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'THREE ESSAYS ON THE GLOBAL FINANCIAL CRISIS OF 2007-2008'

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STATEMENT OF AUTHORSHIP

I hereby declare that the presently submitted Doctoral Thesis constitutes an original academic work of my own exclusive authorship, and that all third party contributions are duly and fully acknowledged.

Lisbon, the 11th of January, 2013,

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DOCTORAL THESIS ABSTRACT

The present Doctoral Thesis is comprised of three empirical essays addressing the Global Financial Crisis of 2007 – 2008. The said essays analyse distinct, but interconnected issues pertaining to this fundamental research topic. In the first paper, a careful examination is conducted in order to ascertain whether the 'Subprime' Crisis in the U.S.A. might have been duly forecasted using publicly available data. This hypothesis is confirmed by using two distinctive methodologies applied to a set of financial indicators, which independently confirm the predictability of the said financial shock. The second paper addresses the degree of heterogeneity of banking responses in forty two countries in the wake of the Global Financial Crisis. By employing a novel methodology – the Heterogeneous Regime-Switching Model (HRSM) –, representative country banking institutions worldwide are deemed to have had quite distinctive and heterogeneous responses to the onset of the global systemic event under scrutiny, and these responses may be grouped according to certain clusters. The third paper addresses the impact of the Global Financial Crisis upon the Euro Area and corresponding sovereign debt schedules. An updated academic survey is first conducted regarding the topic of the impact of excessive Member States' sovereign debt in the wake of the systemic breakdown. The survey is followed by an empirical study using quadratic econometric specifications demonstrating that the over-accumulation of sovereign debt in the Euro Area is strongly associated with the diminishment of output growth in the latter Area, and that sound sovereign debt thresholds in key Euro Area Member States have been unwisely breached.

Keywords: Global Financial Crisis, Early Warning Systems, Heterogeneous Regime-Switching Model, Euro Area Sovereign Debt

JEL Classification Codes: G01, E5

RESUMO DA TESE DOUTORAL

A presente Tese Doutoral abarca três ensaios académicos empíricos que analisam a Crise Financeira Global de 2007 – 2008. Estes ensaios analisam questões científicas distintas, mas interligadas entre si, relativamente a este fundamental tópico de investigação. O primeiro ensaio investiga cuidadosamente a hipótese segundo a qual a Crise '*Subprime*' nos E.U.A. poderia ter sido adequadamente prevista por recurso a dados publicamente disponíveis. Esta hipótese é verificada por recurso a duas metodologias alternativas, devidamente aplicadas a um conjunto de indicadores estritamente financeiros, sendo confirmada a previsibilidade do dito choque financeiro. O segundo ensaio investiga, no seguimento da Crise Financeira Global, o grau de heterogeneidade dos comportamentos de instituições financeiras em quarenta e dois países. Utilizando uma inovadora metodologia – intitulada *Heterogeneous Regime-Switching Model (HRSM)* –, constata-se que os distintos sistemas financeiros nacionais reagiram de forma diferenciada e heterogénea ao choque financeiro global sob estudo, sendo estas respostas passíveis de serem agrupadas em certas categorias. O terceiro ensaio investiga o impacto económico da Crise Financeira Global sobre a Zona Euro e, em particular, sobre a dinâmica da respectiva dívida soberana. Primeiramente, é elaborado um *survey* académico actualizado relativamente ao tópico do excessivo endividamento público e respectivo impacto sobre o produto económico, prestando-se particular atenção ao contexto do choque sistémico sob análise. Este *survey* académico é seguido de uma aplicação empírica envolvendo especificações econométricas quadráticas que atestam que a excessiva acumulação de dívida soberana na Zona Euro está associada a um processo de decrescimento económico da dita Zona, e que níveis óptimos associados a rácios de dívida pública em determinados Estados Membros foram imprudentemente ultrapassados.

Palavras-chave: Crise Financeira Global, Sistemas de Detecção Antecipada, Modelo HRSM-S, Dívida Soberana da Zona Euro

Classificação JEL: G01, E5

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DEDICATION

To Vanita and Chandrakant, for their undying love and moral support.

To Kashi Ma and Prabhudas Bhimjee, for their spiritual guidance and blessings.

IN MEMORIAM

In very fond remembrance of my (Late) Beloved Father, Dr. Chandrakant Prabhudas, who departed before the present Doctoral Thesis could have been submitted. He was a beacon of wisdom in his unrelenting support of my doctoral endeavours. He was – and shall always remain - a flourishing source of personal and professional inspiration throughout my life. We shall forever remain most trusted and uttermost loyal Friends.

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CHAPTER ONE. INTRODUCTION

The Global Financial Crisis of 2007 – 2008 constituted a most resounding and scarring global economic event, with far-reaching macroeconomic and social consequences, which deeply affected the lives of millions of concerned citizens worldwide.

Paradoxically, when the said systemic breakdown is solely contemplated from an academic perspective, it nevertheless constitutes a most enriching economic phenomenon, worthy of a proper academic scrutiny.

It is therefore under the influence of this latter perspective that the present Doctoral Thesis, comprised of three essays on the Global Financial Crisis of 2007 – 2008, should be considered, so that the modest academic contribution it so passionately strives to convey might constitute a future reference for the academic community seeking to address such a daunting and polymorphic research topic. Furthermore, it is also hoped that our humble contribution might also be of service to the supervisory and/or regulatory community, in view of the strategic importance of certain topics herein scrutinised.

Our first Working Paper (Chapter Two) suggests the possibility that the 'Subprime' Crisis in the U.S.A. might have been anticipated, by using key financial indicators within the context of two mutually exclusive and efficient forecasting methodologies.

Our second Working Paper (Chapter Three) analyses the highly heterogeneous performance of the global banking industry during the 'Subprime' cycle, by employing a highly innovative model, the Heterogeneous Regime-Switching Model.

Our third Working Paper (Chapter Four) is divided into two sections. The first conducts an extensive academic survey addressing the research topic of sovereign over-indebtedness in the Euro Area. The second focuses on the pressing issue involving the optimal limits of sovereign over-indebtedness in the Euro Area, taking into consideration the architecture of a historical concept initially proposed by the literature, the sovereign debt Laffer curve.

CHAPTER TWO. FINANCIAL INDICATORS AS PREDICTORS OF THE 'SUBPRIME' FINANCIAL CRISIS – THE ROLE ON NON-PARAMETRIC METHODS

ABSTRACT: This paper examines the performance of two innovative forecasting methodologies, which are applied to the 'Subprime' Financial Crisis in the U.S.A. The corresponding forecasts, when applied to a set of financial indicators, timingly predict the onset of the latter systemic episode in this country. The accurate predictions were issued under the framework of the Early Warning Systems (EWS) and Net Price Increase/Decrease (NPI/NPD) methodologies to the analysis of the said financial shock in the U.S.A. These predictions were first signalled by analysing the Put-Call Ratio, a bellwether options market statistic. The latter statistic was subjected to the protocol prescribed by the widely used 'signals' modelling approach within the EWS literature and subsequently validated by the NPI/NPD methodology. The application of the 'signals' approach to our sample data yielded potent and persistent anticipating signals as to the occurrence of the impending systemic crisis, as early as 19 months before the peak of economic activity registered in the U.S.A. These findings were also subjected to stringent robustness tests, which, notwithstanding, continued to attest to the quality of the results. In addition, our findings were also validated by the use of other equally predictive financial indicators. It is hoped that further research might contribute to the use of this and other financial market statistics and corresponding predictive methodologies as signalling tools of subsequent financial crises.

KEYWORDS: Global Financial Crisis, Subprime Crisis, Put-Call Ratio, Early Warning Systems, Signals Approach, Net Price Increase/Decrease, Crisis Prediction

JEL Codes : G01, G1, G18

2.1. INTRODUCTION[1]

The profound and largely unexpected magnitude of the 'Subprime' Crisis[2] has highlighted the need for specific supervisory instruments that might signal in advance the future occurrence of such striking and devastating systemic events.

Although the occurrence of the 'Subprime' Crisis was overwhelmingly associated with the deflation of the housing and credit bubbles in the United States of America (U.S.A.), it is no less true that the said failure should be clearly understood in the light of a dynamic and evolving financial innovation framework. In this respect, and just to name an example, securitization constitutes a prime instance of these innovative forces at work.

The financial and macroeconomic implications associated with the systemic disruption pertaining to the breakdown of these highly complex and dynamical processes indicate the need for implementing a corresponding set of equally innovative supervisory tools that might enable regulators to foresee (and, whenever possible, to mitigate and/or contain) the excesses associated with innovative, but morally hazardous financial instruments. Therefore, the enormous importance pertaining to the implementation of these systems cannot be over-stressed, insofar as the augmentation of the array of predictive supervisory instruments at the disposal of the regulatory community constitutes a major line of defence against the severe impact of extreme financial events.

This paper mainly proposes and examines a bellwether instrument - the Put-Call Ratio - as an efficient financial crisis signalling indicator. Our contribution will be accomplished using the 'signals' approach methodology, which is inscribed within the heterogeneous body of knowledge already assembled in the Early Warning Systems (EWS) academic literature. As shall be seen in the forthcoming sections, our proposed indicator – a variant of the Put-Call Ratio, a widely used financial benchmark indicator in the options market in the U.S.A. - possesses powerful anticipating signalling capabilities. The said indicator and methodology might ultimately be of service to the supervisory arsenal at the disposal of monetary and financial authorities.

[1] The Figures and Tables mentioned in the present Chapter have been collected in Appendix A (end-of-chapter).

[2] A distinction will be made between the 'Subprime' Crisis as a localised U.S. extreme financial event and the ensuing Global Financial Crisis as a global systemic shock; in the context of the present document, we will only address the former financial event.

Our findings will subsequently be validated by the use of additional predictive financial indicators (mostly of daily periodicity). Finally, we propose an alternative methodology - the Net Price Increase/Decrease (NPI/NPD) - in order to strengthen the quality of our findings. The business cycle leading up to the 'Subprime' Crisis will be the focal point of our research, in view of the fact that it constitutes the origin of the Global Financial Crisis presently under way.

Thus, the scientific question presiding over the present paper - concerning the validity of higher-frequency financial indicators as potential supervisory tools - will address the efficiency of the signalling capabilities of the said financial indicators relative to the occurrence of this latest systemic breakdown in the U.S.A.

In order to achieve this purpose, two mutually exclusive methodologies will be employed, the 'signals' approach and the NPI/NPD approach. On the one hand, the application of the 'signals' approach will yield forecasting results that are quite robust, highlighting the tremendous potential of the Put-Call Ratio as a powerful signalling tool. The onset of the crisis under scrutiny will be foretold, under the 'signals' approach, nineteen months prior to the peak of economic activity in the U.S.A. On the other hand, the validating NPI/NPD methodology yields quite credible forecasting results as early as twenty months prior to the onset of the financial event under study.

Our paper will adopt the following structure. Section 2 will mainly review the most relevant literature on Early Warning Systems (EWS) pertinent to the architecture of our paper. Section 3 will provide a brief review of the idiosyncrasies of the 'Subprime' Crisis, present the main transmission channels associated with this systemic event and explain the importance of stock markets within the EWS literature. Section 4 will present some essential definitions pertaining to the options markets, introduce the Put-Call Ratio and specify the underlying data pertaining to our chosen indicator. Section 5 will review the main tenets of the 'signals' approach methodology, introduce the baseline empirical findings thereof, and perform robustness and validation checks. Section 6 will present an alternative methodology, and corresponding empirical findings. Section 7 will finally present the main conclusions drawn from our overall findings.

2.2. LITERATURE REVIEW

In the present section, we will present some initial considerations pertaining to the literature herein reviewed (sub-section 2.2.1.), review the most appropriate EWS seminal literature (sub-section 2.2.2.), review the 'Subprime' Crisis EWS-related literature (sub-section 2.2.3.) and, finally, review the literature addressing the taxonomy of financial crises (sub-section 2.2.4.).

2.2.1. INITIAL CONSIDERATIONS

Prior to addressing and reviewing the main academic literature on EWS, it would be extremely important to point out not only the main motivation, but also the utmost importance of this challenging academic task of anticipating systemic breakdowns.

Given the enormous economic impact associated with the 'Subprime' Crisis (or any other similar systemic financial event of the same order of magnitude, for that matter), any credible lines of scientific enquiry should strive to propose indicators capable of anticipating the advent of systemic economic breakdowns. In turn, these indicators should, at least, help supervisory authorities to mitigate (but preferably, to deter) the traditional *full-blown negative impact* associated with the occurrence of such events. Therefore, in our judgement, *awareness as to the potential occurrence of a systemic failure (should the processes that led to this perception be properly conducted) is preferable to no awareness at all*.

Furthermore, it is our understanding that there were evident signs of impending distress within the financial sector during the ascending phase of the preceding real estate and credit bubbles. These signs reflected a degree of financial vulnerability that was latent prior the 'Subprime' Crisis, but became quite manifest in the aftermath of the Crisis. Our proposed financial bellwether indicator will provide surmounting evidence in support of this latter understanding relative to the distress levels pertaining to the stock and options markets. This indicator will be duly introduced and analysed in the fourth section of the present document.

In addition, our findings pertaining to the adoption of the Put-Call Ratio as a signalling indicator do suggest that the latter might be quite an efficient tool in anticipating systemic crises. Within the context of the 'Subprime' Crisis, our results indicate that this extreme event was signalled, in the most optimistic scenario, at least nineteen months before the official peak of economic activity. Even taking into account the imposition of more stringent criteria, the systemic episode is foretold ten months in advance of the peak of economic activity.

The above-mentioned results were further validated by analysing additional, more specific, financial indicators. Accordingly, these results clearly indicate that when our proposed indicators are inscribed within the EWS framework, they clearly possess powerful anticipating abilities.

In view of the structural importance associated with the proposal of signalling indicators to the EWS literature, we will review *en passant* the most significant papers that have focused on stock market indicators as an anticipatory tool. This review[3] will also include a commentary on the latest available EWS literature survey, which will trace the main aspects associated with this literature's evolution. This section ends with the review of a more updated literature on the taxonomy of financial crises, so that the 'Subprime' Crisis might be given a more updated definitional framework.

This panoramic review is of importance for three main reasons. First and foremost, and given the proximity between our proposed indicator and other potential higher frequency[4] financial indicators, it will allow us to validate the use of this latter class of indicators, which have been historically neglected in the EWS literature. That is, our argument will sustain that higher frequency financial indicators (as is the case of our stock market-related indicator) are a promising and powerful subset of EWS indicators that merit further research within the context of existing literature.

Second, it will allow us to articulate and review some of the previous methodological options associated with the use of stock market-related indicators. Notwithstanding, the range of methods employed and the crisis definitions to which they are applied might be different from the approach herein pursued.

[3] The cut-off point to the research process of this paper was September, the 1st, 2010.
[4] We consider higher frequency indicators to possess a periodicity ranging from a daily to a yearly range; thus, intra-daily periodicities are not encompassed by our definition.

Third, the analysis of the stock market performance indicator as an anticipatory tool in previous EWS research will also allow us to pinpoint some potential common shortcomings associated with the use of higher frequency financial indicators as a signalling class. The existence of these shortcomings might also help explain why this class of indicators has not been extensively used in the literature.

Thus, the papers herein reviewed not only constitute an attempt to encompass the most representative and well-known documents in the EWS literature, but also seek to portray an otherwise highly diverse strain of economic literature necessary to our research. In this effort, it would not come as a surprise that some important documents may have been left out of this review. However, we will focus our review on the body of research that is in strict accordance to the nature and scope of our proposed signalling indicators. Lastly, these documents will be presented and reviewed according to their chronological order of publication.

2.2.2. REVIEW OF EWS FOUNDATIONAL LITERATURE

Our succinct review will start with the seminal paper in the EWS literature, authored by Kaminsky, Lizondo and Reinhart (1998). This was one of the first papers in this strand of literature to address stock market performance as a signalling indicator for financial crises.

It should be noted that the paper under review was eminently concerned with the design of specific early warning systems for currency crises (the paper was drafted in the aftermath of the Asian currency crises). Given the intensity of the debate surrounding the fallout from the said crisis, the authors crucially point to the "need to develop a warning system that helps monitor whether a country may be slipping into a potential crisis" (Kaminsky, Lizondo and Reinhart, 1998:1).

Besides proposing a methodology based on the 'signals' approach, the paper provides a well-documented empirical analysis based on a diverse set of proposed indicators that were subjected to the said approach.

Among the several indicators analysed by the authors, the stock market performance indicator figures prominently as a crisis signalling indicator. Indeed, the

stock market performance indicator is deemed to be quite effective in this capacity. Under the auspices of the 'signals' approach, it correctly predicts approximately two thirds of the crises that have occurred in the scrutinized period (Kaminsky, Lizondo and Reinhart, 1998:20, Table 1).

Overall, and where the treatment of financial sector variables is concerned, there are two interesting points that warrant our attention.

First, the financial sector is already deemed to be an important source of disruption and a 'purveyor' of financial (i.e., currency) crises. In fact, this latter paper is quite attentive to the role played out by financial liberalization processes (as a potential disruption factor), as opposed to all other financial influences.

Second, and most importantly, the stock market performance indicator is explicitly viewed as a variable belonging to the family of real sector variables. This sub-set includes, among others, real GDP growth, output, employment/unemployment and wages (Kaminsky, Lizondo and Reinhart, 1998:10).

Within the context of our own research, we do not entirely concur with this later categorical assumption due to the fact that it does not distinguish and isolate 'pure' financial shocks from real economic shocks. Accordingly, we will pursue a different approach, as shall be seen throughout our paper. This topic will also be addressed in the following paper review.

In the aftermath of the Asian Crisis, Kaminsky (1999) authors a subsequent paper dedicated to the development of the 'signals' approach within the EWS literature. This paper is mainly concerned with the efficiency of distinct composite indicators as leading indicators of currency and banking crises, and, more specifically, with the fact that these crises are anticipated by a sharp period of distress (a concerning sign of economic vulnerability).

In order to achieve the intended research goal, the author examines 102 financial (strictly currency-related or banking-related) crises from a country-wide sample of both emerging market and industrialized countries. The paper's author ultimately draws some important conclusions about the potential output loss associated with the occurrence of these breakdowns. This analysis is pursued within the framework of the chosen indicators' signal efficiency capabilities (Kaminsky, 1999: 1 and 35). These

indicators are initially analysed as univariate variables (prior to their inclusion in the composite index), so that their individual signal potency is duly ascertained.

Where the results associated with the stock market performance indicator are concerned, the latter variable is included in a set of leading indicators associated with growth (output) slowdown (Kaminsky, 1999: 9, Table 2). That is, this indicator's rise signals real output buoyancy, while the indicator's decline signals a growth slowdown.

However, we would like to draw attention, once again, to the fact that this financial market indicator is closely associated with a real economic variable, pointing to a potential incongruence in the EWS literature. The incongruence arises whenever a financial market breakdown is followed by a real economy aftershock, i.e., whenever a real shock is preceded by a financial shock. In this case, transmission channels facilitate the transmission of the negative impact of the breakdown in the financial markets to the real economy, through a temporal lag structure. Therefore, the combined financial and real event occurrence is measured by the performance of a financial market statistic, but does not discriminate between the 'pure' financial shock and the real economy shock. The former typically precedes the later in a 'pure' financial systemic event.

As shall be seen at the end of the present section, when our own definition of financial crisis is duly presented, our paper will follow a different line of enquiry. This is due to the fact that we will advocate that *financial market indicators should be used in the metric of 'pure' financial shocks*, as opposed to being used as a 'loose' measure of combined financial market and real market shock incidence or vulnerability. We believe this distinction to be of the utmost importance, in view of the fact that indistinctively combining the effects associated with financial and real shocks might disregard the heterogeneous causes, nature and timing associated with each of these two sequential shocks belonging to the same crisis episode. Therefore, we will strictly confine ourselves to the incidence of financial shocks, contrary to traditional practice in the EWS literature, which tends to erase this fundamental distinction between these distinct types of shocks.

The univariate treatment given to the stock market performance indicator (along with the other chosen indicators) is based on the above-mentioned non-parametric 'signals' approach; the latter was co-developed by the author (Kaminsky, 1999: 12 and 13). After finding the appropriate threshold for each variable under study, above (or

below, depending on the case) which an anticipatory signal is emitted, the author then addresses the robustness associated with the performance of each individual indicator.

The stock market performance indicator is again found to be significantly more accurate - *vis-à-vis* other indicators pertaining to this study - in predicting banking crises (as a specific class of financial crisis).

In view of the financial vulnerability unleashed by the Asian Crisis and its repercussions upon an increasingly globalised economic network intertwining industrialized nations and emerging markets, Goldstein, Kaminsky and Reinhart (2000) further expand the design of EWS taking into consideration both of these latter markets. The argument of this monograph closely follows the non-parametric 'signals' extraction procedure, and comprehensively addresses both currency and banking crises.

In fact, the latter banking crises are generally defined either as an event signalling a bank run or as the establishment of a large-scale government assistance program; in this context, these authors duly observe that "banking crises tend to follow sharp declines in asset prices" (Goldstein, Kaminsky and Reinhart, 2000:15).

However, we would like to draw attention to the fact that this definition, although quite inclusive, is not entirely comprehensive. This is due to the fact that the latter crisis definition does not capture some morally hazardous tensions arising from the balance sheet side of financial institutions as soon as they arise. That is, bank runs or large-scale government bailouts generally occur when these tensions escalate into potential insolvencies at later stages of a given financial crisis.

A straightforward example of this type of tensions is manifest in the liquidity shock pertaining to the 'Subprime' Crisis. The underlying deteriorating credit event in subprime mortgages in the U.S.A. rapidly gave way to a severe liquidity shock that occurred through "an amplification mechanism due to asymmetric information resulting from the complexity of the structured mortgage products and, subsequently, as a result of a more widespread re-pricing of risk which may have taken the form of a decrease in global investors' risk appetite" (Frank, González-Hermosillo and Hesse, 2008:5).

By contrast, both our proposed crisis definition and indicator would serve as an efficient gauge for the occurrence of this specific type of complex crisis, as shall be seen once these concepts are introduced. This is justified by the fact that the tacit

consideration of transactions involving equity and equity indexes (as a general proxy for asset prices) further influences and negatively reflects the intensity of this globalised liquidity shock within the scope of both our proposed indicator and adopted crisis definition.

Returning to the stock market performance indicator analysed in the reviewed monograph, the results associated with the latter indicator in connection to the prediction of banking crises are, once again, quite interesting. In the reviewed monograph, the decline in stock prices is considered to be the second best indicator of a looming banking crisis and this indicator is only surpassed by the real exchange rate. Just as a reminder, a decline in equity prices is highly positively correlated to a weakness in asset prices, and this principle is applicable to all the papers herein reviewed that address this fundamental signalling indicator.

Simultaneously, the monograph's authors also conclude that the 'signals' approach is an efficient non-parametric signalling methodology. Nevertheless, these authors also produce a critical judgement pertaining to the shortcomings associated with this methodology's application. In this context, the authors point out that the application of this methodology carries two main disadvantages. First, the referred application is less sympathetic to the production of statistical tests of significance that might signal, within a probabilistic framework, the occurrence of a given crisis (i.e., the methodology is non-parametric). Second, the application of this methodology may result in a signalling emission process that might omit valuable information unless the adopted signalling threshold is effectively breached (Goldstein, Kaminsky and Reinhart, 2000:16). Notwithstanding, the accrued benefits to our specific research clearly outweigh the potential disadvantages associated with the application of this methodology, as our findings will confirm.

Another distinguishing factor pertaining to this monograph concerns the fact that its authors have explicitly embraced the use of monthly data in their empirical research. After carefully weighing the advantages and disadvantages of the use of data according to this periodicity, the authors have concluded that the use of "monthly data permit us to learn much more about the timing of early warning indicators, including differences among indicators in the first arrival and persistence of signals" (Goldstein, Kaminsky and Reinhart, 2000:14). Notwithstanding, in the context of our reviewed monograph,

and taking into consideration the high degree of volatility present in the time series associated with most of the indicators studied by these authors (including the stock market performance indicator), the majority of the indicator variables contained in the dataset is subjected to a data transformation process (Goldstein, Kaminsky and Reinhart, 2000:26, Table 2.3). In the case of equity prices, these authors transform the time series associated with the latter into a 12-month growth rate.

Furthermore, this monograph also highlights one of the most relevant regulatory issues associated with the establishment of a credible set of reliable early warning indicators, the so-called 'Lucas Critique'. The monograph's authors point out that, once a specific set of indicators is empirically identified, "it is possible that policymakers would henceforth behave differently when these indicators were flashing than they did in the past, thereby transforming these variables into early warning indicators of corrective policy action rather than of financial crisis" (Goldstein, Kaminsky and Reinhart, 2000:17).

This is indeed a most complex side-effect associated with this research topic. The acknowledgement by market participants of the range and scope of predictable supervisory (or even, regulatory) actions pursued by efficient regulators on the basis of publicly chosen indicators will necessarily provoke a further reaction by these market participants (e.g., anticipating a central bank interest rate movement). That is, a complex feedback cycle is introduced whereby the regulators not only observe the said indicators, but also act upon them. Subsequently, market participants react to the regulator's initial reaction, and so forth.

On the other hand, from a theoretical viewpoint, the 'Lucas Critique' is indeed a very formidable phenomenon to be reckoned with, in view of the fact that, the higher the potency and efficiency of the emitted signal, the higher the attention paid by market participants to accommodative and compliant regulatory actions. That is, higher signal efficiency induces a greater degree of market feedback. Obviously, the underlying assumption associated with this chain of reasoning refers to the fact that the regulator openly chooses to publicly avow the inclusion of a certain key statistic as a supervisory tool.

Nevertheless, and adopting a pragmatical viewpoint, the authors stress that "all too often, policymakers are inclined to ignore distress signals on the grounds that, this

time, the situation [any given crisis] is really different or that there are overriding political objectives against corrective action. Furthermore, even if the signals are heeded and corrective actions are taken, they may not be sufficient to prevent the crisis. If the feedback from the indicators to corrective policy action were strong and consistent, we would not have been able to identify useful indicators in the first place" (Goldstein, Kaminsky and Reinhart, 2000:109 and 110).

Although our findings will herald the over-riding effectiveness of our proposed indicator, we will abstain from passing any judgement pertaining to the implications of the 'Lucas Critique' upon our findings. This is due to the fact that, in the case of higher frequency financial indicators, this issue might have to be dealt with only when an appropriate set of indicators is adequately identified *and* information as to the composition thereof is deemed to be strategically important in order to be made publicly available to market participants. Notwithstanding, we fully acknowledge the fundamental importance and implications of this issue pertaining to the EWS academic literature, most specially within the context of our own findings.

Kaminsky and Reinhart (2000) further expand their work on the EWS literature by studying the origins of twin crises. The latter are defined as those crisis episodes in which a currency crisis follows the beginning of a banking crisis within the subsequent 48 months (Kaminsky and Reinhart, 2000:17). Their study involves a number of both industrial and developing countries. The paper portrays 76 currency crises and 26 banking crises, covering a time span beginning in the 1970's and ending in 1995.

This paper follows earlier research work herein reviewed, but slightly distances itself from the latter insofar as it mainly focuses on the combined effects of both currency and banking crises. The twin crises are found to be quite devastating and these authors find that the simultaneous occurrence of currency and banking crises produce far more devastating consequences than when these episodes occur in isolation (Kaminsky and Reinhart, 2000:35).

On the other hand, the absence of higher frequency data capturing the precise moment when a financial crisis is underway is duly noted (Kaminsky and Reinhart, 2000:13). A further difficulty is also noted when the cause of the banking problems "do not arise from the liability side, but from a protracted deterioration in asset quality, be it from a collapse in real estate prices or increased bankruptcies in the nonfinancial sector"

(Kaminsky and Reinhart, 2000:13). This resonating consideration echoes a distant, but striking similarity with the systemic event described in our own paper.

Within the context of this working paper, stock market data are used in order to capture the dynamics associated with changes in asset prices, i.e., stock market data are used as a proxy for changes in asset prices. In addition, monthly data were again used in order to obtain both a better perspective of the approach of an impending crisis and the best possible use of the effectiveness of the 'signals' approach (Kaminsky and Reinhart, 2000:19). In the case of the stock market performance indicator analysed by these authors, this variable was included in the dataset as a first difference, i.e., as a 12-month percent change (Kaminsky and Reinhart, 2000:19).

At the same time, a signalling 'window' for banking crises was defined encompassing the 12-month period prior to the beginning of the crisis, as well as the 12-month period subsequent to the banking crisis. This procedure is consistent with previous methodological choices pursued by other reviewed authors. We will not adhere to this practice insofar as the dating of the latest 'Subprime' crisis in the U.S.A. has been duly ascertained by the appropriate governmental agency in charge of dealing with the business cycle dating procedure. The data section will further expound and detail our research choices affecting the chosen data underlying our proposed indicators.

Furthermore, it should be pointed out that the stock market performance indicator was, once again, included in the 'real sector' category of the paper's dataset. In addition to this indicator, this category includes a variable related to industrial production. Our paper will argue that financial variables need a different treatment from real sector variables, specially when taking into account that one of the causes of the 'Subprime' Crisis laid in the formation of the credit bubble in the U.S.A.

Where the performance of the stock market indicator is concerned, the authors observe that *a weakening in equity prices is quite evident prior and during the crises under study*. This pattern is particularly severe when currency and banking crises occur almost simultaneously, given that "the beginning of the recession is also reflected in the stock market, *which [traditionally] collapses the year before the crisis; this collapse is also apparent in other asset markets, most notably real estate*" (Kaminsky and Reinhart, 2000:27).

The authors conclude that the performance of the stock market indicator in predicting banking crises is quite significant. A percentage as high as 81% of these crises were accurately called using the already mentioned 'signals' approach (Kaminsky and Reinhart, 2000:33, Table 1.6, Column entitled 'Banking Crises').

Finally, it should also be observed that the authors also found that there is a major key difference between banking and currency crises, namely through the role played by the real sector. In fact, the real sector indicators chosen by the authors to signal banking crises are quite effective in predicting those episodes. Output and stock prices signalled 89% and 81% (respectively) of the analysed banking crises, emitting efficient early signals in 85% of the crises under study (Kaminsky and Reinhart, 2000:32 and 33 (Table 1.6)).

More importantly, however, is the fact that both banking and currency crises "*are typically preceded by a multitude of weak and deteriorating economic fundamentals*" (Kaminsky and Reinhart, 2000:11). *This indeed further suggests the use of early warning indicators (specially those of financial extraction) as an effective instrument in predicting major disruptive financial events*.

2.2.3. REVIEW OF THE 'SUBPRIME' CRISIS EWS-RELATED LITERATURE

In their latest monograph addressing the historical study of financial crises, Reinhart and Rogoff (2009) also provide a brief overview of the efficiency of various indicators to EWS. In light of the recent 'Subprime' Crisis, real housing prices are also considered to be a valuable indicator to this body of literature (Reinhart and Rogoff, 2009:280, Table 17.1). The said indicator constitutes a most important barometer of real estate market performance, most specially taking into account the present (and past) incidence of real estate-related crises in the U.S.A. For example, Shiller (2008) adequately examines the present Crisis in light of the lessons drawn from previous real estate downturns in the U.S.A., namely the 1925 – 1933 real estate slump (Shiller, 2008:16 to 20).

Notwithstanding, further analysis concerning this important addition to a selected list of indicators should not concern us here. This is due to the fact that we are

only interested in addressing specific financial indicators suitable to the occurrence of 'pure' financial crises (namely, the 'Subprime' Crisis).

Finally, Frankel and Saravelos (2010) conduct a very extensive survey[5] of the EWS literature. This latest survey comprehensively reviews more than eighty papers from the EWS indicators literature, depicting a brief but highly heterogeneous trajectory of this challenging academic field. Although earlier literature on the subject has been deeply rooted in emerging market crises (such as the Latin American and Asian currency crises), the authors observe a renewed interest in this field of expertise due to the occurrence of the 'Subprime' Crisis. That is, the latest systemic breakdown has certainly unleashed the need for the implementation of a stern supervisory framework.

In the context of this survey, the authors explicitly state that "aside from generating increased policymaker interest, the 2008-09 crisis is particularly well suited to undertaking an assessment of the potential usefulness of leading indicators" (Frankel and Saravelos, 2010:2). This latter statement appropriately fits the present paper's firm intention of presenting such indicators[6]. Nevertheless, it should also be pointed out that these authors sustain that the emergence of this 'Subprime'-related strand of literature is still in its infancy. This lack of maturity occurs not only because the crisis had barely reached its apex (at the time of the survey's writing), but also because there was a lack of data on the subject (Frankel and Saravelos, 2010:8).

However, this latter justification warrants further scrutiny on two counts. First, the EWS literature has been, up until the implosion of the 'Subprime' Crisis, strongly concerned with the occurrence of crises in emerging market economies (and corresponding currency crises). It thereby elected indicators (often, low frequency ones such as the current account) most suited to those specific crises, thus neglecting the study of crises in other non-emerging market economies. In reality, this latter fact has deeply contributed to a short sightedness in the EWS literature where the heretofore improbable prospect of financial crises in advanced market economies is concerned.

[5] This survey was released in June of 2010, just as the present paper's drafting process began in July of 2010.

[6] The importance associated with this more recent increased policymaker interest is also confirmed by a publication on the reform and exit strategies associated with the 'Subprime' Crisis produced by the OECD; according to the latter, the enactment of effective early warning mechanisms is one of the key structural elements to the establishment of a broader macro-prudential approach focusing on future financial stability (OECD, 2009:34).

Second, given the existence of credible databases of well-known financial market indicators in the U.S.A., the anticipatory nature of these indicators should have been able to signal the occurrence of a systemic event, *should these indicators have been properly used to that effect*. In retrospect, and given that that was clearly not the case, the issue should not be attributable to lack of data. Instead, *it should be attributed to the lack of awareness as to the potential efficiency of novel approaches to predicting these extreme events in advanced economies*, contrary to what has been suggested by these authors.

Furthermore, difficulties associated with the use of higher frequency indicators have been suggested as far back as the seminal paper of Kaminsky, Lizondo and Reinhart (1998:9), who treat many variables in their respective rates of change, in order to induce series stationarity. In this respect, the approach used in the construction of our proposed indicator will hopefully avoid the use of stationarity-inducing techniques, such as differentiation. *The latter might be associated with the potential loss of long-term information associated with this sort of data transformation.* Nevertheless, the use of these techniques should not be entirely excluded should they be needed as a last resource.

More importantly, the survey's authors also point to a common denominator in the major scientific articles connected to the EWS literature. In effect, a majority of the seminal articles on this topic simultaneously propose their own specific crisis definition (currency crisis, banking crisis, twin crisis, etc.), which are then applicable to a given country or region. As is pointed out by these authors, these can lead to a very wide variation in the way a crisis is defined (Frankel and Saravelos, 2010:3), and the way in which this definition is applied to a specific geography. Understandably, this latter fact deeply contributes to the heterogeneous character of the literature in question.

This diverse supply of crisis definitions is then complemented by an equally diverse set of corresponding indicators deemed most appropriate to the definition at hand. However, according to the survey, "the literature has converged on a narrower set of dependent variables used to measure the intensity and occurrence of crises" (Frankel and Saravelos, 2010:3), while using both discrete and continuous measures to that effect.

At the same time, there are usually no constraints on the periodicity of the chosen indicators, the latter comprising monthly, quarterly or even annual data. Lower frequencies seem to be the most chosen instruments, in light of their low volatility.

Notwithstanding this observed convergence, the range of indicators used is actually quite diverse in its composition. For example, the sub-set of financial indicators includes a country's real exchange rate, the real interest rate, the stock of international currency reserves (measured as a percentage of GDP) and the performance of the stock market indicator (as a proxy for equity market returns). Macroeconomic indicators include, for example, the performance of GDP (although industrial production is often used as a substitute for GDP, given the latter's disparate composition across economies) and the evolution of available credit in the economy. Trade-related indicators are represented, for example, by the performances of the current account, exports or imports, which basically translate the buoyancy of the underlying real economy. Finally, political and/or legal indicators (such as those associated with financial liberalization processes) are also worthy of attention. The latter should indicate whether the underlying economy adequately enforces legal property rights (this latter set of variables can be of enormous importance to foreign investors in emerging economies, for example).

Overall, it should be observed that the referred indicators are associated with differing levels of signalling capabilities, as some perform better than others in signalling a given event. At the top of the table of the leading indicators referring to the latest crisis, international currency reserves and the real exchange rate have stood out as effective leading indicators of the present crisis (Frankel and Saravelos, 2010:28). This is specially true where the currency-related dimension of this systemic event is concerned, although it should also be pointed out that research on this important topic is still under way.

However, we would like to draw attention to the fact that we are predominantly interested in capturing early signals associated with the systemic dimension of the 'Subprime' Crisis in the U.S.A. In the pursuit of this goal, we are therefore interested in using financial market statistics more related with equity markets (and not to the currency markets, notwithstanding the significant validity of this latter approach).

Finally, the survey's authors note that a specific modelling approach (e.g., a parametric or a non-parametric approach) is commonly prescribed in connection to the set of indicators most appropriate to a given crisis definition (Frankel and Saravelos, 2010:5). Again, a certain pattern of heterogeneity is observed, and the latter authors group these distinct modelling approaches in four broad categorizations of similar characteristics.

The first such categorization used in the EWS literature involves the application of linear regression techniques or limited dependent variable probit or even logit econometric specifications. The latter specifications are used in order to test the statistical significance of distinct indicators, across a pre-defined selection of countries, and by determining the probabilistic incidence of a given definition of financial crisis.

A second category of modelling approaches concerns the highly efficient non-parametric methodology entitled 'signals' (or indicators) approach. This methodology was initially developed by Kaminsky, Lizondo and Reinhart (1998), in order to study the efficiency of potential signalling indicators capable of anticipating currency crises. Notwithstanding, it should be pointed out that the use of this methodology is not restricted to the latter crisis definition, quite the opposite. According to this approach, a set of potential univariate indicators is first selected according to their crisis predictability influence as leading indicators of financial crises. The historical evolution of each indicator is then traced, followed by the attribution of a given threshold above which (or below which, according to the indicator's nature) an anticipatory 'signal' is then emitted, should the indicator surpass the corresponding threshold. The signal identification is extracted within a certain time frame, usually defined as a 24-month long 'crisis window' prior to the event being signalled (Kaminsky, Lizondo and Reinhart, 1998:19). The present paper draws on this modelling approach.

A third category of modelling techniques involves the use of "qualitative and quantitative analysis [using panel studies] of the behaviour of various variables around crisis occurrence by splitting countries into a crisis and non-crisis control group" (Frankel and Saravelos, 2010:5). It should be pointed out that this particular methodological strand was predominantly used in the earlier stages of the EWS literature.

A fourth and final category identified by the latest available survey encompasses the employment of innovative methodologies in order to identify and justify the incidence of a given crisis. These more exploratory techniques involve "the use of binary recursive techniques to determine leading indicator crisis thresholds (…), artificial neural networks and genetic algorithms to select the most appropriate indicators (…) and Markov switching models" (Frankel and Saravelos, 2010:5).

Overall, this brief review depicts a profoundly heterogeneous body of academic literature, insofar as the latter encompasses the study of different crisis definitions and their manifestations in different countries and/or geographies. Further diversity is added when the set of chosen indicators is quite disparaging and when the employed modelling techniques are equally heterogeneous.

Notwithstanding this complex approach, the latter is quite rooted in the EWS literature, and the present paper will not depart from this approach. That is, we will also propose a powerful bellwether indicator, followed by other equally suited financial indicators, most suitable to a given crisis definition, using a specific set of mutually exclusive methodologies (first the EWS 'signals' approach, followed by the NPI/NPD approach).

It is hoped that the present proposal might stimulate further research on the specific subset of higher frequency financial indicators liable to be implemented in the prediction of systemic events of financial nature.

2.2.4. REVIEW OF LITERATURE ADDRESSING THE TAXONOMY OF FINANCIAL CRISES

In light of the EWS literature herein reviewed, and prior to proposing a more updated crisis definition, it becomes imperative to highlight two main points that will bear upon our research. First, the literature herein reviewed encompasses a highly diverse set of crisis definitions (from currency crises, to banking crises, to twin crises). Second, within the scope of banking crises, financial variables are not duly treated according to the nature of their predictive value insofar as the measurement of 'pure' financial crises is concerned (these financial variables are normally branded as 'real sector' indicators).

Therefore, a proper definition of the 'Subprime' Crisis will be provided, with recourse to a more updated taxonomy of financial crises, so that the said definition might constitute an adequate 'environment' for the analysis pertaining to our proposed financial indicators. This is in strict accordance to the literature's tradition, according to which each author either proposes and/or works with a certain key crisis definition. We will therefore work with the crisis classification proposed by Felsenheimer and Gisdakis (2008), who classify financial crises according to the financial market or area from which the said crises occur.

The financial crisis taxonomy proposed by these authors encompasses four distinct categories: currency crisis, foreign debt crisis, systemic financial crisis and banking crisis. The first is concerned with speculative attacks on the exchange rate of a given currency that usually result in the said currency's depreciation. The second is concerned with a given country's incapacity to satisfy its foreign debt obligations. The third is concerned with either potential or actual bank runs, or with government intervention in bailing out financial institutions. The fourth is concerned with severe malfunctions or disruptions of a given financial system, which have a significant adverse effect on the real economy (Felsenheimer and Gisdakis, 2008:206 to 208).

Implicit in this taxonomy is the fact that many crises are encompassed in more than one specific crisis category, i.e., two (or even more) types of crises may be involved in a given financial shock episode. For instance, *the 'Subprime' Crisis (as a systemic event) may be classified under the umbrella of all the afore-mentioned major categories. The said crisis has unleashed a U.S. dollar depreciation, sovereign debt crises, systemic financial crises and banking crises, all within the same global episode (although with a varying degree of severity in interconnected but different parts of the globe and distinct timings).*

In light of the possibility that a given episode might be labelled according to different categories, there are further sub-categories that can be construed from the four main types above-mentioned. *The present 'Subprime' Crisis is more aptly characterized as a credit crisis, an offshoot between a systemic and a banking crisis.* Using the definition provided by Felsenheimer and Gisdakis, "a credit crisis affects the banking system or arises in the banking system; the huge importance of credit risk for the functioning of the financial system as a whole bears also a systemic component. *The*

trigger event is often an exogenous shock [in our case, the retraction in home prices], while the pre-credit crisis situation is characterized by excessive lending, excessive leverage, excessive risk taking, and lax lending standards" (Felsenheimer and Gisdakis, 2008:208). This gloomy macroeconomic assessment reflecting a neglectful state of affairs is also espoused by Krugman (2008), who concurs with this pervasive morally hazardous framework affecting the U.S. financial sector (Krugman, 2008:148 to 151).

Moreover, Felsenheimer and Gisdakis (2008) also add that the existence of a credit crunch scenario - as the most virulent form of a credit crisis - is further characterized by a pronounced reduction of lending activities by the banking sector (Felsenheimer and Gisdakis, 2008:208). They further state that the said credit crunch has "a severe impact on the real economy, as the basic transmission mechanism of liquidity (from central banks over the banking sector to non-financials corporations) is distorted by the fact that banks do not provide enough liquidity for the non-financials segment" (Felsenheimer and Gisdakis, 2008:208).

There are two major justifications for the adoption of this latter definitional framework within the architecture of our paper. First, using the full amplitude suggested by this framework when taking into consideration the National Bureau of Economic Research (NBER) crisis dating cycle, *our proposed signalling indicators will certainly allow us to capture the tensions brewing up within the financial sector during the last stages of the inflating phase of the real estate and credit bubbles. As the financial pressures associated with both bubbles mount, the signal emitting process will certainly take place well in advance of the apex of the 'Subprime' Crisis.*

Second, and contrary to previously held banking crisis definitions inscribed in the EWS literature herein reviewed, our adopted definitional framework's full compatibility with the presence of accumulated tensions *prior to* the crisis' apex will allow our research not to rely on end-of-cycle occurrence of effective runs on financial institutions or the establishment of government-sponsored bailouts of ailing financial institutions. *In our judgement, the latter are usually consequences and not symptoms of the underlying crisis under study, and our adopted definitional framework will be quite useful in capturing the initial signs of financial distress*.

Our proposed flagship indicator (a variant of the Put-Call Ratio), duly inscribed within this crisis definitional framework, will be fully described in sub-section 2.4.

Where the informational use of the Put-Call Ratio is concerned, we are not aware of any previous use this indicator might have had in the context of the EWS literature. This may be due to the fact that the historical time series associated with this indicator is rather short-spanned. However, the informational possibilities of this indicator are clearly noticeable, for example, in the research produced by Pan and Poteshman (2006). This research will be further commented in sub-section 2.4.3. of our paper.

More recent academic works concerning EWS topics relevant to our paper will be duly addressed in the following sections, as some of the reference points sustaining these latter papers' architectures will also be extremely useful in our paper's design (as is the case with the paper authored by Davis and Karim (2008)). The same is applicable of other relevant (but not EWS-related) papers, which have been highly influential to our paper's structure (as is the case with the papers authored by Estrella and Mishkin (1995), for example).

2.3. A CONCISE REVIEW OF THE 'SUBPRIME' CRISIS

In the present section, we will first provide a brief overview of the 'Subprime' Crisis, most notably where the existence of underlying financial bubbles and the deflating thereof is concerned. This review will be followed by an equally brief description of the main crisis transmission channels most relevant to the architecture of our own paper. We will finalize this section by addressing the importance of equity markets for the EWS literature.

2.3.1. A REVIEW OF THE 'SUBPRIME' CRISIS

Prior to addressing the object and nature of the 'Subprime' Crisis, there are two caveats that will warrant our attention throughout this section.

First, given the highly complex and multifaceted nature of the global crisis under study, we will presently confine our analysis to the U.S.A., the country at the epicentre of this systemic event. This choice is also due to the fact that the implications of this systemic event on this country's economy are well documented by the 'Subprime' Crisis academic literature.

Second, and given the preceding assumption, we will strictly follow, whenever applicable, the crisis dating methodology proposed by the NBER when presenting data pertinent to our paper. This is justified by the fact that this organisation is solely responsible for the business cycle dating procedure[7]. In addition, our proposed bellwether indicator was extracted from this country's options markets, as shall be seen in the forthcoming section, and this fact, by itself, fully justifies abiding by the NBER guidelines.

The 'Subprime' Crisis is a major disruptive systemic event, deeply rooted in the bursting of the twin bubbles in the real estate and credit markets. These bubbles had been building up internal pressure prior to the moment when this major financial disruption took place. According to Shiller (2008), the very term *subprime*[8] *crisis*

[7] The relevant details referring to this procedure are duly explained in sub-section 2.4.3.

[8] Within the mortgage finance industry, this term refers to a specific category of high risk loan borrowers, most notably those who might exhibit extremely high default probabilities on their mortgage loans; thus, these borrowers' risk profile entails a corresponding high degree of credit risk, which obliges

epitomises the "deflating of a speculative bubble in the housing market that began in the United States in 2006 and has now cascaded across many other countries in the form of financial failures and a global credit crunch" (Shiller, 2008:9). The over-heating of the real estate market in the U.S.A is easily discernible in the steep evolution of the Case-Shiller Index (a major benchmark for the evolution of home prices in this country), most specially in the aftermath of the previous 'Dot-Com' Crisis. This evolution has been depicted in Figure 1, along with the seemingly reactive and lagged response of the S&P500 composite index.

