 12th quarter. Therefore, the results of the dynamic analysis conducted with the GVAR version adopted in our study fits the prevision of Blanchard and Gali (2007) – oil shocks, even when driven by global demand, turns into an exogenous adverse shock for net energy importers countries.

⁴ We owe the GIRFs to Koop et al. (1996) and its application in vector error-correcting models to Pesaran and Shin (1998).

Therefore, the adopted framework – oil prices modeled as a "dominant variable" in a GVAR model – reveals an appropriate tool to investigate the evolution of the economic structure of the euro area members. Notably for Germany, which was the European economy that has most benefited from the heightening of the oil-demand accent in the composition of oil shocks. Even though the statistical significance of its real GDP impulse responses slightly improved when we move from observation window W1 to observation window W2. This feature underlies what might be the most distinctive contribution of the present paper. Germany exhibits in the euro area, along with Portugal, the most impressive shift towards convergence in output fluctuations, when evaluated by the response to global shocks.

The remainder of this paper is organized as follows. Section 2 reports basic data tracking oil shocks episodes and possible related patterns of "regional specialization" across the euro area. Section 3 presents the empirical model specification, the criteria to define the observation windows and the data sources. Section 4 portrays and discuss the results of the dynamical analysis (GIRFs) for two focus groups. The first group comprises the large/open economies, including the United States, the euro-area Core and the euro-area Periphery regions. The second group comprehend eleven initial euro area members, plus Denmark. Section 5 concludes.

2. BASIC FACTS

Two basic facts seem of interest before undertaking the empirical analysis of the euro area dynamics using oil price shocks. First, the evolution of oil prices and its underlying drivers, that is the global demand and oil production, throughout the sample period of 1979Q2-2016Q4. Second, patterns in the economic structure of the euro area members possible leading to different responses to oil shocks of distinct composition.

2.1 Oil Shocks Episodes

Figure 1 displays basic data to tackle the first issue, by plotting the (log) real price of oil over 1979Q2-2016Q4, the (log) oil production, and an indicator of "economic activity"⁵,

⁵ Monthly raw data for the three selected time series (real oil price; oil production and real "economic activity") were retrieved from <u>https://sites.google.com/site/cjsbaumeister/research</u>, on 14 May 2019.

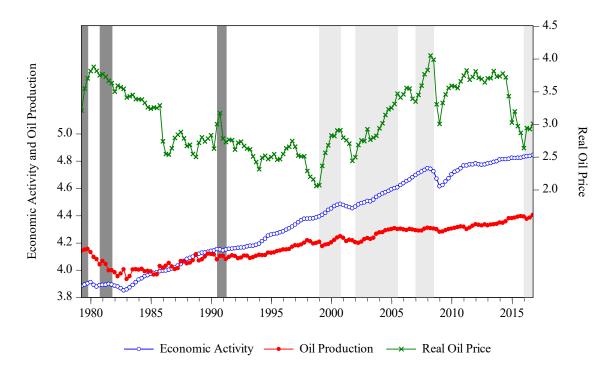


FIGURE 1. OIL PRICE SHOCKS EPISODES DARK SHADED AREAS: SUPPLY-DRIVEN SHOCKS; LIGHT SHADED AREAS: DEMAND-DRIVEN SHOCKS.

Notes: Data Sources: The raw data for the real oil prices, oil production and real economic activity (OECD+6NME industrial production) are from the Baumeister and Hamilton (2019) dataset. The identification of the oil shocks episodes, and its discrimination among demand-driven or supply-driven shocks, are based on the works of Blanchard and Gali (2007), Hamilton (2009), and Baumeister and Hamilton (2019).

again in real terms and logs; plus, the observed oil shocks episodes, marked by the shaded areas. "Economic activity", proxying global demand, is measured by an "extended version of the OECD's index of monthly industrial production in the OECD and six major other countries [Brazil, China, India, Indonesia, the Russian Federation and South Africa]", as proposed by Baumeister and Hamilton (2019, p. 1891). The oil shocks episodes are traced by combining insights from the works of Blanchard and Gali (2007), Hamilton (2009), and Baumeister and Hamilton (2019).

We start by offering some comments on the behavior of the price of oil. From now on, we assume 1986Q1 as a turning point in oil price dynamics and its macroeconomic implications, likewise in Peersman and Van Robays (2009). In so doing, we bear in mind both the "Great Moderation", that is the decline in the U.S. output fluctuations since the mid-1980s (McConnell and Perez-Quiros 2000); and the fall in the short-run price elasticity of oil demand, where 1986Q1 was identified as a break date by a Baumeister and Peersman (2013).

Accordingly, we can see a drop of about 53% in the average real price of oil after 1986, after taking the average of the (log) real price of oil over 1979Q2-1985Q4, which amounts to 3.51, and compare with the average in the period 1986Q1-2016Q4, which amounts to 2.98. On the other hand, and after computing standard deviations in both subperiods, 0.20 in 1979Q2-1985Q4 versus 0.36 in 1986Q1-2016Q4, we can see that the volatility of oil prices augmented after 1986, which is in accordance with the above-noted decrease in the price elasticity of oil demand.

We look now at the evolution of demand and supply for oil in the global market (i.e., the real "economic activity") and oil production time series plotted in Figure 1. From 1979Q2 through 2016Q4, the "economic activity" almost doubled in real terms (a rise of 96%), whereas the quantity of oil produced augmented only 26%. Thus, the data hints the long-run decline in energy intensity, which has been pointed out as one factor, among others', behind the dampening of the output responses to oil shocks (Blanchard and Gali 2007).

Finally, we address the oil price shocks episodes. Dark gray shaded areas in Figure 1 denote oil price surges driven by supply disruptions, whereas light gray shaded areas indicate oil price surges driven by global demand. The 1978-79 episode is related with the "Iranian revolution in the fall of 1978", the 1980-81 with "Iraq's invasion of Iran in September 1980" and the 1990-91 with "Iraq's invasion of Kuwait in August 1990⁶" (Hamilton 2009, p. 220). We follow Blanchard and Gali (2007) when marking the intervals 1999Q1-2000Q4 and 2002Q1-2005Q3 as large oil shock episodes. And given that global demand and the supply of oil were both moving up (see the paths of "economic activity" and "oil production" shown in Figure 1), we have ascribed those episodes to the category of oil demand shocks⁷. Finally, there are the 2007-08 and 2016 oil demand

⁶ For Kilian (2009, p. 1063), "the sharp spike in the real price of oil in 1990-1991 after the invasion of Kuwait is almost entirely due to an increase in precautionary demand". As such, it is an episode that lays in the class of an "oil-specific demand shock" instead of an "oil supply shock". In turn, Blanchard and Gali (2007, p. 10) have downplayed this episode given that it did not meet the defined criteria, where a large oil shock is "an episode involving a cumulative change in the (log) price of oil above 50%, sustained for more than four quarters".

⁷ For (Kilian 2009, p. 1064), "The sharp rise in the real price of oil in 1999-2000" was driven "again by factors specific demand for crude oil."

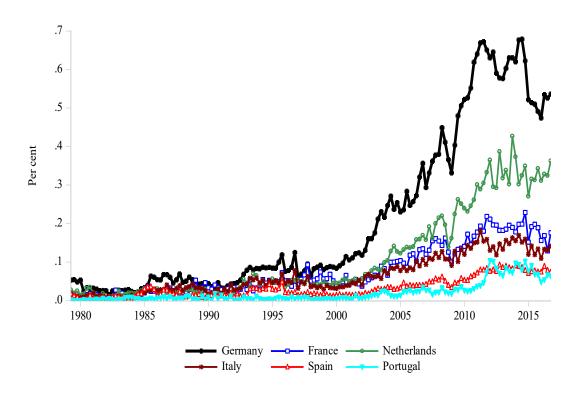


FIGURE 2. EXPORTS TO CHINA

Notes: Source: the authors. The graphic shows the exports of a selected group of euro area countries to China. The exports are expressed as % of GDP of the respective country. Raw data: For GDP, OECD.Stat (series: CPCARSA); For exports to China, IMF Data (Direction of Trade Statistics).

shocks, where we followed the insights provided by Hamilton (2009) and Baumeister and Hamilton (2019).

Overall, we may conclude, in line with the oil literature⁸, that more recent oil shocks were motivated by the rises in the demand for oil, which leads us to the next subsection.

2.2 Oil Demand Shocks and Economic Structures

Figure 2 shows the evolution of the exports to China for a selected group of euro area countries. Two remarkable facts are worth noting in the context of oil shocks. First, the strikingly difference between the first and the second half-periods of the sample: The demand for European products from China started between 1995 and 2000 and grew faster after 2001. That is, overlapping the period where the global demand component in

⁸ That is, the works already quoted when identifying the oil shocks and yet, for example, Baumeister and Peersman (2013).

oil shocks became predominant. Second, the dynamics of German exports in contrast with the almost inexpressive weight of the exports to China from the Iberian countries (Spain and Portugal).