On the other hand, the formation of the real estate bubble was simultaneously accompanied by the formation of a closely correlated second bubble in the credit markets. The latter market is mainly concerned with the issuance of complex, sophisticated and highly profitable credit-related financial derivatives products. The two bubbles were inter-related insofar as the performance of these financial products was manifestly tied to the performance of the underlying real estate markets.

It should be further mentioned that this credit bubble was mainly driven by the securitization process, a financial process widely used by major financial institutions. The latter process may be aptly described as "a structured finance technique in which financial assets, such as bonds, loans and receivables, are pooled together and used as collateral for investors" (Felsenheimer and Gisdakis, 2008:103). In this way, banks and other financial institutions were able to "actively manage their portfolios of credit risks, keeping some and entering into credit derivatives contracts to protect themselves from others" (Hull, 2006:507), thus allowing "companies to trade credit risks in much the same way that they trade market risks" (Hull, 2006:507).

The commercialisation of this huge wave of securitised financial products was deeply facilitated by the banking paradigm prevailing in the financial markets. The said paradigm, which has been dubbed the 'originate-and-distribute' banking model, strove to facilitate the circulation of loan entitlement (irrespective of their nature) throughout the financial system. This was achieved by issuing, re-packaging and off-loading the said loans amongst the financial system's diverse set of market participants (Brunnermeier, 2008:2 and 3). Thus, a loan's originator might not be the same entity as

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lenders to require higher *premia* to satisfy the borrowers' loans; these distinct risk profiles are summarized in these borrowers FICO scores, a widely used credit score appraisal system in the U.S.A.

the recipient of the said loan's underlying credit proceeds. This is due to the fact that the entitlement to those very credits might have been re-packaged and sold to a third party.

This highly complex and fluid entanglement of financial interests among the real estate markets, the mortgage finance markets and the credit derivatives markets is quite efficiently and comprehensively portrayed by Blanchard (2009:6, Figure 2).

When the real estate market performance failed to meet the overtly optimistic expectations of market participants, the underlying financial derivatives products associated with the credit markets – products that were indexed to the U.S. real estate markets - started to exhibit an increasingly higher rate of default. This severe default disruption is quite well documented in an in-depth study of the 'Subprime' Crisis (Calomiris, 2008:99, Figure 2 relating 'Subprime' mortgages according to their 'vintage' years).

In this context, it is therefore not surprising that Blanchard (2009) openly states that "the trigger for the crisis was the decline in housing prices for the United States" (Blanchard, 2009:5). This trigger also precipitated a massive re-appreciation of the risk associated with credit derivatives products held by financial institutions and other institutional market participants.

This sudden, unexpected risk re-appraisal further prompted 'fire sale prices' of these structured products in a scramble for liquidity, thus amplifying the contagion processes associated with the initial real estate shock to the credit derivatives markets (Blanchard, 2009:9 to 13). These 'fire sale prices' are synonymous to the asset price declines mentioned earlier in our text.

Thus, an unexpected real estate downward price trajectory first affected the mortgage financing sector (through a higher default rate on 'Subprime' residential mortgages). It then proceeded to affect the credit derivatives industry (through severe and virulent 'fire sale prices' of securities associated with mortgage financing). It finally proceeded from the financial sector to the real sector of the U.S. economy, critically affecting output growth. By then, market illiquidity started to take its toll on the real economy as production outlays were drastically reduced (these macroeconomic consequences have been portrayed in Figure 2, where a worrisome performance of quarterly GDP growth during the 'Subprime' Crisis is depicted).

We establish this chain of events because it is of the utmost importance to make a clearly drawn distinction between the initial financial shock that was intimately linked with a retraction in residential real estate prices in the U.S.A, and the subsequent shock transmission to the real sector of this economy.

When introducing our proposed flagship indicator, this distinction will become highly relevant insofar as the signalling capabilities of this indicator will certainly anticipate the first negative impulse associated with the initial finance-related shock. That is, *within our signalling 'window', our proposed bellwether indicator will be mainly focused on the events taking place within the framework of the stock market (the latter are manifestly a major reflex of financial markets as a whole), and within the scope of the first initial financial shock.*

We thereby argue that the transmission of the initial financial shock to the real economy *and* its corresponding feedback is most appropriately captured by 'real economy indicators' (as is the case with the industrial output and/or output variables present in several papers herein reviewed connected to the EWS literature). A more through justification for the validity of this research stance will be fully perceptible when our proposed indicator is duly introduced within the adopted crisis definition and timeline. In accordance to the NBER business cycle dating procedures, the crisis stage started immediately in the month after the peak of economic activity was registered by the NBER.

At this point, it is sufficient to point out, once again, that, in the EWS literature, financial indicators are combined with real economy indicators, *whereas the examination of the present financial crisis as a systemic financial phenomenon will require, in our perspective, a more focused attention on 'pure' financial indicators measuring the initial financial shock.*

In our judgement, this is the most appropriate procedure in order to signal the occurrence of the first round impact of an underlying financial event. That is, we are mostly interested in considering the effects associated with the direct impact of the first round of the financial shock on the real economy, and less interested in focusing our attention on the ensuing reflux effects from the real economy to the financial sector, and so forth.

In the following sub-section, a brief review of the transmission channels facilitating the occurrence of this initial shock associated with the first round of effects pertaining to the 'Subprime' Crisis will be provided, as a testimony to our underlying research focus.

2.3.2. A REVIEW OF THE MAIN TRANSMISSION CHANNELS ASSOCIATED WITH THE 'SUBPRIME' CRISIS

The inflating of a buoyant real estate bubble in the U.S.A. during the greater part of the past decade has been unequivocally intertwined with the strengthening and vibrancy of the latter country's economy and financial markets.

During the inflating phase of the said bubble, positive home equity *premia* on rising house prices kept attracting an increasing number of home buyers to the real estate market. This tendency was aggravated by the mortgage industry's intensive use of aggressive lending practices through default-inducing contracts, which also fuelled a credit bubble. These risky borrowing/lending decisions were made based on expectations of a 'perpetual' ascending home price trajectory in the country's real estate market[9].

Within the framework of this cheap credit environment, and once the real estate and associated credit bubbles started to deflate, massive losses were accumulated by both residential buyers and financial market participants alike. The former started to accumulate losses as real estate prices retracted, forcing them to become default borrowers on subscribed mortgage contracts. These binding contracts were underwritten within the contaminated environment of the corrupt lending practices described by Zimmerman (2007). While the latter started to accumulate losses through their possession of real estate-related securities (as lenders, holders or recipients of the accrued mortgage-related credits which went sour after massive default of 'Subprime'-related loans started to kick in, a contagion process which further propagated to other real estate segments in the U.S.A.).

[9] Zimmerman (2007) provides a thoroughly elucidative overview of these risky practices, which ended up with the deflation of the housing bubble and the delinquency of many of these variable-rate contracts, most specially after the 2005-2006 period (Zimmerman, 2007:7 to 20).

On a theoretical level, the macroeconomic consequences associated with a collective cataplectic financial shock have already been thoroughly analysed within the framework of the research pursued by Bernanke and Gertler (2000).

The latter paper's authors have quite accurately summed up the transmission effects associated with financial shocks. In this context, they state that when bank lending activities are curtailed (as was the case with the 'Subprime' Crisis, where market liquidity deeply affected normal banking activities), both consumption expenditures (through individual loans) and investment expenditures (through corporate loans) decrease substantially. This then hinders general economic activity and enhances the fall in house and asset prices, deteriorating, in addition, corporate balance sheets and further diminishing bank lending (Bernanke and Gertler, 2000: 8, 9 and 10).

This is, in essence, the spirit of the financial accelerator model proposed by the referred authors. This model accurately portrays the looping, self-reinforcing negative cycle that begins with the onset of a given financial crisis; the ensuing expected downturn in economic activity; and the corresponding uncertainty in the proper valuation of assets (that might be used as collateral). This cycle further reinforces, in a subsequent moment, the downward price spiral associated with the financial crisis under study (the asset price declines mentioned earlier).

It should be pointed out that this model's main features are utterly observable in the present financial turmoil. Krugman (2008) observes this financial vulnerability largely through the pre-crisis unregulated explosive development of the 'shadow banking system'. The latter supported the overall architecture of the twin bubbles in the real estate and credit markets (Krugman, 2008:160 to 164). It is therefore fundamental to briefly mention these features due to their continuing and devastating influence on the financial markets, and, more specifically, on equity markets (a subject that will warrant our attention in the following sub-section).

Where the contagion effects pertaining to the individual consumer are concerned, there is growing evidence that, at the height of the 'Subprime' Crisis, falling house prices and a feeble state of the economy were already weakening higher-quality mortgages. In fact, "U.S. residential mortgages are [were] experiencing unprecedented credit deterioration" (International Monetary Fund, 2008:11). This gloomy scenario was also extensible to the credit card industry, insofar as the U.S. consumer's "ability to pay

down higher-interest credit card debt with cheaper home equity loans has [had] diminished" (International Monetary Fund, 2008:12). The financial shock has thus exposed the financial industry to increasing stress levels, where the usage of credit lines to support personal consumption expenditures is concerned.

As a matter of fact, this retraction in consumer spending was aptly forecasted as early as November, 2007, by the Federal Reserve Bank of Dallas. A document issued by this latter organisation openly stated that "the sharp reversal of trends in home-price appreciation will also dampen consumer spending growth, an effect that may worsen if the pullback in mortgage availability limits people's ability to borrow against their homes" (DiMartino and Duca, 2007:7).

On the other hand, and where the contagion effects referring to investment expenditures at the height of the 'Subprime' Crisis are concerned, there was also stark evidence, pointing to the fact that "a weakening economic environment is [was] already leading to corporate credit deterioration, especially for firms closely tied to the consumer" (International Monetary Fund, 2008:13).

This worrying finding is further confirmed by Ivashina and Scharfstein (2010), who address the behaviour of bank lending during the Subprime Crisis. They state that "lending volume in the fourth quarter of 2008 (2008:Q4) was 47% lower than it was in the prior quarter and 79% lower than at the peak of the credit boom (2007:Q2)" (Ivashina and Scharfstein, 2010:320).

The important theoretical and empirical considerations presented in the preceding paragraphs are quite decisive to the analysis of the evolution of our proposed indicator on two counts.

First, these considerations' importance cannot be overstated, insofar as they constitute a clear testimony to the fact that positive home equity *premia* (which fuelled both the real estate and credit booms preceding the Crisis) rapidly eroded in the wake of the 'Subprime' Crisis. Simultaneously, expectations on the performance of the U.S. economy suddenly changed for the worse, prompting financial market participants to structurally adjust their equity investment portfolios. Thus, the underlying financial market statistic pertaining to our proposed flagship indicator – the Put-Call Ratio – most aptly captures the evolution of the underlying expectations associated with the

performance of the U.S. economy and its financial markets prior to and at the height of the business cycle. This is due to the fact that the stock market performance indicator is positively correlated with the performance of a buoyant consumer demand and a vibrant corporate supply, two essential conditions for the wholesome advancement of the stock market.

Second, the said considerations also testify to the fact that information pertaining to the impending Crisis (which prompted the abrupt portfolio adjustments based on the re-appraisal of systemic risk) was already circulating through the financial markets. Our proposed indicator fully captures, in quite a straightforward manner, this complex dynamics.

In view of the above-mentioned, and taking into account the results obtained, we will argue that this initial round of financial market tensions and pressures was most aptly anticipated by our proposed bellwether financial indicator. These signalling capabilities are quite visible in the anticipatory signals that were confidently emitted well in advance of the onset of the 'Subprime' Crisis. These findings will be duly presented in the empirical section of our paper. Taking into account what has been heretofore described, we will strive to explain, in the following sub-section, the importance of stock markets for the EWS literature.

2.3.3. THE IMPORTANCE OF STOCK MARKETS FOR EWS

Within the context of the real estate and credit booms taking place in the U.S.A. prior to the 'Subprime' Crisis, the purchase of residential properties had three major direct implications on the U.S. economy. It first contributed to the advancement of the financial sector (most specifically, the mortgage finance sub-sector, but not exclusively); it further promoted the advancement of the construction sector; and, finally, it drove demand pertaining to home-related manufacturing products.

As a general proxy for the exuberant financial health and the real estate vibrancy of the U.S.A. prior to the crisis, both the S&P500 Composite Index and the Case-Shiller Index are presented in Figure 1. Although the demonstration of a potential causal link between the real estate and financial sectors of the U.S. economy is quite beyond the

scope of this paper, the positive association between the performances of each of these sectors is clearly noticeable when these time series are juxtaposed.

Generally speaking, stock markets are usually a yardstick for measuring the financial well-being of any underlying economy, insofar as stock prices measure forward-looking, expected net present values of future dividend streams (Leão, Leão and Lagoa, 2009:150). Within this framework, the stock market's performance is normally tied to the economy's business cycle, and this general statement is quite applicable to the economic environment prior to the bursting of the underlying bubbles.

On the other hand, stock prices simultaneously act as a barometer for both asset price inflation (prior to the bursting of any asset bubble) and asset price deflation (subsequent to the bursting of the said asset bubble). As with any other financial shock, the 'Subprime' Crisis is precisely related to the sudden (and unexpected) sustained asset price deflation that took place, once the Crisis set in.

This prolonged asset price deflation is usually a sign of weaknesses present within financial markets and their corresponding economies. First, a pronounced decline in stock markets has supply-side implications, insofar as they usually signal that "the net worth of corporations has fallen because share prices are the valuation of a corporation's net worth" (Mishkin, 1998:216). Loss of asset value is normally equated with loss of collateral value to corporate financing activities, as financial market lenders to the corporation will be less willing to lend in a strongly declining stock market (Mishkin, 1998:216 and 217). In the 'Subprime' example, the already referred market liquidity pressures and 'fire sale prices' constituted the most severe macroeconomic scenario of a credit crunch caused by a severe and prolonged stock market decline which further precipitated the massive offloading of financial assets onto the market.

Second, a pronounced decline in the stock markets may also signal broader weaknesses in the aggregate demand side of the economy. Prolonged equity asset deflation directly affects private investors. These losses ultimately end up affecting personal consumption expenditures, a major and decisive GDP component.

Therefore, a sustained and prolonged stock market decline leads to the curtailment of bank lending activities (more specifically, to dampened consumer and corporate lending activities), thereby ultimately asphyxiating both personal

consumption expenditures and corporate capital expenditures through the scarcity of available lending capital. This pattern was clearly observable in the crisis episode, as was clearly demonstrated in the preceding section. Thus, the performance of stock markets is a highly accurate reflex not only of aggregate economic conditions in general, but also of specific tendencies within the financial sector.

In order to effectively capture (with the ultimate aim of deterring) the full-blown consequences of financial systemic events, monetary and financial authorities have extensively used sophisticated models to predict the occurrence of the said events.

Notwithstanding this extensive practice, the use of a more simplified approach can also yield significant results from a forecasting perspective. Estrella and Mishkin (1996) adamantly state that "economists often use complex mathematical models to forecast the path of the U.S. economy and the likelihood of recession. But simpler indicators such as interest rates, *stock price indexes*, and monetary aggregates *also contain information about future economic activity*" (Estrella and Mishkin, 1996:1).

Indeed, research previously done by these latter authors has thoroughly confirmed stock prices as an efficient indicator of future financial tensions. They state that "stock prices are useful predictors, particularly 1 and 2 quarters ahead." (Estrella and Mishkin, 1995:4).

As shall be seen in the following sections where our indicator is fully tested, our argument will strive to defend that *our proposed bellwether indicator (as an offshoot of the stock market performance indicator) might have fully anticipated subsequent expected tensions associated with the onset of a retractionary performance of the financial markets (namely, the equity markets) in the wake of the 'Subprime' Crisis. More importantly, we further argue that these tensions were already present in the asset price inflation process that took place prior to the occurrence of the financial shock.* Our empirical findings will confirm the strength of our argument.

2.4. THE PUT-CALL RATIO

The devastating economic consequences associated with the 'Subprime' Crisis have highlighted the need for a specific set of financial indicators capable of signalling this type of financial event in industrialised countries. As Roubini and Mihm (2010) point out, "in most advanced economies, the second half of the twentieth century was a period of relative, if uncharacteristic, calm, culminating in a halcyon period of low inflation and high growth that economists dubbed the 'Great Moderation'. As a result, mainstream economics has either ignored crises or seen them as symptoms of troubles in less developed economies" (Roubini and Mihm, 2010:7).

This latter standing, coupled with the fact that, during the past fifteen years, EWS literature has been highly reactive to the incidence of financial crises outside of the industrialised world (the Latin American crises, the Asian Crises, etc.), fully justifies the fact that emerging market economies have been, up until the present moment, the locus point of research in this body of literature.

Nevertheless, in light of the emerging economies' biased influence within this academic literature, the occurrence of a severe financial shock within the world's most advanced economy should re-address the said bias and also leave a significant bearing on the said literature. This influence will allow conducted research on the latter 'Subprime' Crisis to be fully cognizant of any avenues of research leading to the possibility of anticipating the occurrence of such an improbable systemic event in advanced economies. It is under the influence of this latter assumption that we will also establish our contribution to this exciting field of research.

In the pursuit of such an important research topic, we will first proceed by briefly stating the main concepts associated with the options markets that are fundamental to the basic understanding of our own proposed bellwether indicator. We will then describe in more detail our proposed early warning indicator, based on an adaptation of the Put-Call Ratio, a widely used financial market statistic. We will subsequently present the underlying data relative to our proposed indicator and detail some observations pertinent to the data collection and treatment processes.

2.4.1. SOME ESSENCIAL DEFINITIONS PERTAINING TO THE OPTIONS MARKET

Prior to presenting our proposed indicator based on the Put-Call Ratio, we will proceed with our analysis by providing some basic definitions pertaining to the options market. These latter definitions will be necessary for the full understanding of our proposed flagship indicator. In addition, the importance of the options markets for predictive purposes will also be commented, in view of its strategic importance.

Options are financial instruments that confer the right, but not the obligation, to assume a given financial position relating to a contractually pre-specified underlying asset.

There are basically two types of options: the call option and the put option. The former "gives the holder of the option the right to buy an asset by a certain date for a certain price" (Hull, 2006:181), while the latter option "gives the holder the right to sell an asset by a certain date for a certain price" (Hull, 2006:181). In both types of options, the dates in question are known as the maturity dates, while the specified prices are known as the strike prices (for each type of option involved).

Both call and put options may be traded through specific exchanges or through *over-the-counter* markets. In the former case, trades are executed through pre-set contracts and credit risk associated with potential counter-party default has been virtually eliminated. In the latter case, options contracts may be exchanged through this informal market[10]. Thus, the terms of each contract are not pre-defined by any exchange rules and, once a contract is established, some degree of counter-party credit risk might be involved.

In the course of the 'Subprime' Crisis in the U.S.A., equity options markets provide a valuable insight into this latter extreme event. Kelly, Lustig and Van Nieuwerburgh (2011) sustain that these markets are uniquely equipped to gauge the markets' perception of an impending implementation of too-systemic-to-fail

[10] It should be pointed out that, in terms of total volume of trading, the *over-the-counter* market has become much larger than exchange-traded markets (Hull, 2006:2); notwithstanding, for the purpose of our research, we will confine ourselves to the only exchange-related data available for the U.S.A., which has been published by the Chicago Board Options Exchange (CBOE); the collected data are also found in the Datastream database, the main data source for our paper.

government guarantees (which thus eliminates financial sector tail risk). By contrasting the difference between the price of a basket of put options on individual financial institutions and the price of a put option on a financial sector index, these authors suggest that the structural discrepancy observed in the options markets is attributed to the government's absorption of financial sector aggregate tail risk (Kelly, Lustig and Van Nieuwerburgh, 2011:41 and 42). This line of enquiry validates the options markets as an important informational source.

2.4.2. THE PUT-CALL RATIO: ITS CONTRIBUTION TO THE EWS LITERATURE

Prior to presenting our chosen indicator and discussing its specificities, it would also be deemed most appropriate to briefly review the reasons justifying the study, within the scope of the present paper, of a bellwether financial indicator of prospective financial tensions, specially where the occurrence of banking (or systemic) crises is concerned.

First, the proposal of a flagship indicator has already been established in the academic literature. The research pursued by Estrella and Mishkin (1996) has already advanced an important indicator (the yield curve) as a prospective signalling indicator, and the results have been extremely encouraging. As mentioned earlier, some of these indicators do contain relevant information relative to the future evolution of the economy. Thus, in view of contributing to the forecasting of future financial shocks, an exhaustive regulatory effort to survey all relevant financial indicators should be made, and the present paper will strive to make a modest academic contribution to the advancement of this research topic. More importantly, and taking into account the characteristics of our proposed forerunner indicator, the Put-Call Ratio is deemed to be an important bellwether financial indicator, as shall be seen in the following paragraphs.

Second, and without putting in question "the existence of large scale macroeconometric models and […] the judicious predictions of knowledgeable market observers" (Estrella and Mishkin, 1995:2), any additional methods (and specially, inexpensive ones) should be carried out to confirm (or not) the results obtained by more computationally sophisticated models. Thus, in order to complement the extensive use

of these models by regulators and market participants alike, the through observation of a selected, well-chosen set of indicators might be used to double-check the results emanating from the said models. Therefore, "a quick look at a financial indicator may flag some problem with the results of more involved approaches. If the model and the indicator agree, confidence in the model's results can be enhanced. If the indicator gives a different signal, the model is not necessarily wrong, but it may be worthwhile to review the assumptions and relationships that led to the prediction" (Estrella and Mishkin, 1995:2 and 3).

Third, once a potential suitable indicator has been identified, the application of a modelling approach, such as the 'signals' approach, to the treatment of underlying data produces quite efficient results, by using a very convenient and simplified data treatment process. Obviously, this application should never stand as a perfect substitute for the application of more mathematically advanced models (such as the above-mentioned macroeconometric models), but should instead be used as a joint approach to maximize the fullest possible understanding of the events under study.

Fourth, this modelling approach might be quite adaptable to country-specific factors. Thus, the identification of a thoroughly efficient indicator may yield a better performance over a pre-established set of multiple, non-discriminating variables applicable to a wide range of disparaging situations. In fact, a previous survey on EWS has highlighted the fact that "different sets of variables are relevant for different countries" (Abiad, 2003:45). Complementarily, we might also add that this heterogeneous but systematic procedure, in addition to being applicable to distinct geographies, might also be further applicable to different crisis definitions. Ultimately, this flexible procedure allows us to set forth a powerful indicator (a variant of the Put-Call Ratio) intended to capture a specific banking crisis definition (the 'Subprime' Crisis) in a specific country (the U.S.A.).

As presented by the Chicago Board Options Exchange (CBOE), the Put-Call Ratio is a financial indicator used to measure stock market-related market sentiment. This financial market statistic is computed on a daily basis, and there are several variants of this indicator.

Essentially, the Put-Call Ratio measures, as its name indicates, the volume of put options relative to the volume of call options traded in the CBOE. Within the financial

community, a low value of this indicator indicates a low volume of put options relative to call options, which signals the prospective onset of a bullish financial environment. Reciprocally, a high value of this indicator indicates a high volume of put options relative to call options, which signals the prospective onset of a bearish financial environment. Therefore, high values of our proposed indicator might signal the occurrence of a banking (or systemic) crisis. It is quite important to observe that this indicator encompasses financial transactions in the options markets that were actually contracted upon, reflecting the engagement of present and future contractually- agreed upon financial positions (and not speculative market sentiment). This feature constitutes quite a valuable characteristic in the context of our analysis.

A major assumption surrounding our research corresponds to the expectations that, prior to the onset of a major systemic event (such as the 'Subprime' Crisis), the Put-Call Ratio approaches its upper historical values. In our case, this assumption will be fully validated through the use of the 'signals' extraction procedure. Our findings suggest that our proposed indicator fully heralds the onset of the 'Subprime' Crisis under study. The latter crisis imploded in the aftermath of the bullish financial environment preceding the bursting of the asset bubbles in the real estate and credit markets.

2.4.3. DATA

For the purpose of our research, we will use the CBOE's computed All Options Put-Call Ratio, extracted from the Datastream database[11].

The motivation for the extraction of this particular daily series is twofold. First, this market statistic fully captures both Equity Options and Index Options traded within the CBOE. Second, from all the variants of the Put-Call Ratio proposed by the CBOE, the range associated with this chosen variant dates back to September, 1995, while the remaining time series are only available onwards October, 2003. Were we to use any of these latter series, they would not fully cover the adopted NBER guidelines where the time frame associated with the business cycle that led to the 'Subprime' Crisis is concerned.

[11] The mnemonic for the extracted daily series is CBOEPCR.

The original daily Put-Call Ratio time series is thoroughly depicted in Figure 3. It should be observed that emphasis will be given to the use of monthly data as a basis for future supervisory judgment, in accordance with the revised literature's prescriptions herein reviewed. A basic trend-line was added to the said Figure, so that the series' upward trajectory might be easily discernible.

Notwithstanding, and given the fact that the original series manifests a high degree of volatility around its trend-line, a 7-day moving average and a 31-day moving average were also presented, so that the series' upward trajectory and corresponding trend-line's progression might become even more noticeable. These moving averages were calculated for two odd orders - 7 and 31 -, so that these moving averages have a half-width of 3 and 15, respectively. These half-widths correspond to the missing elements at the beginning and end-point of each of the moving averages, in comparison to the original series' data range (Makridakis, Wheelwright and Hyndman, 1998:89 to 94). Figure 4 simultaneously depicts both moving averages.

On the other hand, careful attention should be paid to data periodicity. In this respect, we will side with Goldstein, Kaminsky and Reinhart (2000:14) where the use of monthly data is concerned. We will thereby adopt the latter as a benchmark to the architecture of our own paper. In addition, following this approach will also be of great advantage due to the fact that it will allow us to compute monthly values from daily data without necessarily imposing a stationarity-related process (such as differencing). This latter process might impose the loss of the long-term properties[12] of the time series in question, a fact that might critically and unnecessarily undermine our own forecasting efforts.

The importance associated with the use of monthly data has already been duly ascertained within the context of the research pursued by Goldstein, Kaminsky and Reinhart (2000), when the latter literature was herein reviewed. Again, it should be noted that the use of this periodicity has been wholeheartedly advocated, for the reasons mentioned earlier, throughout most of the EWS literature related to this modelling approach, and we will also uphold this procedure.

[12] Within the framework of multivariate econometric models involving multiple time series, Brooks (2008) is quite adamant in stating that "differencing [any of the time series involved] will throw information on any long-run relationships between the series away" (Brooks, 2008:293).

Therefore, we will estimate a Put-Call Monthly Ratio by transforming the original daily data into a monthly indicator for the range of data tailored according to the NBER dating procedures. Where the treatment of the original daily Put-Call Ratio data is concerned, data averaging was the preferred method of choice. This was done in order to smooth the original daily data without the loss of the series' long-term properties (namely, its upward trajectory).

In fact, this data transformation procedure also maintains the long-term tendency associated with the Put-Call Ratio, and it is precisely this tendency throughout the business cycle that confirms this market statistic's potential as a signalling indicator.

It should also be noted that another way of obtaining the said monthly data would be to compute the sum of all put option transactions for any given month divided by the sum of all call option transactions for the same month registered by the CBOE. However, data published on the total volume of daily transactions is only available onwards 2003, which would compromise the application of the 'signals' extraction procedure according to the guidelines imposed by the NBER.

Furthermore, it should be observed that the 'Subprime' Crisis is a most strenuous epilogue to a business cycle centred on the dramatic expansion of the real estate and credit markets in the U.S.A. In this context, the said business cycle is normally subjected in this country to a specific dating procedure methodology, duly upheld by the NBER.

For the purpose of our research, we will also uphold the said dating procedure for the time series underlying our proposed forerunner indicator. This will allow the signalling influences of the latter indicator to be adequately circumscribed to the full extent of the business cycle leading up to the onset of the 'Subprime' Crisis (but, as expected, will not include this latter event). That is, our proposed indicator will be circumscribed by the business cycle dating procedure upheld by the NBER.

Thus, in strict accordance to NBER guidelines, November, 2001 and December, 2007, mark the beginning and end-points of the time series associated with our proposed indicator (NBER, 2008:1). By adopting this time frame for our indicator, the latter will be able to capture the events taking place during the expansionary phase of the underlying business cycle.

It is precisely within this ascending phase that we will find strong evidence confirming our indicator's signalling capabilities. That is, during the ascending phase of a given business cycle (or, for that matter, the inflating phase of an economic bubble), Put-Call Ratio values follow an upward trajectory up until the occurrence of a systemic event. This trajectory has been depicted as a simple linear trend in Figures 3, 4 and 5.

Notwithstanding, it should be observed that most of the literature herein reviewed adopts the use of data differencing (which might ultimately cause the loss of the long-term properties of the series) in order to rapidly stabilise the often volatile underlying data, but we have eschewed any further inducement of stationarity in favour of a more balanced procedure.

The Put-Call Monthly Ratio (computed by using data averaging) is fully depicted in Figure 5. In addition, descriptive statistics have also been computed for this monthly series and these results are presented in Table 1. As shall be explained when our threshold is calculated, two of these sample statistics will be of particular importance to the application of the 'signals' extraction approach to our chosen indicator.

Furthermore, it was also deemed relevant to include a very crude depiction of the relationship between the Put-Call Monthly Ratio and a major stock market index, the S&P500 Composite Index. The latter was chosen in view of the fact that it is the most closely watched proxy for the financial market wealth of the U.S.A. First, a XY-scatter plot is depicted in Figure 6. The said Figure illustrates the easily noticeable positive association between the latter variables. Second, a standard Ordinary Least Squares (OLS) regression was fitted to the later series depicting the Put-Call Monthly Ratio as the dependent variable and the S&P500 Composite Index as the independent variable. It should be noted that the said regression results were adjusted for the violation of the OLS model's assumption of no-serial correlation. Taking into account our large sample, this was done by computing the Newey-West estimator, in order to produce adequate standard errors of OLS estimators that are properly corrected for autocorrelation (Gujarati, 2003:475). Notwithstanding, it is not our intention to find the best possible regression fit, but only to provide an overview of the potential association influence the index might bear on our proposed bellwether indicator.

The regression results are summarized in Table 2. According to the regression findings, the coefficient associated with the S&P500 Composite Index is positive (as expected) and the 'R-Square' measure is approximately 30%. That is, the former result signals the positive association between the variables, while the latter indicates that approximately 30% of the variation of the Put-Call Monthly Ratio is explained by the evolution of the S&P500 Composite Index. A one point increase in the value of the S&P500 index is potentially associated with a 0.000314 point increase in the value of the Put-Call Monthly Ratio.

These preliminary results are confirmed by a different, but more sophisticated approach pursued by Pan and Poteshman (2006). These authors find strong informational links between option trading and subsequent stock price movements, by using Put-Call Ratios for stocks. These authors conclude that the predictive relationship functions in the expected direction. That is, "stocks with low put-call ratios outperform stocks with high put-call ratios by more than 40 basis points on the next day and more than 1% over the next week" (Pan and Poteshman, 2006:871). Therefore, this research clearly establishes a link between informed option trading and the future evolution of stock prices, and these results are fully compatible with our own findings.

Nonetheless, it should be pointed out that the Put-Call Monthly Ratio might be influenced by the performance of other benchmark indexes (other than the S&P500 Composite Index), but that fact should not concern us here. Suffice it to say that these satisfactory results indeed point out to the S&P500 Composite Index as a significant influence on our proposed indicator. This fact signals the existence of a significant link between the overall stock markets' performance (however crudely represented by the Composite Index) and our proposed bellwether indicator during the business cycle under study.

Proceeding with our analysis, it should also be noted that we do not possess a sufficiently long historical series on the Put-Call Ratio that would allow us to identify several historical episodes of banking (or systemic) crises in the U.S.A. Thus, our research cannot yet be tested on the major historical systemic episodes that have occurred in this country.

On the other hand, and considering that the focus of our research is on the current recessional bout, the Put-Call Monthly Ratio will be sufficient for this specific

purpose. Notwithstanding, it would be quite interesting to have a record of this indicator for the purpose of identifying crises that occurred in the 1980's and 1990's; if and when this data finally becomes available, it will serve two purposes. First, it will be possible to fully contrast our results with the results pertaining to the application of this procedure to other historical systemic events. Second, it will also allow us to verify the out-of-sample accuracy of this indicator, when the latter is duly applied to multiple historical episodes.

Furthermore, it is hoped that research on EWS based on higher frequency financial data (not only encompassing the Put-Call Ratio, but also other potentially relevant financial indicators within this segment) might further stimulate the computation of historical series, in order to promote the advancement of this research topic.

A drawback associated with this informational shortcoming refers to the fact that the optimisation of the noise-to-signal ratio is not entirely applicable. This is precisely due to the lack of sufficient data input allowing us to capture a larger incidence of historic crisis episodes. This test statistic would allow the signal extraction procedure to be fully optimised within the pursued research. In addition, it would also catalogue the potential efficiency of each indicator under study (in the case multiple indicators were analysed simultaneously). We will further develop this issue when the concept of prediction errors is introduced. Notwithstanding, and in strict accordance with the literature herein previously reviewed, it should be noted that stock market performance indicators have been hailed as one of most efficient signalling indicators available and that our own proposed bellwether indicator's results are in line with previous findings.

2.5. THE 'SIGNALS' APPROACH METHODOLOGY

In the present section, we will first endeavour to present a brief description of the tenets of the 'signals' approach methodology (sub-section 2.5.1.), along with the empirical results associated with our proposed methodology (sub-section 2.5.2.). The obtained results will be subsequently subject to robustness checks by increasing the stringency of model parameters (sub-section 2.5.3.), as well as being properly validated by using additional validating financial indicators (sub-section 2.5.4.).

2.5.1. THE 'SIGNALS' APPROACH METHODOLOGY: A BRIEF THEORETICAL INTRODUCTION

It should be noted that the present work hopes to demonstrate that well-established EWS procedures (more specifically, the 'signals' approach) are not incompatible with the use of higher frequency financial data. That is, the latter data periodicity can actually be factored in without reservations once a suitable protocol for the treatment of underlying data is properly convened upon. The establishment of this protocol (applicable to the data treatment process of higher frequency time series) should also take into account not only the financial nature of the chosen series, but also its relevant economic meaning within the scope of its signalling capabilities. We will strive to demonstrate the tremendous potential of this category of higher frequency indicators to the EWS literature by presenting the findings associated with our proposed indicator computed on a monthly basis.

The present section will describe the application of the 'signals' approach to the case of the Put-Call Monthly Ratio. This procedure was initially developed by Kaminsky, Lizondo and Reinhart (1998), and its use has gained widespread recognition and support within the EWS literature (a fact that our literature review vouches for).

Within the context of the occurrence of banking crises, the original 'signals' extraction methodology is most aptly described by the research conducted by Davis and Karim (2008). This methodology is essentially defined as "a non-parametric approach that assesses the behaviour of single variables prior to and during crisis episodes. The logic is that if aberrant behaviour of a variable can be quantitatively defined then

whenever that variable moves from tranquil to abnormal activity, crisis is forewarned" (Davis and Karim, 2008:99).

An additional advantage in using this procedure for signalling potential crises is that, as banking crises tend to follow pronounced declines in asset prices, "the signals approach is given diagnostic and predictive content by specifying what is meant by an "early" warning, by defining an "optimal threshold" for each indicator, and by choosing one or more diagnostic statistics that measure the probability of experiencing a crisis" (Goldstein, Kaminsky and Reinhart, 2000:15). Thus, this constitutes a most appropriate approach insofar as univariate country specific indicators can be considered either individually or be assembled collectively in order to signal the onset of a specific financial event.

Where the drawbacks of this methodology are concerned, and taking into account that we adhere to the business cycle dating methodology proposed by the NBER, the computation of the thresholds pertaining to each business cycle becomes sample dependent. In addition, the performance of statistical inference testing is not available within the context of the application of this modelling methodology (it is non-parametric, by definition).

Following the terminology adopted by Davis and Karim (2008), let X refer to a specific univariate indicator (in our case, the Put-Call Monthly Ratio), i a given time period, j a particular country (the U.S.A.), S the value of the signal variable (0 or 1).

X^i_j then refers to the value assumed by the indicator Put-Call Monthly Ratio in the U.S.A. in a given month i within the dating interval proposed by the NBER. If we further define $X^i_j *$ as the threshold value for this indicator as a value above which the indicator's signal S^i_j is positive (i.e., it's equal to one), then we have:

$$\{ S^i_j = 1\} = \{ | X^i_j | > | X^i_j * |\} \qquad (1)$$

On the other hand, if the indicator does not breach the threshold value (if it is inferior to the threshold), then we have:

$$\{ S^i_j = 0\} = \{ | X^i_j | < | X^i_j * |\} \qquad (2)$$

Thus, a crisis signal is emitted in (1) and no crisis signal is emitted in (2). That is, a crisis signal takes place whenever the threshold is effectively breached, regardless of the persistence of the emitted signal. It should be pointed out that, due to the nature of the Put-Call Monthly Ratio, the respective threshold is viewed as an upper limit to the progression of this indicator's underlying time series. Reciprocally, other financial indicators might possess a lower limit associated with their time series (instead of an upper limit), but that fact should not concern us in the present sub-section.

As has been mentioned in the literature review, the application of the 'signals' extraction procedure defines a critical time interval – the so-called 'crisis window' – under which the signal's emission takes place (or not). The standard choice pursued by the EWS literature refers to a 24-month long window preceding a given financial event, and we will also adhere to this recommendation.

We will eschew the banking crisis window initially proposed by Goldstein, Kaminsky and Reinhart (2000), who employed a 24-month window around a banking crisis. According to this definition, a signal would be considered effective if emitted "in the 12 months preceding the beginning of the crisis or (in) the 12 months following the beginning of the crisis" (Goldstein, Kaminsky and Reinhart, 2000:27). This was proposed with the firm intention of displacing potential ambiguities or inconsistencies in the crisis dating procedures.

Instead, we will replace this proposed procedure with a specific window prior to the event under scrutiny, thus taking into account the more widely accepted practice of cataloguing U.S. financial crises according to the methodology proposed by the NBER (the official governing body as to the official business cycle dating procedures). In fact, this organisation is poignantly specific as to the precise month in which these events took place.

Therefore, and given the fact that the NBER has pointed to December, 2007, as the month when the peak of economic activity referring to the 'Subprime' cycle occurred, the last crisis window to be monitored is inscribed in the 24 months preceding this date, i.e., it is inscribed between January of 2006 and December of 2007.

Furthermore, particular attention should be paid to the sample mean and sample standard deviation of the Put-Call Monthly Ratio (these sample statistics have been

presented in Table 1). According to the precepts prescribed by the 'signals' extraction procedure, these latter sample statistics will serve to compute the threshold value above which signals are appropriately emitted, as shall be seen in the following sub-section, where our empirical results are presented.

2.5.2. EMPIRICAL FINDINGS – THE BASELINE SCENARIO

We will proceed by presenting our empirical findings according to a baseline scenario where our adopted model's calibrating factor – the threshold level – follows the existing literature's recommendation.

Concerning the application of the 'signals' modelling approach to our specific crisis case, we have initially computed the signalling threshold according to the indications provided by Edison (2003). The latter author has proposed a variant of the 'signals' approach applicable to country specific scenarios. This proposal computes the threshold level – the X^i_j * above-mentioned – as the result of the following equation:

$$X^i_j * \; = \; \mu + \; K * \sigma \,, \qquad K = 1{,}5 \,/\, 2 \,/\, 2{,}5 \qquad (3)$$

where μ is equal to the sample mean of the time series associated with our proposed indicator, σ is equal to the sample standard deviation and the parameter $K = 1{,}5$ is the calibrating system parameter[13] initially suggested by this author (Edison, 2003:41 and 42). Notwithstanding, we will not only work with this latter value, but also adopt more stringent parameter values, in order to robustify our results. Moreover, our sample is delimited by the NBER cycle dating procedure, most notably where the dating of the U.S. 'Subprime' Crisis is concerned.

Furthermore, and taking into account the 'signals approach' literature's recommendations, the signals issuance process will be mainly analysed within the 24-month signalling window. For practical purposes, only the last 24-month signalling

[13] As a matter of reference only, and taking into account the example of an underlying standardized normal distribution, the latter's cumulative value below the said threshold of 1,5 standard deviations around the mean would comprise approximately 93,32% of the said distribution; that is, the remaining 6,68% above this threshold capture the occurrence of the extreme events which might be associated with this distribution; the corresponding normal distribution cumulative values for K = 2 and K = 2,5 are 97,72% and 99,38%, respectively.

window immediately preceding the onset of the 'Subprime' Crisis will be presented. That is, the latter window runs from January of 2006 to December of 2007. Notwithstanding, regulating authorities would certainly compile 24-month windows immediately at the start of the business cycle and would closely monitor the corresponding windows. In the specific case of the 'Subprime' cycle, the latter comprises seventy four months (from November of 2001 to December of 2007), so there would fifty one[14] rolling windows to monitor, for each scrutinised financial indicator.

Taking into account the computation of country specific thresholds, Figure 5 includes these thresholds as horizontal lines throughout the sample. The said thresholds run from the less stringent (K *= 1,5)*, to the intermediate (*K= 2)* and, finally, to the more stringent (K = 2,5). The higher the value of the threshold, the higher the stringency level for the signal emission process. The more stringent findings will be duly presented in the next sub-section.

As Figure 5 clearly shows, the depicted results are indeed quite efficient and expressive. Signals are duly emitted only within the context of the adopted crisis window, and not beforehand. Notwithstanding, the potential existence of prediction errors will be discussed in later stages of this section.

In order to provide a better perspective as to the trajectory of our indicator within the adopted crisis window, we also present Figure 7. This Figure essentially depicts the same information as Figure 5, but only takes into consideration the signalling information contained within the prescribed 24-month last crisis window prior to the onset of the 'Subprime' Crisis. Considering K = 1,5 (the lowest threshold), the first signal (when the indicator surpasses the prescribed threshold) is emitted in June of 2006, barely 6 months into the crisis window, and 19 months before the window's end-point. This early signal is then complemented by three additional strong signal emissions that took place in March, August and November of 2007.

The application of this methodology also contemplates the possibility that it might inadvertently generate prediction errors. The chosen indicator is not prone to

[14] That is, seventy four minus twenty four plus one rolling monthly windows throughout the 'Subprime' cycle.

prediction errors when a signal is emitted and a subsequent crisis occurs within the prescribed window crisis. Or when no signal is emitted and, accordingly, no crisis ensues (in this latter case, the indicator performs its function as a good 'silent' indicator). Quite the contrary, prediction errors occur when the indicator fails to call the crisis when the later effectively occurs (Type I error) or when the indicator calls a crisis that fails to materialize (Type II error) within the crisis window (Davis and Karim, 2008:100).

In our specific case, we are analysing the potential signalling capabilities of an indicator to a crisis (the 'Subprime' Crisis) that occurred immediately after the crisis window. The latter window is inscribed within the pre-established chronological time points duly defined by the NBER (we already know beforehand that after December, 2007, a financial crisis will necessarily ensue). Furthermore, in view of the adopted business cycle dating and crisis window procedures, our last crisis signalling window takes place between January, 2006, and December, 2007.

Thus, the only prediction error that might occur is the Type I error, given that a Type II error cannot occur within this specific crisis window. That is, the possibility that our indicator calls a crisis that does not occur *immediately after this last crisis window is not, in our specific case, a real possibility* (because a crisis definitely occurs after the end-point of the NBER dating). In addition, not even a Type I error occurs, because the indicator effectively emits a signal only within the prescribed crisis window[15].

On the other hand, prediction errors might occur outside the window crisis. Nevertheless, that is not even our case, due to the fact that, according to Figure 5, no signal is emitted prior to the prescribed crisis window, *as the indicator only surpasses the threshold (the horizontal line in the Figure) within the crisis window*. In itself, this fact is revealing of the signalling capabilities of our proposed indicator.

In passing, it should also be mentioned that the ultimate forecasting validity of our indicator in relation to future potential crises in the U.S.A. should be more accurately judged in a future cycle that already has a starting (i.e., a post-Crisis minimum point), but still does not have an end-point (i.e., a maximum).

[15] Notwithstanding, it would be highly abusive to claim that the effectiveness of the signal emitting process associated with our proposed indicator is complete, in view of the already alluded lack of historical data that might ascertain the potential efficiency of the application of the said indicator to other historical episodes and/or crisis definitions.

That is the case of the current U.S. business cycle once a 'trough' point to the current Crisis is determined by the NBER. With respect to this future cycle subsequent to the 'Subprime' Crisis, we are not yet in a position to comment on our indicator's signalling abilities, although we do expect that the good results obtained by our research might encourage further investigation relating to future cycles. Nevertheless, we fully concur with the statement that "the value of any EWS lies in its ability to forewarn policy makers of impending crises and hence on their out-of-sample predictive ability" (Davis and Karim, 2008:108). Hopefully, our results will contribute to the validity of this statement.

Therefore, these results fully support our argument sustaining that the application of the 'signals' extraction procedure to higher frequency financial indicators (in particular to our own proposed bellwether indicator) constitute a very promising avenue of future academic research. Further validating findings pertaining to the application of this approach to additional financial indicators will be presented and discussed in sub-section 2.5.4.

The consequences associated with these and future findings might help regulatory authorities not only to anticipate the advent of prospective financial shocks, but also to ward off the often implacable ensuing aftershocks to the fabric of real economies. The following sub-section will deal with the application of robustness tests to our initial findings.

2.5.3. ROBUSTNESS CHECKS

It should be observed that the original 'signals' approach allowed for the pooling of data from several countries by also using a different multiple - more stringent - country parameter of 2,5 (Edison, 2003:16). In our paper, we will also allow for the upward variation of this important calibrating parameter, by allowing our country-specific research to follow a more demanding line of enquiry. In this way, our findings heretofore presented will be robustified.

Thus, in order to enhance the validation of the results previously presented, we have also presented more demanding findings associated with our proposed indicator using system parameters of 2 and 2,5. These results have been presented in Figure 7, as

reflected in the upper threshold horizontal lines (labelled '' and ''', respectively, for K = 2 and K = 2,5).

Once again, these robust results clearly depict the effectiveness of our initial findings. Signals continue to be emitted, in March and August of 2007 (in the 15th and 20th month of our crisis window). In comparison to the previous results, there is a time lag in the signal emission process, but the results remain quite powerful as before.

Therefore, even considering the application of more stringent thresholds (by allowing for the upward variation of the said system parameter), the results remain quite robust, as the findings continue to suggest the effectiveness of the use of this higher frequency financial indicator in signalling financial shocks.

These findings have been collected and summarized in Table 3. Here, we can thoroughly observe that the emitted signals are both potent and persistent. They are potent insofar as the more acute signals remain robust even when the threshold is raised to meet more stringent criteria. They are also persistent insofar as more than one signal is emitted to herald the prospective impact of a potential impending financial shock.

On the other hand, were we to conduct a sensitivity check on the dimension of the crisis window, our proposed indicator (under the auspices of the adopted methodology) would continue to signal the crisis under scrutiny. The signals emitted in March and August of 2007 would remain robust in a 12-month crisis window prior to the peak of economic activity. While, the signal emitted in August of 2007 would remain robust in a 6-month window prior to the peak of economic activity registered in December of 2007.

Lastly, we would also like to have further verified the strength of these results against a different business cycle. The obvious candidate for this task would be the business cycle leading up to the 'Dot-Com' financial crisis. According to the NBER, this business cycle began with a through point in March of 1991, and ended with a peak point that took place in March of 2001 (the subsequent through occurred in November of 2001, our selected beginning-point for the monthly Put-Call Ratio herein analysed). Unfortunately, we were unable to check these results against this earlier crisis, in view of the fact that available data on our daily market statistic only starts on the 29th of September, 1995. Therefore, we were not able to perform a robustness check based on

this earlier business cycle due to the fact that a vast portion of the series is missing (more than four years' worth of data). Nevertheless, the informal application of this procedure to this incomplete time series data was performed (but not presented in our paper) and the corresponding results continue to demonstrate the effectiveness of our proposed indicator as a potential signalling tool.

Nevertheless, we hope the future availability of historical data on the daily Put-Call Ratio might render this robustness check possible, in view of the fact that a positive check result might further enhance the prospective use of this indicator as a supervisory tool.

The following sub-section will present additional higher frequency financial indicators in order to consubstantiate our argument sustaining the validity of 'pure' financial indicators as predictors of financial crises.

2.5.4. VALIDATION

The present sub-section will strive to enhance the strength of our argument in favour of using 'pure', higher frequency financial indicators as financial crisis predictive tools. For this validating purpose, we will further analyse six individual representative financial indicators. The corresponding results will complement and confirm the powerful predictive findings associated with the Put-Call Ratio.

These validating financial indicators will also be analysed within the EWS framework proposed by this paper. Furthermore, they will continue to be inscribed within the 24-month long 'crisis window' and the calibrating parameters will assume the values K = 1,5 / 2 / 2,5.

It should be noted that the indicators herein scrutinised are generally more specific to certain segments of the financial markets (e.g., rare commodities or the inter-bank markets). This contrasts with the more general resonance of the Put-Call Ratio as a bellwether indicator in relation to the equity and options markets. Notwithstanding, even in the specific case of these indicators, the yielded results continue to exhibit powerful forecasting signals.

The first financial indicator that warrants our attention is the price of gold (Figure 8). Indeed, this rare metal is traditionally viewed as a safe-haven financial investment, most specially in view of the imminent occurrence of financial crises (when its price usually rises). For K = 1,5, Figure 8 depicts the 24-month signalling horizon for the trajectory of the price of gold. Four powerful, persistent and sequential signals are emitted in the period from September, 2007, up to December, 2007 (i.e., four months prior to the peak of economic activity registered by the NBER after which the 'Subprime' Crisis occurred). For K = 2, there are three qualified issued signals, while for K = 2,5, there are no qualified signals issued.

The second indicator included in our analysis is the TED spread (Figure 9). The latter spread reflects the difference between the 3-month US Libor and the effective Fed Funds Target Rate. This spread is important insofar as it reflects the potential liquidity tensions affecting the money markets, most specially the inter-bank markets. A rising and abnormal TED spread usually signals the presence of such financial liquidity pressures. These pressures might lead to the subsequent occurrence of the already mentioned 'fire sale prices' (as described in sub-section 2.3.1.). Thus, Figure 9 depicts this spread throughout the business cycle leading up to the crisis. For K = 1,5 and K = 2, five powerful, persistent and sequential signals are emitted onwards August, 2007, up until December, 2007 (five months prior to the said peak of economic activity). For K = 2,5, there are four such qualified signals in the same period.

The third indicator anticipating the occurrence of the 'Subprime' Crisis is the evolution of the Dow Jones U.S. Financials index (Figure 10). The over-heating U.S. real estate market, along with a corresponding rising level of activity in mortgage finance, were certainly not sustainable, as has been described in earlier sections. Nevertheless, this over-heating inevitably led to a corresponding over-heating in the valuation of financial institutions. These buoyant market valuations were quite easily reversed once the underlying bubbles imploded. That is, the deflating of the real estate and credit bubbles inevitably led to the loss of value of banking institutions involved in mortgage finance-related and concomitant activities. Figure 10 thus depicts the evolution of the said Dow Jones Financials Index. For K = 1,5, an undistinguishable over-heating in the value of these institutions is already noticeable, insofar as the index surpasses the threshold at least 13 months prior to the peak of economic activity. The

first signal is emitted in December of 2006, and further signals are emitted in January, February, April, May and June of the following year. Furthermore, this signal emission process is also characterized by a sudden and precipitous overall loss of market value of financial institutions near the end of the crisis window, which is also in itself quite a revealing fact as to the impending magnitude of the systemic failure. This loss is quite manifest in the pronounced index decline in the second semester of 2007. These two facts combined should have, by itself, signalled the implosion of the referred bubbles and the corresponding loss of value for the banks prior to the onset of the crisis. Ultimately, this loss of value culminated in the severe financial market contagion processes that occurred during the Crisis, and the ensuing bankruptcies of major financial institutions, not only in the U.S.A, but also worldwide. For both parameter values K = 2 and K = 2,5, however, there are no signals issued.

A fourth financial indicator (which is in full agreement with the previous indicator presented) deserving our attention is the composite Return On Assets (ROA) ratio for U.S. banks with assets exceeding USD15 billion (Figure 11)[16]. These large U.S. financial institutions were previously depicted as being major players involved in issuing and trading securitised assets. In the specific case of this variable, the small number of quarterly observations (25) allows for an efficient graphic depiction of the full 'Subprime' cycle window. We therefore opted to present the corresponding Figure including all available quarterly data, instead of the 24-month signalling window (which would only cover eight quarterly ROA observations). Figure 11 depicts the evolution of the said ROA. During the fourth quarter of 2007, this financial indicator surpassed all of the corresponding signalling thresholds[17] (the actual month cannot be identified from our quarterly data), emitting a powerful sign of distress prior to the peak of economic activity in the U.S.A. In addition, a decreasing ROA trend for the period comprising the second semester of 2004 up until the end of 2007 confirms that expectations as to the occurrence of an impending financial shock of some magnitude were already being

[16] Contrary to the financial indicators previously presented, this ROA time series has a quarterly frequency (instead of a monthly frequency); thus, it was not necessary to smooth this time series by recourse to data averaging; however, its importance is strategic in order to provide a comprehensive picture of the impact of the 'Subprime' Crisis upon large U.S. financial institutions that were directly exposed to this systemic breakdown.

[17] This financial ratio is associated with a lower boundary threshold, instead of an upper boundary one; this is due to the fact that what concerns us here is the *decreasing* ROA value – foreboding, for example, the breakdown in the 'originate-and-distribute' banking paradigm - in light of the potential occurrence of a large-scale financial shock (such as the 'Subprime' Crisis).

translated into a lower value for this financial performance indicator. Moreover, the 2007 fourth quarter decline is particularly pronounced and damaging to these financial institutions (representing approximately a staggering 25% loss in value in one single quarter), when taking into consideration even the most stringent robustness scenario.

A fifth financial indicator[18] that is directly related to the essence of the financial crisis under scrutiny involves the total monthly value of securitised consumer credit assets (Figure 12). These securitised assets were being issued at an alarming pace, even as the real estate markets in the U.S.A started to collapse. In the aftermath of the 'Subprime' Crisis, these credit lines were exhausted, given mortgage borrowers increasing limited ability to borrow against their homes (as described in sub-section 2.3.2.). Therefore, the excessive rise in the total value of securitised consumer assets prior to the peak of economic activity should have forewarned of the looming Crisis, namely in view of the impending implosion of the credit markets. Figure 12 thus depicts the evolution of this financial indicator. In it, we observe that the total value of securitised consumer loans exceeded its corresponding upper-boundary threshold several times prior to the peak of economic activity. In fact, considering K = 1,5 , eight signals were emitted in 2007. The first occurred in February, 2007, followed by powerful, persistent and sequential signals emitted from June of 2007 up until December of that same year. For K = 2, there were four such signals, and for K = 2,5 , there were no such signals issued. Thus, the previously presented hypothesis that consumer credits lines might well have been tapped in view of the rising mortgage defaults occurring after 2005 indeed merits further investigation.

Finally, the sixth financial indicator that warrants our attention is the Union Bank of Switzerland (UBS) Global Radar Index (mnemonic: LTARAUX) (Figure 13). The latter effectively constitutes a powerful reference gauging the global appetite for risk in the financial markets. Figure 13 depicts the evolution of this financial indicator. For K = 1,5 , five powerful, persistent and sequential signals are emitted, from April, 2007, up until August of the same year (at least nine months in advance of the peak of economic activity registered in the U.S.A.). For K = 2 and K = 2,5 , however, there were no signals issued.

[18] This financial indicator had a monthly periodicity and, therefore, it was not necessary to smooth the corresponding time series by recourse to data averaging.

On a theoretical level, we would like to observe that, in accordance with the business cycle academic literature, indicators might be grouped in two distinct categories: leading indicators or lagging indicators.

The first *pro-actively signal in advance* the occurrence of a given event (e.g., a financial crisis), while the latter *reactively signal* the occurrence of the said event once it has taken place[19]. In the course of our research, we are most naturally interested in the former category of indicators. In this pursuit, all of the previous financial indicators thus far presented essentially belong to this category.

Notwithstanding, we will also provide an example of a potential EWS lagging indicator. Nevertheless, the latter's use might be viewed solely as a confirmation to the validity of the performance of the previously analysed leading financial indicators (as EWS tools). That is, while leading indicators signal in advance the occurrence of a systemic breakdown, lagging indicators fully confirm the occurrence of these events - but have no anticipatory prowess - and signal the onset of a subsequent economic cycle.

Our analysis[20] of the VIX Volatility Index suggests that this variable is a lagging indicator. In fact, no signal is emitted during the crisis window prescribed by the EWS literature (although its trend is clearly rising), but the VIX is highly reactive once the peak of economic activity has been attained.

In fact, this variable's status as a reactive tool has already been confirmed by Banerjee, Doran and Peterson (2007). These authors state that high levels of this indicator traditionally coincide with market 'bottoms', which thus seem to indicate that stock markets are usually 'oversold' (Banerjee, Doran and Peterson, 2007:3184). Traditionally, a stock market 'bottoms out' well beyond the peak of economic activity (i.e., when a given financial crisis has already taken its toll). This further strengthens our suggestion sustaining that not all higher frequency financial indicators possess EWS-related predictive capabilities.

[19] For example, Sorensen and Whitta-Jacobsen (2004) point to this fundamental distinction by grouping variables in this fashion; these authors state that exports might be considered leading variables in certain countries covered by their analysis, while employment seems to be almost universally acknowledged as a lagging variable (Sorensen and Whitta-Jacobsen, 2004:pp. 411 to 417).

[20] We will not present these results, in view of the fact that, according to the prescribed crisis window, the VIX does not possess anticipatory or forecasting validity in the context of our efforts in identifying 'pure' leading indicators (by recourse to the EWS methodology) of the 'Subprime' Crisis.

Overall, we are able to conclude, in the present section, that several financial indicators (apart from our proposed Put-Call Ratio) also exhibited and emitted signals of looming distress in several distinct segments of the financial markets. In some cases, the signal emission process occurred well in advance of the peak of economic activity associated with the 'Subprime' business cycle.

2.6. THE NET PRICE INCREASE/DECREASE METHODOLOGY

In the present section, an alternative methodology – in the form of the Net Price Increase/Decrease (NPI/NPD) – is presented, with the purpose of demonstrating the versatility of 'pure' financial indicators in predicting future financial events. The use of mutually exclusive methodologies will allow us to conclude that the variables under scrutiny constitute an independent source of crisis signal issuance, regardless of the methodology employed. Thus, the said alternative will clearly mark a distinction between potentially useful variables of financial extraction and the use of specific signalling-oriented methodologies able to furnish accurate predictions from the said variables. A brief introduction to the tenets of the Net Price Increase/Decrease methodology will be presented (sub-section 2.6.1.), followed by the corresponding empirical findings thereof (sub-section 2.6.2.).

2.6.1. THE NET PRICE INCREASE/DECREASE METHODOLOGY: A BRIEF THEORETICAL INTRODUCTION

The findings heretofore presented allow us to confirm our initial hypothesis according to which the 'Subprime' Crisis might have been adequately anticipated through the scrutiny of 'pure' financial indicators.

In order to achieve this purpose, a specific methodology (EWS) was initially applied to a specific set of financial variables. This research effort thus detected underlying pre-'Subprime' crisis deflationary signs during the expansionary phase (or upswing) of the business cycle. That is, the detection of these latent forecasted signals adequately foretold the impending financial shock in the U.S.A., within the timeframe of the business cycle leading up to the 'Subprime' Crisis.

On the other hand, the presented research has clearly distinguished between the scrutiny of some decisive variables of financial extraction and the employment of a specific methodology (EWS) intended to extract signals from the said financial variables.

Thus, there are two fundamental reasons for also implementing a second distinctive methodology in the early detection framework employed by this paper. First,

it will allow us to better complement and validate the findings heretofore described (using the EWS methodology) and potentially enhance the quality of the forecasting results. Second, as there is no perfect methodology for forecasting purposes, regulators should be able to use distinctive competing and mutually exclusive methodologies employing equally distinctive sources of financial information and compare the corresponding results for each source. This would certainly prompt the efficient anticipation of prospective financial distress episodes and subsequently facilitate the pursuit of the most appropriate counter-measures.

Therefore, the adoption of an alternative methodology – as is the case with the Net Price Increase/Decrease procedure hereafter presented - would not only validate the above-mentioned financial variables as a fundamental autonomous source for forecasting future systemic events (regardless of the methodology employed). But it would also contribute to the expansion of the set of efficient methodologies intended to capture the prospect of impending extreme financial events. Once again, it should be observed that these distinct methodologies constitute complementary procedures to the extensive use of advanced econometrics procedures already being employed within central banking organizations. In fact, both of the methodologies herein described are concomitantly passible of being employed in the early and efficient detection of extreme events.

We should start by observing that the NPI/NPD methodology has been developed and is deeply associated with the research topic addressing the asymmetric impact of oil price fluctuations on the macro-economy, as shall be seen in the following paragraphs.

In the context of the analysis of the historical evolution of oil prices, Hamilton (1996) develops the Net Price Increase (NPI)[21] methodology in order to better characterize the latter commodity's price evolution and its overall impact on the U.S. economy. This methodology initially endeavoured to capture abnormal upward price movements in the context of highly volatile oil prices. It is deemed effective in capturing non-linear influences, most specially in the context of oil price hikes and its ensuing impact (Hamilton, 1996:215 to 220).

[21] This methodology is mainly known as the Net Oil Price Increase (NOPI). In the context of the present paper, we will refer to it by using the more abbreviated Net Price Increase (NPI) – or Net Price Decrease (NPD) – expressions, in view of the fact that we will only apply it to variables other than oil.

Ramos and Veiga (2011) extend the use of this methodology to examine the existence of an asymmetric impact of oil price fluctuations on oil and gas industry returns. They conclude that upward oil price movements affect the said industry's returns more than the inverse downward price drops.

According to these authors, the existence of this oil price asymmetric effect constitutes a unique feature of the oil and gas industry. In support of their findings, the authors employ the measure first proposed by Hamilton (1996), while noting that the said measure is quite effective in capturing unsettling price movements, in the context of soaring (or retreating) oil prices. That is, the measure is low in the face of consistent oil price increases (or decreases, in the case of the NPD), but high in the face of abnormal and disruptive (i.e., inconsistent) price behaviour.

Following the terminology proposed by these latter authors, the Net Price Increase/Decrease[22] methodologies may be defined according to the following equations (Ramos and Veiga, 2011:532):

$$NPI_t = \max (0, \ln(X_t) - \ln[\max(X_{t-1} , X_{t-2},\ldots,X_{t-\beta})]) \quad (4)$$

$$NPD_t = \min (0, \ln(X_t) - \ln[\max(X_{t-1} , X_{t-2},\ldots,X_{t-\beta})]) \quad (5)$$

where NPI_t / NPD_t is the Net Price Increase/Net Price Decrease for period t,

X_t is the financial indicator under study,

t is the time subscript

and β is the time frame length.

The time frame length β typically refers to the horizon of the 'signalling window' or filter used in the research and must also reflect the frequency associated with the chosen data (monthly, quarterly, yearly, etc.). Hamilton (1996) uses quarterly data (Hamilton, 1996:217), while Ramos and Veiga (2011) use monthly data (Ramos

[22] In the context of our research, the NPD will only be used with the Return On Assets financial indicator, in view of the latter indicator's nature.

and Veiga, 2011:532). That is, this methodology is quite versatile in capturing abnormal price behaviour for a pre-determined time frame and using a specific frequency, regardless of the lower frequencies to which it is typically applied.

Within the context of our research, we will consider that a 'signal' has been issued by the proposed methodology when either the NPI or the NPD exhibit non-zero values for a given time frame unit[23]. Furthermore, and taking into account the set of pooled signals, our research will be mainly interested in the strongest possible signal as a harbinger for the occurrence of a future systemic event. This is due to the fact that the latter might be associated with a higher probability of occurrence of a potential impending shock than a signal with a lower potency. Taking into account that this methodology portrays abnormal price behaviour, unequivocally strong signals might thus constitute a powerful warning sign for the appropriate regulators, with the strongest signal being associated with the highest probability possible of event occurrence.

Notwithstanding, the present research is, once again, circumscribed by the very inexistence of long time series for the chosen variables, thus undermining the possibility of a comparison between distinct business cycles leading up to the most recent financial systemic episodes.

A major drawback related to the use of this methodology concerns its exclusive application to price-related variables (which are positive, by definition).

On the other hand, there are two fundamental advantages associated with the above-mentioned NPI/NPD definitions. First, the latter definitions are quite useful in assessing the existence of abnormal behaviour relative to a set of pre-defined past values (the length of which – β - is defined *ex ante*[24]). This confers a great flexibility in the analysis of disruptive variable behaviour, specially when taking into account different signalling windows for any given variable under scrutiny. Second, these definitions also provide a yardstick for the measurement of the strength of the underlying signal at each computed time frame for each variable, thus drawing attention to the relative severity of a prospective impending financial episode. Theoretically, the

[23] In comparison to the EWS methodology (where a signal is either issued or not, regardless of its magnitude), the NPI/NPD approach is not binary, thus allowing a given signal's buoyancy to be directly measured.

[24] However, Hooker (1996) considers this *ad hoc* construction to be a disadvantage, a view which we will not partake of, in view of the different context and purpose to which the latter definition is to be applied.

higher a signal's potency, the higher the underlying probability of the occurrence of a given episode, although the corresponding probabilities might not be easily defined.

In the context of the present research, these advantages will be greatly appreciated, insofar as the financial time series herein included are prone to unsettling non-linear behaviour, most specially in the months preceding the U.S. financial meltdown (as can be observed from most of the variables' corresponding Figures).

In order to take advantage of the flexibility associated with the NPI/NPD architecture, we will use the daily periodicity associated with most of the scrutinised variables (whenever daily data is available). We will then compute the 3, 6 and 12-month moving averages under the NPI/NPD framework, in order to arrive at potential signals of impending financial episodes. Notwithstanding, a distinction should be made between the most powerful signal and the earliest signal, in view of the fact that both might not often coincide. In the following sub-section, the main NPI/NPD findings (presented in Figures 14 to 21 of Appendix A), will be fully discussed.

2.6.2. EMPIRICAL FINDINGS

The findings pertaining to the application of the NPI/NPD methodology to the variables included in the present paper are graphically depicted in Figures 14 to 21.

We should start by noting that these Figures depict the full 'Subprime' cycle in accordance with the NBER business cycle dating procedures. That is, the signalling window comprises the entirety of the 'Subprime' business cycle. Moreover, and taking into account the use of daily data and the ensuing volatility associated herewith, the original input data were subjected to moving average procedures in order to smooth the original data. This constitutes a more evolved and demanding alternative to the data treatment procedure pursued under the 'signals' approach. Moving averages were calculated for the following periods: 3-month (90 days), 6-month (180 days) and 12-month (360 days).

Starting with our bellwether indicator, the Put-Call Ratio has been included in our analysis using both daily and monthly data. The latter periodicity was also included

in order to facilitate the comparison between the results achieved under EWS and those referring to NPI/NPD.

In its daily variant (Figure 14), the Put-Call Ratio under NPI issues the strongest signals on the following dates[25]: May of 2006 (3-month), February of 2007 (6-month) and February of 2007 (12-month). The best and most powerful signal is thus issued twenty months before December of 2007 (the date marking the end of the 'Subprime' cycle and the beginning of the 'Subprime' Crisis).

In its monthly variant (Figure 15), the Put-Call Ratio under NPI issues the strongest signals on the following dates: May of 2006 (3-month), May of 2006 (6-month) and May of 2004 (12-month). Of these, the strongest signals are issued under the 3 and 6-month window, but the earliest signal is issued under the 12-month window. Again, the most powerful signals are issued twenty months before the onset of the 'Subprime' Crisis, while the earliest signal is issued in mid-Subprime cycle (May of 2004).

Gold bullion (Figure 16), as a gauge for a potential global macroeconomic 'flight-to-safety' trend, issues the same strongest signal(s) on April of 2006 under all the signalling windows. These strongest signals also constitute the earliest most powerful signals, preceding the onset of the 'Subprime' meltdown by twenty one months.

The 3-month TED spread (Figure 17), as a gauge for a potential global liquidity risk, issues the strongest and earliest signal in November of 2002. In the context of our analysis of the 'Subprime' Crisis, this signal constitutes a 'false positive'. However, a potential explanation for the occurrence of such an early date might be found in the signal's issuance of liquidity tensions in the aftermath of the 'Dot-Com' Crisis. A second potential explanation might involve the fact that NPI/NPD has been specifically designed to address price variables, which might thus limit its application to the variables under scrutiny. Finally, a third potential explanation might involve the occurrence of a localised disruptive event specific to the liquidity markets. Notwithstanding, the second-in-line strongest signals (dated August of 2007, under the

[25] In order to facilitate the comparison between the two mutually exclusive methodologies used in the present paper, we will prefer to concentrate on the month and year of the strongest signal; nevertheless, the actual day is duly referred to in the corresponding Figures, within the textbox labeled 'Date'.

6 and 12-month windows) seem to possess predictive power, preceding the 'Subprime' Crisis by five months.

The Dow Jones U.S. Financials (Figure 18), as a gauge for the over-heating tensions latent in the U.S. financial industry, issues the strongest and earliest signals in November of 2005, preceding the onset of the 'Subprime' Crisis by twenty six months.

The R.O.A. for U.S. banks with assets exceeding USD 15 billion (Figure 19)[26], as a gauge for the condition and performance of major U.S. financial players, issues the strongest and earliest signal in the first quarter of 2004, under both the 3 and 6-month signalling window. There is evidence suggesting a sound predictive power associated with this variable, most specially taking into account that this indicator portrays an increasingly disturbing picture for large financial institutions after the second quarter of 2004. The 12-month window, however, does not issue any positive signal at all during the 'Subprime' cycle.

Total securitized consumer loans (Figure 20), as a gauge for the over-heating expansion of the credit markets, issues the strongest and earliest signal in November of 2002. Again, this signal might reflect existing tensions in the aftermath of the 'Dot-Com' crash, the fact that NPI/NPD is more suited to determine abnormalities in price variables or some market-specific disruption. Nevertheless, the second-in-line most powerful signals (dated June of 2005, under the 6 and 12-month windows) seem to possess a strong predictive power, preceding the onset of the 'Subprime' Crisis by thirty one months.

Finally, the UBS Global Risk Index (Figure 21), as a gauge for global risk appetite, issues the strongest and earliest signal in August of 2002, followed by a signal of lesser potency in March of 2003 (under the 3 and 6-month windows, respectively). Again, this might reflect existing tensions in the aftermath of the 'Dot-Com' crash or the fact that NPI/NPD is more suited to determine abnormalities in price variables or some market-specific disruption. More adequately, a third signal possessing predictive power is issued in June of 2007, preceding the onset of the 'Subprime' Crisis by seven months.

[26] In the case of this specific variable, abnormal behaviour is defined as a sudden and expressive downturn in the latter variable's performance, which justifies the employment of NPD.

In view of the results obtained, the NPI/NPD methodology is also deemed quite promising for predicting the occurrence of the 'Subprime' Crisis, most specially when applied to variables of financial extraction. Nevertheless, there are three issues that merit our attention when addressing the efficiency of this methodology for predictive purposes.

First, the disparaging number of issued signals is a factor to be duly acknowledged. The amount of signal issuance is quite heterogeneous (from a minimum of zero for 12-month R.O.A. indicator to a maximum of 173 for 3-month Gold bullion), and might be quite difficult to interpret. Ultimately, this might bear upon the decision making process, once a potential unsettling episode has been duly signalled. That is, a variable quite prone to significant signal issuance might difficult the pursuit of subsequent actions by the supervisor.

Second, and taking into account each variable individually considered, the use of longer monthly averages typically produces less signals than the use of shorter moving averages. Notwithstanding, the choice of the most important moving average span for each specific indicator should have to take into account the idiosyncratic aspects of the corresponding variable, as there is no clear rule-of-thumb for this parameter's choice.

Third, the existence of a discrepancy between the maximum potency and the earliest signal (should these signals not coincide when a comparison among distinct windows is established) might hinder a subsequent effective regulatory decision process.

In addressing each of the above-mentioned issues, it is most fundamental not only to analyse the impact of each variable *vis-à-vis* multiple historical business cycles leading up to financial crashes. But also to contextualise and compare the said variables within a more enlarged set of equally predictive variables. That is, a careful and efficient supervisory process should always take into account each individually chosen variable both in its historical context (taking into account its former predictive abilities in past episodes) and in its relative context (taking into account the performance of each variable within a larger set of other equally predictive variables).

Finally, Table 4 presents our main findings where the signal issuance dates are concerned. It should be noted that the direct comparison of the results presented under

the two methodologies is not entirely adequate, due to the fact that the underlying procedures are quite distinctive. Notwithstanding, it is interesting to collect and juxtapose the said findings into a single table. A careful examination of the said table prompts the following observations.

First, taking into account our bellwether indicator, the results emanating from both methodologies are quite similar, but there is a clear distinction where our validating indicators are concerned. Overall, the EWS methodology seems more conservative where the signal issuance dates are concerned, generally producing signals later in the 'Subprime' business cycle. While the NPI/NPD methodology seems quite more sensitive to the signal extraction process, producing signals much earlier in the 'Subprime' business cycle (the notable exception is the UBS Global Risk Index).

Second, the NPI/NPD findings seem more volatile, but it should be observed that the dimension of the underlying signalling windows is entirely distinct (in comparison to the EWS methodology), which undermines our comparative efforts. Furthermore, our findings for the NPI/NPD include only those credible signals for which the literature establishes a clear precedent for their existence. That is, some very early dates signalled at the beginning of the cycle and associated with the most powerful signals have been substituted for the next-in-line powerful signals, in order to provide a more realistic prediction, in strict accordance with the 'Subprime' cycle's historical facts.

Overall, both of our adopted methodologies and financial indicators are quite efficient in predicting the systemic event under scrutiny.

2.7. CONCLUDING REMARKS

The present working paper effectively demonstrates the potential use of distinct financial indicators (including the Put-Call Ratio, an options market statistic) as supervisory policy instruments that could have signalled the onset of the 'Subprime' Crisis in the U.S.A. For that purpose, the paper uses a well-established signalling methodology belonging to the Early Warning Systems literature, the 'signals' approach extraction procedure. The use of this latter methodology is then complemented by a second equally promising methodology, the Net Price Increase/Decrease. In view of the obtained results, both our proposed financial indicators and the predictive methodologies might be of importance in signalling future banking (or systemic) crises.

The signalling results emanating from the application of the 'signals approach' methodology to our leading flagship indicators turned out to be quite efficient, powerful and robust, as the results associated with the conducted sensitivity analysis clearly reveal. In order to assess the use of certain 'pure' financial indicators on their own merit, our data were further submitted to the application of an alternative promising methodology (the NPI/NPD) enveloping our proposed indicators of financial extraction, thus strengthening our original findings.

In view of the results obtained, our research effectively achieved two major goals. First, it validated the use of a specific set of higher frequency financial indicators possessing predictive prowess (such as our flagship Put-Call Ratio indicator) as potential signalling tools. Second, it validated the use of both the 'signals' extraction approach, as well as the net price increase/decrease methodologies. The said mutually exclusive methodologies proved to be quite valuable procedures in extracting relevant event signals from the proposed univariate financial indicators, when the latter are applied to the prediction of a specific financial crisis episode.

In this respect, it is hoped that these results might encourage further research on this promising research topic, in order to unveil not only a specific set of optimally chosen financial market statistics, but also other promising predictive methodologies, notwithstanding the subsequent research needed to efficiently calibrate these predictive methodologies.

In subsequent research, the proposed variables might be either individually or collectively considered, once the signalling capability credentials of this set are clearly established, so that its constituent elements might be deemed appropriate to integrate a supervisory arsenal capable of anticipating the onset of future systemic financial crises. As an example, the specific category of higher frequency financial market statistics might include other promising candidates, such as financial leverage ratios. Furthermore, robust crisis-predicting indexes might be assembled comprising the most promising leading financial indicators, although their overall aggregation might pose some methodological problems.

On the other hand, more complex, but potentially rewarding, alternative non-orthodox methodologies might contemplate, for example, the implementation of neural networks or the use of fuzzy logic in the proper implementation of financial crisis-predicting systems.

Notwithstanding the subsequent research needed to firmly select and establish such a fundamental set of indicators and their signal issuing methodologies, the importance of these prospective supervisory tools and procedures cannot be over-stressed, insofar as they constitute the first line of defence against the occurrence of major systemic breakdowns and their corresponding devastating effects on both the very fabric of financial markets and real economies.

APPENDIX A

FIGURE 1: S&P500 COMPOSITE INDEX vs. CASE-SCHILLER INDEX

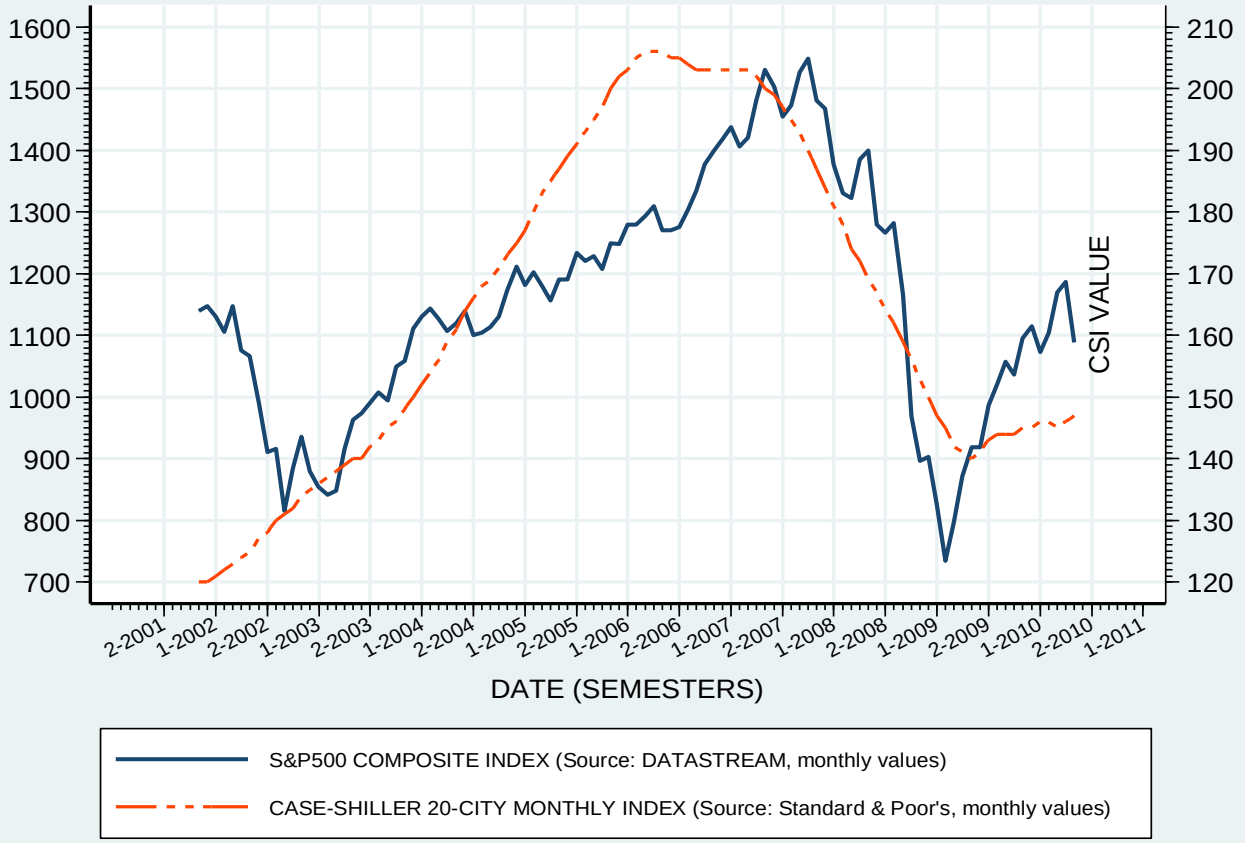


FIGURE 2: U.S. QUARTERLY GDP GROWTH

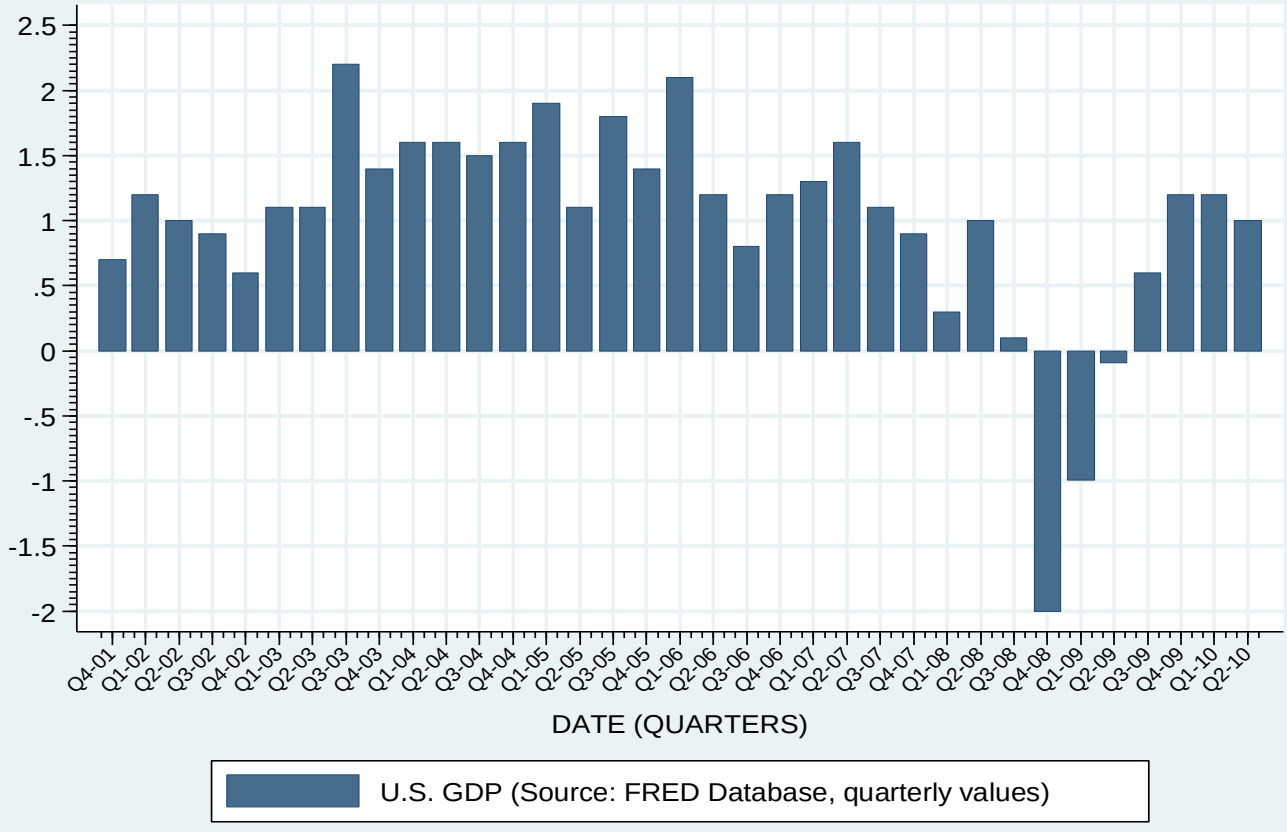


FIGURE 3: PUT-CALL RATIO (DAILY SERIES)

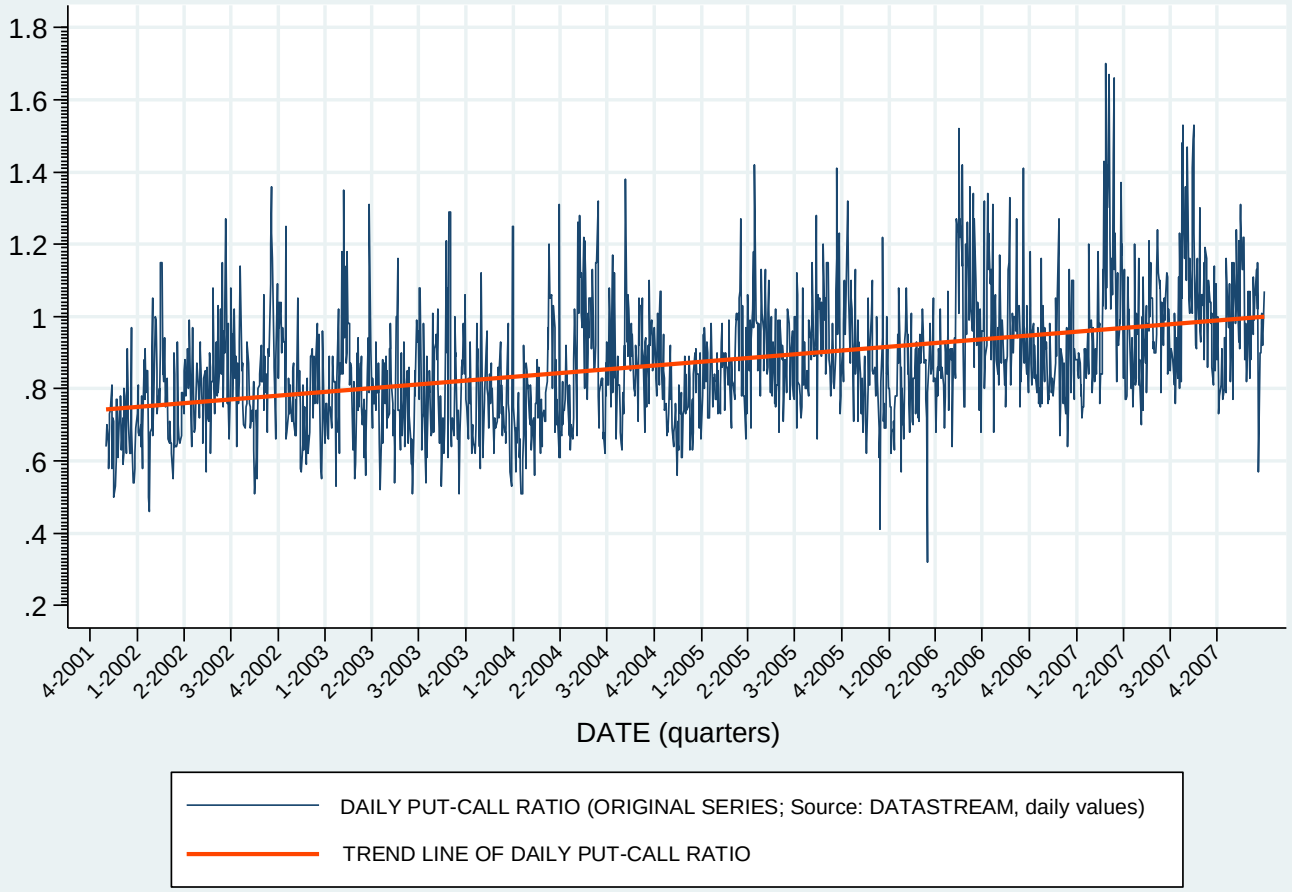
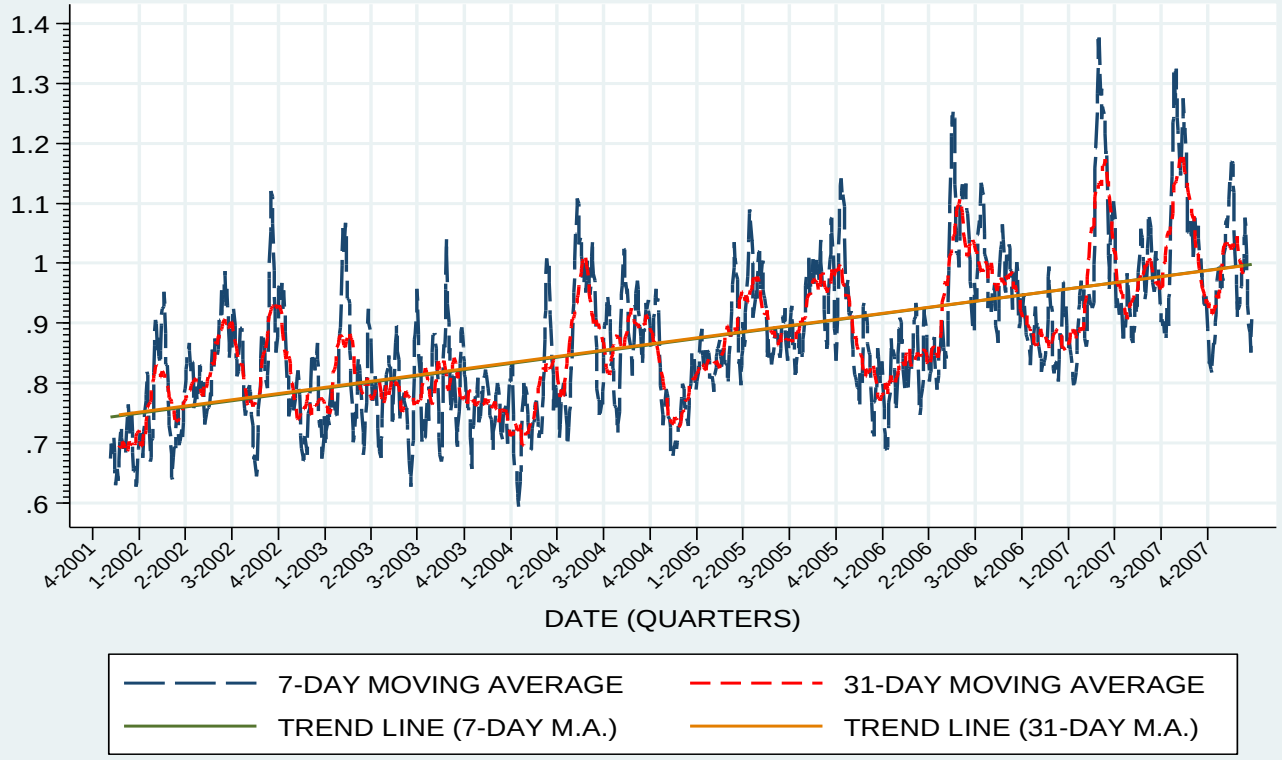
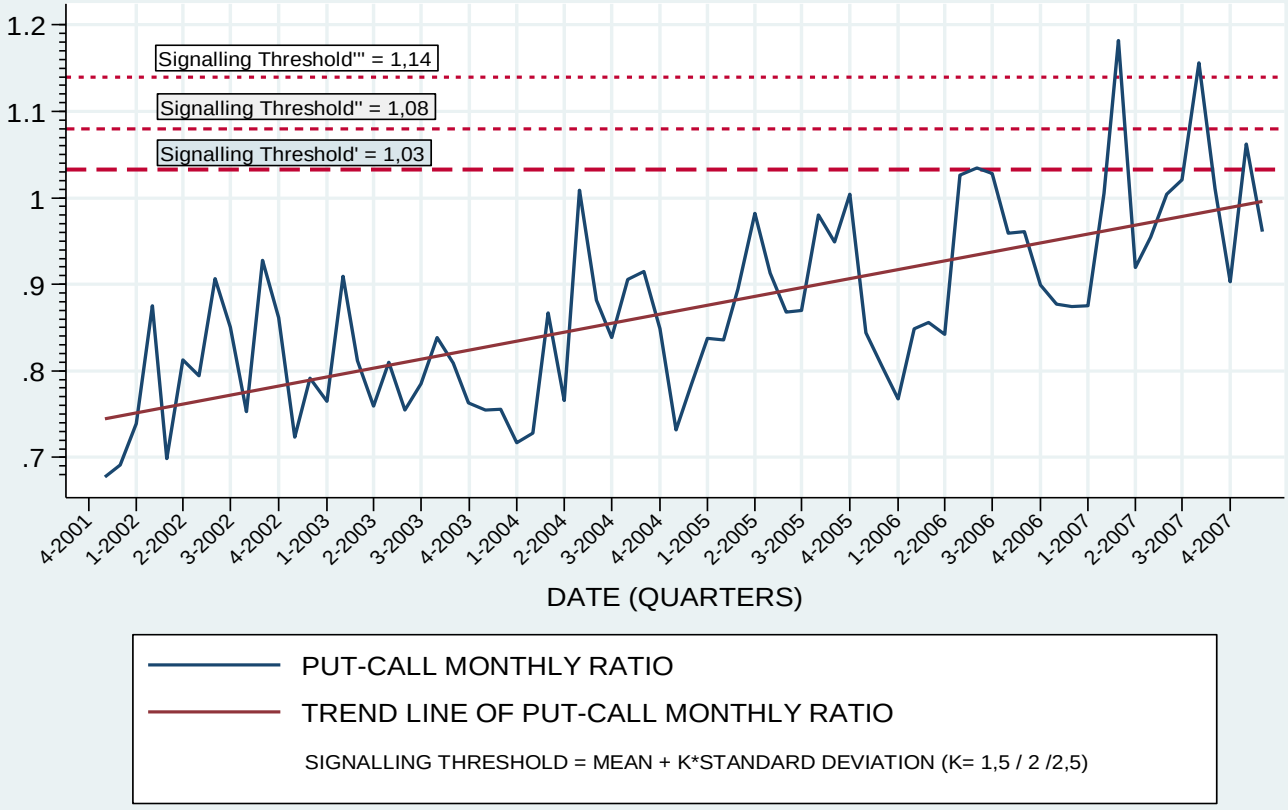