Thus, the oil price series over the sample period of 1979Q2-2016Q4 contains varying patterns which likely make the shocks entertained to that "common global variable" a valuable experiment to study the macroeconomic dynamics of the euro area countries.

3. The Empirical Model

The matter of concern is the dissimilarities in the economic structure among the members of a currency union – the euro area, in case – leading to different behaviors on the macroeconomic variables relevant for conducting (a single) monetary policy.

Hence, the justification for including the real output and inflation in the list of variables of our empirical model is immediate. But before going further, let us make clear the definition of economic structure. In common usage, its scope is restricted to patterns of "regional specialization". See, for example, Krugman (2001), when discussing the optimality of currency areas. That might be enough, we suggest, when the interest lies on output aggregates, either its cyclical fluctuations or the asymmetric responses to global shocks – the latter stemming from patterns of industrial specialization such as those evidenced by the exports to China from Germany and Portugal (see subsection 2.2). However, tackling inflation is not a minor issue in this context. Recall that, in its formal definition, "The primary objective of the ECB's monetary policy is to maintain price stability"⁹; and we also should bear in mind the trade-offs between the output gap and the stabilization of inflation. That said, the underlying structural features that make price adjustments smoother or sluggish are relevant when approaching the fundaments of a currency union. In particular, wage rigidities, as highlighted by Blanchard and Gali (2007) in the context of oil shocks analysis, and that prevail in different degrees across the European countries (see Blanchard 2006).

The purpose of this paper is not going through the analysis of those matters. But we should bear in mind the underlying heterogeneities across the euro area countries. Therefore, we take the economic structure, from now on, in a broader sense, subsuming

⁹ < <u>https://www.ecb.europa.eu/mopo/intro/html/index.en.html</u>>, accessed on 10 June 2019.

U.S.	Euro Area–Core	Euro Area–Periphery	Rest of Asia	
China	Germany	Italy	Indonesia	
Japan	France	Spain	Korea	
UK	Netherlands	Ireland	Thailand	
	Belgium	Portugal	Malaysia	
	Austria	Greece	Philippines	
	Denmark	Finland	Singapore	
Other dev. countries	Rest of W. Europe	Latin America	Rest of the World	
Canada	Switzerland	Brazil	India	
Australia	Sweden	Mexico	Turkey	
New Zealand	Norway	Chile	Saudi Arabia	
		Peru	South Africa	

TABLE 1- COUNTRIES AND REGIONS IN THE GVAR MODEL

Notes: The classification of the (*de facto*) euro adopters, thus including Denmark, under the euro-area Core and euro-area Periphery headings follows Carneiro (2019).

both "regional specialization" and the prices and wages mechanisms embedded in the country-specific institutional frameworks.

After the inclusion of the output and inflation variables, we advance now with the justification for the nominal short-run interest rate. It stems from its central role for the conduct of monetary policy. Furthermore, those three variables form the basic framework for the analysis of monetary policy in the IS/LM model¹⁰.

Because we are dealing with open economies, the real exchange rate enters, while reflecting differentials in nominal interest rates or in expected inflation (Frankel 1979). And given the interlinkages and fast transmission of shocks in the international financial markets, the price of equity and the nominal long-term interest rate are also added.

Finally, the inclusion of the price of oil, that is the common global variable to undertake the "conceptual experiments" – as in the words of Koop et al. (1996) –, by which the behavior of the main macroeconomic variables of interest, the output and inflation, are to be studied.

That choice of variables is aligned with the standard framework of the GVAR, as per the specification proposed by Dees et al. (2007), after the model built by Pesaran et al.

¹⁰ See, for example, Clarida et al. (1999), for a New Keynesian approach and review.

(2004). Although, we take the alternative of modeling the oil prices in a dominant unit, instead of including in the list of endogenous variables of the U.S. country model – a choice to be highlighted and justified ahead, in the subsection 3.2.

The sample geographic coverage, comprising 36 countries and representing around 90% of the world output, is roughly the same as in Dees et al. (2007). However, we added Denmark, Greece, Ireland, Portugal, and excluded Argentina for data limitations. Table 1 shows the full list of countries in the sample, and where the euro adopters are organized under the headings "euro-area Core" and "euro-area Periphery", following the criteria presented by Carneiro (2019).

3.1 The Model Specification

In the specification of the variables, we follow Dees et al. (2007). Thus, the endogenous variables are the (log) real GDP, y_{it} , the inflation rate, π_{it} , the (log) real equity prices, eq_{it} , the (log) real exchange rate, $e_{it} - p_{it}$, the nominal short-term interest rate, r_{it} , and the long-term interest rate, lr_{it}^{11} . Although, in the real GDP definition we normalize the real GDP index by the country population, making $y_{it} = ln(real GDP_{it}) - ln(Pop_{it}/Pop_i)$, and where Pop_{it} states for the population of country *i* in quarter t= 1, ..., 151, and $\overline{Pop_i}$ is the mean of country *I* population over the full sample period, 1979Q2-2016Q4. Hence, we follow the criteria adopted by Carneiro (2019) to get the output data rid of variations stemming from population growth at different rates across countries in a lengthy sample period.¹²

The price of oil is taken as a (dominant) common global variable $p_t^o = ln(POIL_t)$, where $POIL_t$ is the price of oil in USD. It deserves to be noticed that the null hypotheses of weak exogeneity of oil prices is rejected only for three countries (the Netherlands, Norway and Peru) in observation window W1, spanning over 1979Q2-2010Q1; and is rejected only for one country (Malaysia) in observation window W2, spanning over 1986Q1-2016Q4.

¹¹ Interest rates are defined in a quarterly basis, e.g., $r_{it} = 0.25 \times ln(1 + R_{it}^S/100)$, where R_{it}^S is the nominal short-term rate of interest per annum, in percent.

¹² We may pick an elucidative example even restricting the sample to the developed economies: The cumulative growth of the U.S. population was of 45% over 1979-2016, while only 7% for the UK and 10% for Japan.

Variables	U.S. model		Other countries model	
	Domestic	Foreign	Domestic	Foreign
Real output	$y_{US,t}$	$\mathcal{Y}_{US,t}^{*}$	y_{it}	y_{it}^*
Inflation	$\pi_{US,t}$	$\pi^*_{US,t}$	π_{it}	π^*_{it}
Real equity price	eq _{US,t}	_	eq_{it}	eq_{it}^*
Real exchange rate	_	$e^*_{US,t} - p^*_{US,t}$	$e_{it} - p_{it}$	_
Nominal short-term interest rate	r _{US,t}	_	r_{it}	r_{it}^{*}
Nominal long-term interest rate	<i>lr_{US,t}</i>	_	lr _{it}	lr_{it}^{*}
Oil prices (DU)	_	p_t^o	_	p_t^o

TABLE 2-VARX* MODEL SPECIFICATION

Notes: "Other countries model": A domestic variable will not enter a specific country model in case of missing observations. Thus, and in what concerns the euro adopters, the price of equity is not included in the models of Greece, Ireland and Portugal; the short-term interest rate is not included in Denmark; and the long-term interest rate is not included in Denmark; Finland and Greece.

Finally, in the construction of the star variables, that is, the weighted foreign-countries counterparts, y_{it}^* , π_{it}^* , eq_{it}^* , r_{it}^* , lr_{it}^* , we have used the trade weights, averaged over the full sample period.

Table 2 summarizes the country-specific VARX* models as per the described choice of variables¹³. The models are the same for all countries with exception to the United States, which is assumed as the numeraire or "reference country" (Pesaran et al. 2004, p. 130). As such the exchange rate is included as a domestic variable in all countries with exception to the United States, whereas the foreign exchange rate (i.e., the "star" variable) is included in the U.S. model but not in the other countries models. Moreover, because of its leading role in capital markets, the foreign counterparts of the price of equity and of the interest rates are not taken as exogenous variables in the U.S. model; although, and to take due account of second-round effects, the real output and the inflation rate foreign counterparts are included.

¹³ This same VARX* model specification was proposed by (Carneiro 2019).

3.2 The Oil Prices as Dominant Variable

The price of oil enters every country VARX* model as an explanatory variable. Although, to make the GVAR model a "closed system", Pesaran et al. (2004) included the price of oil in the "U.S. model as an endogenous I(1) variable, while retaining it as an exogenous I(1) variables in the remaining regional models", p. 142. That formulation was kept unchanged by Dees et al. (2007), and it is still adopted in GVAR applications¹⁴.

However, in 2013, Chudik and Pesaran introduced the concept of a "dominant variable" (and identically, of a dominant cross-section unit) in a vector autoregressive (VAR) model, whereby "it has non-negligible contemporaneous and/or lagged effects on all other units as the cross-section dimension rises without a bound" p. 625. Moreover, they showed how to specify and estimate an individual auxiliary regression to model for the "dominant variable" and how its effects are translated onto all cross-section units.