FIGURE 4: 7-DAY AND 31-DAY MOVING AVERAGES OF THE DAILY PUT-CALL RATIO



Source of underlying data: DATASTREAM, daily values

FIGURE 5: PUT-CALL MONTHLY RATIO vs. SIGNALLING THRESHOLDS



Source of underlying data: DATASTREAM, daily values

FIGURE 6: PUT-CALL MONTHLY RATIO vs. S&P500 COMPOSITE INDEX

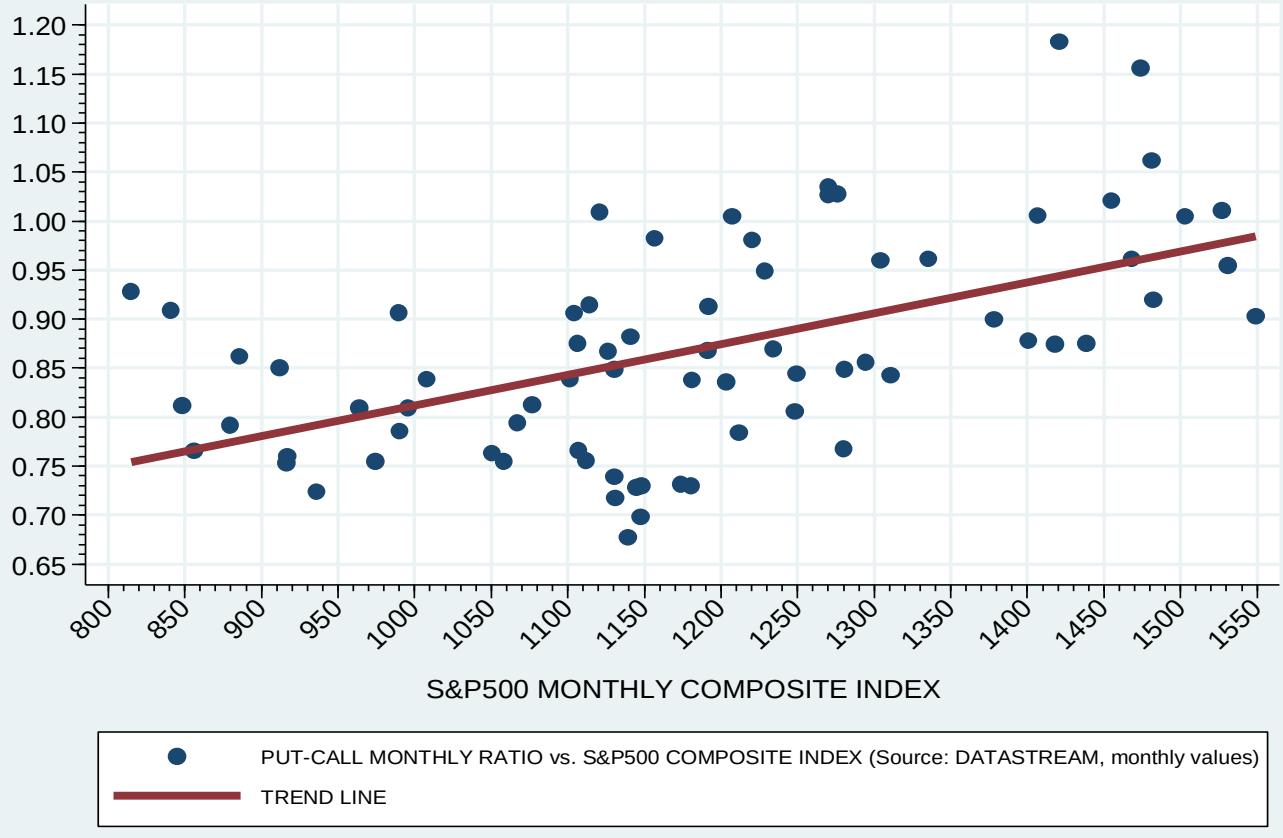
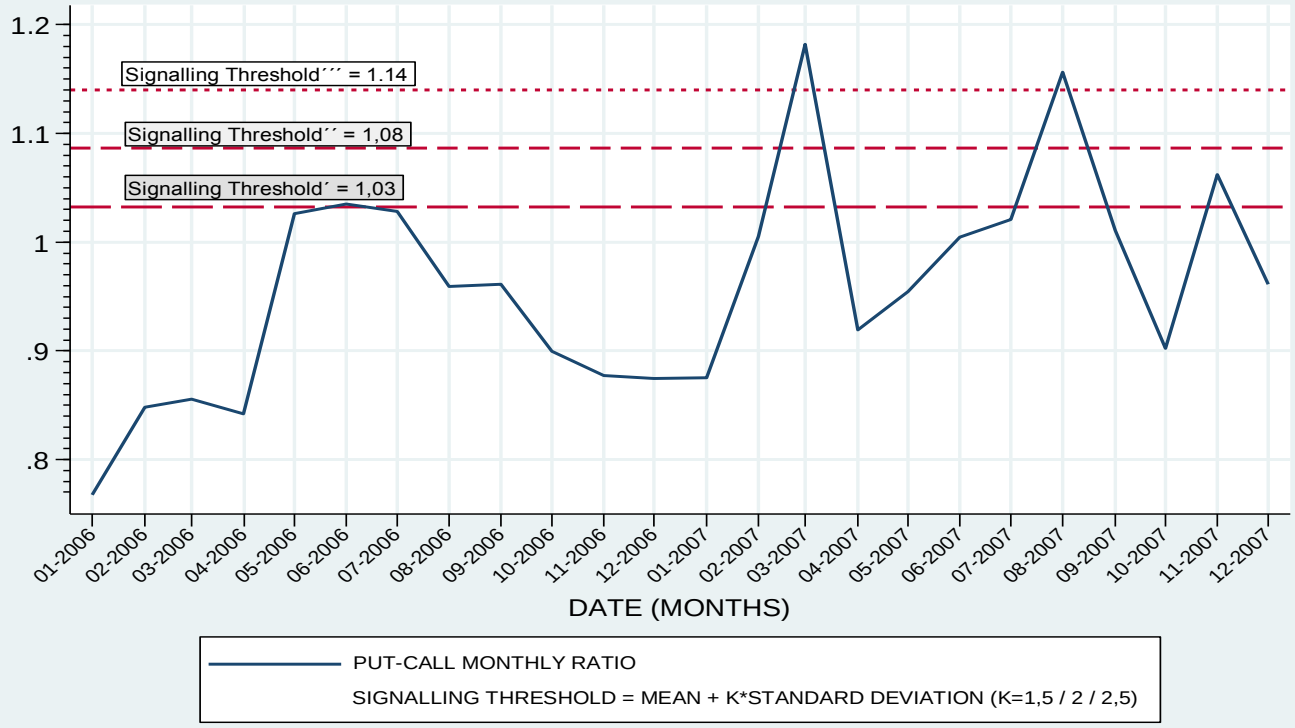
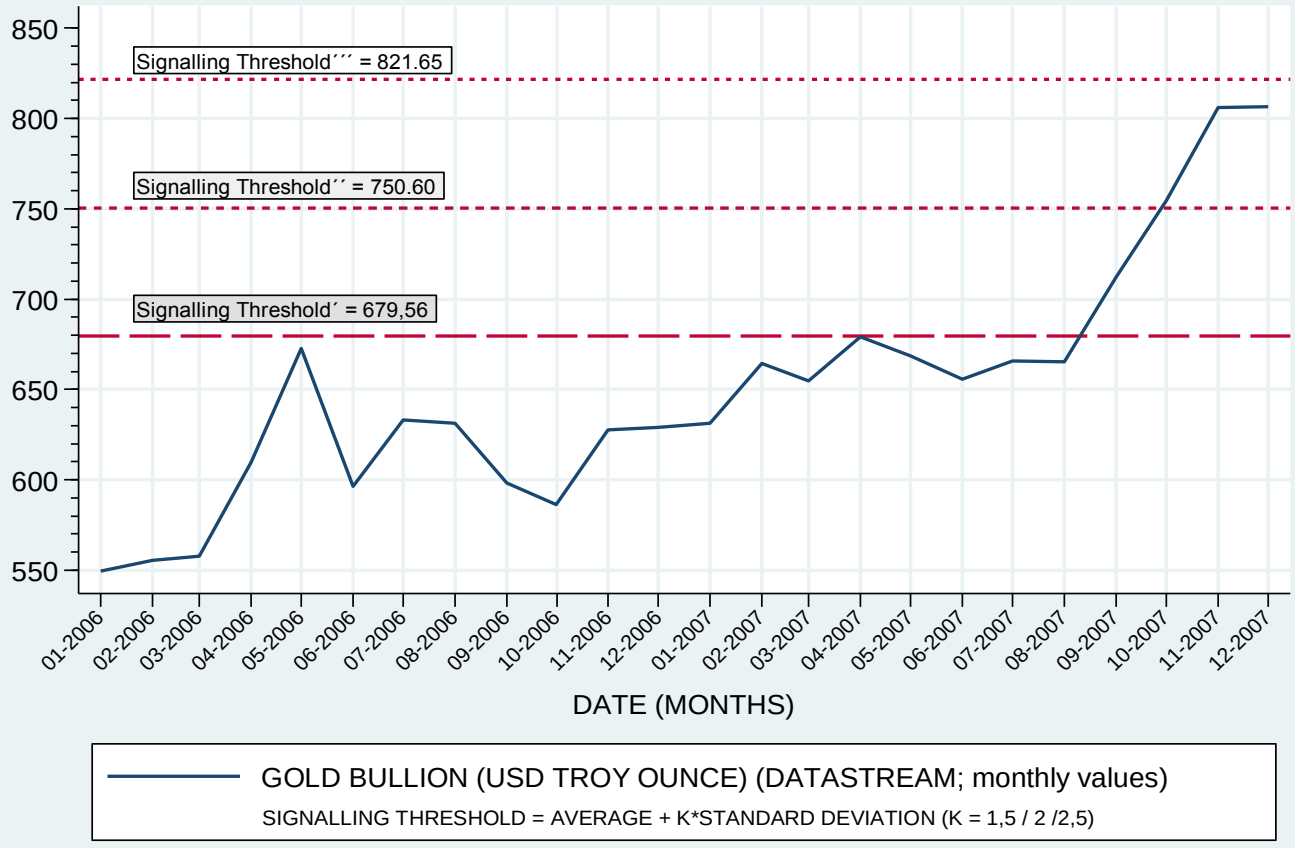


FIGURE 7: 24-MONTH SIGNALLING HORIZON FOR THE PUT-CALL MONTHLY RATIO



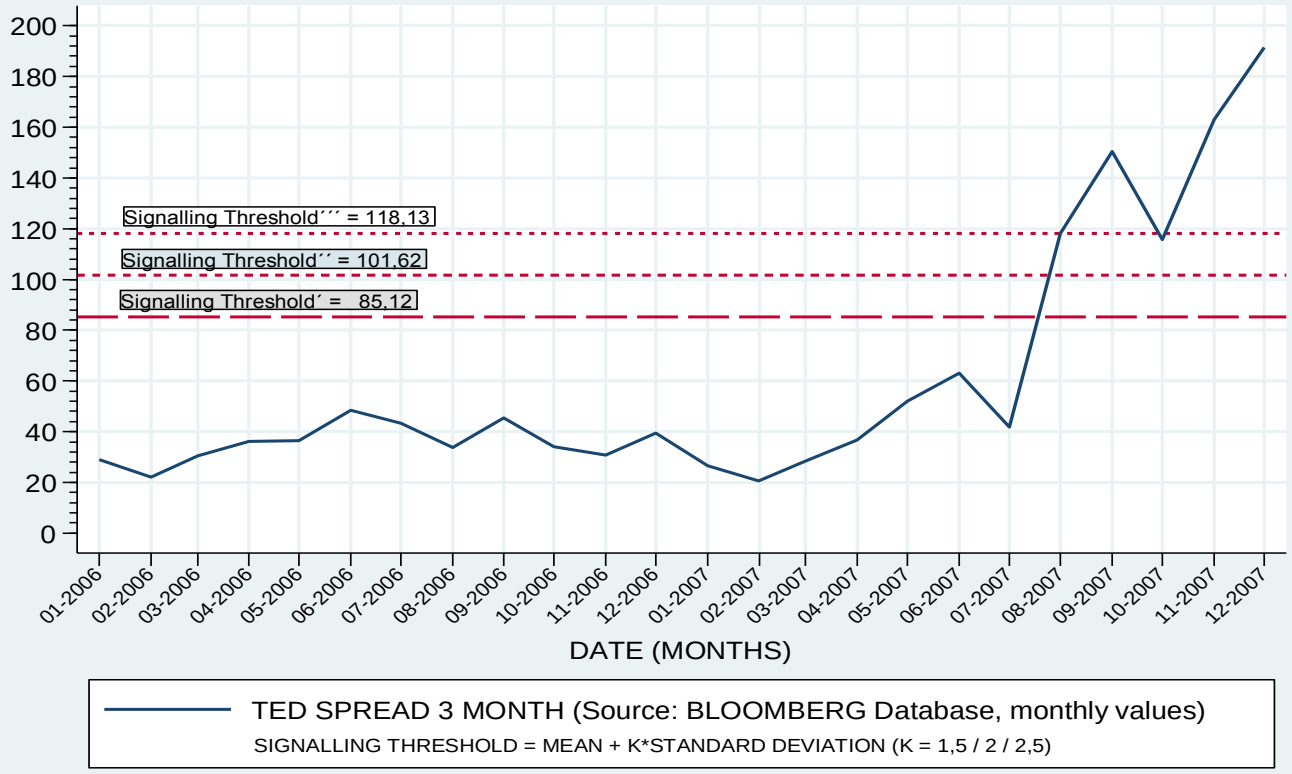
Source of underlying data: DATASTREAM, daily values

FIGURE 8: 24-MONTH SIGNALLING WINDOW FOR GOLD BULLION



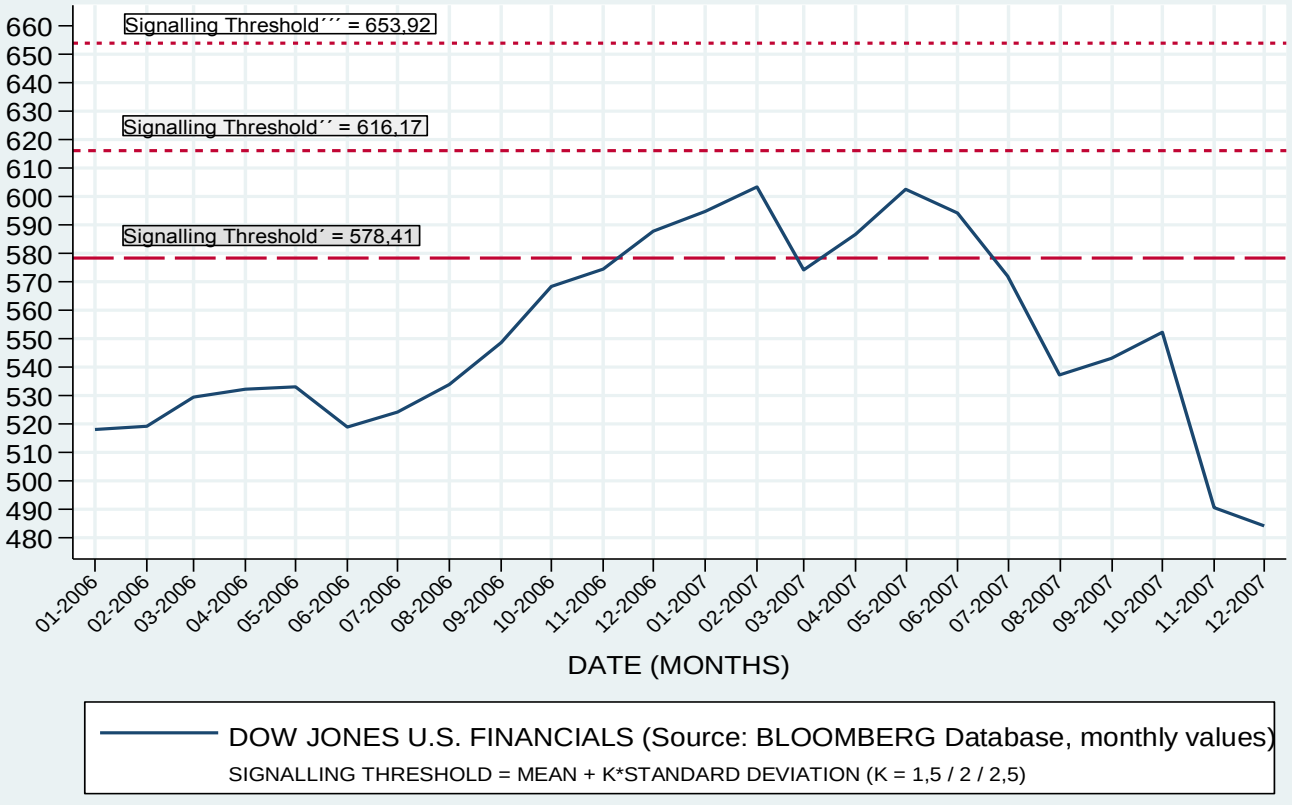
Source of underlying data: DATASTREAM, daily values

FIGURE 9: 24-MONTH SIGNALLING WINDOW FOR 3 MONTH TED SPREAD



Source of underlying data: BLOOMBERG, daily values

FIGURE 10: 24-MONTH SIGNALLING WINDOW FOR DOW JONES U.S. FINANCIALS



Source of underlying data: BLOOMBERG, daily values

FIGURE 11: RETURN ON ASSETS (ROA) FOR U.S. BANKS WITH ASSETS EXCEEDING USD15 BILLION*

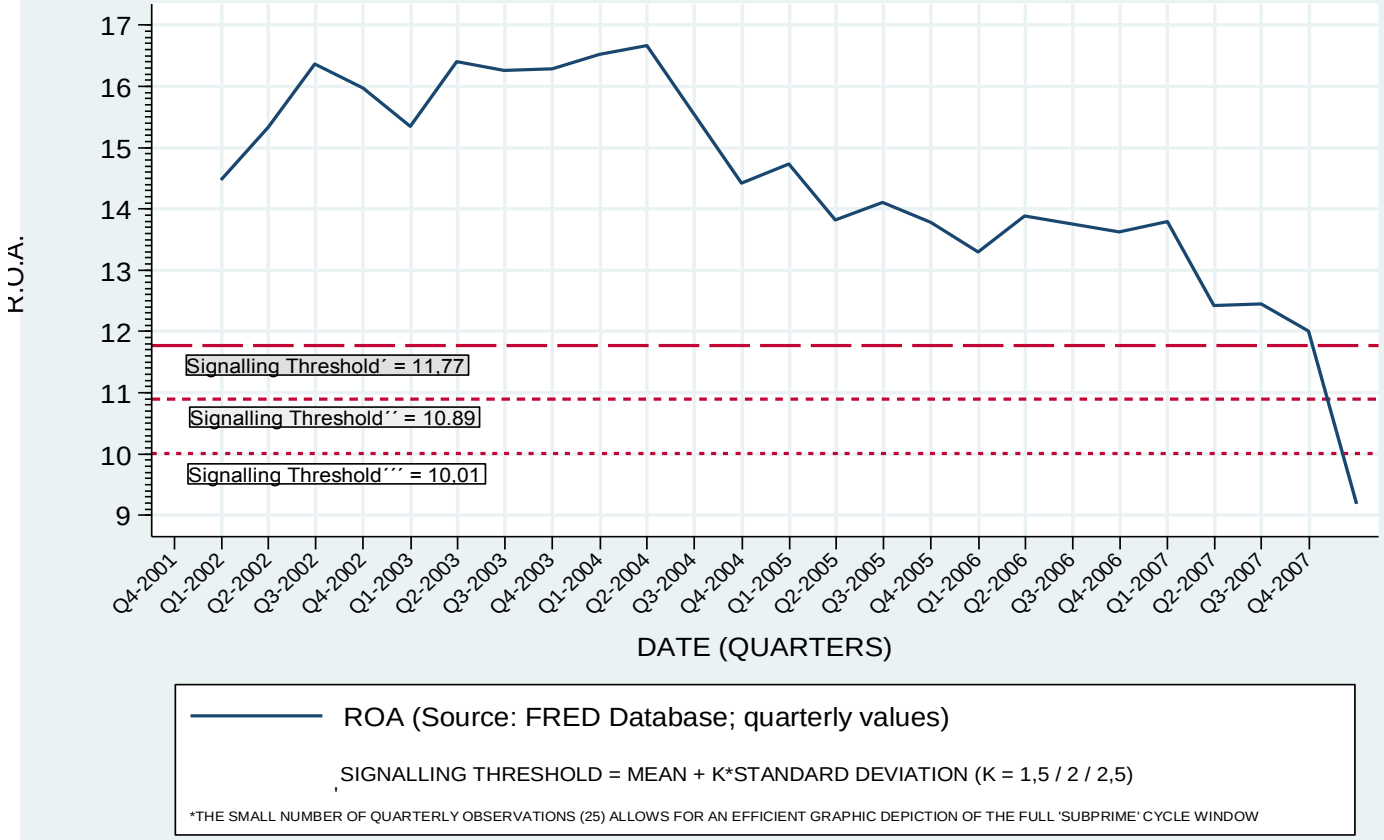


FIGURE 12: 24-MONTH SIGNALLING WINDOW FOR TOTAL SECURITIZED CONSUMER LOANS

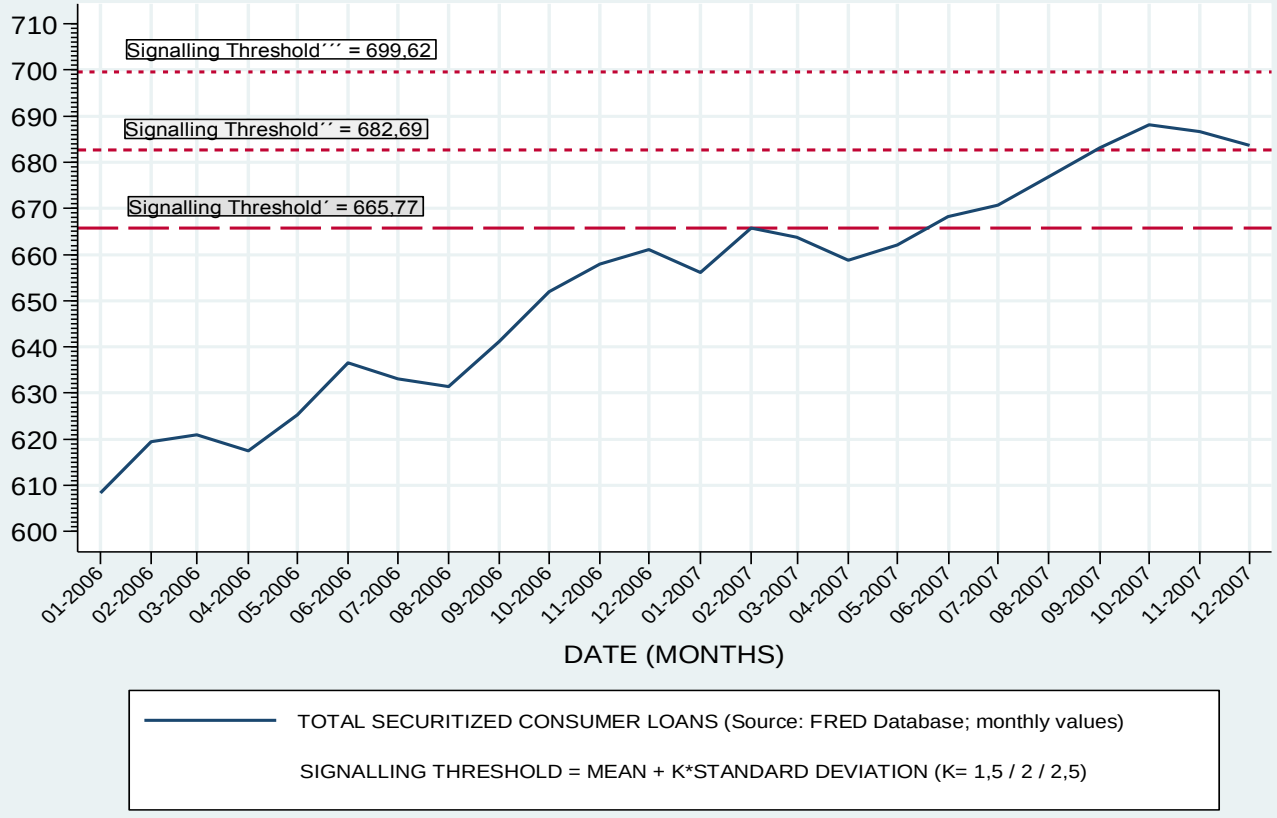
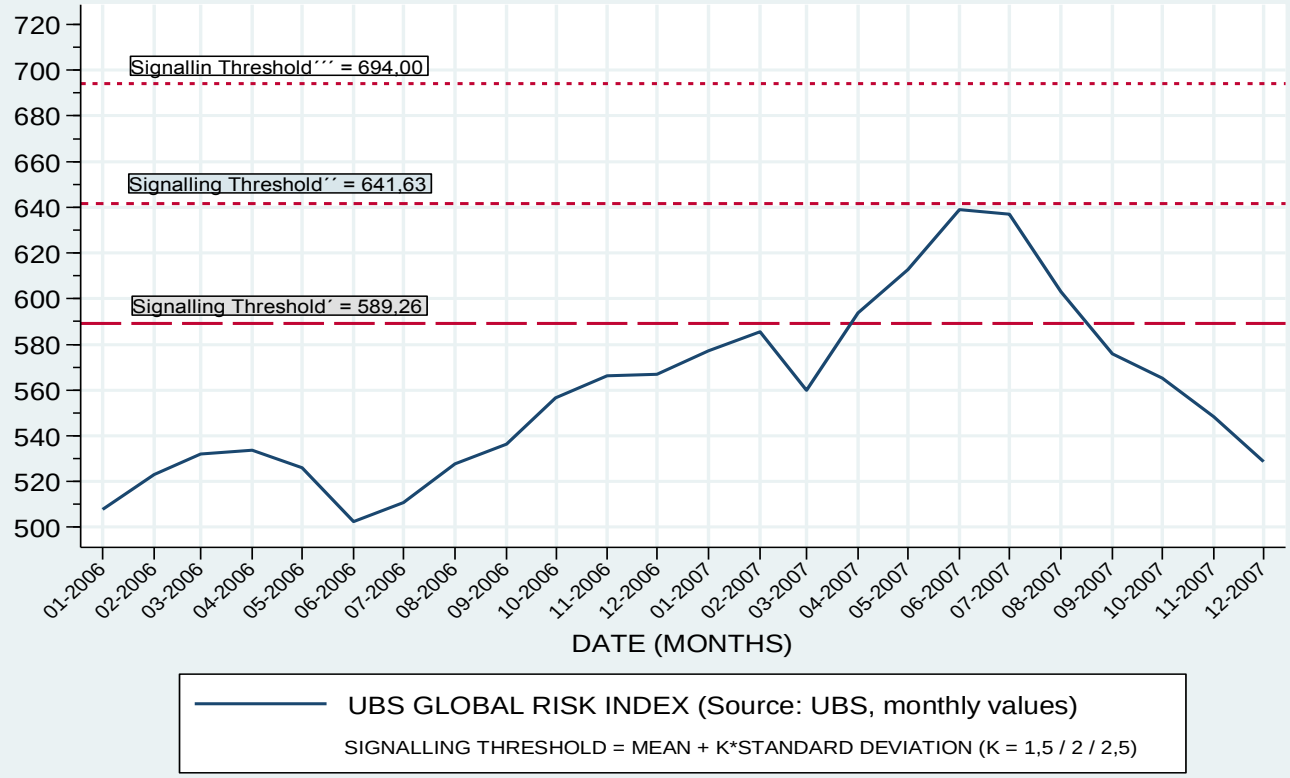
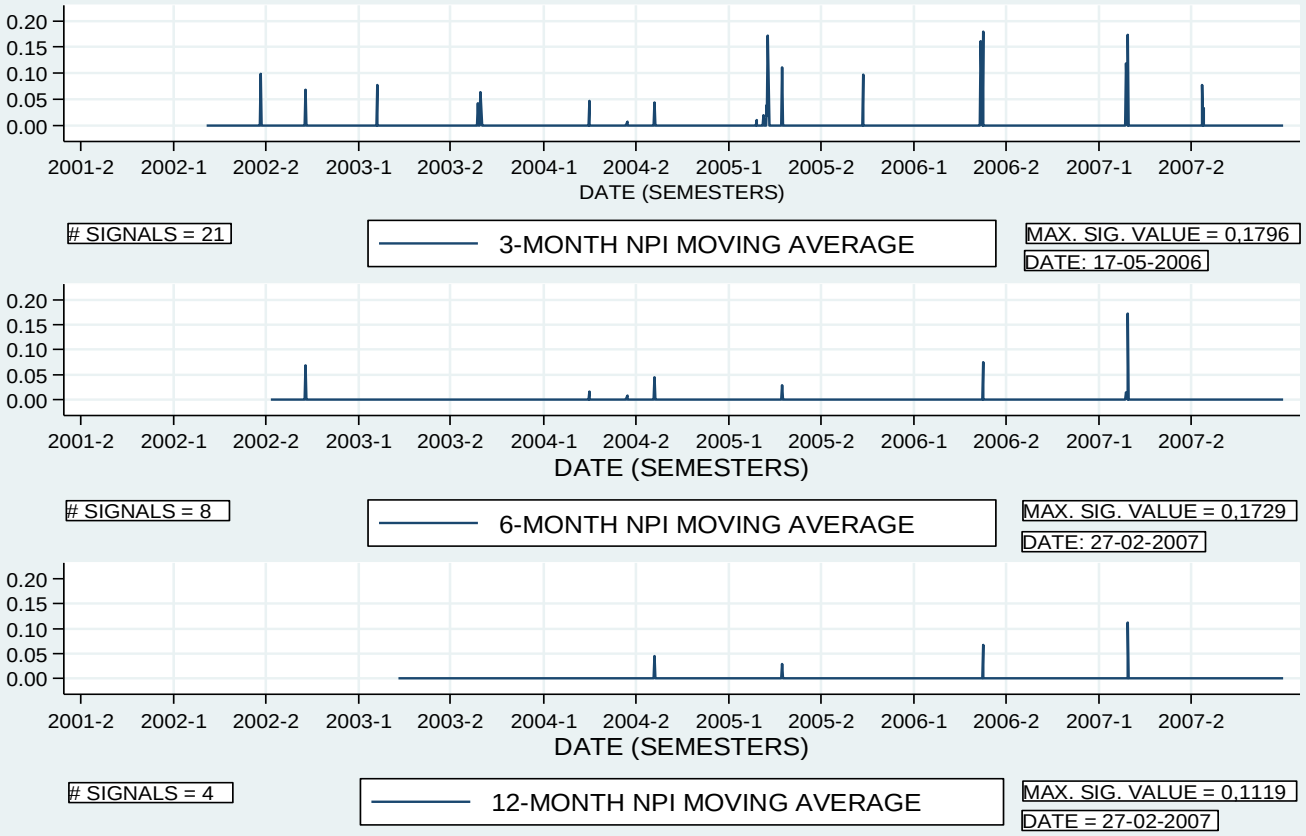


FIGURE 13: 24-MONTH SIGNALLING WINDOW FOR UBS GLOBAL RISK INDEX



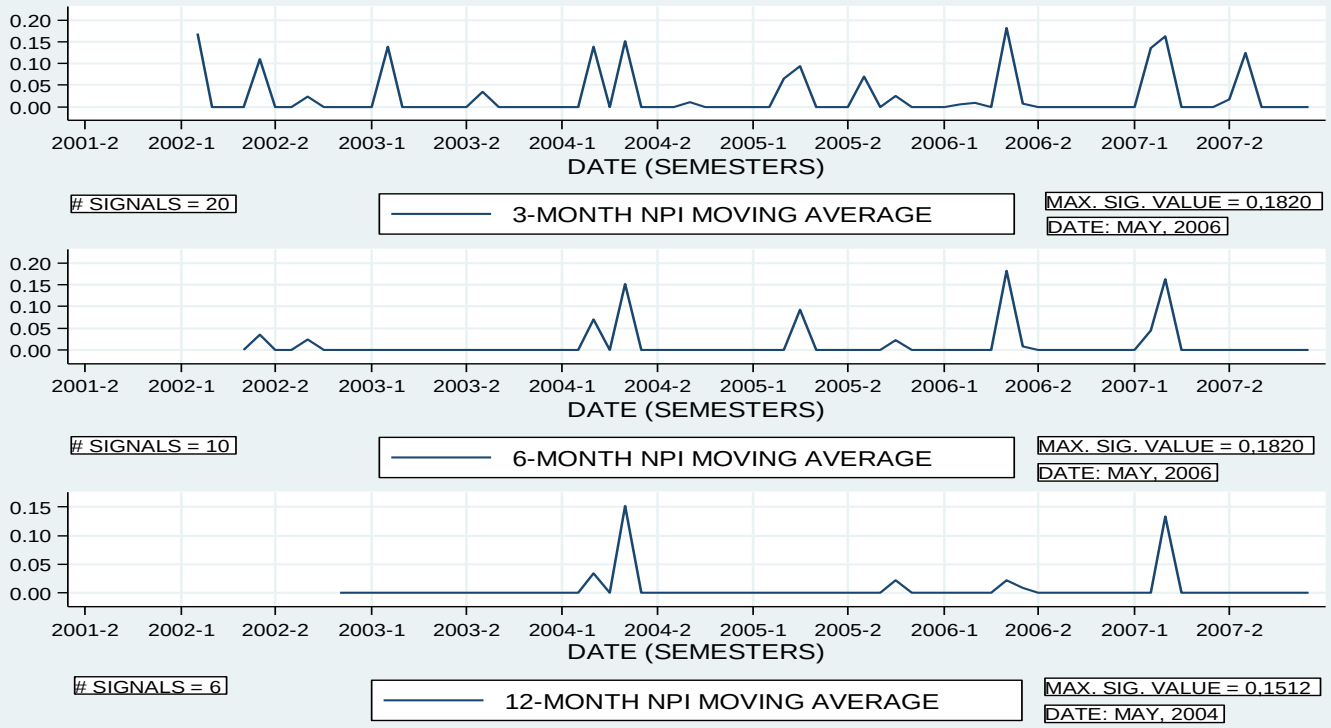
Source of underlying data: UBS, daily values

FIGURE 14: DAILY PUT-CALL RATIO UNDER NPI



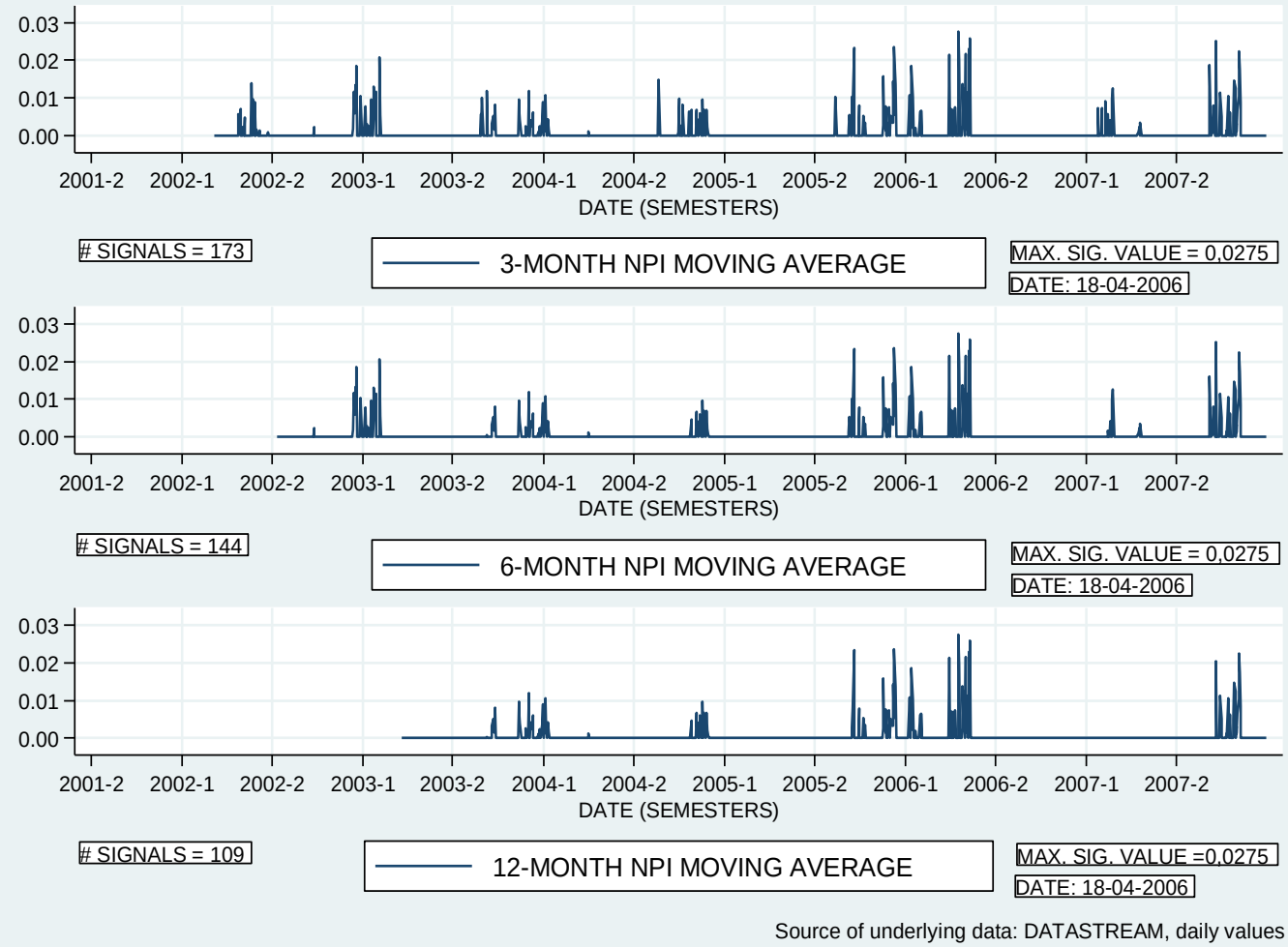
Source of underlying data: DATASTREAM, daily values

FIGURE 15: MONTHLY PUT-CALL RATIO UNDER NPI



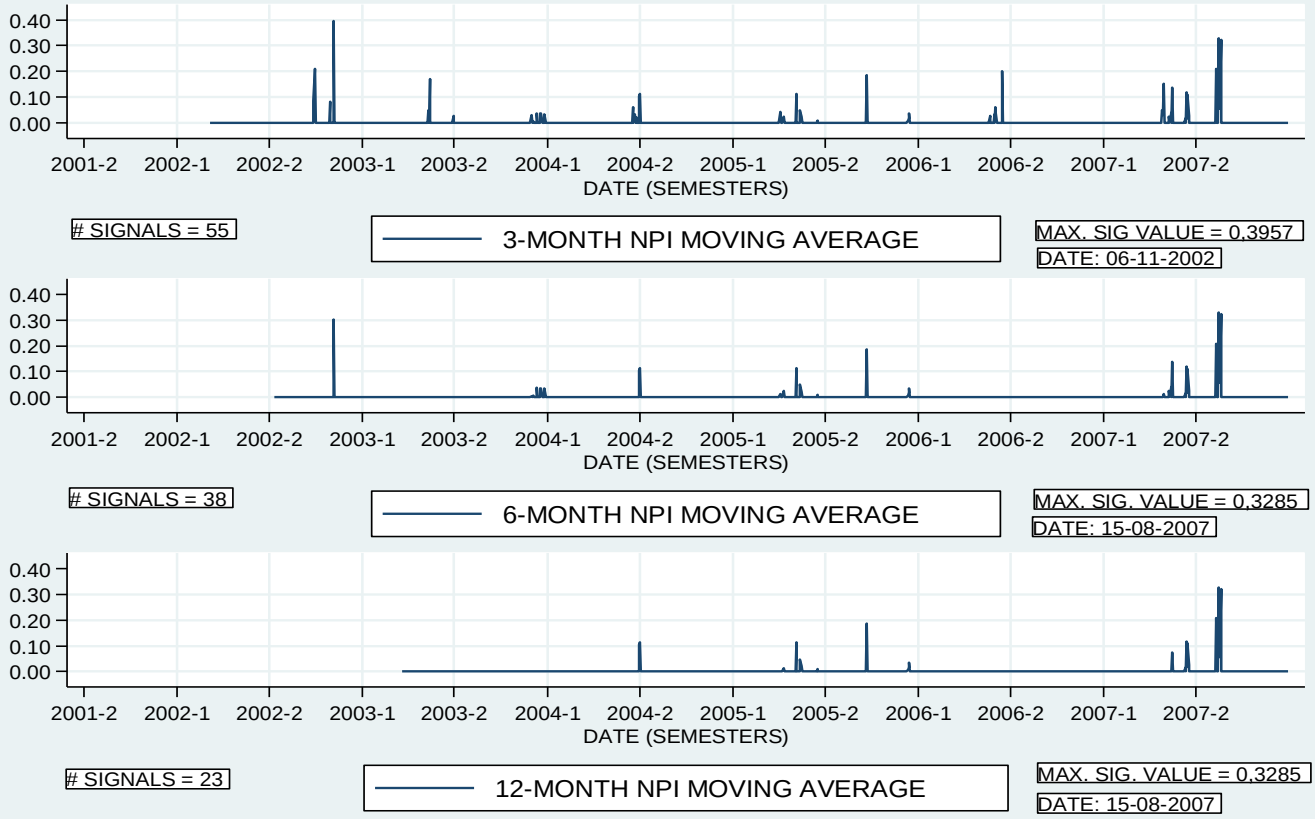
Source of underlying data: DATASTREAM, daily values

FIGURE 16: GOLD BULLION UNDER NPI



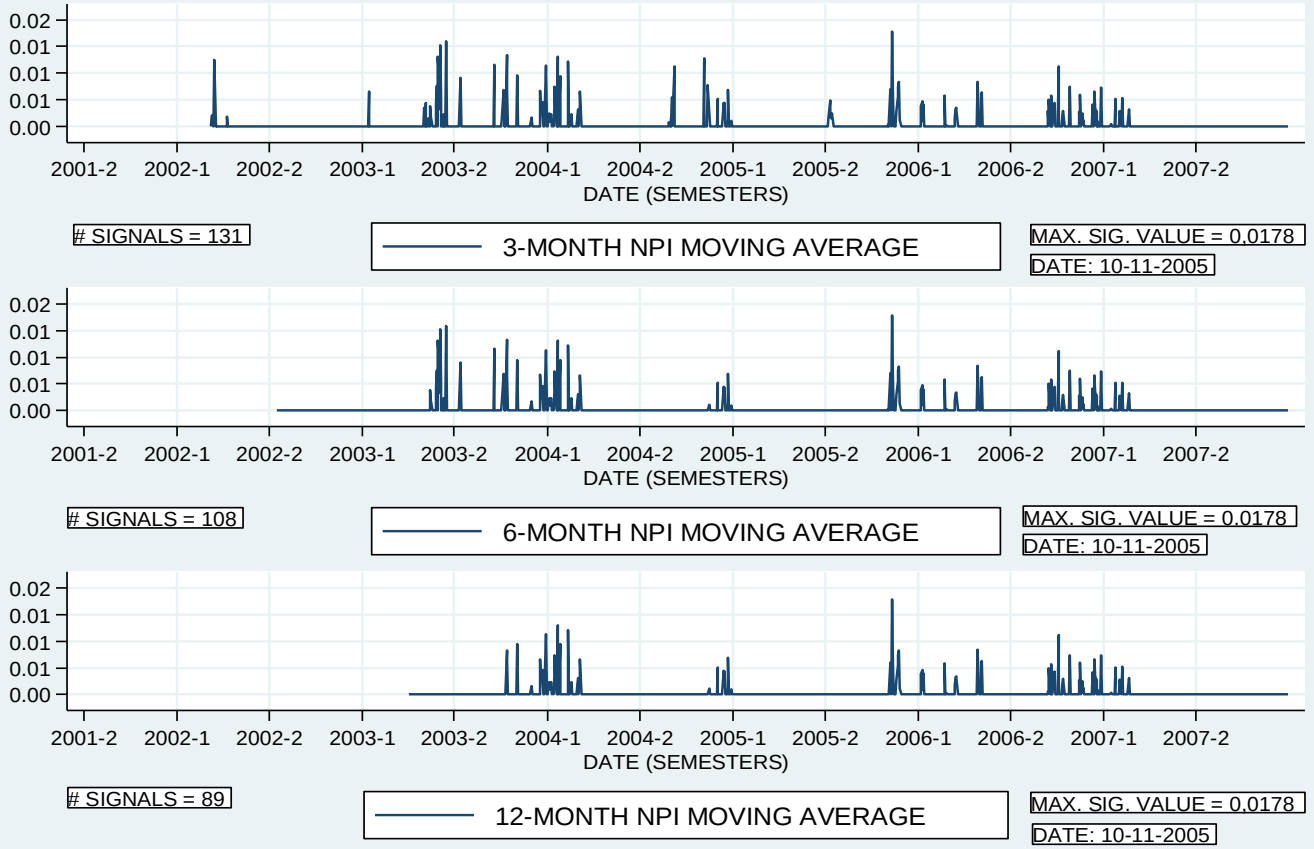
Source of underlying data: DATASTREAM, daily values

FIGURE 17: 3-MONTH TED SPREAD UNDER NPI



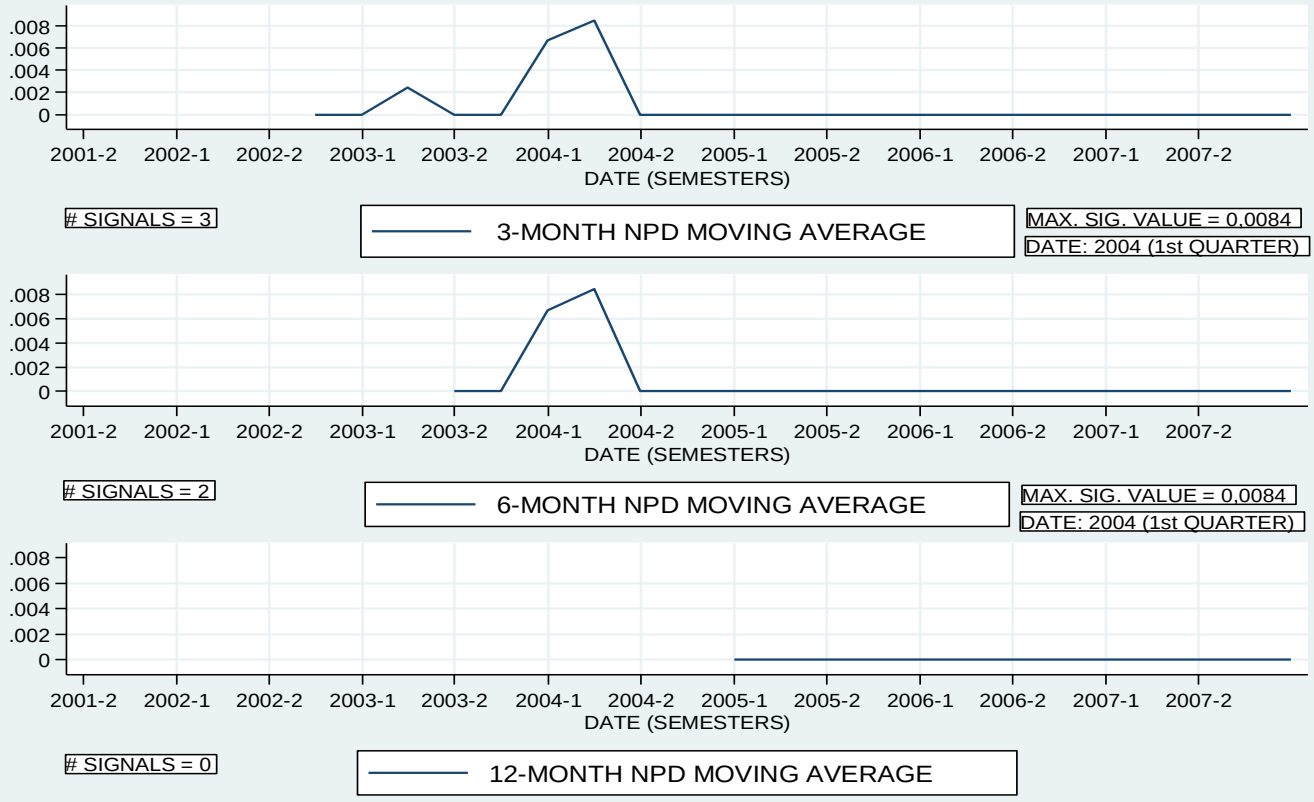
Source of underlying data: BLOOMBERG, daily values

FIGURE 18: DOW JONES U.S. FINANCIALS UNDER NPI



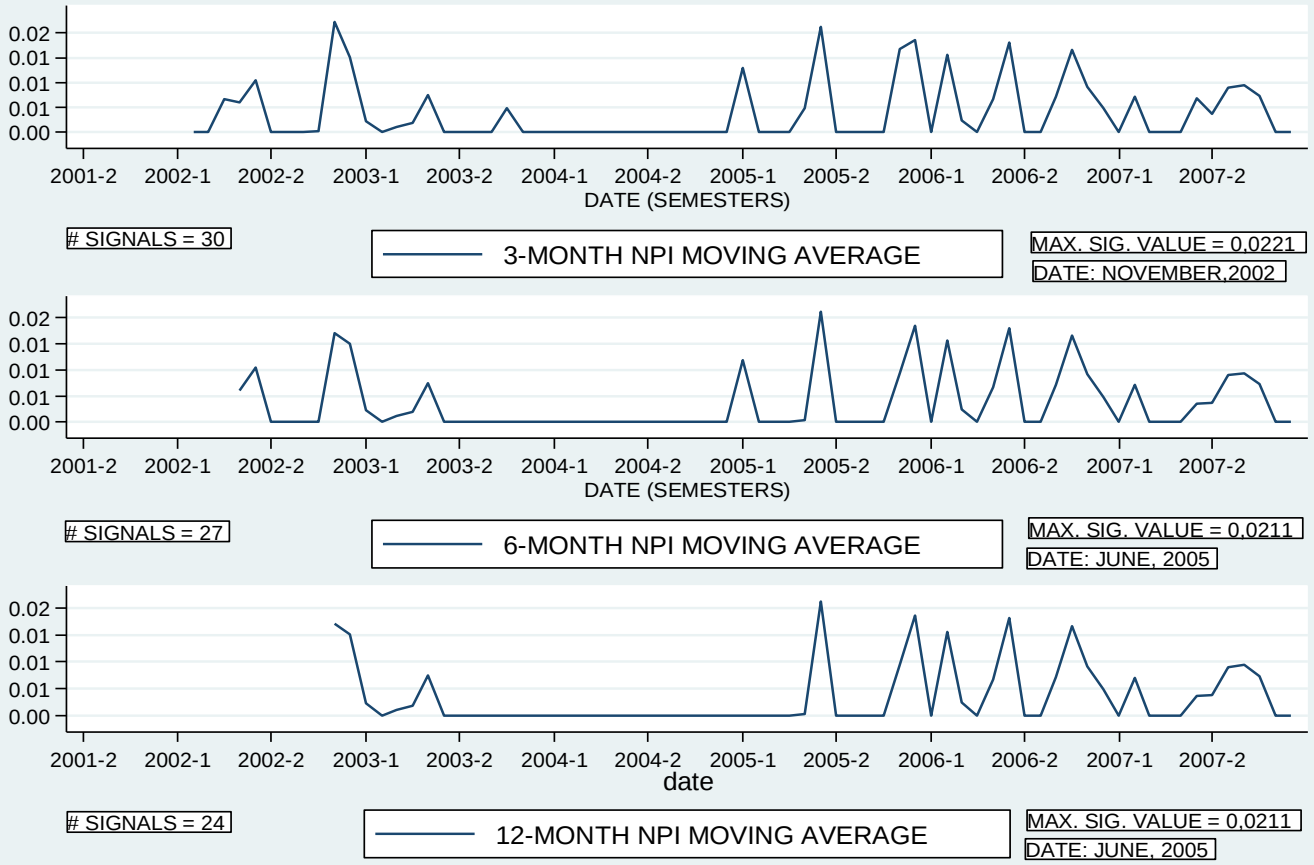
Source of underlying data: BLOOMBERG, daily values

FIGURE 19: R.O.A. FOR U.S. BANKS WITH ASSETS EXCEEDING USD 15 BILLION UNDER NPD



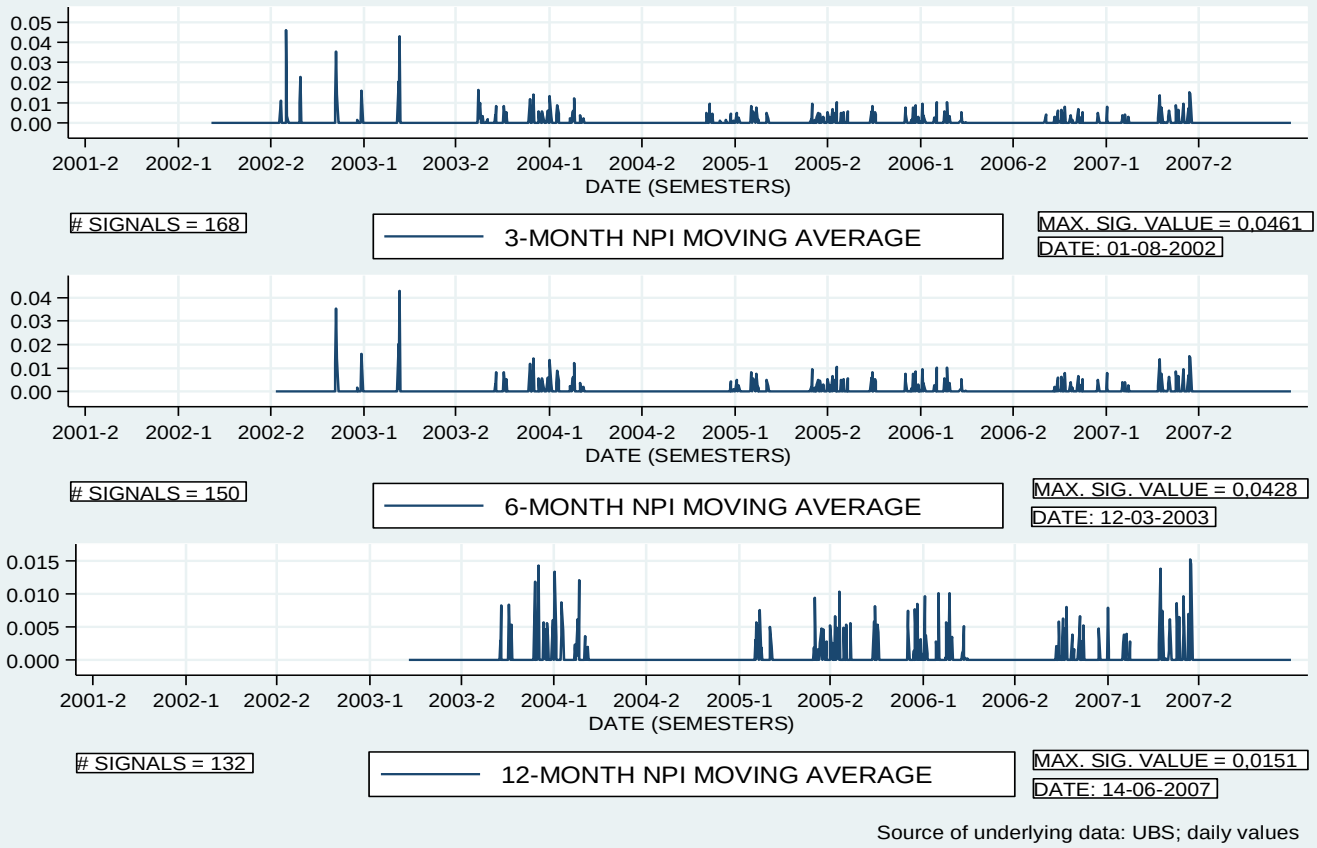
Source of underlying data: FRED, quarterly values

FIGURE 20: TOTAL SECURITIZED CONSUMER LOANS UNDER NPI



Source of underlying data: FRED Database, monthly values

FIGURE 21: UBS GLOBAL RISK INDEX UNDER NPI



Source of underlying data: UBS; daily values

TABLE 1 - DESCRIPTIVE STATISTICS OF MONTHLY PUT-CALL RATIO	
MEAN	**0,870500**
STANDARD DEVIATION	**0,107892**
MEDIAN	0,864347
MODE	1,004285
SAMPLE VARIANCE	0,011640
KURTOSIS	0,085857
SKEWNESS	0,524710
RANGE	0,505000
MINIMUM	0,677272
MAXIMUM	1,182272
NUMBER OF OBSERVATIONS	74

SOURCE OF UNDERLYING DATA: DATASTREAM

TABLE 2 - OLS REGRESSION				
Dependent Variable: MONTHLY PUT-CALL RATIO				
Method: Ordinary Least Squares (OLS)				
Sample: November of 2001 to December of 2007				
Included observations: 74 monthly observations				
NEWEY-WEST HAC Standard Errors and Covariance (lag truncation = 3)				
VARIABLE	**COEFFICIENT**	**Std. Error**	***t*-Statistic**	**Prob.**
CONSTANT	**0.499113**	0.069961	7.134216	**0.0000**
S&P500 COMPOSITE INDEX	**0.000314**	5.83E-05	5.388890	**0.0000**
REGRESSION STATISTICS				
R-squared	0.303388	Mean dependent var		0.870501
Adjusted R-squared	0.293713	S.D. dependent var		0.107893
S.E. of regression	0.090674	Akaike info criterion		1.936439
Sum squared resid	0.591967	Schwarz criterion		1.874167
Log likelihood	73.64824	F-statistic		31.35744
Durbin-Watson statistic	1.258008	Prob (F-statistic)		0.000000

SOURCE OF UNDERLYING DATA: DATASTREAM

TABLE 3 - ROBUSTNESS CHECKS			
	K=1,5	**K=2**	**K=2,5**
NUMBER OF SIGNALS WITHIN CRISIS WINDOW	4	2	2
NUMBER OF SIGNALS OUTSIDE CRISIS WINDOW	0	0	0
DATE OF FIRST SIGNAL	JUNE OF 2006	MARCH OF 2007	MARCH OF 2007
SIGNAL PERSISTENCY (additional signals beyond the first)	MARCH, AUGUST and NOVEMBER OF 2007	AUGUST OF 2007	AUGUST OF 2007

TABLE 4 - SIGNAL ISSUANCE DATES (1)				
SIGNALLING INDICATORS	**SIGNALLING METHODOLOGIES**			
	EWS (2)		**NPI/NPD (3)**	
PUT CALL MONTHLY RATIO	June of 2006	**19**	May of 2006	**20**
PUT CALL DAILY RATIO	n.a.	**n.a.**	May of 2006	**20**
GOLD BULLION	September of 2007	**4**	April of 2006	**21**
3-MONTH TED SPREAD	August of 2007	**5**	August of 2007	**5**
DOW JONES U.S. FINANCIALS	December of 2006	**13**	November of 2005	**26**
R.O.A FOR LARGE U.S. BANKS	October of 2007 (4)	**3**	January of 2004 (5)	**48**
T. SECURITIZED CONSUMER LOANS	February of 2007	**11**	June of 2005	**31**
UBS GLOBAL RISK INDEX	April of 2007	**9**	June of 2007	**7**

(1) The numbers in bold following the presented dates indicate the number of months prior to the onset of the 'Subprime' Crisis.

(2) Earliest signal date for K = 1,5 under the last 24-month signalling window.

(3) Either the maximum signal value, or, alternatively, the next in line most credible signal value for which there is a precedent in the literature.

(4) The underlying signal (surpassing all the thresholds) is dated the last quarter of 2007; this signal is dated according to the first month of the fourth quarter.

(5) This signal is dated according to the first month of the first quarter and most probably reflects the begining of the downward trend in this indicator's value begining in 2004.

CHAPTER THREE. 'HETEROGENEOUS BANKING RESPONSES IN THE WAKE OF THE GLOBAL FINANCIAL CRISIS OF 2007 - 2008: A STUDY INVOLVING THE HETEROGENEOUS REGIME-SWITCHING MODEL'*

*This chapter is a revised version of Bhimjee, D.C.P, Ramos, S.B. and Dias, J.G. (2012), 'HETEROGENEOUS BANKING RESPONSES IN THE WAKE OF THE GLOBAL FINANCIAL CRISIS OF 2007 - 2008: A STUDY INVOLVING THE HETEROGENEOUS REGIME-SWITCHING MODEL', Working Paper, Business Research Unit, ISCTE-IUL, Lisbon.

ABSTRACT: This research demonstrates that the global performance of the banking industry both prior and during the Global Financial Crisis has been highly heterogeneous, notwithstanding the idiosyncrasies of the latest systemic breakdown and the pervasiveness of underlying international financial contagion processes disseminating its impact. In order to achieve this demonstration, we employ a highly innovative Hidden Markov Model, the Heterogeneous Regime-Switching Model (HRSM-S), so that this element of heterogeneity might be aptly portrayed. Our findings suggest that these distinctive banking responses may be grouped in different categories (or 'clusters'), each with its own specific regime dynamics. In addition, these findings are also classified under two distinct constellations of regime dynamics. The latter are clearly identifiable with either a dual state or multi-state where the more extreme environments are usually associated with either bull or bear market regimes, the difference residing in the fact that multi-state findings possess a greater granularity depth. Furthermore, the analysis of a complex web of financial correlations indicates that geo-economical inter-relationships are fundamental in ascertaining the degree of contagion amongst distinct financial systems and banking institutions. Finally, the degree of global synchronization pertaining to the dissemination of the impact of the said crisis is quite overwhelming, revealing the global simultaneous magnitude of the financial crisis under study.

KEYWORDS: Heterogeneous Regime-Switching Model (HRSM-S), Global Financial Crisis, International Financial Contagion, 'Subprime' Crisis, Banking Institutions

JEL Codes: G01, G15, F30

ACKNOWLEDGEMENT

We would very much like to thank Professor José Dias (ISCTE-IUL), to whom the present research is profoundly indebted. Professor Dias, along with our Thesis Supervisor, Professor Sofia Ramos, has been a pillar of wisdom, where the exciting development of this enticing new field of research is concerned. Their joint innovative research outlining the Heterogeneous Regime-Switching Model (HRSM-S) is undoubtedly at the forefront of academic research. The HRSM-S is unquestionably a most promising and auspicious addition to the family of regime-switching models. Moreover, their tireless and invaluable tutelage in navigating the often perilous waters of the underlying data treatment processes is truly outstanding. We are wholeheartedly grateful for letting us embark on this truly remarkable learning experience and wisely lead us through previously uncharted waters.

3.1. INTRODUCTION[27]

The Global Financial Crisis of 2007 – 2008 constituted a most resounding systemic failure, deeply affecting the financial markets, and, more specifically, international banking institutions operating in increasingly borderless markets. This unprecedented extreme credit event of global magnitude, whose implications will be clearly felt for years to come, has certainly left a most decisive imprint on the global banking industry as a whole.

Notwithstanding, banking responses to the Global Financial Crisis should warrant further scrutiny, not least because they did not constitute a unison response to the said systemic failure. Quite the contrary, our research will effectively demonstrate that distinctive banking responses arose in the wake of this major global event. That is, banking institutions, measured by their financial standing, did perform quite heterogeneously, both prior and during the extreme event under study. Accordingly, these heterogeneous responses can be grouped in distinctive categories (or 'clusters'), each associated with its own regime dynamics.

Therefore, our line of scientific enquiry will unveil how heterogeneous these banking responses have been, both prior and during the occurrence of this extreme financial event. This goal will be achieved by carefully unearthing and describing the main traits associated with the said heterogeneity. The latter traits will be revealed using the Heterogeneous Regime-Switching Model (HRSM-S), which belongs to the Hidden Markov family of models.

In pursuit of our scientific enquiry, sub-section 3.2. will first provide a brief overview of the Global Financial Crisis and its implications for the global banking industry. The universal role of banking institutions will be described, followed by a brief analysis of how the latter institutions' performance was globally disrupted by the onset of the global systemic event. International financial contagion processes will also be analysed, in order to account for the global transmission of this unsettling systemic event to other financial geographies. Sub-section 3.3. will review the most relevant literature pertaining to the HRSM-S model application, namely starting with a brief description of Hidden Markov Models and Regime-Switching Models, accompanied by

[27] The Figures and Tables mentioned in the present Chapter have been collected in Appendix B (end-of-chapter).

a full depiction of our adopted model, the Heterogeneous Regime-Switching Model (HRSM-S). Sub-section 3.4. will start by presenting some preliminary considerations concerning our model applications. It will then fully describe the findings associated with the two dual state model applications. These will be followed by two subsequent applications pertaining to the multi-state model, which depict more granular results. Finally, sub-section 3.5. will summarize our main findings.

It is hoped that our main findings, which indeed indicate that banking responses to the Global Financial Crisis were highly heterogeneous, might shed light on some fundamental issues affecting global banking performance throughout the occurrence of systemic episodes. It is further hoped that the present research might constitute an important reference for future macroeconomic policy guidance.

3.2. THE GLOBAL FINANCIAL CRISIS AND THE GLOBAL BANKING INDUSTRY

This section will start by describing the universal role of banking institutions (as the most important category of financial intermediaries). It will then proceed by describing the Global Financial Crisis as a systemic event disrupting the traditional role of banking institutions, with subsequent implications at the bank valuation level. It will finally introduce financial contagion processes as the main transmission channels affecting the value of banking institutions worldwide.

3.2.1. THE UNIVERSAL ROLE OF BANKING INSTITUTIONS

In the pursuit of their for-profit intermediary activities, banking institutions perform various important roles within the aggregate economy. In the present sub-section we will address four such major goals.

First, banking institutions collectively contribute to economic growth by matching accumulated savings with funding needs to productive (or near-productive[28]) investments in the real economy. This is achieved by transferring funds (in the form of bank loans) from a pool of savers to a screened pool of borrowing agents engaging in the said investment opportunities, so that these agents' capital funding needs might be fully satisfied. These agents may be further classified as corporate (e.g., businesses) or non-corporate (e.g., families) borrowers.

Where the present Global Financial Crisis is concerned, bank loans (and specially, residential mortgage loans) became the centre of gravity of the securitisation process. As shall be described in the following sub-section, stagnating residential home prices in the U.S.A., accompanied by higher default rates on 'subprime' mortgages and corresponding securitised assets, became the trigger for the ensuing financial crisis in the U.S.A. This latter fact deeply affected the valuation of securitised assets outstanding, and, subsequently, the very performance of banking institutions holding these assets of uncertain (or even 'toxic') value.

[28] This general category might include personal consumption expenditure loans for various purposes.

Therefore, the banking activity of scheduling capital funds to appropriate borrowers became fraught with some perils, ultimately affecting the very valuation of these financial institutions.

In this extreme framework, banking institutions incurred in a state of lack of appropriate knowledge as a result of the decreasing quality of their own lending standards (the following paragraphs will detail why and how this occurred). Collectively considered, this neglecting framework has traditionally been a catalyst associated with the occurrence of deep financial shocks, as was the case with the current crisis. For example, Brunnermeier (2008) details how this poor oversight by major financial institutions in the U.S.A. became rampant (Brunnermeier, 2008:7 and 8).

Second, banking institutions improve (but do not entirely resolve) the asymmetric information (or agency) problems resulting from the relationship between loan lenders (bank depositors) and loan borrowers (either corporate or non-corporate). Mishkin and Eakins (2006) basically details two distinct asymmetrical information problems.

On the one hand, adverse selection occurs prior to the loan agreement process, when potentially bad credit risks drive out potentially good ones. This is due to the fact that banking institutions are unable to fully screen potential borrowers and select the most appropriate credit risks.

On the other hand, moral hazard occurs after the loan agreement has taken place, when borrowers might engage in subsequent activities detrimental to the full re-payment of the borrowed funds (Mishkin and Eakins, 2006:377).

These agency problems have indeed played a very important role in the latest Global Financial Crisis, ultimately affecting the very valuation of financial intermediaries, and compromising the fulfilment of their proper goals (Hull, 2008: 6 to 8).

Third, banking institutions facilitate the inter-temporal smoothing and cross-sectional risk sharing that cannot be easily diversifiable by any individual financial agents.

This fact might also be viewed as a result of the enforcement of portfolio diversifying strategies organically pursued by banking institutions. According to these strategies, it is preferable for these latter institutions to diversify their investments through several borrowers of distinct risk profiles, instead of over-exposing themselves to a single borrower of funds (Leão, Leão and Lagoa, 2009:77).

According to this line of reasoning, risks can only be inter-temporally smoothed in such a way so as to reduce their impact upon each individual agent's specific welfare. Implicitly, systemic risk cannot be disposed of in this fashion. The present Global Financial Crisis unleashed massive attempts by banking institutions in trying to dispose of financial instruments heavily affected by the onset of undilutable systemic risk.

Fourth, banking institutions also perform a very important corporate governance-related role in large corporations. The cases of Japan and Germany are quite illustrative of this practice. The banking institutions' large equity stakes in these countries' largest corporations allow them to effectively control these corporate institutions (Allen and Carletti, 2008:16 and 17). This control addresses the agency informational issues previously alluded to. Unsurprisingly, the present Global Financial Crisis has elicited a profound revision of pre-crisis corporate governance procedures pursued by major financial institutions.

It should be observed that the simultaneous fulfilment of this universal role comprising these four main goals might be severely jeopardised in certain key economic circumstances. When banking institutions are subjected to and impacted by the occurrence of severe financial crises, a breakdown in the simultaneous pursuit of these goals may severely affect a given banking institution's balance sheet and, subsequently, its market valuation.

The current Global Financial Crisis constituted such a general breakdown, with bank valuations 'plunging into the abyss' at the height of the occurrence of this global systemic event, as our results will show. Figure 1 of Appendix B describes the global evolution of the market valuation of the banking industry in the countries included in our sample. The Global Financial Crisis of 2007 – 2008 has certainly left a decisive negative bearing on the depicted bank valuation performance. In all of the countries considered, the overall valuation of each respective banking industry has been clearly affected by the onset of the financial systemic failure (in differing degrees of severity).

However, a closer visual inspection also reveals that some of the countries included in our sample have seen their respective banking industry valuation return to (and in some cases, even surpass) pre-crisis levels (the cases of Brazil and India are clearly noticeable, while the U.S.A. has not made a similar rebound). This strongly suggests the existence of a differentiated or heterogeneous response dynamics emanating from the performance of the banking industries analysed. Shehzad and De Hann (2013) also confirm this heterogeneity, insofar as they find that stock prices of banks in emerging countries were less affected by the systemic shock than the corresponding prices of their counterparts in industrial economies (Shehzad and De Hann, 2013:117). This differentiated stock price performance of banks will constitute the main concern of our research.

The next sub-section presents a more detailed definition of this severe systemic event. This crisis definitional framework will be of great advantage when examining the empirical findings associated with our model applications.

3.2.2. THE GLOBAL FINANCIAL CRISIS AS A GLOBALLY DISRUPTING SYSTEMIC EVENT FOR THE BANKING INDUSTRY

In this section, we will review in passing the most relevant dynamical factors leading up to the occurrence of the Global Financial Crisis and the ensuing effects for the global banking industry.

Prior to achieving this purpose, there is one caveat that will merit our attention throughout the present sub-section. Given the highly complex and multifaceted nature of the global systemic event under study, we will largely address our review within the context of the country at the epicentre of the 'Subprime' Crisis[29], the United States of America (U.S.A.). Thus, this sub-section will mainly focus on this country's financial crisis episode and its effects upon the global banking industry.

This is justified by the fact that the onset of the present crisis and the implications thereof are quite well documented by the literature pertaining to the

[29] In the context of our research, we will establish a fundamental distinction between the 'Subprime' Crisis (as a localised U.S. event) and the ensuing Global Financial Crisis (as a truly global financial event associated with international financial contagion processes).

'Subprime' Crisis in this country. The same reasoning is not entirely applicable when considering the literature relating the impact of this crisis episode to the majority of the other countries included in our sample, in view of the exiguity of this latter literature.

The 'Subprime' Crisis is a major disruptive systemic event, profoundly associated with the bursting of the twin economic bubbles in the real estate and the credit markets in the U.S.A. These bubbles had been building up internal pressure prior to the moment when this systemic disruption took place.

According to Shiller (2008), the very term *subprime crisis*[30] epitomises the "deflating of a speculative bubble in the housing market that began in the United States in 2006 and has now cascaded across many other countries in the form of financial failures and a global credit crunch" (Shiller, 2008:9). Krugman (2008) also concurs with this analysis by presenting a similar (but more critical) depiction of the economic forces leading up to and surrounding these bubble deflation events (Krugman, 2008: pp. 166 to 172).

It should be acknowledged that, prior to the occurrence of the financial shock, the formation of the real estate bubble was simultaneously accompanied by the formation of a closely correlated second bubble occurring in the credit markets. These latter credit markets are mainly concerned with the issuance of sophisticated and highly profitable credit-related financial derivatives products (Brunnermeier, 2008:pp. 3 to 8).

That is, these two bubbles were deeply interconnected in view of the fact that the performance of these purely financial products was unquestionably tied to the performance of the underlying real estate market assets (Blanchard, 2009:pp. 5 to 8).

In addition, it should be noted that the securitisation process largely drove the evolution of the credit bubble that later imploded. This complex financial transformation process was widely used by major banking institutions in the pursuit of their profit-maximising strategies.

[30] Within the mortgage finance industry, this term refers to a specific category of high risk loan borrowers, most notably those who might exhibit extremely high default probabilities on their mortgage loans. Thus, these borrowers' risk profile entails a corresponding high degree of credit risk, which obliges lenders to require higher *premia* to satisfy the borrowers' loans; these distinct risk profiles are summarized in these borrowers' FICO scores, a widely used credit score appraisal system in the U.S.A. (Felsenheimer and Gisdakis, 2008:72 to 76).

The latter securitisation process may be briefly described as a highly profitable structured finance technique. It allows financial assets (such as bonds, loans or receivables) to be commonly pooled and used as collateral for subsequent investment purposes (Felsenheimer and Gisdakis, 2008:103).

Once the securitisation process was complete, issuing financial institutions had the option of either retaining these complex 'securitised' assets in their respective portfolios, or selling those very assets at a significant profit to other eager institutional investors.

Ultimately, the rising trajectory of home price appreciation in the U.S.A. fuelled both the mortgage finance industry and the credit markets where these mortgages of heterogeneous risk profiles (including 'Subprime' mortgages) were securitised and subsequently traded[31] (Krugman, 2008:148 to 151). This latter fact clearly benefited the vested commercial interests of the banking industry during the ascending phase of the business cycle prior to the onset of the 'Subprime' Crisis.

Banking profits were thus mainly driven by issuing mortgages and trading securitised products assembled from mortgage pools. Therefore, securitisation ended up playing a decisive role in the growth of residential mortgage lending in the U.S.A. and the real estate boom in this country (Shin, 2009: 311). Unsurprisingly, the banking industry strongly benefited from this upward trend.

On the other hand, the worldwide commercialisation of this overwhelming wave of securitised products could not have been achieved without the widespread adoption of a prevalent banking paradigm enveloping the said securitisation technique. This paradigm was wholeheartedly embraced by major financial institutions within the banking sector (most specially, within the U.S.A.).

The said paradigm, which has been termed the 'originate-and-distribute' banking model, strove to facilitate the circulation of securitised assets (irrespective of their extraction and risk profile) throughout the global financial system.

[31] Blanchard (2009) provides a comprehensive visual diagram depicting this complex web of financial interests pertaining to the securitisation architecture. This diagram clearly depicts the banking sector as a most fundamental industry market player within this architecture (Blanchard, 2009:6, Figure 2 entitled "A Visual Sense of the Complexity: From Mortgages to Securities").

This was achieved through the creation of financial market segments in the credit derivatives markets in which synthetic loan-related credits (of mortgage extraction, for example) were pooled, repackaged and sold to institutional investors. For example, mortgage-related securities were an important structured product sold thorough these financial market structures (Brunnermeier, 2008: 2 and 3).

Ultimately, a loan's originator might not be the same entity as the recipient of the said loan's underlying credit proceeds (the former might even be located in an entirely different country/continent than the latter). This is due to the fact that the entitlement to those very credits might have been re-packaged and sold to a third party. These financial transactions heavily involved both U.S. and non-U.S. banking institutions alike. According to this framework, these transactions advanced the sale of securitised products worldwide under the tutelage of a most effective, global and dominant banking paradigm.

In the aggregate, banking institutions were able to off-load credit risks associated with their credit-related investments, by disentangling themselves from these credit risks; while subsequently selling these partitioned risks to interested third parties through properly designed credit-related structured products (Hull, 2006:507). That is, *credit risks became a financial commodity by themselves, traded worldwide.*

Unsurprisingly, the growth of U.S. financial sector assets earmarked for securitisation has been thoroughly explosive. Bhatia (2007) details the evolution of this share of U.S. financial assets since 1980 (Bhatia, 2007:3, Figure 1). Implicitly, this remarkable growth has ultimately enabled major financial institutions to reap significant rewards from the pursuit of these structured financial operations during the inflating phase of the twin bubbles.

This highly complex and fluid entanglement of financial interests involving the real estate markets, the mortgage finance markets and the credit derivatives markets deeply contributed to and aggravated the ensuing financial shock of 2007 – 2008. This shock occurred once the performance of the U.S. real estate markets started to falter.

The overall retraction in housing prices in the U.S.A. thus became the trigger for the ensuing 'Subprime' Crisis that originated in this country (Blanchard, 2009:4). In the terminology initially proposed by Kindleberger and Aliber (2005), this price retraction

was the 'displacement' factor unleashing this critical systemic event (Kindleberger and Aliber, 2005:25).

In fact, when the real estate market performance failed to meet the over-optimistic expectations of investors, the underlying architecture of financial derivatives products sustained by the credit markets started to exhibit an increasingly higher default rate.

This severe default disruption has been quite well documented by Calomiris (2008), who describes the alarming rise in 'Subprime' mortgage default rates for mortgage 'vintage' years after 2005 (Calomiris, 2008:99, Figure 2). These 'subprime' mortgages had been subsequently repackaged and sold as securitised assets worldwide, by major specialised banking institutions. These transactions have implicitly entailed a global and massive dispersion of latent default risk, which became manifest once the systemic crisis set in. In this context, serial 'subprime' default thus contributed to rising worldwide uncertainty, in view of the said global dispersion. Banking institutions were therefore deeply impaired by the sudden loss of this profitable business line in the aftermath of the systemic event.

Furthermore, the retraction in housing prices also prompted a sudden and unexpected re-appraisal of risk pertaining to the afore-mentioned credit derivatives products privately held by banking institutions and other institutional market participants[32]. This re-appraisal was inevitable in view of the rampant risk underestimation prior to the onset of the financial crisis (Blanchard, 2009: 5 and 6).

Once the 'Subprime' Crisis erupted, the upward risk re-appraisal further prompted these latter institutions to promote 'fire sale prices' of these structured financial products. This was done in an attempt to rapidly obtain liquidity from the markets in order to comply with regulatory capital requirements, once the price deflation in the credit markets set in. These market and funding liquidity pressures ultimately threatened the very solvency of banking institutions, enhancing the steep decline in capital ratios throughout the banking sector (Frank, González-Hermosillo and Hesse, 2008:7).

[32] These financial investments were often inscribed in off-balance sheet vehicles ultimately belonging to these banking institutions. This widely used practice was officially (but unwisely) acknowledged in order to facilitate the latter institutions' pursuit of their respective regulatory arbitrage strategies (Krugman, 2008:pp. 158 to 164) (Eichengreen, 2008:pp. 17 to 19).

Thus, the valuation of banking institutions utterly reflected this progressive decrease in the value of 'toxic' assets contained in their respective balance sheets. This risk re-appraisal was quite a sudden and painful adjustment process throughout the crisis. It forced banking institutions to constantly re-appraise, in a downward spiralling mechanism, the value of their assets until uncertainty finally dissipated (Blanchard, 2009:9 to 13).

Therefore, the collapse of the real estate markets subsequently led to the collapse of the credit markets, which had been fundamental to the profitability of the banking industry as a whole. This profitability stemmed from the banking services rendered from mortgage issuing fees to underwriting fees from securitised financial products. Around half of the losses stemming from the 1.4 trillion dollar total exposure to 'subprime' mortgages, were "borne by U.S. leveraged financial institutions, such as commercial banking institutions, investment banking institutions and hedge funds. When foreign leveraged institutions are included, the total [loss volume] rises to two thirds" (Shin, 2009:313).

Ultimately, the 'Subprime' Crisis inevitably affected the performance of the global banking sector, by constraining the collection of fees associated with the creation and sale of securitised products feeding the underlying real estate and credit-related bubbles[33]. It further constrained the banking industry by constricting the value of ('subprime' and non-'subprime') credit derivative assets and real estate collateral posted on mortgage financing, further compounding the negative price spiral in the real estate markets.

That is, the corresponding reduction in banking profitability reflected not only the unexpected real estate downward price trajectory initially affecting the mortgage financing sector, but also the severe contraction of the credit derivatives industry supporting the underlying real estate and credit-related bubbles.

[33] International financial contagion aggravated this process, by 'exporting' the systemic failure worldwide, as shall be seen in the following sub-section.

3.2.3. GLOBAL FINANCIAL CONTAGION PROCESSES ASSOCIATED WITH THE 'SUBPRIME' CRISIS

It should be noted that the concept of international financial contagion has changed over time and still remains quite elusive. Moser (2003) depicts the elusiveness of this concept from a historical perspective (Moser, 2003: 158 and 159). In addition, Corsetti, Pericoli and Sbracia (2010) further confirm this lack of consensus around the concept of financial contagion, at both a theoretical and empirical level (Corsetti, Pericoli and Sbracia, 2010:1).

International financial contagion is more generally defined so as "to describe situations in which a crisis in one country causes crises in other countries, or at least makes them more likely" (Moser, 2003: 160). That is, this broad definition of financial contagion is essentially viewed as a global mechanism facilitating the propagation of adverse shocks that have the potential to trigger financial crises emanating from a given epicentre to other multiple peripheral locations. Contagion is thus more equated with centrifugal causality (and less with simultaneity) events.

On the other hand, the latter definitional framework elaborates on a previous definition proposed by Dornbusch, Park and Claessens (2000), according to which international financial contagion refers to the diffusion of negative market disturbances, as observed through the co-movement in certain financial asset prices (Dornbusch, Park and Claessens, 2000:179).

By combining the said definitions, international financial contagion thus takes place when small financial shocks initially affecting a set of selected institutions within a specific region spread to other markets and economies. This occurs through financial linkages in existence throughout globally integrated financial markets. In view of the degree of international financial integration worldwide, these linkages often propagate almost simultaneously from the financial sector to the underlying real economy (intra-linkages) and, concomitantly, between connected international financial systems (inter-linkages) and respective economies. As prime components in the complex architecture of these financial systems, banking institutions are most obviously exposed to the profound consequences associated with global international financial contagion processes, which assertively impact these institutions' own financial standing (either individually or collectively considered).

Where the present global systemic failure is concerned, the literature on this research topic has primarily established the U.S.A. as the epicentre of the said systemic failure. This country's housing market and the retraction of its residential housing prices has already been identified as the most probable cause associated with the overall collapse of the U.S. financial system in 2007 - 2008.

Through international financial contagion, the ripple effects of this systemic collapse were felt worldwide, in view of the fact that securitised 'toxic' assets were the object of a widespread diffusion. This diffusion process rests on the credit risk transfer hypothesis, which will be described hereinafter. The subsequent global uncertainty surrounding the valuation of these 'toxic' assets ended up affecting the balance sheet of banking institutions worldwide, and, ultimately, their corresponding valuations.

Thus, global exposure to credit derivative securitised assets became the main financial transmission channel, affecting not only specific banking institutions exposed to these securitised assets (in the U.S.A.), but also affecting the global banking industry through international financial contagion processes, once the uncertainty surrounding the very valuation of these assets set in.

On an empirical level, the transmission of adverse global shocks has been thoroughly observed in the co-movement of financial stress between advanced and emerging economies. In particular, banking stress seems to have played a most decisive role in the present financial turmoil in the stress transmission process (International Monetary Fund, 2009:149). In fact, financial links seem to be a main conduit of stress transmission. This is attributed to the fact that emerging economies with higher foreign liabilities in relation to advanced economies have been more affected by a common global shock (initially affecting the latter economies) than emerging economies with weaker links (International Monetary Fund, 2009:164).

On a theoretical level, Allen and Carletti (2008) state that there are essentially two approaches pursued by the existing literature addressing financial contagion.

The first approach examines the direct impact of a given crisis on the balance sheet of banking institutions. The latter institutions are considered to be differently connected and integrated within specific financial network structures (Allen and Carletti, 2008:10 to 13).

A second approach focuses on the indirect balance sheet impact of a given crisis on banking institutions. Each bank portfolio is affected by the decisions undertaken by other banking institutions in the pursuit of their return maximising strategies (Allen and Carletti, 2008:13).

According to the first approach, better connected financial networks are more resilient to contagion, in view of the fact that a proportion of the losses associated with a portfolio owned by any given bank is transferred to other banking institutions through inter-bank contracts (Allen and Carletti, 2008:11). As shall be seen when our methodology and results are duly presented, these connected financial networks might be equated with our adopted definition of financial clusters.

Within the scope of this approach, a recent strand has emerged connecting the risk of financial contagion to the onset of financial innovation. Within this strand, Allen and Carletti (2006) test the credit risk transfer hypothesis associated with the creation of new credit risk transfer instruments (e.g., securitised assets).

According to this hypothesis, credit risk transfer is highly beneficial because it continues to improve risk sharing between financial institutions. By being able to transfer credit risk, a given bank might be able to focus and manage the credit risks in which it has a comparative competitive advantage, thus optimising the use of its capital structure. The credit risk transfer hypothesis is thus in full consonance with the principles underlying the previously presented securitisation technique and the 'originate-to-distribute' globalised banking paradigm.

Under this theoretical framework, optimal conditions are met when banking institutions face a uniform demand for liquidity. On the other hand, when banking institutions face idiosyncratic liquidity shocks, higher demand for liquidity is in turn associated with a greater variability in asset prices (the 'fire sale' prices alluded above). In these latter circumstances, *the transfer of credit risk may induce financial contagion and lead to an overall Pareto reduction in economic welfare by increasing the probability of crisis occurrence* (Allen and Carletti, 2006:110).

In addition to credit risks and liquidity risks, another major cause of loss of value for banking institutions is connected to the performance of counter-party risks. The onset of this specific risk category is normally associated with the potential negative

externalities occurring amongst financial institutions when a financial crisis is underway. In the case of the crisis under study, counter-party risks were exposed by the uncertainty surrounding not only the valuation but also the precise dispersion of the toxic assets held by banking institutions throughout the global financial system.

Indeed, in an extreme event, the specific systemic failure of a major financial institution (as was the case with Bear Stearns or Lehman Brothers) might lead to a clustering of subsequent defaults by other financial agents. Jorion and Zhang (2009) conduct an empirical study addressing this important transmission channel, using both financial and non-financial bankruptcy announcements and the structural dynamics between borrowers and lenders. Although the study encompasses a period prior to the occurrence of the present financial turmoil, it draws important conclusions that might be relevant to our own research.

Attention must be drawn to the fact that traditional models of portfolio credit risk might be seriously misspecified, thus underestimating the occurrence of systemic events. This is due to the clustering of default correlations (associated with serial bankruptcies) occurring throughout systemic episodes, which are not depicted by these more traditional models[34] (Jorion and Zhang, 2009:2085). The overall correlated negative performance of the banking institutions portrayed in our study of the crisis is certainly a reflex of this abrupt change in the market perception of the valuation of securitised assets inscribed within the latter institutions' respective balance sheets. This is particularly more damaging once the deep global uncertainty associated with this valuation process (brought about by the onset of the financial crisis) sunk in.

The following section will review in passing the most relevant literature on the set of theoretical models underlying our empirical paper, the Hidden Markov family of models (HMM). Furthermore, it will fully describe the HRSM-S.

[34] In a prior study of the U.S. credit crunch of 2007, Hull (2008) also concludes that the overall geographical diversity associated with the ownership of securitised assets did not deter the serial default of assets inscribed in mortgage portfolios, as might be initially expected (Hull, 2008:12).

3.3. LITERATURE REVIEW

The global performance of banking institutions will be thoroughly analysed and discussed within the context of the application of a specific model inscribed in the Hidden Markov family of models (HMM). Prior to this application, a brief introduction of HMM models will be provided, followed by a theoretical description of the model employed by our research, the Heterogeneous Regime-Switching Model (HRSM-S).

3.3.1. BRIEF DESCRIPTION OF HIDDEN MARKOV MODELS (HMM) AND REGIME-SWITCHING MODELS (RSM)

A Hidden Markov Model is a parametrized stochastic probability model frequently used in the analysis of economic and financial time series. It essentially consists in two inter-connected processes.

The first is a finite state Markov chain whose states are not directly observable from the available data (i.e., the states are 'hidden'). The second process refers to the emission model associated with each state, which, in the present case, is Markov in nature. That is, the underlying Markov chain is characterized by a transition probability that describes the different probabilities between each of the considered states. Simultaneously, a given state solely depends on the preceding state and the transition probability matrix (Bhar and Hamori, 2004:14 and 15).

Hamilton (1989) further expands this strand of research by introducing regime-switching models in macro-economic data modelling. This author describes an alternative approach to examining non-stationary data, by exploring the consequences of specifying that first differences of an economic time series might follow a non-linear stationary process instead of a linear stationary process (Hamilton, 1989:357 and 358).

There are two main reasons justifying the use of regime-switching models. First, the existence of 'turning points' in a given economic time series is quite proficiently characterized (from a statistical standpoint) as discrete regime shifts. These shifts are essentially episodes in which the dynamic behaviour of a given time series during a given phase is manifestly distinct from the behaviour associated with a preceding phase (Hamilton, 1989:382).

Second, the existence of dramatic breaks (or discontinuities) in the behaviour of many economic time series is often associated with the occurrence of financial crises. During these extreme circumstances, under-utilization of factors of production relative to their long-term tendency is quite prevalent in the scrutinised time series, critically affecting prices. Regime-switching models are also quite suited to capture these abrupt changes in the fundamentals of asset prices (Hamilton, 2005:1).

A major advantage concerning the application of these models to the study of financial crises is that the latter are frequently temporary (or transitional) events by nature. That is, the scrutinised time series are traditionally mean-reverting, so that their performance is reversible once the malign influences associated with the occurrence of these extreme events dissipate. In view of this element of reversibility, transitional matrices depicting the probabilities associated with regime changes are quite a natural and un-forceful way of formulating these complex events and transitions (Hamilton, 2005:3).

Therefore, these models are perfectly suited to analyse and characterise both the 'turning points' and the abrupt changes (discontinuities) occurring in economic and financial time series affected by the occurrence of extreme, but reversible, financial events, of which the Global Financial Crisis is the latest systemic example.

3.3.2. DESCRIPTION OF THE HETEROGENEOUS REGIME-SWITCHING MODEL (HRSM-S)

Heterogeneous Regime-Switching Models (HRSM-S) are an extension of a Markov-Switching Model initially developed by Dias, Vermunt and Ramos (2008) and Dias, Vermunt and Ramos (2009). This novel approach has been further extended by Ramos, Vermunt and Dias (2008) and Dias and Ramos (2010). We will closely follow the guidelines expounded in these two latter papers.

In addition to the innovative theoretical framework proposed by these latter two papers, they also incorporate empirical demonstrations of the application of this novel approach to the field of empirical financial studies.

A most thorough, step-by-step and updated explanation of this theoretical approach can be found in Dias and Ramos (2010). Concomitantly, we will also strive to provide an overview of this methodology, referring the reader to this latter text where the most technical aspects of the model are concerned.

According to Dias and Ramos (2010), the HRSM-S enables the statistical estimation of regime-switching models based on the similarity of the dynamics associated with each homogeneous groups (or clusters). A model with *S* clusters is denominated HRSM-S (Dias and Ramos, 2010:8 and 9).

In order to achieve this estimation, two types of clustering are essentially assumed. Each underlying time series is both assigned to a specific cluster *and* modelled as a regime-switching model.

Let y_{it} represent the value (measured as a return), at time *t*, of each country banking index contemplated in our sample, where $i \in 1,\ldots,n$ and $t \in 1,\ldots,T$. Let $f(y_i;\partial)$ be the probability density function associated with the banking index return rate pertaining to country *i*. The HRSM-S (S being the number of groups or *clusters* associated with this application) is given by:

$$f(y_i;\partial) = \sum_{\omega=1}^{S} \sum_{z_1=1}^{2} \sum_{z_2=1}^{2} \cdots \sum_{z_T=1}^{2} f(\omega,z_1,\ldots,z_T)\, f(y_i \mid \omega,z_1,\ldots,z_T) \qquad (1)$$

The right-hand side of Equation (1) indicates that the underlying model architecture is typical of a mixture model consisting of the time-constant latent variable ω and *T* realizations of the time-varying latent variable z_t. In this context, the observed data density $f(y_i;\partial)$ is obtained by marginalizing over the latent variables (Dias and Ramos, 2010:9).

Furthermore, the term $f(\omega,z_1,\ldots,z_T)$ of Equation (1) can be further transformed into:

$$f(\omega,z_1,\ldots,z_T) = f(\omega)\, f(z_1 \mid \omega) \prod_{t=2}^{T} f(z_t \mid z_{t-1},\omega) \qquad (2)$$

where $f(\omega)$ essentially represents the probability of a given country banking index belonging to a given latent class or cluster ω, with multinomial parameter $\prod_{\omega}$ = P(W=ω), $f(z_1 \mid \omega)$ represents the initial-regime probability and $f(z_t \mid z_{t-1,} \omega)$ represents the latent transition probability (Dias and Ramos, 2010:10).

A main advantage associated with the HRSM-S pertains to the fact that each cluster is allowed to be associated with its own specific regime-switching dynamics. This is in clear contrast to a standard regime-switching model, where the transition probabilities are equal and common to all cases.

Moreover, the observed index return value depends only on the regime applicable at that specific chronological point, i.e., response y_{it} is independent of returns at other moments (this is known as the local independence assumption). Simultaneously, the said observed value is also independent of latent states at other times.