The benefit of opting for treating oils prices as a dominant unit instead of an endogenous variable of a dominant economy, such as the United States, rests on preserving the character of a structural innovation of a shock entertained in the former whereas it is converted to a mere disturbance to the reduced form error term of the oil equation in the latter formulation. We offer the intuition here and leave the formal presentation for Appendix B.

In the GVAR framework all country-specific equations are estimated in a conditional model, whereby each domestic variables of a cross-unit i, x_{it} , is regressed against the lags of the vector formed by domestic variables, $x_{i,t-l}$, and a list of weak exogenous variables comprising the foreign counterparts, x_{it}^* , the respective lags, $x_{i,t-l}^*$, plus the common global variable, w_t , and its lags, w_{t-l} . Suppose now that i = 0 indexes the U.S. country-specific model. When the common global variable is included in the list of the U.S. endogenous variables, w_{0t} , the respective equation is estimated within the U.S. cross-unit, and therefore the shocks to oil prices are entertained to the reduced-form error term.

Let us now consider the dominant unit alternative specification. In this case, the equation for the common global variable is estimated in a "marginal" model, where w_t is regressed against its lags, w_{t-l} and, possibly, the lags of the so-called "feedback"

¹⁴ See, for example, Dees (2016).

variables, such as weighted averages of the output and inflation variables of all countries in the sample. Therefore, a perturbation of the error term of this equation represents a shock to the price of oil. In this sense, the shock is identified, even though not its source. Namely, an oil prices shift driven by an increase in aggregate global demand, or a surge in oil-specific demand or even a disruption in oil production, as per in the Kilian (2009) decomposition. However, the "source" of the perturbation, when driven by the demand side, is not missed within the adopted framework. As we show in Appendix B, given that the impulse response analysis is conducted through the generalized impulse response functions (GIRFs), the effects of correlated shocks are integrated out and thus captured by the model. See, for example, cross-correlated variations in the output of export countries when surges in oil prices are originated by economic growth in China.

It is worth noting that the GVAR methodology offers the possibility of identifying oil shocks in the sense of Kilian (2009). Namely, by imposing sign restrictions on the impulse responses and bounds on impact-elasticities, as undertaken by Cashin et al. (2014), to study the effects of oil shocks across different types of countries, such as the developed or emerging economies, the oil-importers or exporters (with or without large reserves). In their model specification, the price of oil enter the U.S. model as an endogenous variable; and to capture the effect of supply-side disruptions, a second global variable is added, the oil production, which is included as an endogenous variable of a region assembling energy-exporters with large reserves (Saudi Arabia plus Bahrain, Kuwait, Oman, Qatar and UAE).¹⁵

3.3 Data, Sample and Observation Windows

The GVAR (Global Vector Auto Regressive) modeling website created by L. Vanessa Smith¹⁶ provides a dataset – the most recent version covering the 1979Q1-2016Q4 period – to run a GVAR model based on the specification proposed by Dees et al. (2007). However, it does not include Ireland, Portugal, Greece and Denmark. Therefore, we have used the "2016 dataset" built by Carneiro (2019), which covers all euro-area countries

¹⁵ An alternative approach but to study country-specific oil-supply shocks is offered by the "GVAR-Oil model" proposed by Mohaddes and Pesaran (2016), without recourse to identifying restrictions. A model for the oil market is built separately and then combined with the country-specific VARX* models within a Global VAR.

¹⁶ Available at <u>https://sites.google.com/site/gvarmodelling/</u>.

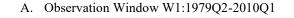
(ex-Luxembourg) and is based on the sources described by Smith and Galesi (2014, 167-177), whenever suitable.

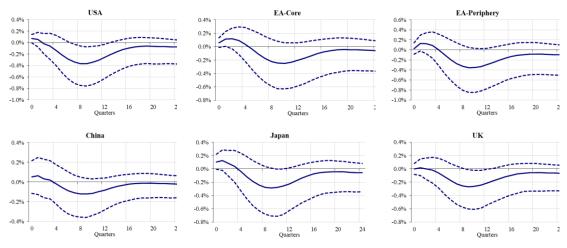
A full description of the "2016 dataset" is provided by Carneiro (2019, Appendix C). But we report here the main data sources. For the real GDP and the Consumer Prices, the International Financial Statistics (IFS), the OECD.Stat and the Inter-Development American Bank (IDB) dataset; for equity prices, the MSCI Country Index available from the Thomson Reuters Datastream; for exchange rates, the Bank of England database, supplemented with IMF dataset; for short-term and long-term interest rates, the OECD MEI data and the IFF dataset, and for oil prices, the IMF "Primary Commodity Prices" dataset.

The full sample goes from 1979Q2 to 2016Q4. Two sorts of regime changes are of interest to the present work. First, the "Great Moderation" starting in the mid-1980s and the prevalence of oil demand shocks after that, whereas oil supply shocks prevailed beforehand (the large episode being on 1990-91, see Figure 1). Second, the introduction of the euro in 1999, preceded by the nominal convergence process and the implied financial integration for the Peripheral countries, which effects became noticeable around 1996 (Fagan and Gaspar 2007).

Hence, it would be desirable to conduct the dynamic analysis over subperiods separated by the break dates associated with those regime changes and examine the corresponding impulse responses of the macroeconomic variables of interest. However, and despite the merits of the GVAR methodology in dealing with the curse of dimensionality problem, we need enough lengthy data samples to obtain statistically significant results when conducting the impulse response analysis. Our empirical model comprehends 188 endogenous variables, considering the 36 countries covered, and that for some of them not all the six specified domestic variables are available; plus, the oil prices. A possible empirical strategy to deal with those constraints is to overlap part of the elected subsamples¹⁷. To implement that strategy, we started by choosing only one break date, namely the observation of 1986Q1, in the case following Peersman and Van Robays (2009). Afterwards, we defined the following observation windows, W1 and W2, assembling the same number of 124 observations: 1979Q2-2010Q1 and 1986Q1-2016Q4. By so doing, the second observation window (W2) is to a large extent

¹⁷ See, for example, Dees (2016).





B. Observation Window W2: 1986Q1-2016Q4

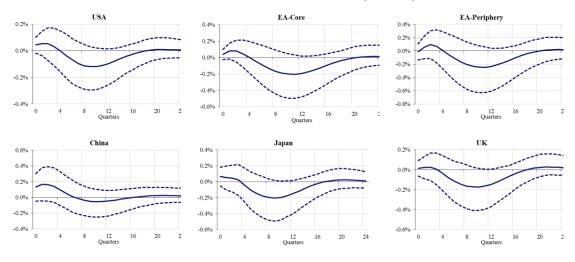


FIGURE 3. ESTIMATED RESPONSES OF REAL OUTPUT TO AN OIL PRICE SHOCK. LARGE/OPEN ECONOMIES

Notes: Generalized Impulse Response Functions (GIRFs) for a Positive Unit (1 s.e.) Shock to Oil Prices; Bootstrap Mean Estimates with 90% Bootstrap Error Bounds. This shock is equivalent to a fall of around 11-12% in the price of oil.

superimposed on (i) the subperiod of oil demand shocks prevalence and (ii) the euro adoption regime, given that it started around 1996 as mentioned. Furthermore, the data related to the global financial crisis of 1988-89 enter both estimation subsamples, as such neutralizing possible outliers' effects.

4. **RESULTS AND DISCUSSION**

The main results of the estimated model over the real GDP and Inflation variables are reported by portraying and summarizing the generalized impulse response functions (GIRSs) elicited for two focus groups. First, focus group I, covering the large/open economies, namely the United States, the euro-area Core region, the euro-area Periphery region, China, Japan and the United Kingdom. Second, focus group II, comprehending the euro-area countries taken individually.

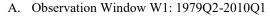
We discuss the results by comparing the GIRFs profiles. We evaluate the possible impacts of the Great Moderation (and the prevalence of oil demand shocks), and the effects of the euro regime on its adopters, by moving the dynamical analysis from observation window W1, over 1979Q2-2010Q1, to observation window W2, over 1986Q1-2016Q4.

4.1 Large/Open Economies

Figure 3 displays the GIRFs for the effects of a positive shock to the price of oil on the real GDP for focus group I. Panel A portrays the GIRFs for observation window W1 and Panel B portrays the GIRFs for observation window W2. The size of the shock is one standard error, which results in 11-12% per quarter increase in the price of oil.

The response of the U.S. output to the oil shocks, when we move from observation window W1 to observation window W2, offers a starting point to evaluate the performance of the model specified in section 3.1. Let us bring in mind the Great Moderation, the correlated decline in energy intensity and the possible heightening of oil demand shocks in the composition of the oil price shocks, as shown in subsection 2.1. Hence, by advancing the time frame, we expect a reduced impact of oil shocks on the U.S. economy. The shape and the size of the portrayed GIRFs go into that direction. When we move from panel A to panel B in Figure 3, we can see a milder reaction in the U.S. real GDP to an oil shock of the same magnitude. More precisely, the trough, observed between the 9-10th quarters has lessened from -0.37% in observation window W1 down to -0.12% in observation window W2¹⁸.

¹⁸ See the Output file in the supplemental link for the median estimates.



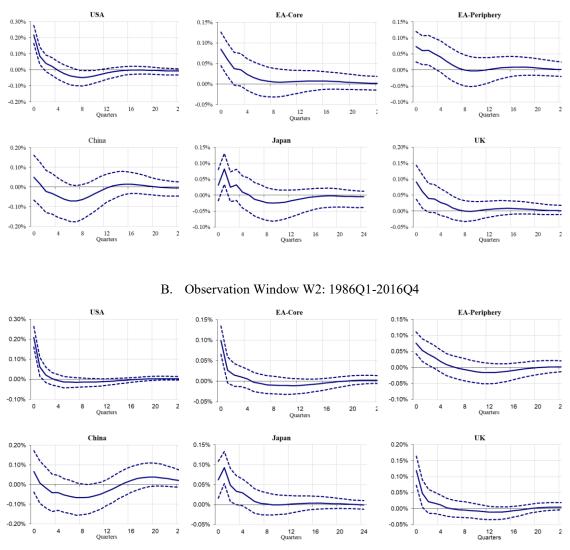


FIGURE 4. ESTIMATED RESPONSES OF INFLATION TO AN OIL PRICE SHOCK. LARGE/OPEN ECONOMIES

Looking now at the remaining economies in this focus group, we find evidence of a declining impact of oil shocks in GDP after 1986 again, although smoother than the one observed for the United States. Moreover, the distance within the euro area economies has shortened. In observation window W1, the GDP downfall touched -0.25% in the Core versus -0.35% in the Periphery; whereas in observation window W2 was of -0.20% in the

Notes: Generalized Impulse Response Functions (GIRFs) for a Positive Unit (1 s.e.) Shock to Oil Prices; Bootstrap Mean Estimates with 90% Bootstrap Error Bounds. This shock is equivalent to a fall of around 11-12% in the price of oil.

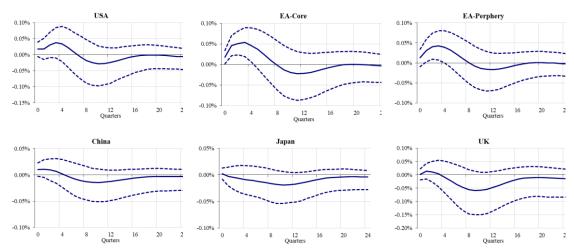
Core versus -0.25% in the Periphery. This result matches the increased synchronicity across the euro area members after the euro adoption found by Aguiar-Conraria et al. (2013) although using a different methodology (wavelet analysis) and data (Economic Sentiment Indexes).

The empirical evidence exhibited in observation window W2, whereby the impact of oil shocks turns negative, and statistically significant, around the 12th quarter, despite being "demand-driven", with exception only to China, likely corroborates the conjecture made by Blanchard and Gali (2007), when arguing that "if the price of oil rises as a result of, say, higher Chinese demand, this is just like an exogenous oil supply shock for the remaining countries." p. 17. By the same token, those results go against the conclusion that oil demand shocks did not have a significant (adverse) impact on oil-importing countries, as sustained by Baumeister and Hamilton (2019), after an empirical analysis based on sign restrictions to identify the composition of oil shocks.

Finally, all GIRFs fade out around or even before the 24th quarter. This outcome seems consistent with a temporary oil shock, as it is the case of the experiment undertaken in the present work. Moreover, we should not expect an irreversible downward effect on real GDP even from a permanent oil price shock, as shown by Aguiar-Conraria and Wen (2007).

We address now the impact of oil price shocks on inflation. Figure 4 displays the related GIRFs for focus group I, that is the estimated responses of inflation to a positive one standard error shock to the price of oil. Its size is always the same, equivalent to an increase in the oil prices of around 11-12%.

On impact, the effect in the United States (22-21%) is considerably higher than for the other economies in both the observation windows (Panels A and B). Namely, around 0.09-0.10% for the euro-area Core; 0.07-0.08% for the euro-area Periphery; 0.05-0.07% for China; 0.08-0.09% for Japan and 0.09-0.12% for the United Kingdom. Similar results, in particular, stronger effects on the United States inflation in comparison with the euro area, have been found by Dees et al. (2007, p. 23) and by Cashin et al. (2014, see Figures 2 and 4). Differences in the transmission mechanism are the explanation advanced by Peersman and Van Robays (2009). The direct pass-through effects of energy prices rise are arguably stronger in the United States rather than in the European economies.



A. Observation Window W1: 1979Q2-2010Q1

B. Observation Window W2: 1986Q1-2016Q4

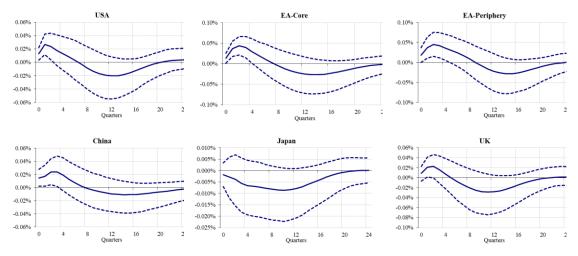


FIGURE 5. ESTIMATED RESPONSES OF SORT-TERM INTEREST RATES TO AN OIL PRICE SHOCK. LARGE/OPEN ECONOMIES

Notes: Generalized Impulse Response Functions (GIRFs) for a Positive Unit (1 s.e.) Shock to Oil Prices; Bootstrap Mean Estimates with 90% Bootstrap Error Bounds. This shock is equivalent to a fall of around 11-12% in the price of oil.

For the United States, the European economies, and the United Kingdom, the effects of the oil price shock on inflation die out faster in the second observation window (Panel B), thus showing conformity with the Great Moderation environment. But it is worth noting that the euro-area Periphery lags the U.S., as well as the euro-area Core and the United

Kingdom changing patterns. And that persistent sluggish reaction happened despite the convergence in the short-term interest rates across the euro area, as we will see next.

Figure 5 presents the responses of short-term interest rates to an oil price shock for focus group I. Some salient features become apparent when confronting the dynamical analysis (GIRFs) displayed in Panel A with Panel B, or loosely speaking when heightening the Great Moderation support.

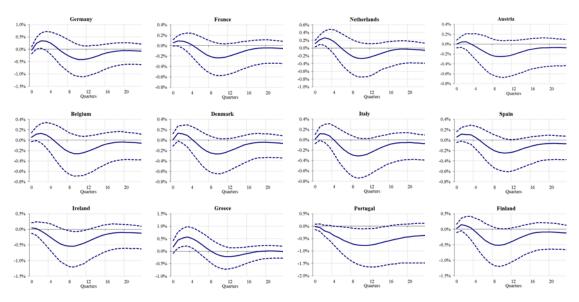
First, the responses of short-term interest rates were statistically significant only for the euro-area economies in observation window W1. The primacy of the Bundesbank rule might be an appropriate qualificative for the European forerunner in this domain. Second, exception made to Japan, which has been confronted with the zero lower bound since the late 1990s, the responses of short-term interest rate became significant in observation window W2 for all countries/regions in focus group I. Third, the response of the United States turned faster along with the Great Moderation. The peak is reached at the first quarter in observation window W2 whereas it had been at the third quarter in observation window W1.

Some further notes to interpret the results found for short-term interest rates responses combined with those reported for inflation and the real GDP. After the Great Moderation, we can see smoother negative impacts of oil shocks on GDP, prompt but milder short-term interest rates reactions and faster inflation adjustments. Without disregarding the already mentioned declining energy intensity and the possible change in the composition of the oil price shocks, we may conclude with an insight of Blanchard and Gali (2007, p. 5): "The stronger commitment by central banks to maintaining a low and stable rate of inflation ...may have led to an improvement in the policy trade-off that make it possible to have a smaller impact of a given oil price increase on both inflation and output simultaneously".

4.2 Euro Adopters

We tackle now the earlier euro adopters, excluding Luxembourg, but adding Denmark, whose currency is pegged to the euro. Hence, as already noted in above, focus group II comprehends Germany, France, Netherlands, Austria, Belgium, and Denmark, within the euro-area Core; and Italy, Spain, Ireland, Greece, Portugal and Finland, within the euro-area Periphery.