These assumptions can be formulated as follows:

$$f(y_i \mid \omega, z_1, \ldots, z_T) = \prod_{t=1}^{T} f(y_{it} \mid z_t) \qquad (3)$$

where the probability density that a particular observed index return value at time t conditional on the regime in place at that chronological point - $f(y_{it} \mid z_t)$ – is assumed to have the specification of a univariate Gaussian density function (Dias and Ramos, 2010:11).

In fact, the standard regime-switching model introduced by Hamilton (1989) thus constitutes a special case of the HRSM-S. It can be obtained by assuming there is no heterogeneity in the model, i.e., through the elimination of the grouping variable ω. In the case of our application, the HRSM-1 (S=1) would stipulate that all country banking indexes possess a homogeneous dynamics and belong to the same unique latent class (or category of countries).

Furthermore, the parameters of the HRSM-S are estimated using a Maximum-Likelihood (ML) estimation procedure of the log-likelihood function:

$$l(\partial;y) = \sum_{i=1}^{n} \log f\,(y_i; \partial) \qquad (4)$$

The Expectation-Maximization (EM) algorithm can subsequently be used to solve this maximization problem. In the first step ('E-step') the expected value of the log of the likelihood function is computed, conditional on the observed data and the initial parameter estimates. In the second step ('M-step'), the function is maximized in order to obtain the updated values of the parameter estimates, and this iterative procedure is continued until a predefined level of precision is reached (McCutcheon, 2002:64).

Nevertheless, it should be pointed out that the application of the EM algorithm requires both a lengthy computational effort and a cumbersome computer storage capacity. Therefore, the application of this algorithm is often impractical, if not even impossible.

To circumvent this operational problem, a special variant of the EM algorithm – the Baum-Welch (BM) algorithm - has been advanced by the literature, enabling the above-mentioned maximization problem to be more easily solved (Dias and Ramos, 2010:12).

Furthermore, the choice of the appropriate number of latent classes *S* is traditionally based on the analysis of statistical information criteria, such as the Bayesian Information Criterion (BIC) or the Akaike Information Criterion (AIC). The former is preferable to the latter, in view of the fact that it is considered more conservative (less prone to overestimation). Thus, the BIC value will be used within the framework of the present paper, and the most appropriate value of *S* will be found when the value of the BIC is at its minimum.

Lastly, our expectations as to the application of this statistical model should also be addressed. The present Global Financial Crisis is deemed to have strongly affected

the banking systems of both advanced and emerging economies, with a stronger emphasis on the former.

In this context, the application of this statistical model will yield discriminating and enlightening results as to the differing performance of distinct banking systems and their respective institutions, once the magnitude of this great financial shock is accounted for. Our results will effectively demonstrate that there are different regime dynamics, and that banking institutions were heterogeneously affected by this severe financial shock. As a consequence, banking responses to the global financial shock were equally heterogeneous.

The following section addresses the empirical results obtained by the application of the HRSM-S, taking into consideration the most appropriate research choices undertaken.

3.4. EMPIRICAL RESULTS

Prior to presenting our findings, we will first proceed by presenting some preliminary considerations concerning our chosen data and appropriate research options in sub-section 3.4.1., as the latter will be most relevant to the full understanding of our findings. We will then proceed by presenting and commenting our findings in sub-sections 3.4.2. and 3.4.3. Whilst the former sub-section portrays the findings associated with a dual state regime dynamics, the latter sub-section portrays the findings associated with a multi-state regime dynamics.

3.4.1. PRELIMINARY CONSIDERATIONS

The HRSM-S will be applied to a numerous and highly diverse set of country banking indexes in order to study the heterogeneity of the regime dynamics associated with the impact of the Global Financial Crisis upon different representative banking systems and institutions worldwide.

The countries included in our paper are the following: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China[35], Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Ireland, Israel, Italy, Japan, Luxembourg, Malaysia, Mexico, Netherlands, Norway, Pakistan, Peru, Philippines, Poland, Portugal, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom and United States.

The corresponding banking indexes are used as a proxy for banking institutions' responses for each country included in our sample. That is, each of the countries included is uniquely represented by a sole banking index. This was done in order to adopt a uniform standard capable of allowing international comparisons across the countries comprised in our sample.

The collected indexes have been extracted from the Datastream database, taking into consideration a weekly frequency.

[35] Due to data availability constraints, Chinese banking institutions will only be included in our model applications comprising the 2007 – 2010 period.

In addition, these indexes have been uniformly referenced in United States Dollars (USD)[36]. This was done in order to facilitate international comparisons, and also to allow the use of these indexes as uniform data inputs to the applications pertaining to our chosen model.

The present paper is mainly concerned with the impact of the Global Financial Crisis upon banking institutions, and the latter's heterogeneous responses to this global systemic event. Accordingly, the adopted time frame will be as follows.

The beginning point of our indexes will be the year 2002 (more specifically, the 2nd of January of the latter year), and this choice was made on two counts.

First, it is the year subsequent to the occurrence of the previous global financial crisis – the 2001 'Dot-Com' Crisis. Second, our choice is in agreement with the beginning of the upward trajectory of the 'Subprime'-related business cycle that directly led to the present crisis[37].

On the other hand, the end-point of our data is the 25th of August, 2010 (the beginning of our paper's drafting process); this ample time frame will allow us to address the full impact of the Crisis.

That is, the time interval between 2002 and 2010 encompasses not only the upward phase of the global business cycle prior to the occurrence of the Global Financial Crisis, but also the ensuing downward phase.

It is important to provide some relevant summary statistics pertaining to the collected country banking data. These important statistics have been collected in Table 1 of Appendix B.

Besides presenting the standard descriptive statistics associated with each country banking index, Table 1 also presents the respective results for the Jarque-Bera (JB) statistic. The results obtained indicate that the rejection of the null hypothesis of

[36] Notwithstanding, we would like to observe that the overall performance of the USD *vis-à-vis* all the other currencies might also have a bearing on our results, but this influence will be disregarded in our research, in view of the lack of a better alternative.

[37] For example, in the case of the United States, the epicenter of the present Crisis, the official business cycle dating committee – the National Bureau of Economic Research (NBER) - dated this upward phase associated with the 'Subprime' cycle between November, 2001 and December, 2007 (National Bureau of Economic Research, 2008:1).

normality can be safely undertaken, the *p-values* associated with the JB statistic for each and every country's time series is close to zero.

Essentially, our study comprises four model applications, the first two pertaining to the existence of a dual state regime dynamics, while the latter two are associated with the multi-state regime dynamics. In addition, the models associated with each regime dynamics will further comprise both the pre-Crisis and post-Crisis frameworks (addressing the 2002 – 2010 period) or only the post-Crisis framework (addressing the more reduced 2007 -2010 period).

By adopting this specific time frame for our first and third model applications (covering the 2002 – 2010 period), both the benefits associated with the expansionary phase and the devastating financial consequences associated with the contractionary phase of the 'Subprime'-related business cycle will be most adequately portrayed by the HRSM-S.

However, taking into consideration that the initial impact and subsequent severity of the Global Financial Crisis might have structurally altered the regime dynamics associated with our variable set, two subsequent model applications will also be envisaged, in order to further confirm the amplitude of heterogeneous banking responses during the systemic episode.

That is, in addition to the first and third enlarged model applications covering the 2002 – 2010 time frame, these subsequent model applications (the second and the fourth) will exclusively address the global impact of the systemic episode, by covering and focusing on the more recent period from 2007 up to 2010.

Comparisons amongst these distinct model applications will allow us to better capture the dynamics associated with the analysed global systemic event, according to which the demise of both Bear Stearns and Lehman Brothers became this extreme financial event's major hallmarks.

More fundamentally, it is of the utmost importance to observe that regime polarity parameterization is thus adequately incorporated into our model applications. This is done in order to efficiently accommodate and capture the mains traits of the performance of heterogeneous national banking sectors under distinctive and extreme financial environments. These environments range from the dual state framework to the

multi-state framework, where the incorporation of a higher number of scrutinised states in this latter framework is quite accommodative to a highly complex and globalised financial environment.

That is, in view of the theoretical model presented in the preceding sub-section, our model applications will allow us to simultaneously take into consideration different time frames, as well as the existence of multiple mutually exclusive regimes (i.e., regime polarity). This is achieved by adopting either a dual state regime dynamics (two regimes) or a multi-state regime dynamics (three or more regimes) in a specific model application. Ultimately, the benefits accruing from a greater regime granularity are thus incorporated into our findings.

There are two main advantages associated with the incorporation of this latter regime dynamics parameterization conferring a greater regime granularity. First, model applications contemplating a higher number of regimes confer a greater degree of flexibility to our findings, thus allowing for a thorough understanding of the performance of the distinct banking systems surveyed and corresponding institutions. This approach is specially efficient in order to capture the behaviour of country banking industries operating under the context of mild regimes that are markedly neither bull nor bear. Second, the adoption of the said parameterization complementarily robustifies the set of findings associated with the dual state regime dynamics where regimes are dichotomically labelled as either bull or bear. Accordingly, the multi-state regime dynamics allows us to subsequently incorporate intermediate regimes between the initial two more extreme bull and bear market regimes, therefore enriching our overall results.

A final observation should address the research design pertaining to our empirical applications. Our findings will stem from four distinct HRSM-S model applications. The first two model applications will be computed under a dual state regime dynamics framework (sub-section 3.4.2.), whilst the last two model applications will be computed under a multi-state regime dynamics framework (sub-section 3.4.3.).

The first model application addresses the global business cycle leading up to the Crisis, by including both the expansionary and contractionary phases associated with the ‘Subprime’-related global business cycle. While the second model application is circumscribed to the specific Crisis episode, by exclusively addressing the

contractionary phase and its immediate aftermath. Both the first and second model applications will be computed only taking into consideration a dual state regime dynamics where there co-exist two mutually exclusive regimes (either bull or bear).

The third model application is equivalent to the first model mentioned in the preceding paragraph, while the fourth model is equivalent to the second model therein mentioned. The main difference to the models outlined in the previous paragraph pertains to the fact that both the third and fourth model applications will be computed taking into consideration a more realistic multi-state regime dynamics framework, where there might co-exist three or more mutually exclusive regimes, adding a greater granular depth to our findings.

The findings associated with all these four model applications will be scrutinised in the following two sub-sections.

3.4.2. EMPIRICAL RESULTS ASSOCIATED WITH THE DUAL STATE REGIME DYNAMICS FRAMEWORK

The present sub-section will focus on the model applications computed under the auspices of a dual state regime dynamics. Sub-section 3.4.2.1. addresses the full-cycle model application, encompassing both the expansionary and contractionary phases of the global 'Subprime' business cycle. While sub-section 3.4.2.2. only addresses the post-Crisis (i.e., contractionary) model application. Both model applications only take into consideration the existence of the two mutually exclusive states of either bull or bear regime dynamics.

3.4.2.1. THE 2002 – 2010 DUAL STATE MODEL APLICATION

First, the HRSM-S dual state model application has been estimated using distinct discrete values of S (S=1,2,3,4,5). Table 2 presents the system parameter results associated with these five different estimations.

According to our decision rule, the optimal model estimation has a value of S equal to 3, i.e., the optimal model estimation has three latent classes (or clusters). This

essentially means that the optimal solution has three mutually exclusive and distinctive clusters, each operating under a specific type of mutually exclusive regime dynamics at a given point in time. The dual state HRSM-3 thus yields the minimal BIC value - equal to 105860.32 - , accompanied by a log-likelihood of –52902.31 and a number of free parameters equal to 15.

Second, the results pertaining to the cluster dimension, the distribution of the country banking indexes across the three latent classes and the degree of membership to each class are summarized in Table 3. Generally speaking, each country's set of banking institutions may be classified under one of the three distinct clusters (the cluster that maximizes the membership probability). Each country's membership can be duly observed in the corresponding modal class column. Each of the clusters will be associated with its own distinctive regime dynamics (either bull or bear).

The estimated prior class membership probabilities – representing the size of each cluster – are 70.4% (cluster 1), 26.5% (cluster 2) and 3.2% (cluster 3)[38]. That is, the differences among the prior membership probabilities are quite substantive, indicating that the underlying banking institutions associated with each country are unevenly distributed across latent classes. In fact, the probability of a specific set of banking institutions belonging to the first cluster is quite high (more than two thirds).

The same Table 3 provides the posterior probabilities indicating each country's degree of membership in relation to a specific cluster. The dominant cluster – cluster 1 – is comprised of the following 29 countries: Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Luxembourg, Malaysia, Mexico, Netherlands, Norway, Peru, Philippines, Portugal, Singapore, Spain, Sweden, Switzerland, Taiwan, United Kingdom and the United States. Cluster 2 is comprised of the following 11 countries: Argentina, Brazil, Czech Republic, Hungary, India, Japan, Pakistan, Poland, Russia, South Africa and Thailand. Cluster 3 is comprised by a single country: Turkey.

These results further suggest that individual membership cluster assignments are overwhelmingly high (at the very least, superior to 96%), except for the cases of Japan

[38] These values have been rounded, and are, therefore, approximate values.

(77.5%), Poland (83.2%) and Taiwan (84.1%)[39]. Nevertheless, these probabilities do indicate that, collectively considered, the banking institutions are assigned with very high probabilities to their respective clusters. That is, each considered country banking institution predominantly gravitates around one of the three specified clusters.

In conjunction with the results associated with the preliminary statistics of Table 1 (namely, the standard deviation figures), cluster 1 exhibits a lower degree of volatility in comparison to cluster 2 (cluster 3 is solely composed by Turkey, which exhibits a high volatility). Notwithstanding, these numbers should be viewed rather cautiously, in view of the fact that the comparison of intra-cluster standard deviations (those values associated with banking institutions belonging to the same cluster) exhibit some disparaging differences.

Third, each regime's profile and respective dynamics are described in Table 4, panels (a) and (b). P(*Z*) represents the estimated probabilities that banking institutions might be in a given regime (1 or 2), over the chosen time frame (the latter probabilities are not country-specific). Thus, there are essentially two regimes, regime 1 and regime 2. Over time, banking institutions are in regime 1 and regime 2 with 25% and 75% of probability, respectively. Regime 1 exhibits negative returns (-0.657) coupled with a high variance (92.464), while regime 2 exhibits positive returns (0.394) coupled with a low variance (8.956).

Following the recommendation suggested by the literature[40] and implemented by Dias and Ramos (2010), these regime dynamics may be associated with the dynamics of bear (regime 1) and bull (regime 2) markets, and we will also adhere to this dual state terminology[41].

The results are in line with the common acknowledgement pertaining to the presence of asymmetry of volatility in financial markets. That is, the said volatility is

[39] These results indicate that the Latent Class clustering processes underlying our research constitute a highly flexible methodology, insofar as membership to a given cluster is not binary, but rather gradative. Thus, a certain degree of uncertainty in ascribing membership is appropriately acknowledged (Vermunt and Magidson, 2002:90 and 91).

[40] For example, Ang and Bekaert (2002) depict the co-existence of alternating regimes (Ang and Bekaert, 2002:1139).

[41] This terminology was also successfully implemented using an altogether different methodology, the Markov Regime-Switching VAR framework, according to which a 'stable' and a 'risky' regimes coexisted alternately (Guo, Chen and Huang, 2011:108).

very much likely to be higher when the performance of financial markets is faltering and lower when the said performance is strong and vibrant (Dias and Ramos, 2010:15).

P(Z | W) represents the estimated probabilities that each country's set of banking institutions is in a given regime, conditional on the specificities of each individual cluster. A closer observation of the provided probabilities allows us to conclude that the banking institutions belonging to the set of countries associated with cluster 1 are more likely to be in a bullish (79.4%) than a bearish regime (20.6%). For banking institutions belonging to cluster 2, the corresponding probabilities are 67.7% (bull) and 32.3% (bear). Finally, Turkish banking institutions are more prone to being in a recessionary state (with a probability of 59.9% of being in a bearish mode, against the probability of being in a bullish mode of 40.1%).

A preliminary glance at these statistics suggests that banking institutions inscribed in the more advanced economies belonging to cluster 1 (Euro Zone banking institutions, for example) are less likely to be in a bearish state. Quite the contrary, banking institutions belonging to emergent market economies represented in cluster 2 are more likely to have a subdued financial performance than their respective counterpart institutions belonging to the first cluster. An important theoretical assumption underlying our reasoning refers to the fact that banking performance is pro-cyclical with the global business cycle. That is, banking performance is buoyant in bullish states, while it remains depressed in bearish states[42].

More importantly, the latter distinction is also quite important insofar as one of its potential implications refers to the resilience exhibited by more advanced banking systems (collectively considered) to the impact of systemic crises. Given that the only truly global crisis encompassed by our study refers to the Global Financial Crisis, the fact that banking systems and institutions in advanced market economies have had a higher probability of being in a bullish environment within the analysed period stands out as an important finding. A possible explanation for this finding might be related to the development and maturity of interconnected financial networks previously alluded

[42] In abstract, this reasoning precludes certain idiosyncratic banking industries from a global business cycle sustained on 'pure' competitive practices. For example, this is the case of permanently and heavily subsidized banking systems which are somewhat insulated from the pressures of a competitive global business cycle.

to in sub-section 3.2.3. The paper will further delve into the latest Crisis scenario in the following sub-section.

An issue prompting future research refers to the fact that some countries whose financial systems were least exposed to the direct impact of the Global Financial Crisis were associated with positive GDP growth rates throughout the said crisis. Outstanding examples include Brazil and India, two of the emergent market countries included in cluster 2.

Cross-referencing this fact with our results suggesting that cluster 2 is more prone to bearish states further prompts the question as to how these apparently more fragile set of banking institutions are nevertheless associated with more vibrant economies. That is, how is it possible that banking systems and institutions more prone to bearish states were more likely to be associated with (and even, supportive of) more resilient underlying economies during the latest Global Financial Crisis? This important question merits further academic research addressing the interaction of financial systems and the corresponding real economies (which is not the aim of the present working paper).

According to Beltratti and Stulz (2009), a possible explanation for country-wide differing performance of large[43] banking institutions' stock returns may reside in a powerful combination of factors involving the role of regulation, the quality of bank governance and the specificities of a given bank's balance sheet (Beltratti and Stulz, 2009:21).

Where the latter determinant is concerned, the existence of a successful securitisation line of business prior to the bursting of the credit bubble was a highly prized banking attribute valued by the stock markets. The over-development of this business line may have subsequently exposed large banking institutions to risks that led these institutions to perform very poorly once the Crisis occurred.

This is the essence of the *Tsunami explanation* of the Global Financial Crisis, according to which there was a complete over-hauling of expectations associated with bank stock returns before and after the Crisis. Before the Crisis, stock markets favoured

[43] These authors' sample included the world's largest banking institutions, i.e., those holding assets in excess of $50 billion at the end of 2006. This comprised 98 banking institutions, of which 19 were U.S. banking institutions (Beltratti and Stulz, 2009:2).

banking business strategies involving financial innovation-related products. Subsequently, the occurrence of the Crisis may have shifted market expectations in favour of more conservative banking business strategies promoting staple products (Beltratti and Stulz, 2009:2). That is, the inter-cluster heterogeneous behaviour might be explained by this through and decisive over-hauling of the expectations of financial investors maximizing their return – risk strategies. An important assumption pertaining to this latter reasoning concerns the fact that the underlying banking institutions in our sample operated within globally integrated financial markets.

Furthermore, the existence of large-scale banking operations involving securitisation business lines may have severely strained the transmission channels to the real economy (for example, by constraining the availability of credit, once liquidity pressures set in). At a macroeconomic level, this fact may have caused the more advanced economies heavily dependent on sophisticated credit channels to succumb more severely to the effects of the Crisis. Cross-referencing the performance of banking institutions depicted in Figure 1 and the findings of Table 4 (b), and notwithstanding the fact that banking institutions belonging to Cluster 1 seem to be less prone to recessionary states, this combined set of facts might explain the more severe contraction in financial systems and economies associated with Cluster 1.

Returning to the analysis of the results described in Table 4 (b), the transition probabilities between the two regimes for each of the three clusters are also presented. The diagonal values of the transition matrix may be classified according to their closeness to the value of one. A closer proximity to this value indicates that the clusters exhibit regime persistence. Once banking institutions belonging to a certain cluster enter into a given regime, they are likely to stay in that regime for some time, that is, transition between bearish and bullish modes becomes less likely for these institutions.

Our results show that the banking institutions associated with countries belonging to cluster 1 are more likely to stay in a given regime than those referring to cluster 2 countries (95.7% and 98.8% *vs.* 84.8% and 92.8%, respectively for regimes 1 and 2). That is, regime transience is generally low (but more prevalent in this latter cluster). It should be further observed that inter-cluster differences are more significant for the bear regime, but they are not, overall, significantly different between these two clusters, insofar as both clusters exhibited strong regime persistence. On the other hand,

Turkish banking institutions (cluster 3) exhibit a lesser degree of regime persistence (74.6% and 62.1%, respectively, for regimes 1 and 2), which is in agreement with the high volatility associated with the performance of these banking institutions.

A further important consideration has to do with the regime sojourn time presented in Table 4. This latter definition indicates the expected time (measured in weeks) banking institutions take to move out of a given regime. Cluster 1 banking institutions tend to take a more significant amount of time to come out of a bear regime (23.095) or to come out of a bull regime (84.746) than cluster 2 banking institutions (6.566 and 13.908, respectively). As the sole representative of cluster 3, Turkish institutions have the lowest sojourn time (3.932 and 2.636) between regimes.

Fourth, the HRSM-1 (S = 1) is a specific case of the HRSM-S. The former is equivalent to the standard regime-switching model. Contrary to the heterogeneous model, it does not account for the fundamental differences in the regime-switching dynamics. That is, the standard regime-switching model assumes all the cases have exactly the same probabilities. By contrast, the HRSM-S allows for the existence of a specific regime-switching dynamics for each of the considered clusters (Dias and Ramos, 2010:10 and 16).

In order to contrast these two distinct situations, the results associated with the HRSM-1 (S = 1) have also been presented. Table 5 depicts the results associated with this specific model application. Herein, the data depict a broader, but similar situation to the one depicted in the preceding Table, although certainly without accounting for the enriching and enlightening heterogeneity depicted by the HRSM-3 (S = 3).

The findings pertaining to this particular specification reveals that regime 1 is associated with negative returns (-0.669) and a high variance (92.592), while regime 2 is associated with high returns (0.394) and a low variance (9.277). That is, once again, regimes 1 and 2 might be associated with bear and bull market dynamics. The estimated regime probabilities P(Z) indicate that *the banking institutions pertaining to all the countries collectively considered* are more likely to be in a bullish (87%) than a bearish regime (13%) in the context of this particular non-heterogeneous specification.

On the other hand, these banking institutions exhibit strong regime persistence. The respective transition probabilities indicate that banking institutions tend to operate

in a bearish (94%) or bullish state (98.1%). While transitioning from bearish to bullish (6%) or bullish to bearish (1.9%) happens much less frequently. That is, banking institutions are less prone to regime changes (they continue to exhibit strong regime persistence), even in the case where the element of heterogeneity is not accounted for.

Fifth, summary information pertaining to the durations of bear and bull regimes for each of the considered countries is also presented in Table 6. The latter describes the mean, first quartile (Q1), median, third quartile (Q3) and inter-quartile range (IQR) of the number of weeks that a given set of banking institutions belonging to a given country continued in a given regime (1 or 2) before switching to the opposite regime.

Where bear market durations are concerned, the vast majority of cases indicate that the mean is higher (slightly, or, in some instances, more than slightly) than the median, which suggests that the underlying duration distributions are asymmetric. In fact, this finding also points to the existence of episodic moments associated with bear regimes. Notable exceptions to this finding concern the case of banking institutions in Mexico and Portugal, where the reverse seems to be the case.

Where bull market durations are concerned, the positive discrepancy between means and medians is more pronounced, and the only notable exemption to this rule concerns the case of banking institutions in Israel.

It should also be observed that mean and median bear regimes are inferior in length to their respective mean and median counterparts in bull regimes, as would be expected. However, notable exceptions to this rule are the cases of Turkey (where the comparison between the means under the two regimes is concerned) and Belgium, France, Japan and Portugal (where the comparison between the medians under the two regimes is concerned). These outlier cases seem to indicate that regime durations affecting banking institutions in these countries are more persistent in bear regimes than in bull regimes.

Sixth, the synchronization of banking institutions, as measured across the countries analysed, is also presented. Following the recommendations suggested by Dias and Ramos (2010), synchronization is measured by the likelihood that banking institutions share the same regime, and it is quantified by their proposed logit-based

correlation measure (Dias and Ramos, 2010:21). This measure has the advantage of filtering out the extreme observations normally observed during crisis episodes.

Table 7 describes a correlations matrix depicting financial synchronization across all analysed countries. In view of the large sample used in the research, it is preferable to concentrate on the overall patterns of the matrix (notwithstanding the fact that some countries, such as Argentina and Australia, exhibit a very low level of correlation when compared with all of their counterparts in other regions). A major feature of this Table concerns the fact that the overwhelming majority of the correlations therein described are positive. This indicates a high level of financial synchronization within the global 'Subprime' cycle across our chosen sample, thus reflecting a varying (but positive) degree of interconnectedness between banking institutions and corresponding financial networks.

What is truly important to observe is the overall general level of association amongst countries belonging to the same geo-economical gravitational field. For example, banking institutions belonging to countries of the European Union generally exhibit a higher level of association amongst themselves. The same reasoning applies to NAFTA countries. Thus, greater financial and economic integration amongst countries sharing strong geo-economical ties might constitute powerful causal factors enabling this overall synchronization pattern. Reciprocally, a lower degree of association might be justified by more complex and idiosyncratic banking system characteristics of the countries included in our sample (such as the lesser degree of openness of a given banking system to international investors, the existence of capital controls, the onset of political instability, the very absence of trade interconnectedness, etc.).

In order to better illustrate these correlation relationships, a graphical depiction of the above-mentioned matrix has also been presented. Figure 2 reproduces the information presented in the previous paragraph, and confirms the hypothesis of higher absolute correlation between countries belonging to the same regional blocs.

Seventh, the synchronization of heterogeneous timeline patterns pertaining to the performance of banking institutions belonging to the three different clusters is also presented. Figures 3, 4 and 5 depict the posterior probabilities associated with the banking institutions belonging to each of the countries inscribed within each one of the three specific clusters previously described. The said probabilities refer to the

possibility that a given country's set of banking institutions might be under the influence of a bear or a bull regime at time *t*. More specifically, and taking into account each country under a specific chronological point, the shaded area then represents a more than 50% probability that the said country's set of banking institutions might be operating under a bear regime. That is, the shaded area generally depicts a stronger bear regime influence over a (weaker) bull regime influence. Moreover, each of the presented figures is divided into four, roughly equivalent, chronological sub-panels. This procedure not only facilitates the analysis of each individual case at different stages of the business cycle, but also provides a clearer picture of the corresponding international financial crisis contagion processes at specific points in time.

Figure 3 depicts the said probabilities for the countries belonging to cluster 1. The first sub-panel (from January, 2002, to March, 2004) depicts the systemic consequences associated with the aftermath of the 'Dot-Com' Crisis in some of the countries considered in our sample[44]. For example, U.S. and U.K. banking institutions experienced a severe downturn in their overall performance, while banking institutions belonging to countries such as Australia and Luxembourg were seemingly not affected by the consequences of this crisis.

The second sub-panel (from March, 2004, to May, 2006) portrays a very buoyant dynamics of the global banking sector, insofar as the overwhelming majority of banking institutions were clearly passing through a period of strong financial performance. According to our previously presented analysis, this period witnessed (generally speaking) the leveraged build-up in the real estate and credit markets, to whose development these banking institutions were certainly most fundamental intermediaries.

The third sub-panel (from May, 2006, to June, 2008) depicts the escalating tensions affecting the activity of banking institutions. More specifically, this time frame's latter portion already exhibits some strains (in differing degrees of severity) in some (but not all) of the countries comprised in cluster 1. Ireland seems to have been particularly affected by the Crisis, followed by the U.K. and Austria. In the opposite

[44] When assessing the impact of the Global Financial Crisis upon banking institutions, we will exclusively take into account the amount of time indicated by the posterior probabilities associated with the bear regime in each of the considered countries; we will therefore refrain from commenting the severity of the financial downturn in each set of national banking institutions by any other measure than the respective country evolution according to these probabilities.

spectrum, some countries' banking institutions continued to operate under a bull regime. Chile, Hong Kong, Israel, Malaysia and Mexico are prime examples of countries where their respective banking institutions were not slightly hindered (according to our metrics) by any downturn in financial activity during this time frame.

The fourth (and final) sub-panel most adequately portrays the truly global and synchronized impact of the devastating consequences of the Global Financial Crisis upon banking institutions belonging to cluster 1. These specific findings are also applicable to the remaining clusters within this time frame, as shall be seen in the forthcoming paragraphs. In addition, this finding is in agreement with both the adopted definition of international financial contagion processes and stress transmission linkages, previously alluded to in sub-section 3.2.3.

Generally speaking, 2007 and 2008 were quite critical for the performance of the global banking industry. Indeed, four major and resounding systemic failures severely disrupted the industry, aggravating the consequences pertaining to the international financial contagion processes previously described. These four examples - Bear Sterns, Lehman Brothers, Northern Rock and IKB - were all connected to the implosion of the real estate and credit market bubbles. They illustrate both the interconnectedness amongst banking institutions operating in globalised markets and the devastating effects associated with international financial contagion processes.

Overall, the impact of these systemic failures should be viewed not only according to these institutions' degree of connectedness and strategic importance in the financial world (Bear Stearns, Lehman Brothers), but also in view of their sweeping exposure to underlying real estate markets (Northern Rock) and to securitised portfolios (IKB), thus justifying the high degree of intra- and inter-cluster synchronization.

In fact, all the countries and their respective banking institutions encompassed within this first cluster were overwhelmingly affected by the ecclosion of the Global Financial Crisis, to which the above-mentioned failures were certainly a most decisive (but not exclusive) catalyst. Within this cluster, the most affected banking institutions seem to be located in Greece and Ireland, followed by Austria, Belgium, Denmark, Finland, France and Germany. The least affected institutions are those located in Chile, Malaysia and Peru.

Figure 4 depicts the regime probabilities for the countries belonging to cluster 2. The yielded results portray a far more 'fuzzy' picture of the underlying international contagion processes. Up until March of 2004, all of the banking institutions belonging to countries in cluster 2 are often associated with a bear regime (but with differing degrees of severity). This is particularly damaging in the aftermath of the 'Dot-Com' Crisis, most specially to those institutions located in Argentina, Brazil and Japan (first sub-panel). Banking institutions in Poland seem to have been the least affected.

The second and third sub-panels (comprising the period from March, 2004, up to June, 2008) describe a higher susceptibility of the banking institutions comprised in this cluster to a bear regime. In clear contrast with the financial performance associated with institutions belonging to the countries of the previous cluster, the overall synchronized performance of the banking institutions associated with cluster 2 is generally influenced by a bear regime (even if more diffusely), specially during 2006. During the second and third quarters of the latter year, this cluster's banking institutions were particularly exposed to a severe recessional state, although the durations of the said impacts were quite varied across the countries therein comprised. During the time span covered by these two sub-panels, the overall picture is one of a higher propensity to a more subdued financial performance, when compared with their counterparts in cluster 1.

Notwithstanding, the fourth (and final sub-panel) details the same propensity to international financial contagion in the aftermath of the Global Financial Crisis as the banking institutions associated with the previous cluster. In this respect, the same overall conclusions (as to the breadth and synchronization associated with the financial shock) also apply to the banking institutions associated with cluster 2.

Finally, Figure 5 depicts the said probabilities for the only country in cluster 3 (Turkey). Herein, the results are indeed quite erratic, with Turkish banking institutions exhibiting a very volatile performance during the complete length of the time frame adopted in our research, when compared with the majority of its sample counterparts.

Overall, there are two outstanding facts that warrant attention in this graphic depiction of international financial contagion processes. The first concerns the breadth of the impact of the Global Financial Crisis on the overall performance of banking institutions worldwide. The second concerns the high degree of synchronization associated with international financial contagion processes pertaining to the global

systemic failure (even when taking into account the heterogeneity of banking responses).

3.4.2.2. THE 2007–2010 DUAL STATE MODEL APLICATION

The results previously presented address the application of the dual state HRSM-S model to the full extent of the 'Subprime'-related global economic cycle. That is, it not only comprises the period reflecting the expansion of the real estate and credit bubbles worldwide, but also the subsequent time frame when the said bubbles imploded.

The present sub-section's model application will allow us to further distinguish the results, solely taking into account the time frame involving the occurrence of the global financial shock and its immediate aftermath. Under this framework, the start date regarding our chosen weekly time series data will be the 4th of July, 2007, while the end date to the said series will be the 25th of August, 2010. The start date reflects the month where the first signs of financial distress occurred in the financial markets[45], a date after which some major financial systemic failures took place (e.g., Bear Stearns, Lehman Brothers). Furthermore, our model application will also contemplate the specific case of Chinese banking institutions (the corresponding time series data was duly available for the 2007 – 2010 period), in addition to the banking institutions pertaining to the countries already included in the 2002 – 2010 model application.

A model application for this time frame does not portray a more discriminating framework. Table 8 illustrates the HRSM-S model application parameter results. The latter estimation was performed using distinct discrete values of S (S= 1,2,3,4,5), and the corresponding system parameter results are associated with these five different values for S.

[45] The month of July, 2007, witnessed a series of smaller defaults and loss warnings by U.S. financial institutions exposed to 'subprime' assets. As a premier U.S. financial player, Bear Stearns publicly acknowledged, on the 17th of July, 2007, major losses (up to 90%) on two of its hedge funds specializing in 'subprime'-related debt investments (Cox and Glapa, 2009:2 and 3). In addition, mortgage delinquencies started their steep ascent in the second semester of 2007 (Financial Crisis Inquiry Commission, 2011:216, Figure 11.1 referring to U.S. total) (Frank, González-Hermosillo and Hesse, 2008:5).

According to the results thus obtained, the optimal value of *S* is one (*S*=1). In accordance with our previously presented decision rule, this is the optimal value of *S* that yields the minimal BIC value - equal to 44155.22 - accompanied by a log-likelihood of –22064.53 and a number of free parameters equal to 7. It should be observed that this value of *S* also reflects the occurrence of international financial contagion processes.

Thus, the results yielded by the latter model application do not allow us to further discern amongst the vector of scrutinised banking institutions, insofar as the said results reflect the absence of heterogeneity in the response behaviour of the said institutions in the aftermath of the Global Financial Crisis. That is, all of the banking institutions associated with the countries included in our sample are confined to the same unique cluster. Table 9 illustrates the composition of this sole cluster that, most naturally, comprises the total set of countries included in our study. Herein, both the prior and posterior probabilities are all equal to one, revealing the strongest possible probabilistic adherence of banking institutions to this sole cluster.

In addition, this unique cluster is characterized by the existence of two different regimes, as can be observed in Table 10. Regime 1 is associated with negative returns (equal to –1.765) and a very high variance (183.429), while regime 2 is associated with slightly negative returns (-0.006) and a much lower variance (20.506). Thus, the distinction stated in the previous sub-section regarding the existence of bear and bull regimes is not applicable to the latter results, insofar as both regimes exhibit negative returns. Notwithstanding, regime 2 is the dominant regime (80.1%), when compared with regime 1 (19.9%). These numbers reflect a significantly difficult period for banking institutions worldwide.

The transition probabilities are also presented in the said Table. Again, regime persistence (95.2% and 98.7%, for regimes 1 and 2 respectively) seems to dominate over regime transition (4.8% and 1.4% for transitioning from regime 1 to 2, and vice-versa). Sojourn time (measured in weeks) is more extended in regime 2 (74.074) than regime 1 (20.704).

As expected, these results are in full agreement with an efficient portrayal of a protracted global systemic crisis episode, where negative returns, coupled with a high volatility, are its major hallmarks.

In view of the above-mentioned findings, but taking into consideration the potency of international financial contagion processes throughout the crisis episode, we should nevertheless observe that the results associated with the present sub-section do not fully account for the occurrence of discriminating financial responses to the Global Financial Crisis. In their study of the global transmission mechanisms in the equity markets during the present global financial turmoil, Ehrmann, Fratzscher and Mehl (2009) analyse and confirm the existence of a set of heterogeneous equity market responses to the said crisis (Ehrmann, Fratzscher and Mehl, 2009:3).

Furthermore, and taking into account the fact that this latter research also encompasses the performance of the global banking industry (as an important component of the referred equity markets), the pursuit of the heterogeneous response hypothesis should not be dismissed in the context of our own research, which will also have to take into account a multi-state regime framework.

That is, in order to ascertain whether the latter heterogeneous hypothesis is indeed pertinent to our own research exclusively addressing the banking system, we will broaden the scope of our model application by taking into account the potential existence of a multiplicity of intermediate states in addition to the ones addressed by the dual state model heretofore estimated. Thus, by incorporating a more broadened set of intermediate regimes – apart from the bear and bull market ones -, it is hoped that a more discriminating (i.e., granular) set of findings might be unearthed.

Accordingly, our subsequent model applications will take into account the simultaneous existence of multiple clusters exhibiting distinct regime dynamics as well as a broader spectrum of framework states according to which our sample's banking institutions might be operating under. This model parameter enlargement will ultimately robustify the results of the dual state model applications by encompassing a more realistic environment for the performance of banking institutions globally through a multi-state modelling approach.

The two model applications presented in the following sub-section are equivalent to the previous two models expounded in sub-sections 3.4.2.1. and 3.4.2.2., although they have been estimated under the auspices of a multi-state regime environment potentially comprising multiple states and corresponding regime dynamics.

3.4.3. EMPIRICAL RESULTS ASSOCIATED WITH THE MULTI-STATE REGIME DYNAMICS FRAMEWORK

In parallel to sub-section 3.4.2., we will initially estimate a third model application covering the entirety of our 'Subprime' global cycle. Finally, a fourth model application will also be estimated exclusively covering the recessionary phase of the latter global business cycle, namely the Crisis aftermath. In these model applications, both the number of clusters and the number of regimes are duly optimised (the latter parameter is not fixed and equal to two, as in sub-section 3.4.2.).

3.4.3.1. THE 2002 – 2010 MULTI-STATE MODEL APLICATION

The main findings associated with this third model application are summarized in the following points.

First, the simultaneous optimization solution of system parameters is detailed in Table 11. Therein, these parameters vary between one and five (for S) and two and five (for K). The BIC optimization rule is now applied to the bivariate pairs of S and K, under the assumption pertaining to the existence of heterogeneity under a multi-state regime framework. That is, our optimization rule will exclude the case where there is a sole cluster and/or there are only two alternating regimes, as these cases have already been dealt with in the preceding sub-sections.

Under this assumption, which is linked to our quest for banking heterogeneity under the auspices of a more realistic regime framework encompassing intermediate states, the minimization of the BIC criterion – equal to 104031.14 - yields an optimal solution of (S=2, K=3). That is, there are two distinct clusters operating under three mutually exclusive regimes. In addition to the two end-of-spectrum bull and bear market regimes, there is an intermediate regime, the characteristics of which will be shortly described.

Notwithstanding, it should be observed that, in absolute terms, the BIC value is also optimised for cases that either display homogeneity (S=1, K=5) or that display a dual state regime alternation (S=3, K=2), which are not in agreement with the goals of

the present sub-section. It should however be pointed out that, in these specific cases, the very existence of these latter optima might potentially signal the high degree of interconnectedness amongst banking institutions globally during the adopted time frame. This issue has already been referred to in previous sub-sections. Our heterogeneous findings are in full agreement with the findings suggested by Ehrmann, Fratzscher and Mehl (2009).

Second, the results pertaining to the estimated prior class probabilities, the cluster dimension, the posterior probabilities associated with the distribution of the banking institutions across the two latent classes (reflecting the degree of membership to each class) and the respective modal class are summarized in Table 12.

The estimated prior class probabilities are 29.6% (cluster 1) and 70.4% (cluster 2), which reflects the fact that the first cluster is significantly less sizable than the second cluster and that banking institutions are unevenly distributed across these two clusters prior to the onset of the systemic event under study.

The estimated posterior class probabilities reflect the degree of membership associated with each of the two clusters in question. The modal class column ascribes each country to a specific cluster, taking into account these probabilities. Thus, cluster 1 comprises the following 12 countries: Argentina, Brazil, Czech Republic, Hungary, India, Israel, Pakistan, Poland, Russia, South Africa, Taiwan and Thailand. While cluster 2 comprises the following 29 countries: Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Italy, Japan, Luxembourg, Malaysia, Mexico, Netherlands, Norway, Peru, Philippines, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, the U.K. and the U.S.A.

Overall, a contrast between Table 3 and Table 12 reveals an overlap between the clusters associated with the above-mentioned model application and the first model application associated with the dual state findings. This fact is noticeable in both the number and composition of the overlapping clusters.

There are, however, two noticeable changes. First, there is a reduction in the number of observed clusters (from three to two), mainly due to the suppression of the third cluster exclusively composed by Turkey (first model) and its subsequent inclusion in the second cluster of the multi-state model. Second, there is an increase in the number

of regimes (from two to three) in light of the introduction of an intermediate regime in the multi-state model, thus providing a more realistic and balanced perspective on the performance of the banking industries herein encompassed during the global business cycle under scrutiny.

This overlapping result is not entirely unexpected, insofar as it implies that there is a greater certainty in ascribing a given set of country banking institutions in our sample to a specific cluster dynamics framework. That is, the 'Subprime' global business cycle has elicited a differentiated set of responses from banking institutions, but the introduction of a greater granularity in our model applications does not radically alter the composition of the clusters. The same reasoning is valid to the posterior probabilities associated with both model applications, which remain largely unaffected by the introduction of an intermediate regime.

Third, the multi-state application yields the results described in Table 13 (a), where each regime's profile and respective dynamics are concerned. The probabilities that the banking institutions might be in one of the three regimes are 9.1% (regime 1), 49.2% (regime 2) and 41.7%. Regime 1 exhibits negative returns and a very high degree of volatility (respectively, -1.85 and 177.17), regime 2 exhibits positive returns associated with a much lower degree of volatility (respectively, 0.25 and 22.641), and regime 3 exhibits the highest (positive) returns with the lowest possible volatility (respectively, 0.434 and 4.943). That is, regime 1 is again markedly associated with a bear market dynamics, regime 2 is associated with a mild bull market dynamics, and regime 3 is associated with a buoyant bull market dynamics.

In addition, Table 13 (b) describes the regime probabilities associated with each individual cluster – as defined by $P(Z|W)$ –, suggesting that banking institutions associated with cluster 1 are in a bearish environment with a probability of 9.1%, in a mild bull environment with 71.1%, and in a bullish environment with a probability of 19.8%. Similarly, the banking institutions associated with cluster 2 are in a bearish environment with a probability of 9%, in a mild bull environment with a probability of 40%, and in a bullish environment with a probability of 51%. That is, banking institutions belonging to this latter cluster have a higher probability of operating under more bullish financial conditions during the adopted crisis time frame. This is specially more resounding in view of the fact that the probability of operating in a recessionary

state is practically the same (approximately 9% for both clusters). In this respect, the main difference between the clusters concerns the much higher probability of performance of cluster 1 countries under a subdued bull market, when compared to that of cluster 2 countries (respectively, 71.1% and 40%).

A possible explanation for this specific finding might reside in the degree of exposure to the expansive dual global bubble in the real estate and credit derivatives markets. This is noticeable in the context of the financial performance of banking institutions belonging to the most advanced economies comprised in our sample, as can be attested by the composition of cluster 2. Simultaneously, the same conclusion might be reached taking into consideration the fact that the banking institutions of the countries belonging to cluster 2 exhibit more integrated financial structures within complete network structures than their respective counterparts in cluster 1. That is, financial networks that are more efficiently connected might shelter banking institutions that are more inclined to international financial diversification processes. Accordingly, these institutions are more efficient in dispersing a higher proportion of their portfolios' gains to other networked institutions in relation to their counterparts in lesser integrated financial networks (Allen and Carletti, 2008:11).

The transition probabilities between these two regimes for each of the two clusters are also presented. Strong intra-cluster regime persistence continues to be observed during this period, with banking institutions belonging to both clusters exhibiting very high probabilities of staying in a given regime (with 93.1%, 95.0% and 85.1% *vs.* 93.9%, 96.2% and 98.1%, respectively for clusters 1 and 2, and for regimes 1, 2 and 3). Throughout the global 'Subprime' business cycle, regime persistence is the norm in both clusters, with a minimum value of 85.1% for the third regime associated with the first cluster. That is, the existence of high inter-regime transience probabilities within the same cluster, most specially during our adopted time frame which encompasses a systemic breakdown, might constitute an important research lead, but our findings do not support this regime-alternating hypothesis.

Where the sojourn time (measured in weeks) is concerned, banking institutions associated with cluster 1 tend to take a lesser amount of time to come out of any given regime than their cluster 2 counterparts (14.388 *vs.* 16.420, 19.920 vs. 26.110 and 6.693 vs. 52.632, respectively for regimes 1, 2 and 3). The difference is greatest in the sojourn

time associated with regime 3 (52.632 – 6.693 = 45.939), suggesting that cluster 2 banking institutions tend to stay a far substantially higher amount of time in strong bull regimes. A potential explanation for this result might have to do with the profitability buoyancy exhibited by banking institutions belonging to the countries comprised in cluster 2. The latter institutions operated under credit and real estate asset bubble environments throughout the scrutinised business cycle, as the cases of the U.K. and the U.S.A. can expressively attest to. This constitutes an important finding that might be ultimately connected with the buoyancy and sustainability of asset price booms in these latter countries and the corresponding association with credit-related financial cycle booms through a deep financial interconnectedness.

Fourth, the multi-state model application pertaining to the existence of a sole cluster is also presented. This non-heterogeneous model application is also characterized by the existence of three regimes, as can be observed in Table 14. Herein, regime 1 is associated with a bearish framework (negative returns coupled with very high volatility), regime 2 is associated with an intermediate bull framework (low but positive returns coupled with medium volatility) and regime 3 is associated with a bullish framework (high positive returns coupled with a very low volatility).

On the other hand, P(z), as the average probability of a given banking institution being in a specific regime is quite high in the case of an intermediate bull environment (regime 2 with 51.8%), followed by that of the bull environment (regime 3 with 38.7%) and, lastly, followed by that of the bearish environment (9.5%).

The corresponding transition probabilities also indicate a very strong regime persistence across the three regimes (this persistence is highest in the bullish state), with corresponding very low probabilities associated with regime transience. Sojourn time (in weeks) is also highest in this bullish framework (42.553), followed by the intermediate regime (34.014), and, lastly, by the bear regime (15.974).

Fifth, the synchronization of heterogeneous timeline patterns for the country banking institutions belonging to both clusters is also presented. The posterior probabilities described in Figures 6 and 7 indicate a significant synchronized impact associated with the occurrence of the Global Financial Crisis across our sample. These results are in strict accordance with the synchronization findings associated with the corresponding dual state model pertaining to the 2002 – 2010 time frame.