A. Observation Window W1: 1979Q2-2010Q1



B. Observation Window W2: 1986Q1-2016Q4

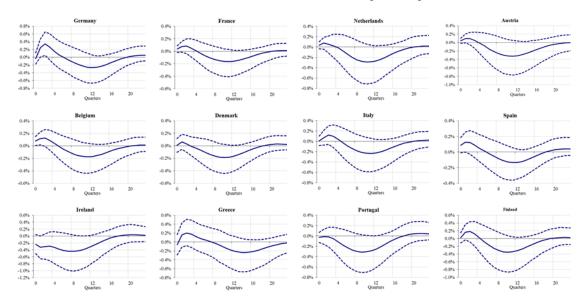


FIGURE 6. ESTIMATED RESPONSES OF REAL OUTPUT TO AN OIL PRICE SHOCK. EURO ADOPTERS

Notes: Generalized Impulse Response Functions (GIRFs) for a Positive Unit (1 s.e.) Shock to Oil Prices; Bootstrap Mean Estimates with 90% Bootstrap Error Bounds. This shock is equivalent to a fall of around 11-12% in the price of oil. Focus Group II (Euro adopters): The euro area members plus Denmark.

Figure 6 portrays the GIRFs of oil shocks on real GDP. Overall the effects are statistically significant. However, with respect to the Core countries, this is the case only

in observation window W2, despite the milder responses. The GIRF of Germany seems of particular interest in this context while being the developed economy that has most benefited from the expansion of the large emerging and transition economies, namely China, as illustrated by Figure 2. For observation window W2, the estimated effect of the oil price shocks on the German real GDP is positive over the first year, reaching the peak of 0.35% in the second quarter, but it turns negative between the sixth and the 18th quarter, touching the trough of -0.27% at the 12th quarter.

We suggest that the initial comovements of the oil prices and the German GDP reflect the demand effect, and where the oil price surge conveys the signal of an increase in global demand. Although, in the medium run, the model captures the second-round effects of an oil price shock on the German net energy-importing foreign counterparts, on top of the adverse specific impact of higher energy prices in its domestic economy and those stemming from the price stabilization monetary policy reaction.

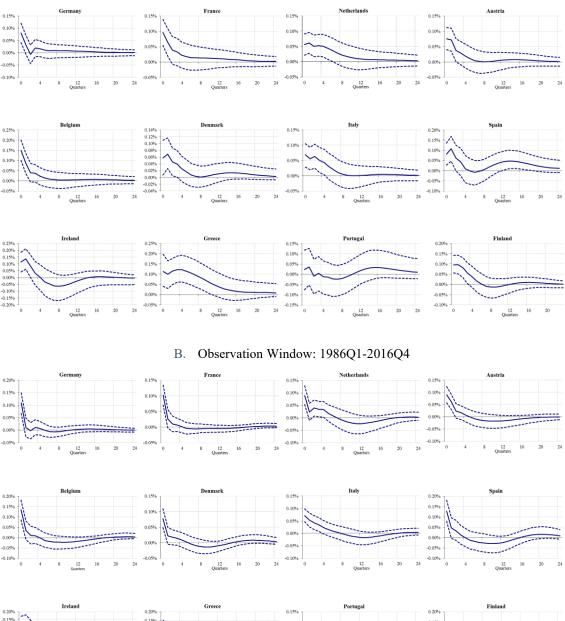
We look now to the GIRFs at the troughs across the remaining Core and the Peripheral countries when moving from observation window W1 to observation window W2. The following comments seem pertinent.

First, and as already noted, the reactions of the output to oil shocks are milder in the second sub-sample, overlapping the Great Moderation. And again, the change towards moderation is more noticeable in the Peripheral countries, denoting convergence to the Core. The median of the troughs lowered from -0.42% to -0.27% in the Periphery; whereas only from -0.26% to -0.23% in the euro-area Core (see Table A. 1 in Appendix A).

Second, the dispersion of the effects is higher in the euro-area Periphery. The standard errors of the troughs are 0.20% in observation window W1 and 0.10% in observation window W2 for the Periphery versus 0.06 % in both observation windows for the Core. Portugal, Ireland and Finland are the countries where oil shocks have harsh impacts on real GDP. Hence, the results denote accordance with the findings of Aguiar-Conraria and Joana Soares (2011), where those same countries plus Greece showed the less synchronized business cycle with the rest of Europe over the period 1975-2010.

Third, the responses of real GDP in Portugal and Greece offer both expected and unexpected, even contradictory, profiles. Portugal industrial specialization was based on traditional industries (e.g., textiles), as such, being more exposed to the increasing

A. Observation Window: 1979Q2-2010Q1



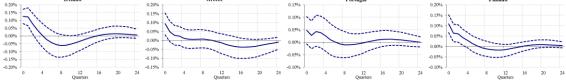


FIGURE 7. ESTIMATED RESPONSES OF INFLATION TO AN OIL PRICE SHOCK. EURO ADOPTERS

Notes: Generalized Impulse Response Functions (GIRFs) for a Positive Unit (1 s.e.) Shock to Oil Prices; Bootstrap Mean Estimates with 90% Bootstrap Error Bounds. This shock is equivalent to a fall of around 11-12% in the price of oil. Euro adopters: The euro area members plus Denmark.

competition of the large emerging economies. Given that, an oil demand shock is typically assimilated to an exogenous oil supply shock as pointed out by Blanchard and Gali (2007). A flat response of the Portuguese GDP in the first year (contrasting with the rise in Germany), followed by a decline from the second throughout the fourth year, fits its economic structure well. Greece, another peripheral country with roughly the same real GDP per capita as Portugal, shows an entirely different reaction. In observation window W1 the response to the oil price shock is even positive; in observation window W2, it is not statistically significant. The discrepant responses of the Portuguese and Greek outputs to the oil shocks illustrate the higher degree of heterogeneity across the Peripheral countries.

We turn now to the effects of oil price shocks on inflation across the euro adopters. By inspecting the GIRFs portrayed in Figure 7, we get some information that the aggregate for euro-area Core did not convey – namely, the earlier and predominant German flavor. Earlier, in the sense that inflation adjustment was already fast in Germany over the period tracked by observation window W1. Predominant, while exhibiting the pattern to which the remaining countries in the euro-area Core, notably France, converged (see Panel B in Figure 7).

Concerning the Peripheral countries, the responses of inflation denote a nonconvergent pattern to the Core, as already noted when reporting the results for its aggregate (i.e., the GIRFs displayed in Figure 4 for the euro-area Periphery as a whole region).

The case of Italy, as the larger economy in the euro-area Periphery, seems of particular interest. As we can see in Figure A. 1 (in Appendix A), portraying the GIRFs for the short-run interest rate response to an oil price shock, the estimated responses of Italy are statistically significant and somewhat resembling Germany's. More precisely, in both observation windows, the peak is around 0.05% for Italy versus 0.04% for Germany, and the average across the first year is 0.04% versus 0.03%. However, the stabilization of inflation remained sluggish in Italy in observation window W2. We suggest that the explanation might be found in the labor market rigidities prevalent in Italy¹⁹.

¹⁹ See, for example, Brunnermeier et al. (2016, Chapter 12, Loc. 4529) for a summary description of the "restrictive" Italian labor market.

4.3 Robustness

Oil prices provide the opportunity to simultaneously test mounting inflation and decreasing output. Therefore, they look a nice "*conceptual* experiment"²⁰ to test heterogeneities across the economic structure of a currency union member states. We do not know an alternative disturbance with similar effects. But we can check the responses of the real output to a common adversarial shock. A global negative shock to the real prices of equity likely offers that possibility.

Recall that financial interlinkages framed within an international setting was precisely at the heart of the seminal work of Pesaran et al. (2004) when building the GVAR methodology. Therefore, we entertained a global shock on the real equity prices over observation windows W1 and W2. The GIRFs for the 12 euro adopters (including Denmark) are portrayed in Figure A. 2, in Appendix A. For a forthright comparison with the results previously obtained from the oil shocks, Table A. 1 and Table A. 2 report the estimated values at the troughs and their elementary statistics (i.e., the medians and the standard errors).

The results from the shock on the real prices of equity are aligned with those obtained from the oil shocks in the following items. First, Germany, showed the larger (lagged) adverse effect across the Core economies in observation window W1; and converged to the median of the Periphery in observation window W2²¹. Second, Portugal showed the larger adverse effect across the Peripheral economies in observation window W1; and converged to the median of the Periphery in observation window W2. Third, the degree of heterogeneity in the Periphery has dropped. However, the results are misaligned where not showing now the convergence of the output responses of the euro-area Periphery as region to the euro-area Core.

5. CONCLUSION

Output and inflation were the macroeconomic variables of interest to evaluate the evolution of economic structures across the euro area member states as the euro

²⁰ Here, we borrow the "conceptual experiment" expression from Pesaran and Shin (1998, p. 18).

²¹ Bayoumi and Eichengreen (2018) have found similar results for the period after the Maastrich Treaty. Namely, the alignment of the output responses of Germany to "shocks to aggregate demand and sometimes also to aggregate supply" with the Periphery.

experiment moved ahead. And oil shocks were the selected *conceptual* experiment to undertake that study. The GVAR was the adopted methodology, although assuming oil prices as a "dominant variable". As expected, the responses (GIRFs) exhibit temporary effects; that is, the disturbed variables have adjusted to their initial levels. But somehow in contradiction with the more recent oil literature, they were statistically significant (or very close to) even when oil demand shocks were prevalent. More specific results are highlighted next.

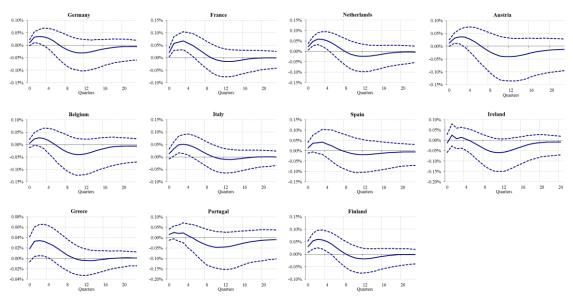
The empirical evidence obtained for Germany is noticeable for three reasons. First, it is illustrative of the merits of the methodology employed. Measured by exports weighted by GDP, Germany was the European economy that has most beneficiated from the expansion of the Chinese economy. Oil demand shocks were prevalent in that same period, tracked by our second observation window W2, spanning from 1986Q1 through 2016Q4. The estimated effects of oil shocks on the Germany output revealed positive on impact, *a la* Kilian (2009), and turned into negative around the 12th quarter, *a la* Blanchard (2006). Second, the Germany stance on fast stabilization of inflation has defined the adjustment pattern later exhibited by all developed economies, including the United States. Third, the convergence of the larger (lagged) negative responses of the German output to global shocks towards the median of the euro-area Periphery.

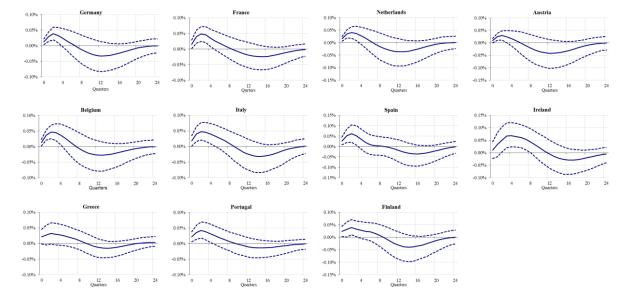
Concerning the Periphery, the results point to decreasing heterogeneity across that region (notably for Portugal), and convergence towards the Core. However, the latter was not verified when using an alternative experiment to oil shocks, namely a negative global shock to the real prices of equity.

Finally, inflation estimated responses to oil shocks were clearly distinct between the Core and the Periphery. Furthermore, there was no evidence of improvement on the sluggish adjustment of inflation in the Periphery to a global shock as the euro experiment went ahead.

APPENDIX A

A. Observation Window 1979Q2-2010Q1

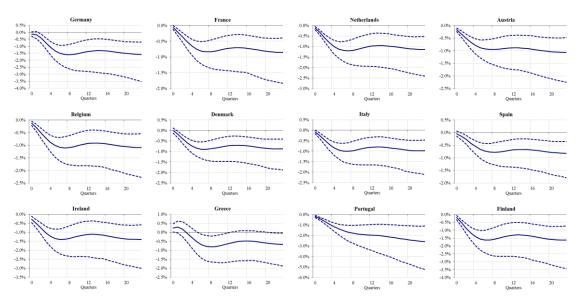




B. Observation Window 1986Q1-2016Q4

FIGURE A. 1. ESTIMATED RESPONSES OF SORT-TERM INTEREST RATES TO AN OIL PRICE SHOCK. EURO ADOPTERS

Notes: Generalized Impulse Response Functions (GIRFs) for a Positive Unit (1 s.e.) Shock to Oil Prices; Bootstrap Mean Estimates with 90% Bootstrap Error Bounds. This shock is equivalent to a fall of around 11-12% in the price of oil. Denmark is not included because of data limitations.



A. Observation Window W1: 1979Q2-2010Q1

B. Observation Window W2: 1986Q1-2016Q4

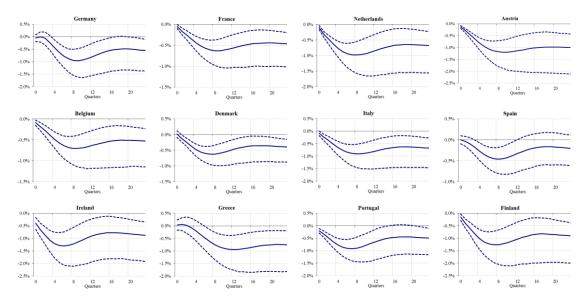


FIGURE A. 2. ESTIMATED RESPONSES OF REAL OUTPUT TO A NEGATIVE (1 S.E.) GLOBAL SHOCK TO REAL EQUITY PRICES. EURO ADOPTERS

Notes: Generalized Impulse Response Functions (GIRFs) for a negative unit (1 s.e.) global shock to real equity prices; Bootstrap Mean Estimates with 90% Bootstrap Error Bounds. Focus Group II (Euro adopters): The euro area members plus Denmark.

Country	Trough	
-	Observation Window W1	Observation Window W2
	1979Q2-2010Q1	1986Q1-2016Q4
EA-Core		
Germany	-0.41%	-0.27%
France	-0.24%	-0.17%
Netherlands	-0.27%	-0.29%
Austria	-0.25%	-0.32%
Belgium	-0.26%	-0.17%
Denmark	-0.27%	-0.19%
Median	-0.26%	-0.23%
SE	0.06%	0.06%
EA-Periphery		
Italy	-0.31%	-0.24%
Spain	-0.25%	-0.13%
Ireland	-0.54%	-0.44%
Greece	-0.22%	-0.24%
Portugal	-0.78%	-0.31%
Finland	-0.52%	-0.35%
Median	-0.42%	-0.27%
SE	0.20%	0.10%

	TABLE A. 1–Troughs of the GIRFs t	or the Real GDP after a Positive	(1 s.e.) Shock to Oil Prices
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Notes: The generalized impulse response functions (GIRFs) are shown in Figure 6. The troughs have been extracted from the Output files, "\gvarOIL_79_2010\GIRFs\DOMINANT UNIT MODEL 1se pos shock to OIL PRICES" (see the Excel sheet <graphs_bs REAL GDP per capita_edited>) and from "\gvarOIL_86_2016\GIRFs\DOMINANT UNIT MODEL 1se pos shock to OIL PRICES", available at the supplemental link.

Country	Trough		
-	Observation Window W1	Observation Window W2	
	1979Q2-2010Q1	1986Q1-2016Q4	
EA-Core			
Germany	-1.61%	-0.96%	
France	-0.86%	-0.63%	
Netherlands	-1.21%	-0.98%	
Austria	-1.08%	-1.20%	
Belgium	-1.11%	-0.70%	
Denmark	-0.90%	-0.62%	
Median	-1.09%	-0.83%	
SE	0.25%	0.21%	
EA- Periphery			
Italy	-1.01%	-0.91%	
Spain	-0.83%	-0.46%	
Ireland	-1.40%	-1.30%	
Greece	-0.81%	-0.95%	
Portugal	-2.62%	-0.92%	
Finland	-1.63%	-1.26%	
Median	-1.01%	-0.93%	
SE	0.63%	0.27%	

TABLE A. 2–Troughs of the GIRFs for the Real GDP after a Negative (1 s.e.) Global Shock to Real Equity Prices

Notes: The graphs of the generalized impulse response functions (GIRFs) are available at the Output file in the supplemental link. The troughs have been extracted from the files "\gvarOIL_79_2010\GIRFs\DOMINANT UNIT MODEL 1se pos shock to OIL PRICES" (see the Excel sheet <graphs_bs REAL GDP per capita_edited>) and from "\gvarOIL_86_2016\GIRFs\DOMINANT UNIT MODEL 1se pos shock to OIL PRICES" (see the Excel sheet <graphs_bs REAL GDP per capita_edited>), available at that same Output file in the supplemental link.

APPENDIX B

MODELING SHOCKS TO OIL PRICES IN A DOMINANT UNIT

The purpose of this Appendix is to show that shocks to oil prices when oil prices is modeled in a "dominant unit" preserve the meaning of a structural innovation without waiving the effects of cross-correlated shocks captured by the generalized impulse response functions (GIRFS) in a GVAR framework.