Figure 6 details the said impact to cluster 1 countries. Up until mid-2008, the countries therein comprised were mostly alternating between regimes 2 and 3, the former being the dominant state between the two, notwithstanding country-specific idiosyncrasies. Therefore, during this time frame, intermediate bull and bull regimes seem to dominate over the bear regime. In addition, Argentina, Brazil and Russia seem to have experienced the financial impact of the 'Dot-Com' Crisis in 2002.

However, the financial impact associated with the occurrence of the present Global Financial Crisis seems to have been widely felt in 2008 across our cluster sample. The said impact was transversally persistent, structural and synchronized across the whole cluster. Accordingly, the summer of 2008 seems to have witnessed the full onset of the impact of the Global Financial Crisis for all the countries herein comprised. The corresponding bear regime duration varied across countries, with Hungary being, on this issue, the worst hit country, while Argentina seems to have been the least affected. The systemic Crisis mostly subsided in 2009, although the rebound capacity is quite distinct across the cluster. Hungary, for example, was overpowered by a further bear episode in 2010 affecting its banking institutions.

Figure 7 details the corresponding financial impact to cluster 2 countries. The corresponding results further confirm that the Global Financial Crisis indeed constituted a systemic episode of persistent, structural and highly synchronized impact throughout the cluster's sample.

These attributes can be clearly discerned in the fact that banking institutions belonging to both the U.K. and the U.S.A., which were clearly at the epicentre of the systemic episode under study, operated under a very bullish environment throughout the 'Subprime' cycle. Once the systemic crisis set in in 2008, these institutions were subjected to a severe downturn that only subsided in mid-2009. Overall, these institutions overtly experienced a sustained asset price boom that was followed by a severe downturn of systemic magnitude.

The main difference to the previous Figure pertains to the fact that the overall propensity to experience a bull regime for the countries included in cluster 2 is much higher than that associated with cluster 1 countries. This important finding might help explain the formation of the real estate and credit bubbles, most specially where the case of the most advanced economies herein included are concerned. Taking into

consideration the two financial contagion approaches suggested by Allen and Carletti (2008), - reviewed in sub-section 3.2.3. -, our findings also confirm that a high degree of financial inter-connectedness is ultimately positively correlated with the development of the above-mentioned twin asset price booms. Under the influence of the latter bubbles, financial institutions reaping the benefits of financially integrated structures were subsequently compromised by the implosion thereof, through severe financial contagion processes. As observed in both Figures 6 and 7, the occurrence of the systemic event under study is truly global and simultaneous. Furthermore, the same conclusion pertaining to the elevated synchronization of the onset of the global systemic episode is reached when contrasting Figures 3, 4 and 5 with Figures 6 and 7.

On the other hand, a more nuanced difference pertaining to the dual state and multi-state model applications concerns the fact that, whereas under the former, Turkey constituted a single cluster (dual), under the latter, Turkey is incorporated within cluster 2 (multi-state). This aligns this country's interests with those of the constellation of the European Union countries, and, more specifically, also reflects the alignment of financial links between Turkish and Euro Union financial institutions.

3.4.3.2. THE 2007–2010 MULTI-STATE MODEL APLICATION

Analogous to the reasoning pursued under the dual state model application, a model application pertaining to the multi-state 2007 – 2010 time frame was also estimated. This was performed in order to provide a more granular assessment of the Global Financial Crisis' systemic impact on country banking institutions.

First, the optimal choice of parameter values for S (clusters) and K (regimes) is made taking into account a modified version of the previously used BIC optimising rule. The introduction of this rule variant is due to the fact that, for each value of K, the corresponding value of S is equal to one, as can be observed from Table 15. As K increases, the BIC value decreases, but with an ever smaller marginal impact upon the system's efficiency, as measured by the rate of change in the BIC value. Accordingly, we will seek to optimise the number of regimes – thereby effectively curbing the computation of an excessive number of states -, by choosing the value of K equal to the first regime associated with a marginal contribution to the BIC value inferior to 50 basis

points. By following this rule, we are effectively implementing a twofold optimisation. Accordingly, the value of S is equal to one, while the value of K is equal to four. That is, the optimal result yields a sole undifferentiated and non-heterogeneous cluster, operating under the framework of four distinct regimes. In comparison to the dual-state model counterpart, the main difference pertains to the existence of a greater number of states (4 *vs.* 2).

Second, the results pertaining to the estimated prior class probabilities, the cluster composition and the posterior probabilities associated with the distribution of the banking institutions within the sole homogeneous latent class (reflecting the degree of membership to the sole cluster or modal class) are summarized in Table 16. Our entire sample is encompassed within the sole cluster, with the maximum adherence possible (with a probability equal to one).

Third, the estimated regime dynamics, regime occupancy and regime transition pertaining to the multi-state model application addressing the aftermath of the Global Financial Crisis is also presented. This non-heterogeneous model application is characterized by the existence of a sole cluster operating with four possible regimes, as can be observed in Table 17. Herein, regime 1 is associated with a strong bearish framework (severe negative returns of -4.671 coupled with a very high volatility of 377.092), regime 2 is associated with a mild bearish environment (mild negative returns of -0.982 with a low volatility of 17.124), regime 3 is associated with a very subdued bearish framework (low negative returns of -0.068 associated with a medium volatility of 55.227) and, finally, regime 4 is associated with a strong bull environment (high returns of 0.936 coupled with a very low volatility of 10.46).

On the other hand, P(z), as the average probability of a given banking institution being in a specific regime, is quite high in the case of intermediate states 3 (34.8%) and 2 (30.5%), followed by the bullish regime 4 (28.4%). The average probability of operating under the most severe contractionary regime 1 is 0.063.

The corresponding transition probabilities indicate a very mixed regime persistence across the four regimes. On the one hand, regime persistence is high in regimes 1 (88.6%) and 3 (94.3%). Severe and subdued bear market regimes are persistent. On the other hand, regime persistence is quite low in regimes 2 and 4 (transitioning from regimes 2 to 4 and 4 to 2 is very likely). That is, the probability of

regime transience involving mild recessions and bullish environments is quite high. Finally, sojourn time (in weeks) is highest in subdued bear markets (17.575) and lowest in bullish environments (1.001). Simultaneously, sojourn time is significantly higher in severe bear markets (8.787) when compared to that of bull market states (1.001).

In comparison to the dual-state counterpart, the present model application adds a greater degree of regime granularity, notwithstanding the fact that the conclusions remain the same.

Finally, we would like to draw some final considerations pertaining to the overall findings associated with our empirical model applications.

In view of the results obtained, it should be observed that the previously referred findings sustaining the heterogeneity of banking responses are fully validated by the findings associated with our distinct model applications.

Notwithstanding, a full assessment of the different model applications should also take into account any potential shortcomings. In this context, we would like to observe that the findings described in this section point out three shortcomings in the HRSM-S framework.

First, the estimation of the model applications is sensitive on the chosen periodicity, which might have a direct bearing on the application's results. However, this shortcoming is attenuated by the fact that different model applications (each associated with a specific input periodicity) might also constitute powerful robustness tests as to the existence of response heterogeneity across the data input spectrum.

Second, the adoption of the U.S. Dollar as the standard benchmark for our analysed time series, while facilitating international comparisons, does not take into account the evolution of exchange rates and their corresponding impact on our research. However, a model taking into account the effects of exchange rates would not easily allow for the isolation of 'pure' banking responses.

Third, further research should also contemplate the construction and implementation of structural breaks testing that might more clearly identify the onset of specific systemic episodes that are transversal to the adopted sample.

Notwithstanding these limitations, we would also like to draw attention to a potentially important research issue that might warrant further investigation. This issue refers to the fact that, while the model applications pertaining to the long model applications (2002-2010) exhibit multiple clusters, the short model applications (2007-2010) pertaining to the aftermath of the Global Financial Crisis exhibit a sole cluster. Table 18 succinctly sums up the main characteristics of our model applications and highlights this specific finding.

Should this finding constitute a non-spurious event, it might be of further interest as a subsequent and fundamental research topic. Its strategic importance lies in the fact that this structural reduction in banking performance heterogeneity in the aftermath of the latest global systemic episode might also be directly applicable to the occurrence of other systemic financial events – either historical or future -, apart from the Global Financial Crisis presently under study. This issue constitutes a promising research topic and merits further research.

Where the specific case of the present Global Financial Crisis is concerned, a potential financial explanation for this interesting finding pertains to the fact that the occurrence of a systemic shock of global magnitude might have jeopardised the pursuit of the heterogeneous return – risk strategies by banking institutions worldwide. That is, the performance of banking institutions might have been jointly affected by the occurrence of a globally adverse common shock, such as the widespread massive rise in 'toxic' assets held by banking institutions worldwide.

Thus, the post-crisis homogeneity hypothesis implicit in this reasoning pertains to the fact that common negative shocks inherent to the occurrence of systemic failures induce a loss of heterogeneity, in view of the transversality of the said financial shocks. In view of the present working paper's stated goals, our empirical research is not capable of assessing the validity of this hypothesis. The latter hypothesis needs to be properly addressed within the context of the theoretical model underlying the framework of our strictly empirical model applications.

In the following section, we will summarize our main conclusions.

3.5. CONCLUDING REMARKS

The Global Financial Crisis of 2007 – 2008 has been a truly systemic breakdown of unprecedented proportion, deeply affecting financial markets and institutions, in particular banking institutions worldwide.

During the occurrence of such a truly global event, banking institutions in pursuit of their individual and rational profit-maximizing strategies may have prompted a collective display scarred by irrational outcomes and ensuing lack of market equilibria, thus re-enforcing the very momentum of the said systemic failure. This pattern was clearly observable in the latest global financial systemic event.

Notwithstanding, these seemingly irrational outcomes disguised a highly heterogeneous pattern of individual banking behaviour in response to the Global Financial Crisis. Throughout our research, we have demonstrated the underlying banking response differentiation in the context of the latest systemic failure.

Our applications of the HRSM-S model have unearthed a framework of heterogeneous banking responses. The first and third model applications comprised the full extent of the 'Subprime'-related business cycle leading up to the present Global Financial Crisis (including its aftermath). While the second and fourth model applications strongly emphasised the systemic crisis component.

Our findings may be summarized in the following four main points.

First, our results suggest that heterogeneous responses are most appropriately captured within the architecture of the HRSM-S clusters, whose overall membership probabilities were quite convincing as to the efficiency of this heterogeneous response categorization.

Second, each of the distinctive clusters grouping similar responses possesses a distinctive regime dynamics. These latter regimes, which are common to all clusters, are clearly identifiable with traditional bull and bear financial regime dynamics, thus contributing to a greater insight into the performance of banking institutions throughout this global episode. These findings are further extended by addressing the existence, within a multi-state framework, of intermediate states between bear and bull market states, thus adding a deeper regime granularity to our findings.

Third, a mapping of the correlations amongst distinct banking institutions worldwide further discriminates the degree of inter-connectedness amongst different financial systems, which contributes to a greater understanding of the geo-financial networks' responses to the latest systemic crisis.

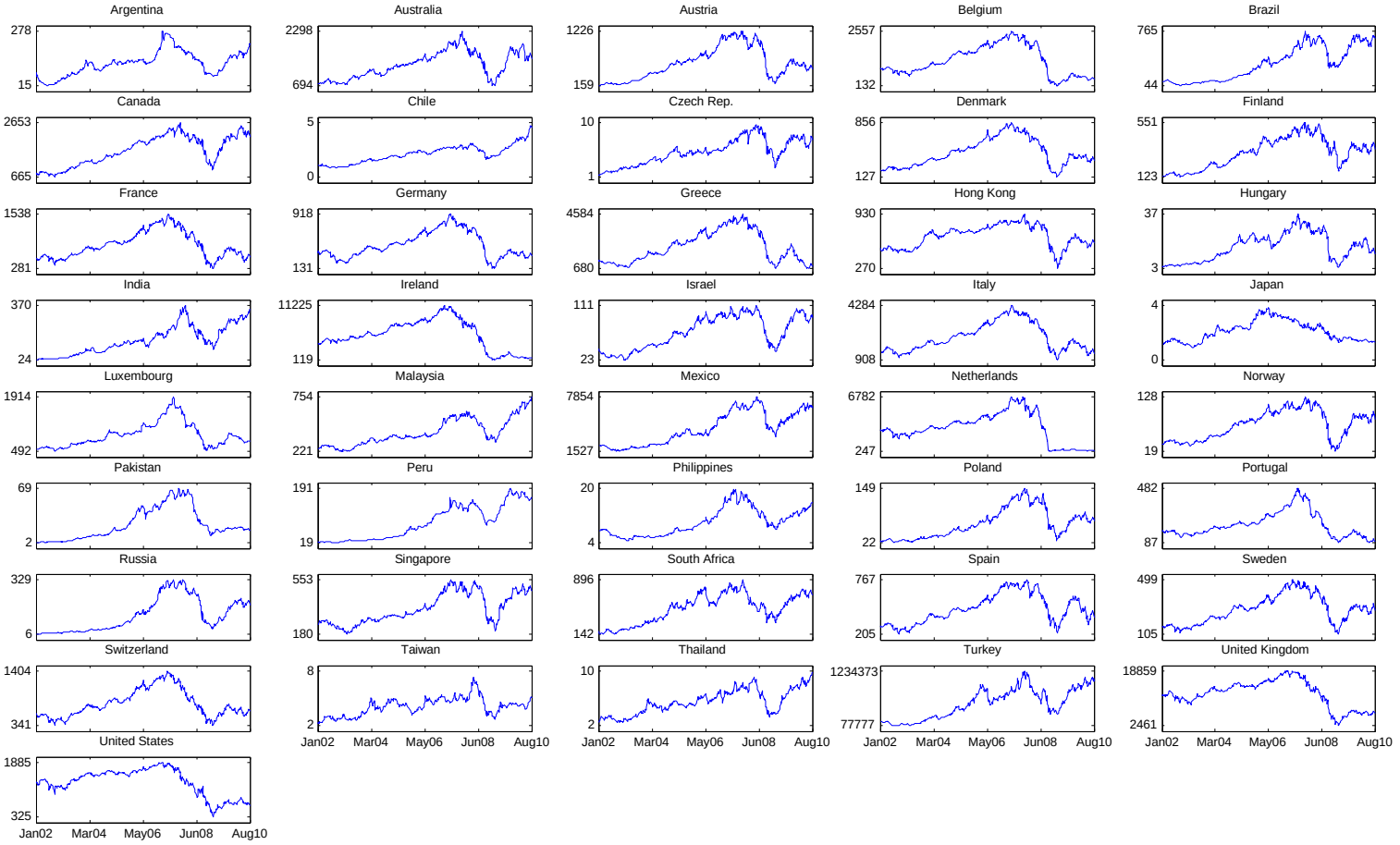
Fourth, the inter- and intra-cluster synchronization patterns of the banking institutions' responses to the Global Financial Crisis finally completes our research, by describing how perfectly synchronized individual country responses were to this global systemic failure. This synchronization occurred even when taking into account the high degree of heterogeneity observed in the said responses addressing the global systemic event under scrutiny.

An important research topic that surrounds our research concerns the fact that the onset of the Global Financial Crisis might be associated with a loss of heterogeneity associated with the impact of a transversal common shock. This research lead might constitute an important reference for the future study of the impact of other (both past and future) extreme systemic events.

Our research has unearthed a comprehensive variety of worldwide banking responses elicited in the wake of the Global Financial Crisis. It might only be hoped that our adequate portrayal of the latter heterogeneous responses might constitute a most helpful instrument in designing more idiosyncratic (and hence, more effective) supervisory policy responses addressing the occurrence of future financial systemic events, in full acknowledgement of the fundamental importance of banking heterogeneity responses.

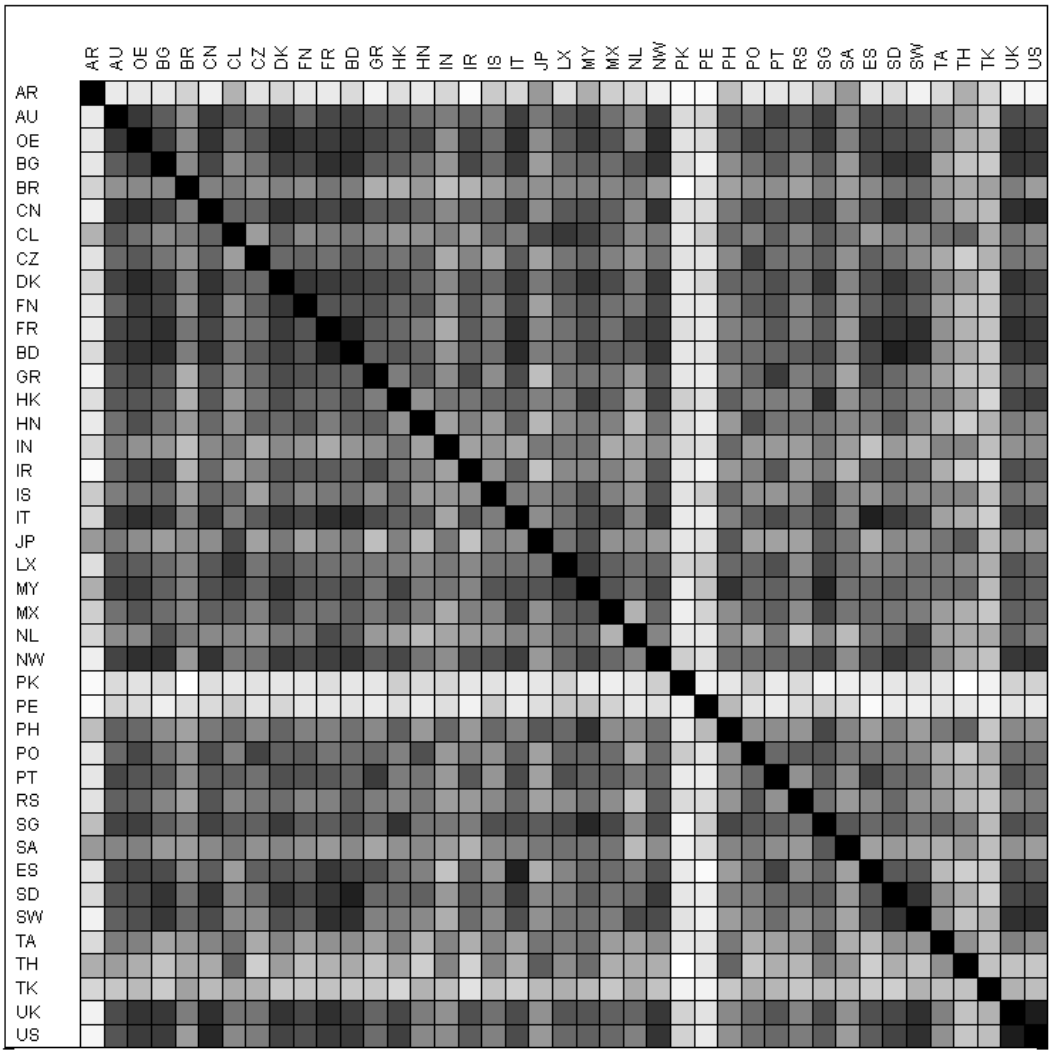
APPENDIX B

FIGURE 1 - TIMES SERIES FOR EACH COUNTRY BANKING INDEX*



Source of underlying data: Datastream. *China is not included in this Figure due to full data unavailability.

FIGURE 2 – ABSOLUTE CORRELATIONS* **



*This Figure depicts the minimum and maximum correlation values (-1 and 1, respectively) within a color grading scale. Minimum (white) and maximum (black) constitute the extreme values of this scale, with a linear grading of grey colors depicting intermediate correlation values.

** Similar Figures corresponding to subsequent model applications that will be herein presented have not been included in order to avoid encumbering the length of the present document; notwithstanding, the said Figures are available upon request.

FIGURE 3 - ESTIMATED POSTERIOR BEAR REGIME PROBABILITY AND LATENT MODAL CLASS ADHERENCE WITHIN LATENT CLASS 1 FOR THE DUAL STATE MODEL APPLICATION (2002 – 2010)

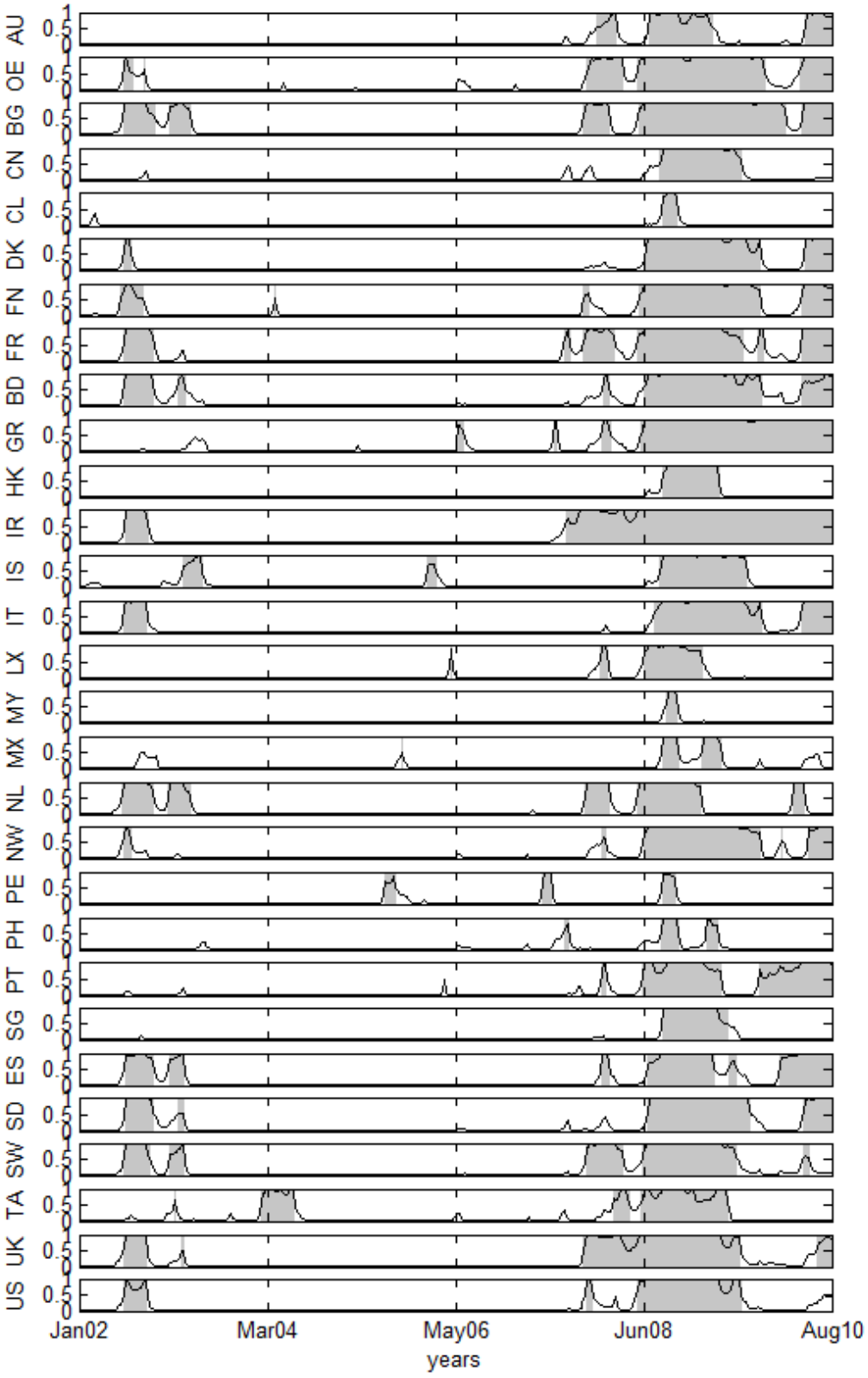


FIGURE 4 - ESTIMATED POSTERIOR BEAR REGIME PROBABILITY AND LATENT MODAL CLASS ADHERENCE WITHIN LATENT CLASS 2 FOR THE DUAL STATE MODEL APPLICATION (2002 – 2010)

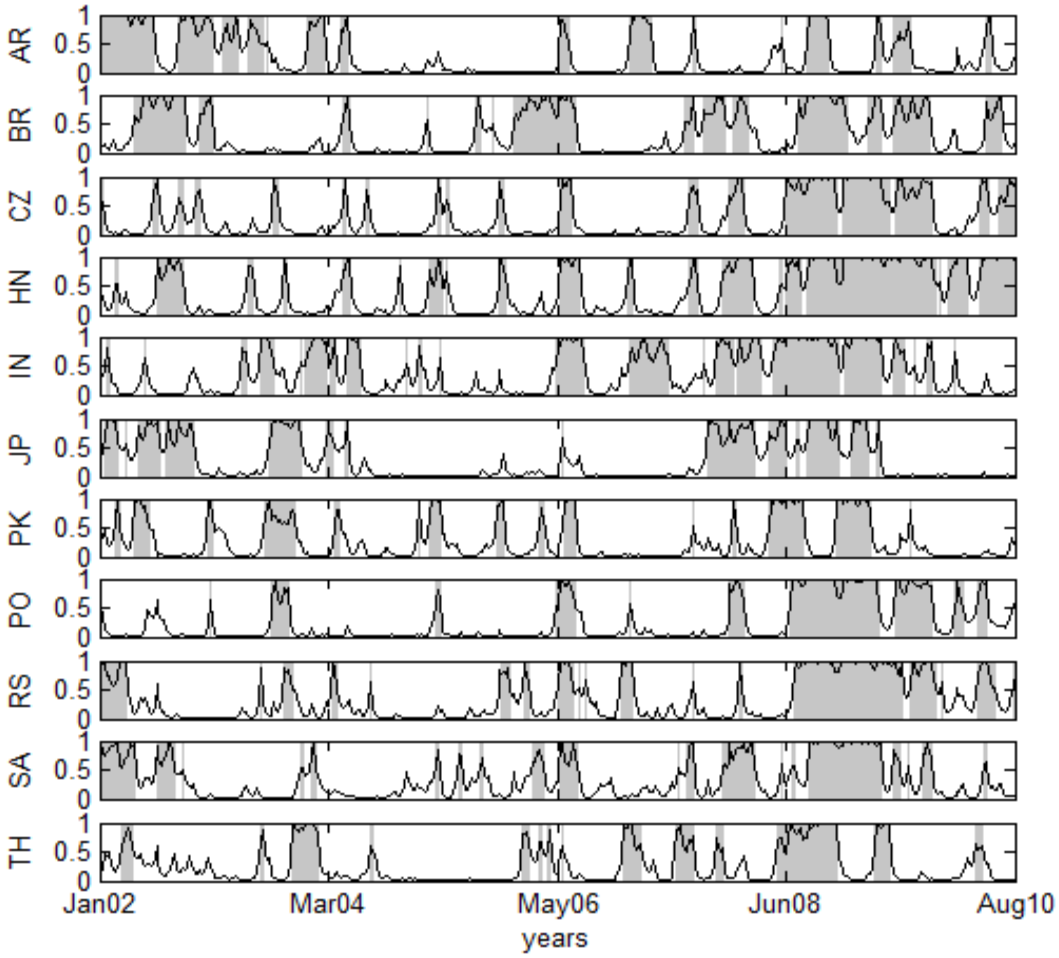


FIGURE 5 - ESTIMATED POSTERIOR BEAR REGIME PROBABILITY AND LATENT MODAL CLASS ADHERENCE WITHIN LATENT CLASS 3 FOR THE DUAL STATE MODEL APPLICATION (2002 – 2010)

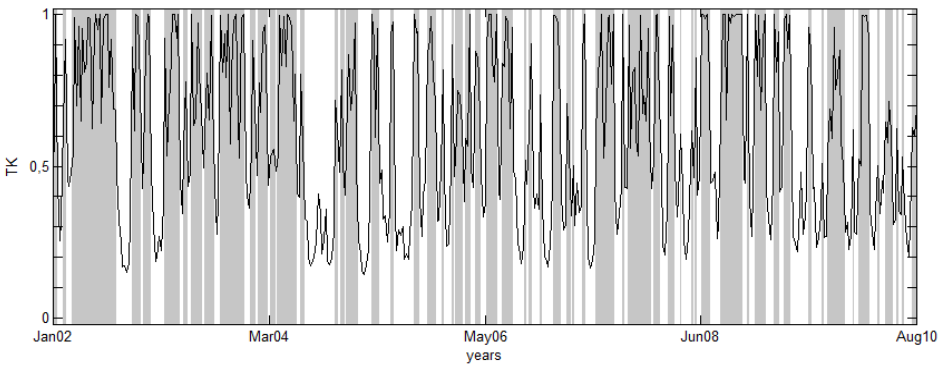


FIGURE 6 - ESTIMATED POSTERIOR BEAR REGIME PROBABILITY AND LATENT MODAL CLASS ADHERENCE WITHIN LATENT CLASS 1 FOR THE MULTI-STATE MODEL APPLICATION (2002 – 2010)

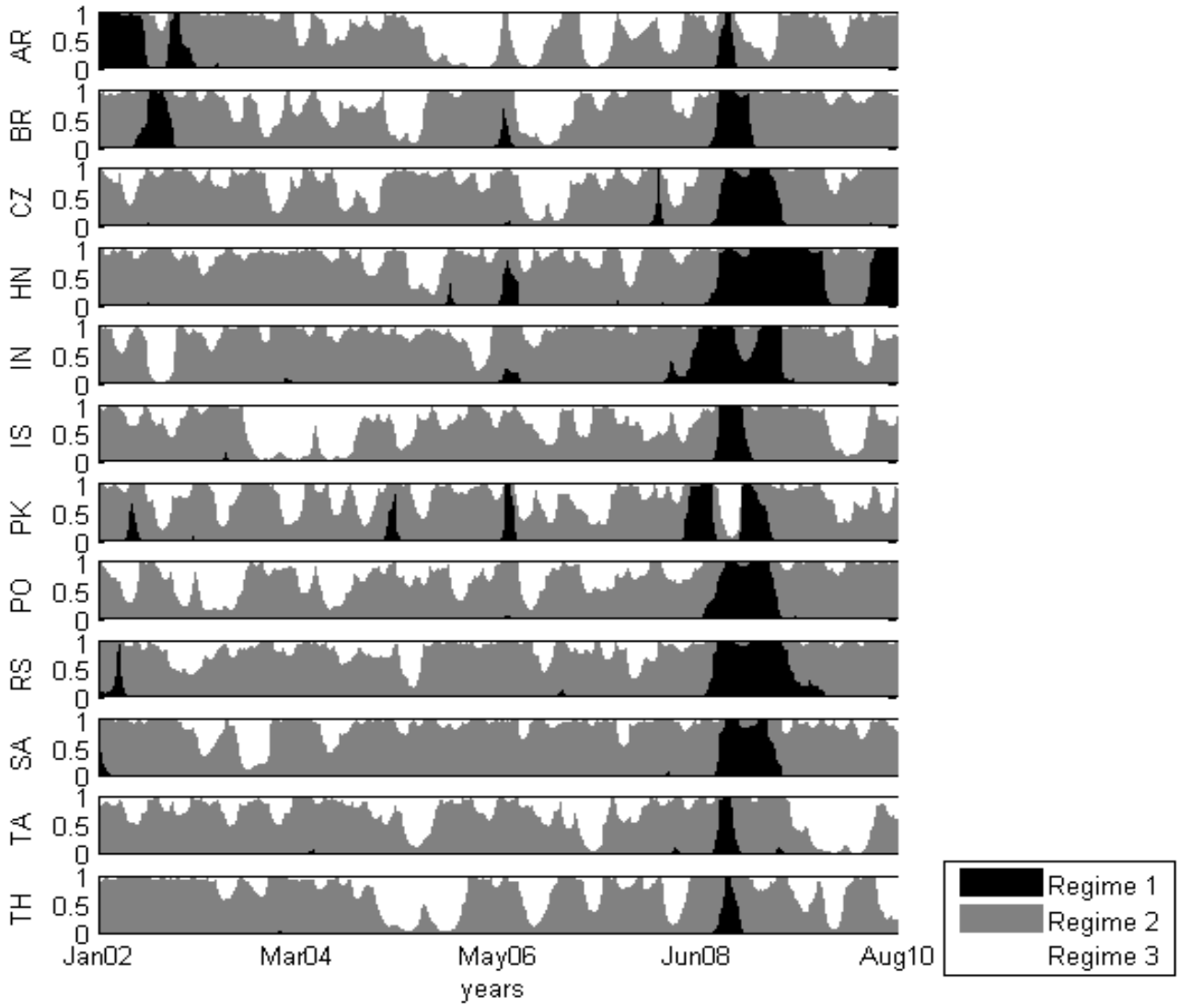


FIGURE 7 - ESTIMATED POSTERIOR BEAR REGIME PROBABILITY AND LATENT MODAL CLASS ADHERENCE WITHIN LATENT CLASS 2 FOR THE MULTI-STATE MODEL APPLICATION (2002 – 2010)

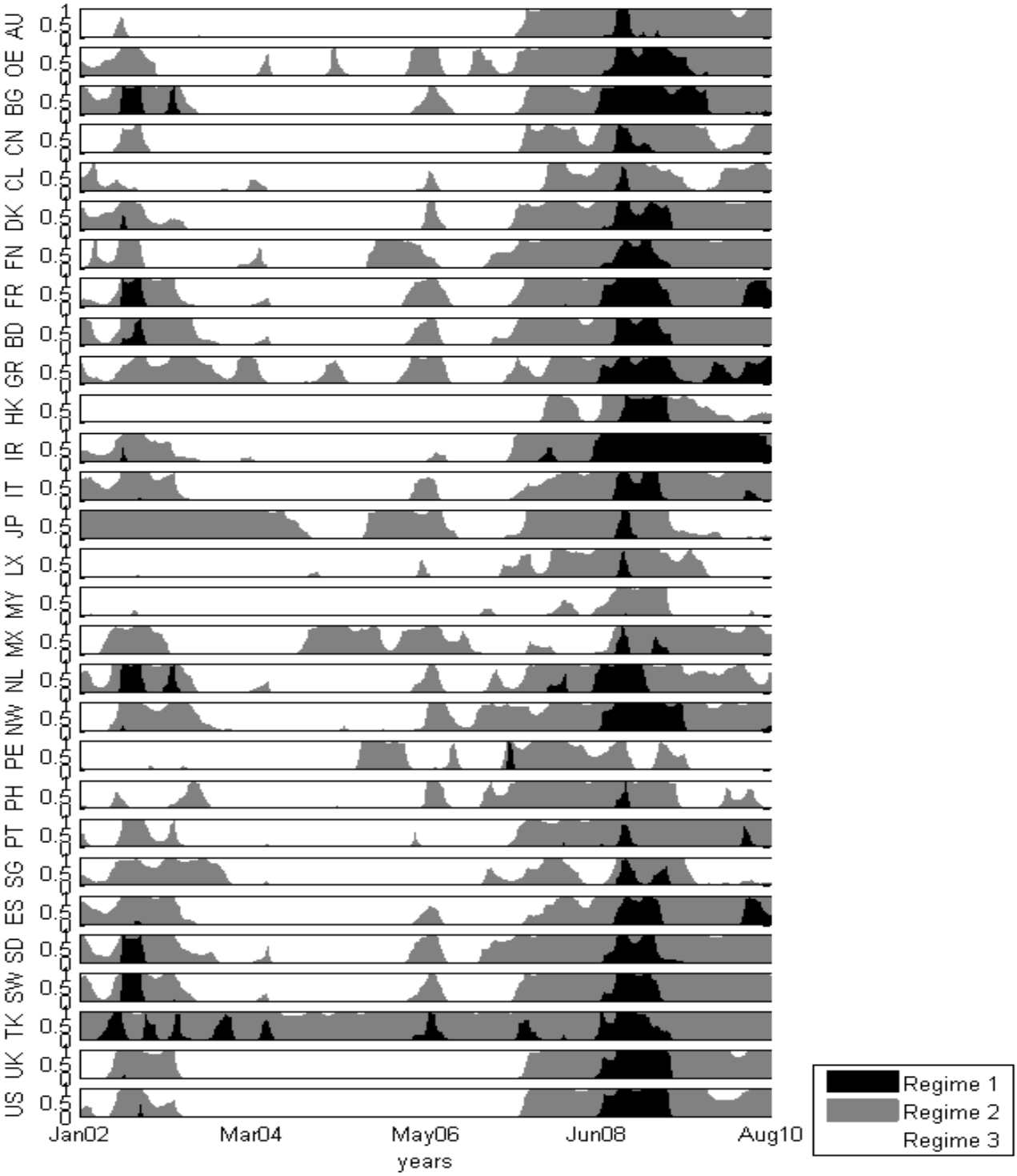


TABLE 1 - PRELIMINARY STATISTICS*

COUNTRY	Mean	Median	Std. Deviation	Skewness	Kurtosis	Jarque-Bera test	
				[both adjusted for bias]		statistics	p-value
Argentina (AR)	0,145	0,455	5,695	-0,938	8,474	605,80	0,000
Australia (AU)	0,153	0,546	4,049	-1,000	10,382	1059,51	0,000
Austria (OE)	0,235	0,735	5,457	-0,784	7,122	351,07	0,000
Belgium (BG)	-0,171	0,555	7,132	-1,185	11,455	1398,17	0,000
Brazil (BR)	0,408	0,770	5,919	-1,538	12,732	1890,95	0,000
Canada (CN)	0,218	0,385	3,510	-0,255	5,763	141,19	0,000
Chile (CL)	0,295	0,501	3,239	-1,169	12,716	1811,47	0,000
Czech Rep. (CZ)	0,383	0,393	5,714	-0,588	8,437	558,70	0,000
Denmark (DK)	0,086	0,455	4,798	-0,728	10,466	1047,40	0,000
Finland (FN)	0,217	0,460	4,723	-1,515	16,157	3310,61	0,000
France (FR)	0,018	0,524	5,583	-0,057	6,915	275,67	0,000
Germany (BD)	-0,047	0,299	5,519	-0,896	9,300	776,30	0,000
Greece (GR)	-0,112	0,428	5,383	-0,699	6,793	294,66	0,000
Hong Kong (HK)	0,028	0,132	3,348	-0,477	11,774	1410,62	0,000
Hungary (HN)	0,266	1,063	7,465	-1,320	11,541	1449,62	0,000
India (IN)	0,596	0,690	5,809	0,316	6,312	203,94	0,000
Ireland (IR)	-0,438	0,134	11,672	-0,253	29,401	12675,42	0,000
Israel (IS)	0,176	0,326	4,362	-0,109	5,780	138,94	0,000
Italy (IT)	-0,024	0,247	4,475	-0,446	6,105	187,33	0,000
Japan (JP)	-0,007	0,000	4,582	-0,049	4,423	35,67	0,000
Luxembourg (LX)	0,064	0,278	3,129	-0,414	8,534	565,11	0,000
Malaysia (MY)	0,255	0,284	2,656	-0,120	5,147	82,95	0,000
Mexico (MX)	0,257	0,554	3,986	-0,929	12,572	1723,72	0,000
Netherlands (NL)	-0,487	0,283	8,462	-8,634	132,343	310152,74	0,000
Norway (NW)	0,198	0,587	6,170	-0,908	11,909	1498,24	0,000
Pakistan (PK)	0,471	0,642	5,356	-0,894	6,583	289,65	0,000
Peru (PE)	0,457	0,191	3,175	0,705	10,457	1042,45	0,000
Philippines (PH)	0,182	0,150	3,527	-0,004	5,511	112,41	0,000
Poland (PO)	0,241	0,599	5,492	-1,349	10,166	1063,42	0,000
Portugal (PT)	-0,139	0,142	3,892	-0,661	6,135	208,41	0,000
Russia (RS)	0,753	0,983	6,636	-0,625	13,104	1878,83	0,000
Singapore (SG)	0,155	0,082	3,684	0,453	10,366	996,53	0,000
South Africa (SA)	0,324	0,466	5,451	-0,644	7,348	370,92	0,000
Spain (ES)	0,047	0,291	4,618	-0,398	6,032	176,32	0,000
Sweden (SD)	0,114	0,531	5,122	-0,599	7,356	368,01	0,000
Switzerland (SW)	0,012	0,139	4,925	-0,236	6,579	233,91	0,000
Taiwan (TA)	0,178	0,206	4,363	0,019	5,265	91,27	0,000
Thailand (TH)	0,308	0,252	4,525	-0,088	3,760	10,35	0,006
Turkey (TK)	0,398	0,912	7,048	-0,596	4,698	77,19	0,000
United Kingdom (UK)	-0,146	0,105	5,129	-0,691	13,647	2089,84	0,000
United States (US)	-0,159	0,017	4,903	-0,167	12,091	1498,63	0,000

* This Table reports the descriptive statistics and the Jarque-Bera test statistics referring to the time series portraying the performance - measured as weekly returns - of each of the selected country banking sectors. The values refer to logarithmic first differences.

TABLE 2 - HRSM-S DUAL STATE MODEL ESTIMATION (2002 – 2010)*			
S (MODEL PARAMETER)	**LOG-LIKELIHOOD**	**NUMBER OF FREE PARAMETERS**	**BIC**
1	-52961,86	7	105949,72
2	-52913,14	11	105867,12
3	**-52902,31**	**15**	**105860,32**
4	-52899,64	19	105869,84
5	-52898,54	23	105882,49

* This Table portrays the estimation of the HRSM-S, using different values of S (S = 1,2,3,4,5). The optimal solution (S = 3) yields the lowest BIC value.

TABLE 3 - ESTIMATED PRIOR PROBABILITIES, POSTERIOR PROBABIBILITIES AND MODAL CLASSES FOR HRSM-3 (*S*=3)*

	Cluster 1	Cluster 2	Cluster 3	Modal Latent Class
Prior probabilities	0,704	0,265	0,032	
Posterior probabilities				
Country				
Argentina (AR)	0,000	1,000	0,000	2
Australia (AU)	1,000	0,000	0,000	1
Austria (OE)	0,999	0,001	0,000	1
Belgium (BG)	1,000	0,000	0,000	1
Brazil (BR)	0,034	0,967	0,000	2
Canada (CN)	1,000	0,000	0,000	1
Chile (CL)	1,000	0,000	0,000	1
Czech Rep. (CZ)	0,001	0,999	0,000	2
Denmark (DK)	1,000	0,000	0,000	1
Finland (FN)	1,000	0,000	0,000	1
France (FR)	0,999	0,001	0,000	1
Germany (BD)	0,962	0,038	0,000	1
Greece (GR)	1,000	0,000	0,000	1
Hong Kong (HK)	1,000	0,000	0,000	1
Hungary (HN)	0,000	1,000	0,000	2
India (IN)	0,013	0,987	0,000	2
Ireland (IR)	1,000	0,000	0,000	1
Israel (IS)	1,000	0,000	0,000	1
Italy (IT)	1,000	0,000	0,000	1
Japan (JP)	0,225	0,775	0,000	2
Luxembourg (LX)	1.000	0.000	0.000	1
Malaysia (MY)	1,000	0,000	0,000	1
Mexico (MX)	0,998	0,002	0,000	1
Netherlands (NL)	1,000	0,000	0,000	1
Norway (NW)	1,000	0,000	0,000	1
Pakistan (PK)	0,000	1,000	0,000	2
Peru (PE)	1,000	0,000	0,000	1
Philippines (PH)	0,999	0,001	0,000	1
Poland (PO)	0,168	0,832	0,000	2
Portugal (PT)	0,978	0,022	0,000	1
Russia (RS)	0,000	1,000	0,000	2
Singapore (SG)	1,000	0,000	0,000	1
South Africa (SA)	0,000	1,000	0,000	2
Spain (ES)	1,000	0,000	0,000	1
Sweden (SD)	1,000	0,000	0,000	1
Switzerland (SW)	0,999	0,002	0,000	1
Taiwan (TA)	0,841	0,159	0,000	1
Thailand (TH)	0,005	0,995	0,000	2
Turkey (TK)	0,000	0,000	1,000	3
United Kingdom (UK)	1,000	0,000	0,000	1
United States (US)	1,000	0,000	0,000	1

* This Table reports the estimated Prior probabilities describing the size of each Latent Class or Cluster (the results point to the existence of three distinct Clusters). Furthermore, the estimated (country-specific) Posterior probabilities represent banks' degree of membership (taking into account each individual country) to each of the Clusters in question. The maximum Posterior probability for each country yields the corresponding Modal Latent Class.

TABLE 4 (a) - ESTIMATED MARGINAL PROBABILITIES OF REGIMES

	P(Z)*		Return (mean)		Risk (variance)	
	Regime 1	**Regime 2**	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
	0,25	0,75	-0,657	0,394	92,464	8,956
	(0,021)	(0,021)	(0,151)	(0,028)	(2,789)	(0,184)

TABLE 4 (b) - ESTIMATED CLUSTER-SPECIFIC PROBABILITIES OF REGIMES, REGIME OCCUPANCY FOR EACH CLUSTER, REGIME TRANSITION AND SOJOURN TIME**

	Cluster 1		Cluster 2		Cluster 3	
	Regime 1	**Regime 2**	**Regime 1**	**Regime 2**	**Regime 1**	**Regime 2**
P(Z|W)**	0,206	0,794	0,323	0,677	0,599	0,401
	(0,022)	(0,022)	(0,024)	(0,024)	(0,052)	(0,052)
Regime 1	0,957	0,043	0,848	0,152	0,746	0,254
	(0,005)	(0,005)	(0,020)	(0,020)	(0,075)	(0,075)
Regime 2	0,012	0,988	0,072	0,928	0,379	0,621
	(0,001)	(0,001)	(0,010)	(0,010)	(0,102)	(0,102)
Sojourn time (weeks)	23,095	84,746	6,566	13,908	3,932	2,636

* P(Z) represents the average proportion of banking institutions in each regime. The mean and variance of each regime are also presented. Standard errors are presented in parenthesis.

** P(Z|W) represents the proportion of banking institutions in each regime for each of the three considered Clusters. Standard errors are presented in parenthesis. Sojourn time represents the expected amount of time a banking institution takes to exit a given regime.

TABLE 5 - HRSM-1 (*S*=1) ESTIMATED REGIME DYNAMICS, REGIME OCCUPANCY AND ESTIMATED REGIME TRANSITION*

Regimes	**Return (mean)**	**Risk (variance)**	**P(Z)***	**Transition probabilities**		**Sojourn time (weeks)**
				Regime 1	Regime 2	
Regime 1	-0,669	92,592	0,130	0,940	0,060	16,779
	(0,152)	(2,776)	(0,061)	(0,005)	(0,005)	
Regime 2	0,394	9,277	0,870	0,019	0,981	52,083
	(0,028)	(0,190)	(0,061)	(0,002)	(0,002)	

* P(Z) represents the average proportion of banking institutions in a given regime, taking into account that all of the latter institutions are grouped in a single Cluster (assuming there is no heterogeneity). Standard errors are presented in parenthesis.