For the sake of clarity, we start by writing, straightforward, the VARX*(p, q) model for the individual country *i*, but before the inclusion of a common variable²²:

$$x_{it} = a_{i0} + a_{i1}t + \Phi_{i1}x_{i,t-1} + \dots + \Phi_{ip}x_{i,t-p_i} + \Lambda_{i0}x_{it}^*$$
(1)
+ $\Lambda_{i1}x_{i,t-1}^* + \dots + \Lambda_{iq_i}x_{i,t-q_i}^* + u_{it}$

where \mathbf{x}_{it} is a $k_i \times 1$ vector of domestic variables, \mathbf{x}_{it}^* is a $k_i^* \times 1$ vector of foreign (star) variables, and \mathbf{u}_{it} is a vector of idiosyncratic country-specific shocks, for t = 1, 2, ..., T.

The vector of foreign variables is defined as

$$x_{it}^* = \sum_{j=0}^{N} w_{ij} x_{jt}, \quad w_{ii} = 0$$
⁽²⁾

with w_{ij} , j = 0, 1, 2, ..., N, a set of weights such that $\sum_{j=0}^{N} w_{ij} = 1$. The weights are commonly based on the trade (imports plus exports) share of country *j* in country *i*.

In matrix notation (2) is written as

$$x_{it}^* = \widetilde{W}_i' x \tag{3}$$

²² See Chudik and Pesaran (2016) for a compact description of the GVAR methodology and Smith and Galesi (2014, User Guide) for a more detailed presentation, in particular the procedures to include a dominant unit in the GVAR, pp. 152-8.

where $\widetilde{W}_i \equiv [w_{ji}]$ is the $k \times k_i^*$ matrix of country-specific weights and $x_t = (x'_{0t}, x'_{1t}, \dots, x'_{Nt})'$ is $k \times 1$ vector collecting all endogenous variables in the global model (including the U.S., indexed by 0); as such $k = \sum_{i=0}^{N} k_i$.

We rewrite now the VARX*(p,q) model for country *i*, but augmented of one common variable w_t^{23}

$$x_{it} = a_{i0} + a_{i1}t + \Phi_{i1}x_{i,t-1} + \dots + \Phi_{ip}x_{i,t-p_i} + \Lambda_{i0}x_{it}^* + \Lambda_{i1}x_{i,t-1}^*$$

$$+ \dots + \Lambda_{iq_i}x_{i,t-q_i}^* + \psi_{i0}w_t + \psi_{i1}w_{t-1} + \dots + \psi_{iq_{i_W}}w_{t-q_{i_W}} + u_{it}$$
(4)

where w_t is determined in a univariate "dominant unit" model (i.e., the marginal model²⁴), which is defined as follows, when including lagged "feedback variables":

$$w_{t} = \mu_{0} + \mu_{1}t + \phi_{w1}w_{t-1} + \dots + \phi_{w\tilde{p}}w_{t-\tilde{p}} + \lambda_{1}'\tilde{x}_{t-1} + \dots + \lambda_{\tilde{q}}'\tilde{x}_{t-\tilde{q}} + \eta_{t}$$
(5)

and where $\tilde{\mathbf{x}}_t$ is a $k_w^* \times 1$ vector of global cross-sections averages and λ_j , $j = 1, ..., \tilde{q}$, is the $k_w^* \times 1$ dimensional vector collecting the λ_{jl_w} coefficients associated with the l_w^{th} global variable, $\tilde{\mathbf{x}}_{l_w,t-j}$. In matrix notation the "feedback variables" are written as

$$\widetilde{x}_t = \widetilde{W}_w x_t \tag{6}$$

where \widetilde{W}_w is $k_w^* \times k$ weight matrix, assumed time invariant, and $x_t = (x'_{0t}, x'_{1t}, \dots, x'_{Nt})'$ is the vector of global endogenous variables.

It is worth noting that only the "lagged" although not the contemporaneous values of \tilde{x}_t enter equation (5), as \tilde{x}_t is not weakly exogenous for the parameters of the dominant unit model²⁵.

²³ We keep w_t to represent the dominant variable as the common practice in the GVAR literature. The context and the different sort of indexation make clear the distinction to the trade weights notation (w_{ij}). ²⁴ For a definition of "conditional" and of "marginal" models see, for ex., Garratt et al. (2006, pp. 58-59). ²⁵ See Lütkepohl and Krätzig (2004, pp. 99 and 108) for the definition of a weakly exogeneity in its general terms and in the context of cointegration. See Garratt et al. (2006, pp. 57-59) for a formal treatment and for the definition of a "long-run" forcing a weakly exogenous *I*(1) variable.

The country-specific conditional models (4) and the marginal model (5) must be combined and solved for the "complete" global VAR model. To start the procedure, we have to get rid of the star variables. Hence, define $\mathbf{z}_{it} = (\mathbf{x}'_{it}, \mathbf{x}^{*\prime}_{it})'$, a vector of dimension $(k_i + k_i^*) \times 1$; and after making $p_i = q_i$, rewrite equation (4) as follows:

$$A_{i0}z_{it} = a_{i0} + a_{i1}t + A_{i1}z_{i,t-1} + \dots + A_{ip_i}z_{i,t-p_i}$$

$$+ \psi_{i0}w_t + \psi_{i1}w_{t-1} + \dots + \psi_{iq_{iW}}w_{t-q_{iW}} + u_{it}$$
(7)

with

$$\mathbf{A}_{i0} = (\mathbf{I}_{k_i}, -\mathbf{\Lambda}_{i0}), \quad \mathbf{A}_{ij} = (\mathbf{\Phi}_{ij}, \mathbf{\Lambda}_{ij}), \quad \text{for } j = 1, \dots, p_i$$

and where A_{i0} and A_{ij} are $k_i \times (k_i + k_i^*)$ dimensional matrices; and A_{i0} is non-singular.

Define, now, the $(k_i + k_i^*) \times k$ link matrices

$$W_i = (E'_i, \widetilde{W}'_i), \tag{8}$$

where E_i is the $k \times k_i$ dimensional selection matrix that select x_{it} , namely $x_{it} = E'_i x_t$ and \widetilde{W}_i is the weight matrix introduced in (3).

Therefore, we may substitute z_{it} in (7) for $W_i x_t$ and get rid of the exogenous (star) variables, x_{it}^* , while preserving the VARX* coefficients already estimated.

$$A_{i0}W_{i}x_{t} = a_{i0} + a_{i1}t + A_{i1}W_{i}x_{t-1} + \dots + A_{ip_{i}}W_{i}x_{t-p_{i}} + \dots + \psi_{i0}w_{t} + \psi_{i1}w_{t-1} + \dots + \psi_{iq_{i_{W}}}w_{t-q_{i_{W}}} + u_{it}$$
(9)

to build the global system we just need to stack all those equations, i.e., the expression given in (9) for the i = 0, 1, 2, ..., N countries,

$$G_0 x_t = a_0 + a_1 t + G_1 x_{t-1} + \dots + G_p x_{t-p} + \dots$$

$$+ \psi_0 w_t + \psi_1 w_{t-1} + \dots + \psi_p w_{t-p} + u_t$$
(10)

where G_0 and G_j , with $j_t = 1, ..., p$, are $k \times k$ matrices, and a_0 , a_1 and u_t are $k \times 1$ vectors:

$$G_{0} = \begin{pmatrix} \mathbf{A}_{00} \mathbf{W}_{0} \\ \mathbf{A}_{10} \mathbf{W}_{1} \\ \vdots \\ \mathbf{A}_{N0} \mathbf{W}_{N} \end{pmatrix}, \quad G_{j} = \begin{pmatrix} \mathbf{A}_{0j} \mathbf{W}_{0} \\ \mathbf{A}_{1j} \mathbf{W}_{1} \\ \vdots \\ \mathbf{A}_{Nj} \mathbf{W}_{N} \end{pmatrix},$$
$$a_{1} = \begin{pmatrix} a_{01} \\ a_{11} \\ \vdots \\ a_{N1} \end{pmatrix}, \quad \psi_{j} = \begin{pmatrix} \psi_{0j} \\ \psi_{1j} \\ \vdots \\ \psi_{Nj} \end{pmatrix}, \quad u_{t} = \begin{pmatrix} u_{0t} \\ u_{1t} \\ \vdots \\ u_{Nt} \end{pmatrix}$$
(11)

and $p = max\{max p_i, max q_i, max q_{i_W}\}$.

Next, we solve the system for the global $k \times 1$ vector of endogenous variables $x_t = (x'_{0t}, x'_{1t}, \dots, x'_{Nt})'$ "combined" with the dominant variable w_t , which is preserved as weakly exogenous. Define the $(k + 1) \times 1$ vector of all observable variables $y_t = (x'_t, w_t)'$ and, after making $p = \tilde{p} = \tilde{q}$, stack equations (5) and (10) to obtain the "combined model":

$$H_0 y_t = h_0 + h_1 t + H_1 y_{t-1} + \dots + H_p y_{t-p} + \zeta_t$$
(12)

where

$$H_{0} = \begin{pmatrix} \boldsymbol{G}_{0} & -\boldsymbol{\psi}_{0} \\ \boldsymbol{0}_{1 \times k} & 1 \end{pmatrix}, \quad \boldsymbol{h}_{0} = \begin{pmatrix} \boldsymbol{a}_{0} \\ \mu_{0} \end{pmatrix}, \quad \boldsymbol{h}_{1} = \begin{pmatrix} \boldsymbol{a}_{1} \\ \mu_{1} \end{pmatrix}$$
$$H_{j} = \begin{pmatrix} \boldsymbol{G}_{j} & \boldsymbol{\psi}_{j} \\ \boldsymbol{\lambda}_{j}' \widetilde{\boldsymbol{W}}_{w} & \boldsymbol{\phi}_{wj} \end{pmatrix}, \quad j = 1, \dots, p, \quad \boldsymbol{\zeta}_{t} = \begin{pmatrix} \boldsymbol{u}_{t} \\ \eta_{t} \end{pmatrix}$$

Assuming that G_0^{-1} exists the matrix H_0 is invertible:

$$H_0^{-1} = \begin{pmatrix} G_0^{-1} & -G_0^{-1}\psi_0 \\ 0 & 1 \end{pmatrix}$$
(13)

which is block higher triangular, "showing the casual nature of the common (dominant) variables, w_t ", as highlighted by Chudik and Pesaran (2016:170).

Finally, multiplying both sides of (12) by H_0^{-1} we obtain the "complete" GVAR model:

$$y_t = c_0 + c_1 t + C_1 y_{t-1} + \dots + C_p y_{t-p} + H_0^{-1} \zeta_t$$
(14)

with

$$c_j = H_0^{-1} h_j, \quad j = 0, 1; \quad C_j = H_0^{-1} H_j, \quad j = 1, \ldots, p$$

For which the moving average representation is given by

$$y_t = d_t + \sum_{s=0}^{\infty} B_s \varepsilon_{t-s}$$
$$= \varepsilon_t + B_1 \varepsilon_{t-1} + B_2 \varepsilon_{t-2} + \dots$$
(15)

where d_t represents the deterministic component of y_t , B_s can be derived recursively as

$$B_{s} = C_{1}B_{s-1} + C_{2}B_{s-2} + \dots + C_{p}B_{s-p}, \quad s = 1, 2, \dots$$

with $B_{0} = I_{k+1}, B_{s} = 0$, for $s < 0$ (16)

and $\boldsymbol{\varepsilon}_t = (\boldsymbol{\varepsilon}'_{0t}, \boldsymbol{\varepsilon}'_{1t}, \boldsymbol{\varepsilon}'_{2t}, \dots, \boldsymbol{\varepsilon}'_{Nt}, \boldsymbol{\varepsilon}_{wt})'$ is given by

$$\varepsilon_t = H_0^{-1} \zeta_t = \begin{pmatrix} G_0^{-1} (u_t - \eta_t \psi_0) \\ \eta_t \end{pmatrix}$$
(17)

Looking at (17) we can see that $\varepsilon_{wt} = \eta_t$. Recall now that η_t is the disturbance term in the dominant variable w_t model, that is, the "marginal model" expressed in (5). Hence, shocks to w_t equation in the MA (∞) representation (15) are preserved as structural innovations.

Let us now write the GIRFs for the GVAR model expressed in (15), for a shock defined by $v_t = e'_l \zeta_t$ at time *t*, where $e_l = (0, 0, ..., 0, 1, 0, ..., 0)'$ is the selection vector, with unity at the l^{th} element:

$$GIRF(h, y_t; z_t) = E\left(y_{t+h} | v_t = \sqrt{e_l' \Omega_{\zeta} e_l}, T_{t-1}\right) - Ey(t+h|T_{t-1})$$
$$= \frac{B_h H_0^{-1} \Omega_{\zeta} e_l}{\sqrt{e_l' \Omega_{\zeta} e_l}}, \quad h = 0, \ 1, \ 2, \ \dots,$$
(18)

Where T_{t-1} is the information set up to time t - 1, B_h is computed as in (16), and Ω_{ζ} is the covariance matrix of the "combined model" error terms, that is of the model expressed in (12).

To show that the structural impulse responses (SGIRF) for a common variable modeled in a dominant unit simplifies to the GIRF written in (18), we reproduce next the SGIRF definition given in Smith and Galesi (2014:157-58), after small adjustments to harmonize the notation:

$$SGIRF(h, y_t; v_t) = E\left(y_{t+h} | v_t = \sqrt{e_l' \Sigma_v e_l}, T_{t-1}\right) - E(y_{t+h} | T_{t-1})$$

$$= \frac{B_h (P_{Ho} H_0)^{-1} \Sigma_v e_l}{\sqrt{e_l' \Sigma_v e_l}}, \quad h = 0, \ 1, \ 2, \ \dots,$$
(19)

where the matrix P_{Ho} come from the standard Cholesky decomposition to identify the structural innovations in a "block" formed by the dominant unit and the U.S. economy (Smith and Galesi 2014: 157), and the index v refers to the vector of error terms $v_t = (u'_{1t}, ..., u'_{Nt}, \dot{v}'_t)$, where \dot{v} stands for the vector of structural shocks in the system of equations written for the "block".

While having only one, already identified, structural innovation $\varepsilon_{wt} = \eta_t$, as shown in (17), we may drop P_{Ho} . Moreover, for a "block" formed by one single dominant variable, w_t , $v_t = (u'_{1t}, ..., u'_{Nt}, \dot{v}'_t) = (u'_{1t}, ..., u'_{Nt}, \eta_t)'$, implying that $Cov(v_t) = Cov(\zeta)$ or $\Sigma_v = \Omega_{\zeta}$. Therefore, both the numerator and denominator of (19) collapse into their counterparts in (18). It should be noticed that when l = k + 1, where k + 1 indexes the common (dominant) variable, the denominator in (19) renders the standard deviation of the structural innovation in the "marginal model", *viz.* $\sqrt{e_l' \Sigma_v e_l} = \sqrt{e_l' \Omega_\zeta e_l} = \sqrt{E(\varepsilon_{wt}^2)} = \sigma_{\eta}$.

Finally, it might be interesting to explain the meaning of "structural" within the framework of a generalized impulse response function by inspecting the covariance matrix of the error terms. Hence, let us write the $(k + 1) \times (k + 1)$ dimensional covariance matrix of the country specific residuals u_t and the structural shock η_t

$$Cov(\boldsymbol{v}_{t}) = \begin{pmatrix} Var(\boldsymbol{u}_{1t}) & \cdots & Cov(\boldsymbol{u}_{1t}, \boldsymbol{u}_{Nt}) & Cov(\boldsymbol{u}_{1t}, \eta_{t}) \\ \vdots & \cdots & \vdots & \vdots \\ Cov(\boldsymbol{u}_{Nt}, \boldsymbol{u}_{1t},) & \cdots & V(\boldsymbol{u}_{Nt}) & Cov(\boldsymbol{u}_{Nt}, \eta_{t}) \\ Cov(\eta_{t}, \boldsymbol{u}_{1t},) & \cdots & Cov(\eta_{t}, \boldsymbol{u}_{Nt},) & Var(\eta_{t}) \end{pmatrix}$$
$$= \begin{pmatrix} \boldsymbol{\Sigma}_{u} & Cov(\boldsymbol{u}, \eta_{t}) \\ Cov(\eta_{t}, \boldsymbol{u}) & Var(\eta_{t}) \end{pmatrix}$$

When l = k + 1, the structural generalized impulse response functions for shock set to one standard deviation (s.d.) of η is written as

$$SGIRF(h, y_t; v_{k+1,t}) = \frac{\begin{pmatrix} B_{h1} & B_{h2} \\ b'_{h1} & b_{h2} \end{pmatrix} \begin{pmatrix} G_0^{-1} & -G_0^{-1}\psi_0 \\ 0_{1\times k} & 1 \end{pmatrix} \begin{pmatrix} Cov(u, \eta_t) \\ Var(\eta_t) \end{pmatrix}}{\sigma_{\eta}}}{\sigma_{\eta}}$$
$$= \begin{pmatrix} B_{h1} & B_{h2} \\ b'_{h1} & b_{h2} \end{pmatrix} \begin{pmatrix} \sigma_{\eta}^{-1}G_0^{-1}(I_k - \psi_0)Cov(u, \eta_t) \\ \sigma_{\eta} \end{pmatrix}, \qquad (20)$$
$$h = 0, \ 1, \ 2, \ \dots,$$

Equation (20) make the properties of the SGIRF immediately apparent: It is "structural" in the sense of being entertained by an identified shock, σ_{η} , and "generalized" once reflecting the distribution of the errors across the different equations in the global

model, by taking into account their cross-correlations, in case captured by the term $Cov(u, \eta_t)$.

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