TABLE 6 - ESTIMATED REGIME DURATIONS (IN WEEKS)*

Countries	Bear regime					Bull regime				
	Mean	Q1	Median	Q3	IQR	Mean	Q1	Median	Q3	IQR
Argentina (AR)	8,1	3,0	8,0	11,0	8,0	22,0	4,0	12,0	29,0	25,0
Australia (AU)	22,7	12,0	17,0	39,0	27,0	127,7	19,0	54,0	310,0	291,0
Austria (OE)	25,2	3,5	20,0	49,5	46,0	65,0	7,0	20,0	145,5	138,5
Belgium (BG)	31,0	14,5	19,0	88,0	73,5	59,2	8,5	17,0	131,0	122,5
Brazil (BR)	11,1	4,0	7,5	19,0	15,0	19,7	5,0	10,0	27,0	22,0
Canada (CN)	50,0	-	50,0	-	-	200,5	54,0	200,5	347,0	293,0
Chile (CL)	9,0	-	9,0	-	-	221,0	93,0	221,0	349,0	256,0
Czech Rep. (CZ)	7,2	2,0	4,0	9,0	7,0	17,9	4,0	16,5	27,0	23,0
Denmark (DK)	30,3	5,0	17,0	69,0	64,0	120,0	26,0	27,0	307,0	281,0
Finland (FN)	22,2	2,5	14,0	46,0	43,5	68,0	24,5	29,0	131,0	106,5
France (FR)	21,3	4,0	18,5	19,0	15,0	53,8	8,0	17,5	27,0	19,0
Germany (BD)	23,4	4,5	18,0	45,0	40,5	66,8	17,0	23,0	138,5	121,5
Greece (GR)	31,8	3,0	5,0	60,5	57,5	81,0	22,0	40,0	140,0	118,0
Hong Kong (HK)	35,0	-	35,0	-	-	208,0	67,0	208,0	349,0	282,0
Hungary (HN)	9,3	2,0	5,0	12,5	10,5	14,4	3,0	13,0	24,0	21,0
India (IN)	7,4	1,0	3,0	12,0	11,0	12,6	1,5	5,0	17,0	15,5
Ireland (IR)	87,0	14,0	87,0	160,0	146,0	138,5	28,0	138,5	249,0	221,0
Israel (IS)	23,7	6,0	12,0	53,0	47,0	95,0	56,5	97,5	133,5	77,0
Italy (IT)	32,7	14,0	19,0	65,0	51,0	117,7	23,0	27,0	303,0	280,0
Japan (JP)	8,7	2,0	8,0	14,0	12,0	21,9	3,0	5,0	36,0	33,0
Luxembourg (LX)	13,7	1,0	5,0	35,0	34,0	102,5	49,5	83,5	155,5	106,0
Malaysia (MY)	7,0	-	7,0	-	-	222,0	93,0	222,0	351,0	258,0
Mexico (MX)	8,0	1,0	10,0	13,0	12,0	106,8	39,5	110,5	174,0	134,5
Netherlands (NL)	18,6	10,5	15,0	28,5	18,0	59,7	16,0	21,5	55,0	39,0
Norway (NW)	18,8	2,0	5,0	42,5	40,5	71,4	13,5	22,0	154,0	140,5
Pakistan (PK)	6,3	2,0	4,0	8,0	6,0	22,3	10,0	19,0	33,0	23,0
Peru (PE)	7,0	6,0	7,0	8,0	2,0	107,5	76,5	90,5	138,5	62,0
Philippines (PH)	7,0	3,0	7,0	11,0	8,0	107,5	36,0	61,5	179,0	143,0
Poland (PO)	7,9	1,0	4,0	9,0	8,0	26,2	8,5	25,0	39,0	30,5
Portugal (PT)	31,7	3,0	44,0	48,0	45,0	118,7	21,0	22,0	313,0	292,0
Russia (RS)	6,7	1,0	2,5	7,0	6,0	16,7	6,0	14,0	23,5	17,5
Singapore (SG)	40,0	-	40,0	-	-	205,5	62,0	205,5	349,0	287,0
South Africa (SA)	6,5	2,0	2,5	7,5	5,5	16,1	5,0	9,0	19,0	14,0
Spain (ES)	18,2	5,0	13,0	32,0	27,0	57,0	9,0	23,5	28,0	19,0
Sweden (SD)	25,3	10,5	17,5	40,0	29,5	87,5	21,0	29,5	154,0	133,0
Switzerland (SW)	21,6	6,5	16,0	39,5	33,0	57,2	11,0	20,5	39,0	28,0
Taiwan (TA)	21,0	5,5	15,0	36,5	31,0	73,4	28,5	57,0	126,5	98,0
Thailand (TH)	6,0	2,0	4,0	9,0	7,0	20,9	8,0	16,0	27,5	19,5
Turkey (TK)	4,1	1,0	3,0	6,0	5,0	3,5	1,5	3,0	5,0	3,5
United Kingdom (UK)	30,0	6,0	12,0	54,0	48,0	82,8	23,5	36,0	142,0	118,5
United States (US)	27,0	4,0	14,0	63,0	59,0	92,5	26,5	40,5	158,5	132,0

* This Table represents regime duration, defined as the length of time (measured in weeks), banking institutions associated with a given country take to switch to the opposite regime. Descriptive statistics (namely, the mean, first quartile, median, third quartile and interquartile range) are sequentially presented in columns for each of the considered regimes.

TABLE 7 – FINANCIAL SYNCHRONIZATION*

	AR	AU	OE	BG	BR	CN	CL	CZ	DK	FN	FR	BD	GR	HK	HN	IN	IR	IS	IT	JP	LX	MY	MX	NL	NW	PK	PE	PH	PO	PT	RS	SG	SA	ES	SD	SW	TA	TH	TK	UK	US
Argentina (AR)	1,00																																								
Australia (AU)	0,08	1,00																																							
Austria (OE)	0,11	0,77	1,00																																						
Belgium (BG)	0,10	0,64	0,74	1,00																																					
Brazil (BR)	0,18	0,42	0,47	0,47	1,00																																				
Canada (CN)	0,08	0,76	0,79	0,70	0,49	1,00																																			
Chile (CL)	0,30	0,65	0,55	0,46	0,50	0,59	1,00																																		
Czech Rep. (CZ)	0,12	0,58	0,65	0,55	0,44	0,61	0,39	1,00																																	
Denmark (DK)	0,16	0,73	0,83	0,75	0,49	0,78	0,60	0,59	1,00																																
Finland (FN)	0,11	0,60	0,76	0,71	0,45	0,75	0,46	0,60	0,77	1,00																															
France (FR)	0,08	0,71	0,75	0,81	0,54	0,72	0,51	0,56	0,76	0,67	1,00																														
Germany (BD)	0,16	0,73	0,79	0,80	0,51	0,78	0,53	0,63	0,75	0,66	0,83	1,00																													
Greece (GR)	0,05	0,65	0,72	0,64	0,32	0,63	0,46	0,56	0,70	0,66	0,63	0,61	1,00																												
Hong Kong (HK)	0,13	0,65	0,67	0,62	0,32	0,64	0,41	0,54	0,69	0,58	0,59	0,64	0,50	1,00																											
Hungary (HN)	0,09	0,56	0,69	0,54	0,39	0,59	0,42	0,59	0,58	0,63	0,50	0,60	0,62	0,44	1,00																											
India (IN)	0,16	0,50	0,43	0,41	0,25	0,46	0,49	0,34	0,46	0,41	0,34	0,42	0,44	0,55	0,36	1,00																									
Ireland (IR)	-0,02	0,58	0,70	0,71	0,31	0,59	0,38	0,48	0,65	0,63	0,63	0,60	0,68	0,53	0,49	0,37	1,00																								
Israel (IS)	0,22	0,51	0,56	0,59	0,39	0,58	0,56	0,37	0,59	0,48	0,52	0,55	0,44	0,58	0,39	0,41	0,43	1,00																							
Italy (IT)	0,16	0,74	0,80	0,75	0,49	0,73	0,51	0,64	0,76	0,71	0,81	0,83	0,69	0,62	0,60	0,35	0,62	0,50	1,00																						
Japan (JP)	0,40	0,52	0,45	0,39	0,43	0,45	0,69	0,37	0,52	0,37	0,46	0,51	0,26	0,49	0,29	0,52	0,24	0,48	0,45	1,00																					
Luxembourg (LX)	0,13	0,66	0,64	0,57	0,47	0,65	0,78	0,53	0,66	0,59	0,56	0,55	0,52	0,51	0,45	0,52	0,46	0,54	0,56	0,55	1,00																				
Malaysia (MY)	0,31	0,73	0,74	0,62	0,50	0,69	0,73	0,60	0,77	0,66	0,66	0,70	0,55	0,73	0,53	0,53	0,48	0,67	0,68	0,67	0,74	1,00																			
Mexico (MX)	0,19	0,56	0,66	0,57	0,48	0,62	0,60	0,50	0,69	0,55	0,56	0,62	0,52	0,61	0,50	0,34	0,49	0,49	0,70	0,44	0,62	0,66	1,00																		
Netherlands (NL)	0,16	0,44	0,46	0,67	0,51	0,46	0,45	0,42	0,52	0,53	0,69	0,62	0,39	0,37	0,28	0,35	0,38	0,41	0,48	0,44	0,56	0,56	0,30	1,00																	
Norway /NW)	0,07	0,72	0,80	0,78	0,41	0,79	0,52	0,53	0,77	0,70	0,74	0,77	0,64	0,70	0,54	0,45	0,65	0,67	0,74	0,40	0,59	0,70	0,58	0,48	1,00																
Pakistan (PK)	0,03	0,15	0,12	0,15	0,01	0,13	0,09	0,12	0,10	0,11	0,13	0,10	0,10	0,19	0,14	0,17	0,11	0,12	0,09	0,10	0,18	0,09	0,07	0,11	0,20	1,00															
Peru (PE)	-0,02	0,18	0,15	0,07	0,14	0,15	0,21	0,12	0,17	0,11	0,10	0,12	0,09	0,14	0,08	0,13	0,05	0,20	0,09	0,13	0,23	0,25	0,17	0,10	0,14	-0,07	1,00													
Philippines (PH)	0,26	0,62	0,58	0,44	0,36	0,52	0,57	0,46	0,61	0,49	0,49	0,55	0,46	0,62	0,40	0,59	0,39	0,59	0,50	0,65	0,58	0,79	0,45	0,44	0,55	0,09	0,27	1,00												
Poland (PO)	0,10	0,58	0,71	0,55	0,43	0,68	0,49	0,73	0,61	0,63	0,54	0,58	0,59	0,48	0,68	0,39	0,50	0,43	0,62	0,37	0,61	0,60	0,57	0,34	0,56	0,21	0,11	0,43	1,00											
Portugal (PT)	0,10	0,72	0,66	0,64	0,44	0,64	0,62	0,55	0,69	0,66	0,65	0,60	0,76	0,51	0,53	0,39	0,66	0,41	0,70	0,37	0,69	0,62	0,61	0,52	0,59	0,09	0,09	0,44	0,58	1,00										
Russia (RS)	0,12	0,62	0,62	0,48	0,37	0,66	0,48	0,52	0,57	0,47	0,50	0,61	0,50	0,48	0,53	0,38	0,39	0,47	0,58	0,36	0,45	0,55	0,44	0,25	0,61	0,15	0,14	0,42	0,64	0,43	1,00									
Singapore (SG)	0,25	0,72	0,74	0,62	0,50	0,72	0,64	0,61	0,75	0,63	0,64	0,68	0,59	0,79	0,54	0,53	0,51	0,68	0,70	0,64	0,69	0,83	0,71	0,45	0,69	0,06	0,21	0,71	0,65	0,61	0,55	1,00								
South Africa (SA)	0,40	0,48	0,49	0,41	0,39	0,46	0,53	0,43	0,48	0,42	0,40	0,47	0,35	0,44	0,46	0,38	0,31	0,46	0,49	0,52	0,56	0,56	0,54	0,27	0,44	0,07	0,14	0,48	0,52	0,44	0,40	0,64	1,00							
Spain (ES)	0,11	0,68	0,71	0,69	0,47	0,63	0,38	0,62	0,67	0,63	0,77	0,71	0,67	0,55	0,50	0,24	0,58	0,42	0,87	0,32	0,47	0,59	0,58	0,51	0,66	0,09	0,03	0,38	0,54	0,73	0,47	0,58	0,36	1,00						
Sweden (SD)	0,14	0,66	0,70	0,79	0,55	0,78	0,47	0,56	0,77	0,70	0,77	0,87	0,58	0,59	0,62	0,40	0,60	0,53	0,76	0,46	0,51	0,62	0,54	0,57	0,75	0,11	0,08	0,49	0,51	0,58	0,58	0,62	0,40	0,64	1,00					
Switzerland (SW)	0,06	0,62	0,68	0,78	0,59	0,69	0,46	0,44	0,68	0,62	0,80	0,80	0,50	0,51	0,46	0,32	0,58	0,46	0,68	0,43	0,54	0,56	0,51	0,69	0,69	0,12	0,07	0,38	0,46	0,57	0,43	0,53	0,36	0,65	0,79	1,00				
Taiwan (TA)	0,14	0,50	0,50	0,36	0,39	0,47	0,55	0,34	0,48	0,36	0,44	0,44	0,37	0,49	0,30	0,48	0,32	0,48	0,36	0,54	0,51	0,56	0,39	0,37	0,44	0,10	0,11	0,52	0,32	0,37	0,40	0,59	0,32	0,28	0,43	0,41	1,00			
Thailand (TH)	0,33	0,38	0,32	0,25	0,34	0,33	0,61	0,20	0,38	0,26	0,31	0,33	0,24	0,35	0,20	0,48	0,18	0,47	0,33	0,64	0,45	0,56	0,32	0,33	0,32	0,01	0,10	0,60	0,23	0,32	0,30	0,51	0,40	0,20	0,33	0,24	0,44	1,00		
Turkey (TK)	0,17	0,23	0,27	0,20	0,37	0,28	0,34	0,30	0,23	0,22	0,24	0,23	0,22	0,16	0,30	0,25	0,12	0,24	0,19	0,27	0,33	0,28	0,23	0,34	0,24	0,06	0,05	0,22	0,34	0,30	0,23	0,27	0,26	0,21	0,20	0,31	0,25	0,24	1,00	
United Kingdom (UK)	0,06	0,69	0,79	0,77	0,51	0,80	0,53	0,53	0,79	0,72	0,81	0,75	0,61	0,71	0,51	0,43	0,68	0,55	0,69	0,43	0,67	0,67	0,62	0,61	0,78	0,19	0,11	0,46	0,57	0,66	0,48	0,67	0,42	0,68	0,70	0,81	0,50	0,25	0,31	1,00
United States (US)	0,04	0,67	0,75	0,75	0,39	0,83	0,46	0,52	0,73	0,68	0,77	0,76	0,57	0,75	0,46	0,45	0,63	0,49	0,69	0,40	0,59	0,61	0,59	0,50	0,78	0,18	0,09	0,42	0,55	0,59	0,51	0,64	0,38	0,64	0,73	0,80	0,43	0,23	0,26	0,88	1,00

* This Table describes pairwise financial synchronization (through correlation) between banking institutions belonging to each pair of the countries included in our sample. The values range from a minimum of -1 to a maximum of 1.

TABLE 8 - HRSM-S DUAL STATE MODEL ESTIMATION (2007 – 2010)*			
S (MODEL PARAMETER)	LOG-LIKELIHOOD	NUMBER OF FREE PARAMETERS	BIC
1	**-22064,53**	**7**	**44155,22**
2	-22064,21	11	44169,54
3	-22064,14	15	44184,35
4	-22064,11	19	44199,24
5	-22064,12	23	44214,21

* This Table portrays the estimation of the HRSM-S, using different values of S (S = 1,2,3,4,5). The optimal solution (S = 1) yields the lowest BIC value.

TABLE 9 - ESTIMATED PRIOR PROBABILITIES, POSTERIOR PROBABILITIES AND MODAL CLASS FOR HRSM-1 (S=1)*

	Cluster 1	Modal Latent Class
Prior probabilities	1,000	
Posterior probabilities		
Country		
Argentina (AR)	1,000	1
Australia (AU)	1,000	1
Austria (OE)	1,000	1
Belgium (BG)	1,000	1
Brazil (BR)	1,000	1
Canada (CN)	1,000	1
Chile (CL)	1,000	1
China (CH)	1.000	1
Czech Rep. (CZ)	1,000	1
Denmark (DK)	1,000	1
Finland (FN)	1,000	1
France (FR)	1,000	1
Germany (BD)	1,000	1
Greece (GR)	1,000	1
Hong Kong (HK)	1,000	1
Hungary (HN)	1,000	1
India (IN)	1,000	1
Ireland (IR)	1,000	1
Israel (IS)	1,000	1
Italy (IT)	1,000	1
Japan (JP)	1,000	1
Luxembourg (LX)	1.000	1
Malaysia (MY)	1,000	1
Mexico (MX)	1,000	1
Netherlands (NL)	1,000	1
Norway (NW)	1,000	1
Pakistan (PK)	1,000	1
Peru (PE)	1,000	1
Philippines (PH)	1,000	1
Poland (PO)	1,000	1
Portugal (PT)	1,000	1
Russia (RS)	1,000	1
Singapore (SG)	1,000	1
South Africa (SA)	1,000	1
Spain (ES)	1,000	1
Sweden (SD)	1,000	1
Switzerland (SW)	1,000	1
Taiwan (TA)	1,000	1
Thailand (TH)	1,000	1
Turkey (TK)	1,000	1
United Kingdom (UK)	1,000	1
United States (US)	1,000	1

* This Table reports the estimated Prior probabilities describing the size of the unique Latent Class or Cluster. Furthermore, the estimated (country-specific) Posterior probabilities represent banks' degree of membership (taking into account each individual country) to the sole Cluster in question. The maximum Posterior probability for each country (equal to one for all countries) yields the corresponding Modal Latent Class.

TABLE 10 - HRSM - (S = 1) ESTIMATED REGIME DYNAMICS, REGIME OCCUPANCY AND ESTIMATED REGIME TRANSITION*

Regimes	Return (mean)	Risk (variance)	P(Z)	Transition probabilities		Sojourn time (weeks)
				Regime 1	Regime 2	
Regime 1	-1,765	183,429	0,199	0,952	0,048	20,704
	(0,376)	(8,815)	(0,026)	(0,008)	(0,008)	
Regime 2	-0,006	20,506	0,801	0,014	0,987	74,074
	(0,065)	(0,528)	(0,026)	(0,002)	(0,002)	

* P(Z) represents the average proportion of banking institutions in a given regime, taking into account that all of the latter institutions are grouped in a single Cluster. The mean and variance of each regime are also presented. Standard errors presented in parenthesis.

TABLE 11 - HRSM-S MULTI-STATE MODEL ESTIMATION (2002 - 2010)*				
S (CLUSTERS)	**K** (REGIMES)	LOG-LIKELIHOOD	NUMBER OF FREE PARAMETERS	BIC
1	2	-52961,86	7	105949,72
2	2	-52913,14	11	105867,12
3	2	-52902,31	15	**105860,32**
4	2	-52899,64	19	105869,84
5	2	-52898,54	23	105882,49
1	3	-52001,52	14	104055,03
2	**3**	**-51972,86**	**23**	**104031,14**
3	3	-51959,52	32	104037,87
4	3	-51954,80	41	104061,86
5	3	-51946,90	50	104079,48
1	4	-51757,18	23	**103599,78**
2	4	-51730,09	39	103605,01
3	4	-51721,52	55	103647,29
4	4	-51722,34	71	103708,34
5	4	-51709,83	87	103742,74
1	5	-51639,07	34	**103404,40**
2	5	-51673,75	59	103566,61
3	5	-51667,10	84	103646,14
4	5	-51645,53	109	103695,84
5	5	-51625,32	134	103748,25

* This Table portrays the estimation of the HRSM-S, using different values of S (S = 1,2,3,4,5) and K (K = 2,3,4,5). The combined optimal solution (S = 2 , K = 3) yields the lowest BIC value for all the considered cases where heterogeneity is assumed to occur (i.e., S > 1) in the presence of a more realistic regime alternation framework with intermediate regimes (i.e., K > 2).

TABLE 12 - ESTIMATED PRIOR PROBABILITIES, POSTERIOR PROBABILITIES AND MODAL CLASSES FOR HRSM (S = 2, K = 3)*

	Cluster 1	Cluster 2	Modal Latent Class
Prior probabilities	0,296	0,704	
Posterior probabilities			
Country			
Argentina (AR)	0,997	0,003	1
Australia (AU)	0,000	1,000	2
Austria (OE)	0,001	0,999	2
Belgium (BG)	0,000	1,000	2
Brazil (BR)	0,955	0,046	1
Canada (CN)	0,000	1,000	2
Chile (CL)	0,000	1,000	2
Czech Rep. (CZ)	0,996	0,004	1
Denmark (DK)	0,000	1,000	2
Finland (FN)	0,000	1,000	2
France (FR)	0,000	1,000	2
Germany (BD)	0,000	1,000	2
Greece (GR)	0,044	0,956	2
Hong Kong (HK)	0,000	1,000	2
Hungary (HN)	0,959	0,041	1
India (IN)	0,980	0,020	1
Ireland (IR)	0,000	1,000	2
Israel (IS)	0,976	0,025	1
Italy (IT)	0,000	1,000	2
Japan (JP)	0,030	0,970	2
Luxembourg (LX)	0,000	1,000	2
Malaysia (MY)	0,000	1,000	2
Mexico (MX)	0,005	0,995	2
Netherlands (NL)	0,000	1,000	2
Norway (NW)	0,002	0,998	2
Pakistan (PK)	1,000	0,000	1
Peru (PE)	0,000	1,000	2
Philippines (PH)	0,000	1,000	2
Poland (PO)	1,000	0,001	1
Portugal (PT)	0,000	1,000	2
Russia (RS)	0,993	0,008	1
Singapore (SG)	0,000	1,000	2
South Africa (SA)	0,998	0,002	1
Spain (ES)	0,000	1,000	2
Sweden (SD)	0,000	1,000	2
Switzerland (SW)	0,000	1,000	2
Taiwan (TA)	0,976	0,024	1
Thailand (TH)	0,950	0,050	1
Turkey (TK)	0,072	0,929	2
United Kingdom (UK)	0,000	1,000	2
United States (US)	0,000	1,000	2

* This Table reports the estimated Prior probabilities describing the size of each Latent Class or Cluster (the results point to the existence of two distinct Clusters). Furthermore, the estimated (country-specific) Posterior probabilities represent banks' degree of membership (taking into account each individual country) to each of the Clusters in question. The maximum Posterior probability for each country yields the corresponding Modal Latent Class.

TABLE 13 (a) - ESTIMATED MARGINAL PROBABILITIES OF REGIMES FOR THE 2002 - 2010 MULTI-STATE MODEL APPLICATION

P(Z)*			Return (mean)			Risk (variance)		
Regime 1	**Regime 2**	**Regime 3**	**Regime 1**	**Regime 2**	**Regime 3**	**Regime 1**	**Regime 2**	**Regime 3**
0,091	0,492	0,417	-1,850	0,250	0,434	177,170	22,641	4,943
(0,012)	(0,031)	(0,034)	(0,349)	(0,055)	(0,029)	(8,169)	(0,649)	(0,146)

TABLE 13 (b) - ESTIMATED CLUSTER-SPECIFIC PROBABILITIES OF REGIMES, REGIME OCCUPANCY FOR EACH CLUSTER, REGIME TRANSITION AND SOJOURN TIME**

	Cluster 1			Cluster 2		
	Regime 1	**Regime 2**	**Regime 3**	**Regime 1**	**Regime 2**	**Regime 3**
P(Z|W)	0,091	0,711	0,198	0,090	0,400	0,510
	(0,021)	(0,030)	(0,029)	(0,015)	(0,028)	(0,034)
Regime 1	0,931	0,069	0,001	0,939	0,061	0,000
	(0,015)	(0,016)	(0,004)	(0,010)	(0,010)	(0,000)
Regime 2	0,008	0,950	0,042	0,014	0,962	0,024
	(0,002)	(0,012)	(0,011)	(0,002)	(0,004)	(0,004)
Regime 3	0,001	0,148	0,851	0,000	0,019	0,981
	(0,003)	(0,030)	(0,029)	(0,000)	(0,002)	(0,002)
Sojourn time (weeks)	14,388	19,920	6,693	16,420	26,110	52,632

* P(Z) represents the average proportion of banking institutions in each regime. The mean and variance of each regime are also presented. Standard errors presented in parenthesis.
** P(Z|W) represents the proportion of banking institutins in each regime for each of the two considered Clusters. Standard errors presented in parenthesis. Sojourn time represents the expected amount of time banking institutions take to exit a given regime.

TABLE 14 - HRSM (S = 1, K = 3) ESTIMATED REGIME DYNAMICS, REGIME OCCUPANCY AND ESTIMATED REGIME TRANSITION*

Regimes	**Return (mean)**	**Risk (variance)**	**P(Z)**	**Transition probabilities**			**Sojourn time (weeks)**
				Regime 1	Regime 2	Regime 3	
Regime 1	-1,776	172,041	0,095	0,937	0,012	0,000	15,974
	(0,336)	(7,772)	(0,013)	(0,008)	(0,002)	(0,000)	
Regime 2	0,271	21,332	0,518	0,063	0,971	0,023	34,014
	(0,052)	(0,588)	(0,024)	(0,008)	(0,003)	(0,003)	
Regime 3	0,427	4,815	0,387	0,000	0,018	0,977	42,553
	(0,030)	(0,148)	(0,028)	(0,000)	(0,002)	(0,003)	

* P(Z) represents the average proportion of banking institutions in a given regime, taking into account that all of the latter institutions are grouped in a single Cluster. The mean and variance of each regime are also presented. Standard errors presented in parenthesis.

TABLE 15 - HRSM-S MULTI-STATE MODEL ESTIMATION (2007 - 2010)*				
S (CLUSTERS)	**K** (REGIMES)	LOG-LIKELIHOOD	NUMBER OF FREE PARAMETERS	BIC
1	2	-22064,53	7	**44155,22**
2	2	-22064,21	11	44169,54
3	2	-22064,14	15	44184,35
4	2	-22064,11	19	44199,24
5	2	-22064,12	23	44214,21
1	3	-21860,08	14	**43772,49**
2	3	-21854,30	23	43794,56
3	3	-21851,80	32	43823,20
4	3	-21849,50	41	43852,24
5	3	-21849,52	50	43885,93
1	**4**	**-21783,01**	**23**	**43651,98**
2	4	-21761,75	39	43669,27
3	4	-21756,44	55	43718,44
4	4	-21754,61	71	43774,60
5	4	-21763,11	87	43851,39
1	5	-21737,38	34	**43601,83**
2	5	-21713,59	59	43647,70
3	5	-21709,94	84	43733,85
4	5	-21699,32	109	43806,05
5	5	-21702,83	134	43906,50
1	6	-21707,06	47	**43589,80**
2	6	-21685,83	83	43681,89
3	6	-21670,87	119	43786,52

* This Table portrays the estimation of the HRSM-S, using different values of S (S = 1,2,3,4,5) and K (K= 2,3,4,5,6). The combined optimal solution (S = 1 , K = 4) yields the lowest BIC value taking into account the presence of a more realistic regime alternation framework with intermediate regimes (i.e., K>2).

TABLE 16 - ESTIMATED PRIOR PROBABILITIES, POSTERIOR PROBABILITIES AND MODAL CLASS HOR HRSM (S=1, K=4)*		
	Cluster 1	**Modal**
Prior probabilities	1,000	
Posterior probabilities		
Country		
Argentina (AR)	1,000	1
Australia (AU)	1,000	1
Austria (OE)	1,000	1
Belgium (BG)	1,000	1
Brazil (BR)	1,000	1
Canada (CN)	1,000	1
Chile (CL)	1,000	1
China (CH)	1,000	1
Czech Rep. (CZ)	1,000	1
Denmark (DK)	1,000	1
Finland (FN)	1,000	1
France (FR)	1,000	1
Germany (BD)	1,000	1
Greece (GR)	1,000	1
Hong Kong (HK)	1,000	1
Hungary (HN)	1,000	1
India (IN)	1,000	1
Ireland (IR)	1,000	1
Israel (IS)	1,000	1
Italy (IT)	1,000	1
Japan (JP)	1,000	1
Luxembourg (LX)	1,000	1
Malaysia (MY)	1,000	1
Mexico (MX)	1,000	1
Netherlands (NL)	1,000	1
Norway (NW)	1,000	1
Pakistan (PK)	1,000	1
Peru (PE)	1,000	1
Philippines (PH)	1,000	1
Poland (PO)	1,000	1
Portugal (PT)	1,000	1
Russia (RS)	1,000	1
Singapore (SG)	1,000	1
South Africa (SA)	1,000	1
Spain (ES)	1,000	1
Sweden (SD)	1,000	1
Switzerland (SW)	1,000	1
Taiwan (TA)	1,000	1
Thailand (TH)	1,000	1
Turkey (TK)	1,000	1
United Kingdom (UK)	1,000	1
United States (US)	1,000	1

* This Table reports the estimated Prior probabilities describing the size of the unique Latent Class or Cluster. Furthermore, the estimated (country-specific) Posterior probabilities represent banks' degree of membership (taking into account each individual country) to the sole Cluster in question. The maximum Posterior probability for each country (equal to one for all countries) yields the corresponding Modal Latent Class.

TABLE 17 - HRSM (S = 1, K = 4) ESTIMATED REGIME DYNAMICS, REGIME OCCUPANCY AND REGIME TRANSITION*

Regimes	P(Z)	Return (mean)	Risk (variance)	Transition probabilities				Sojourn time (weeks)
				Regime 1	Regime 2	Regime 3	Regime 4	
Regime 1	0,063	-4,671	377,092	0,886	0,000	0,113	0,000	8,787
	(0,015)	(1,070)	(42,287)	(0,025)	(0,001)	(0,025)	(0,001)	
Regime 2	0,305	-0,982	17,124	0,000	0,062	0,049	0,889	1,067
	(0,022)	(0,118)	(0,936)	(0,000)	(0,016)	(0,008)	(0,016)	
Regime 3	0,348	-0,068	55,227	0,022	0,010	0,943	0,026	17,575
	(0,034)	(0,177)	(4,278)	(0,004)	(0,023)	(0,007)	(0,023)	
Regime 4	0,284	0,936	10,460	0,000	0,999	0,000	0,001	1,001
	(0,020)	(0,103)	(0,650)	(0,000)	(0,005)	(0,002)	(0,004)	

* P(Z) represents the average proportion of banking institutions in a given regime, taking into account that all of the latter institutions are grouped in a single Cluster. The mean and variance of each regime are also presented. Standard errors presented in parenthesis.

TABLE 18 - SUMMARY OF THE MAIN CHARACTERISTICS OF THE ESTIMATED MODEL APPLICATIONS

		REGIME GRANULARITY			
		DUAL STATE		MULTI-STATE	
		NUMBER OF OPTIMAL LATENT CLASSES	NUMBER OF OPTIMAL REGIMES	NUMBER OF OPTIMAL LATENT CLASSES	NUMBER OF OPTIMAL REGIMES
TIME FRAME	LONG MODEL APPLICATION (2002-2010)	3	2	2	3
	SHORT MODEL APPLICATION (2007-2010)	1	2	1	4

CHAPTER FOUR. EURO AREA SOVEREIGN RISK IN THE AFTERMATH OF THE GLOBAL FINANCIAL CRISIS

ABSTRACT: This research demonstrates the existence of optimal sovereign debt thresholds latent in the relationship between sovereign debt and economic output for selected Euro Area Member States since the introduction of the Euro up to the aftermath of the Global Financial Crisis. The paper is divided into two main sections. It initially conducts a literature survey, which is followed by an empirical application. In the survey, it initially addresses the origin and description of the latter systemic event, and the ensuing macroeconomic policies (both monetary and fiscal) in contravention thereof. It then proceeds by characterizing the historical interconnection between output and sovereign debt in the context of the sovereign debt literature, paying particular attention to the concept of the sovereign debt Laffer curve. Taking into consideration the impact of the Global Financial Crisis on sovereign debt as a most reliant countercyclical fiscal policy instrument in the aftermath of the said event, the main determinants of Euro Area sovereign debt spreads are also carefully scrutinized. Finally, in the empirical section, the output – sovereign debt nexus is properly contextualized within the Euro Area monetary framework, most specially taking into consideration the impact of the global systemic event. Empirical research leading to the estimation of sovereign debt Laffer curves for selected Member States of the Euro Area is then presented, along with the corresponding optimal sovereign debt – output thresholds.

KEYWORDS: Global Financial Crisis, Euro Area, Sovereign Debt, Sovereign Debt Laffer Curve, Optimal Sovereign Debt Threshold

JEL Codes: G01, E62, E44, F34

4.1. INTRODUCTION[46]

The present sovereign debt turmoil constitutes a most cumbersome epilogue to the current Global Financial Crisis, a systemic event that has deeply scarred the international financial environment and affected the performance of real economies globally. In order to countervail the economic impact on the fabric of real economies, the most advanced economies most affected by this systemic event have pursued expansionary monetary and fiscal policies that have deeply endeared the public purse.

Where the pursuit of expansionary fiscal policies is concerned, the financing burden has fallen upon the public debt policy instrument as the main financing tool. The said burden has been conspicuously noticeable in the feeble state of the public finances of Euro Area Member States in the aftermath of the Global Financial Crisis, an event to which the corresponding Member States' economies have overwhelmingly fallen prey.

Taking account of the depth and extent of the said Member States' interventions, the latter States' ensuing, but inevitable, breach of the Stability and Growth Pact in the wake of the systemic crisis has exposed the Euro Area as a whole to a major economic frailty. The latter pertains to the economic impact of excessive sovereign debt accumulation on the macroeconomic performance of Euro Area Member States' economies.

Thus, by taking full advantage of a nuclear concept previously proposed by the sovereign debt literature – the sovereign debt Laffer curve - we will strive to answer a most worrying question pertaining to the present sovereign debt turmoil affecting the Euro Area: is the excessive sovereign debt accumulation by Member States, in the aftermath of the Global Financial Crisis, detrimental to the said Member States' economic output schedules? We will contextualize the latter research question within the framework of the Euro Area as a common optimal currency area, and also by framing the latter question between the introduction of the Euro as a common accounting currency (in 1999) and the aftermath of the present Global Financial Crisis (until 2012).

[46] The Figures and Tables mentioned in the present Chapter have been collected in Appendix C (end-of-chapter).

This fundamental research question is quite crucial on two counts. First, the present sovereign debt turmoil has deeply shaken the belief in the Euro Area as an optimal currency area, by exposing individual Member States' fiscal frailties in the aftermath of the global systemic event. Second, the latter event has also encumbered Member States' national accounts for the following decades and has impacted the corresponding economies quite heterogeneously, giving rise to a centrifugal and divisive two-speed Euro Area, most specifically where the performance of economic output is concerned.

In pursuit of our research, sub-section 4.2. briefly addresses the origin and development of the Global Financial Crisis, as well as the scope of the ensuing monetary and fiscal responses to the said global systemic shock. Sub-section 4.3. provides a brief overview of the main concepts needed to address and circumscribe the sovereign debt debate. Sub-section 4.4. examines the main determinants of Euro Area sovereign debt spreads in the aftermath of the global financial shock, thus exposing the state-of-the-art literature on this crucial subject (sub-sections 4.3. and 4.4 thus survey existing sovereign debt literature in the context of our research question). Sub-section 4.5. describes our main findings pertaining to the existence of optimal sovereign debt thresholds in selected Member States of the Euro Area. Finally, sub-section 4.6. summarizes our main findings.

Notwithstanding the fact that the present research is not allowed to benefit from the insightfulness usually provided by historical retrospective, it is hoped that the main findings herein described might ultimately contribute (albeit modestly) to the cohesiveness and future prosperity of the Euro Area. The latter's continuity crucially rests on the design of a common innovative policy response to present and future shocks of systemic magnitude, taking into account the powerful insightfulness and discerning precepts of sound macroeconomic theory.

4.2. THE GLOBAL FINANCIAL CRISIS: A BRIEF OVERVIEW OF THE GLOBAL SYSTEMIC EVENT AND ENSUING MACROECONOMIC POLICY RESPONSES

In the present sub-section, we will begin by providing a brief overview describing not only the genesis, development and diffusion pertaining to the present global financial event, but also the ensuing macroeconomic policy responses (namely, those of monetary and fiscal extraction) undertaken to curtail the severity of the global systemic shock.

4.2.1. THE SUBPRIME CRISIS OF 2007 – 2008 AS THE HERALD OF THE GLOBAL FINANCIAL CRISIS

The Global Financial Crisis constituted a globalised disruptive systemic event, and its origins lay in the bursting of the Subprime Crisis[47] of 2007 – 2008 in the United States of America (U.S.A). The latter financial cataplexy occurred as a consequence to the bursting of the twin bubbles in the real estate and credit markets in the U.S.A.

According to Shiller (2008), the very term *subprime*[48] *crisis* epitomizes the "deflating of a speculative bubble in the housing market that began in the United States in 2006 and has now cascaded across many other countries in the form of financial failures and a global credit crunch" (Shiller, 2008:9). Unsurprisingly, the said speculative housing bubble was duly accompanied by a feverous mortgage lending activity in support of the said housing bubble, most notably in the subprime segment of the residential real estate market in the U.S.A.

On the other hand, the formation of the real estate bubble was simultaneously accompanied by the formation of a closely related second bubble in the credit

[47] In the context of our research, a fundamental distinction between the Subprime Crisis (as a localised U.S. extreme event) and the ensuing Global Financial Crisis (as a truly global financial event associated with international financial contagion processes) will be respected. This approach is in agreement with that followed by Mishkin (2010).

[48] Within the mortgage finance industry, this term refers to a specific category of high risk loan borrowers, most notably those who might exhibit extremely high default probabilities on their mortgage loans. Thus, these borrowers' risk profiles entails a corresponding high degree of credit risk, thus obliging lenders to require higher *premia* to satisfy the borrowers' loans; these distinct risk profiles are summarized in these borrowers' FICO scores, a widely used credit score appraisal system in the U.S.A.

derivatives markets. The latter market is essentially concerned with the issuance of sophisticated and highly profitable credit-related financial derivatives products that were mainly designed through the securitization of home mortgages issued on the back of rising residential housing prices (Krugman, 2008: 149 and 150). These financial products were appropriately inscribed within a shadow banking system designed to enable regulatory arbitrage, whereby financial institutions were given the possibility of transferring some complex and risky financial assets from their balance sheets into off-balance sheet vehicles (Krugman, 2008:160 to 164).

There are two quite distinguishing attributes pertaining to the present Global Financial Crisis that warrant our attention. First, it should be noted that the formation of these two bubbles (and, in particular, the bubble in the credit markets) was mainly driven by the said securitization process. This financial process was widely used by major financial institutions operating in globalised financial markets. The said process may be aptly described as "a structured finance technique in which financial assets, such as bonds, loans and receivables, are pooled together and used as collateral for investors" (Felsenheimer and Gisdakis, 2008:103). This technique enabled banks and other financial institutions to "actively manage their portfolios of credit risks, keeping some and entering into credit derivatives contracts to protect themselves from others" (Hull, 2006:507), thus allowing "companies to trade credit risks in much the same way that they trade market risks" (Hull, 2006:507).

Second, the commercialization of this huge wave of securitised financial products was deeply enabled by a new banking paradigm prevailing in the financial markets. This recent paradigm, which has been termed the 'originate-and-distribute' banking model, facilitated the circulation of loan entitlements related to securitised financial products (irrespective of their nature and issuance) throughout the global financial system. This was achieved by issuing, re-packaging and off-loading these sophisticated financial products comprising the said loans amongst the financial system's heterogeneous set of market participants (Brunnermeier, 2008:2 and 3). Therefore, a given loan's originator might not be the same entity as the recipient of the said loan's underlying credit proceeds. This is due to the fact that the entitlement to

those very credits might have been re-packaged and sold to a third party, thus passing on to the final holder the corresponding credit risk. This effectively contributed to the unprecedented dissemination of credit risk on a truly global scale, thus transforming credit risk into a financial commodity on its own standing and merit.

Therefore, the two bubbles were quite inter-related insofar as the performance of these financial products was manifestly tied to the performance of the underlying real estate markets, through the widespread use of the securitization technique under the auspices of the prevailing 'originate-to-distribute' banking paradigm.

Blanchard (2009) quite comprehensively depicts this highly complex and quite fluid entanglement of financial interests amongst real estate markets, mortgage finance markets and credit derivatives markets (Blanchard, 2009:7, Figure 2).

As soon as the U.S. real estate markets started to falter, declining residential housing prices led to unexpected massive losses on mortgage-related financial securities (Mishkin, 2009:574 and 575) (Mishkin, 2010:2).

That is, the decline in housing prices deeply compromised the ability of mortgage borrowers – particularly that of Subprime mortgage borrowers - to fully comply with the financial obligations related to their mortgages. The overall rise in mortgage delinquency subsequently compromised the quality of underlying mortgage-related credit derivatives products, which were issued on the back of misplaced expectations of ever-rising home prices. This severe mortgage default disruption is depicted in Calomiris (2008), which portrays the abrupt (but persistent) rise in Subprime mortgage delinquencies, particularly for the mortgage vintage years of 2006 and 2007 (Calomiris, 2008:99, Figure 2, top panel). Zimmerman (2007) also confirms the overwhelming rise in Subprime mortgage delinquencies (those exhibiting a delay of over sixty days), most specially for the mortgage vintage years immediately preceding the great systemic shock (Zimmerman, 2007:13, Exhibit 6).

On the other hand, the subsequent unexpected risk re-appraisal associated with credit derivatives financial products pertaining to the housing boom inevitably prompted

the so-called 'fire sale prices'[49] of these structured products. This essentially consisted in a massive attempt to off-load these securities of increasingly uncertain value in an unwieldy scramble for liquidity. The latter event effectively amplified the depressing contagion processes associated with the initial real estate shock to the credit derivatives markets (Blanchard, 2009:10 to 14).

More specifically, as the value of these mortgage-backed securities plummeted, the collateral value of these securities also fell sharply, thus compromising the hitherto widely accepted strategy of financing financial institutions' short-term liabilities with longer-term mortgage-backed securities in the repurchase agreement (or 'repos') markets. That is, as higher 'haircuts'[50] set in, the same amount of collateral supported a lesser amount of borrowing, which prompted a massive deleveraging process obliging financial institutions to forcefully sell their securitised assets in order to obtain short-term liquidity. This self-reinforcing depressing pricing cycle has been quite aptly described by Mishkin (2010) as an adverse feedback loop (Mishkin, 2010:2).

It should also be borne in mind that this amplified decrease in the value of exposed financial institutions' securitised assets and subsequent deleveraging process was necessary in order for the said financial institutions to comply with their minimum capital adequacy requirements and to satisfy their stakeholders as to the need to pre-empt the looming risk of insolvency (Blanchard, 2009:13).

Thus, an unexpected real estate downward price trajectory not only affected the mortgage financing sector through a higher default on subprime residential mortgages; but also proceeded to affect the credit derivatives industry through the ensuing 'forced' sale of mortgage-backed securities in a collective search for liquidity. Thus, financial institutions exposed to these structured products were forced to deleverage their financial positions, unleashing a 'bank run' on the afore-mentioned shadow banking

[49] This concept addresses the 'forced' sale of assets whose prices are below the expected present value of its underlying payments (Blanchard, 2009:12).

[50] This concept addresses the collateral requirements – typically, an amount superior to the value of the loan – needed in order to secure the financing in question; the 'haircut' is the difference between the value of posted collateral and the value of the loan ((Mishkin, 2010:2).

system and further depressing the availability of credit, while ultimately pushing the U.S. economy into a deep recession.

4.2.2. THE GLOBAL FINANCIAL CRISIS

But how did this apparently localized extreme event[51] in the U.S.A. propagate globally? Although the scope of the present paper addresses the full impact of the Global Financial Crisis on the sovereign debt debacle of the Euro Area, it is nevertheless worth mentioning the basic tenets of international financial contagion processes that led to the present Euro Area sovereign debt turmoil. These contagion processes were crucial in the propagation of the impact of the Subprime Crisis and its subsequent metamorphosis into the Global Financial Crisis and, ultimately responsible for the abrupt change in the public debt levels of Euro Area Member States.

The recent Global Financial Crisis has highlighted the lack of a prevalent and unanimous definition of international financial contagion processes, a dynamical concept which still remains quite elusive (Corsetti, Pericoli and Sbracia, 2010:1).

In the context of the present paper, we will embrace the more macroeconomic definition reviewed by Pericoli and Sbracia (2003), stating that "contagion is a significant increase in the probability of a crisis in one country, conditional on a crisis occurring in another country" (Pericoli and Sbracia, 2003:574). The latter definition might be complemented by a more detailed micro-financial definition, presenting contagion as a process of co-movement in prices and quantities across markets, conditional on the fact that the said co-movement was triggered by a financial crisis occurring in a given market or set of markets (Pericoli and Sbracia, 2003:575). Taking into account the scope of the above-mentioned definitions and the literature heretofore reviewed, we will therefore consider that the U.S. Subprime Crisis of 2007 – 2008

[51] According to Eichengreen, Mody, Nedeljkovic and Sarno (2009), securities guaranteed by Subprime mortgages accounted for a mere three percent (3%) of U.S. financial assets (Eichengreen, Mody, Nedeljkovic and Sarno, 2009:2).

constituted the epicentre of the subsequent Global Financial Crisis[52], and that international financial contagion processes facilitated the metamorphosis of the former into the latter.

Furthermore, Allen and Carletti (2006) present an appropriate theoretical approach linking the risk of financial contagion to the onset of financial innovation. According to this approach, the creation of new credit risk transfer instruments (e.g., securitised assets) is highly beneficial insofar as it consolidates the process of risk sharing among financial institutions. By being able to transfer risks, a given financial institution is more capable of actively managing its portfolio of credit risks. This is achieved by focusing on those in which the said institution has a comparative advantage and by transferring those risks which might jeopardize its strategies. Certain non-optimal conditions may arise according to which financial institutions may face idiosyncratic shocks leading to a greater variability in asset prices. Under these specific non-optimal circumstances, the transfer of credit risk may induce financial contagion and lead to an overall Pareto reduction in economic welfare by increasing the probability of crisis occurrence (Allen and Carletti, 2006:110).

Correspondingly, Eichengreen, Mody, Nedeljkovic and Sarno (2009) empirically test for the possibility of international financial contagion among large financial institutions, thus indirectly validating the fundamental tenet of the said credit risk transfer hypothesis mentioned in the preceding paragraph. The authors analyze the evolution of the common factors underlying weekly variations in Credit Default Swaps (CDS) associated with the institutions included in their sample[53]. These authors find that, after the onset of the Subprime Crisis in the U.S.A., there was a significant rise in the share of the variance accounted for by the common factors influencing the behavior

[52] The alternative explanation to international financial contagion would be the 'common fundamentals' framework proposed by Reinhart and Rogoff (2011). The latter proposal states that Europe's real estate markets were also associated with corresponding real estate bubbles. We partially concur with these authors' assessment, although, in our view, the latter authors overlook the fact that there was no European moral hazard-related subprime shock to speak of, despite the fact that *some* (but certainly *not all*) European countries might have had real estate asset bubbles of their own; the same authors also acknowledge the great importance of the 'cross-country linkages' approach underlying our analysis (Reinhart and Rogoff, 2011:19 to 25).

[53] The countries included in this sample are: the U.S.A., the United Kingdom, Germany, Switzerland, France, Italy, the Netherlands, Spain and Portugal.

in CDS spreads pertaining to the major financial institutions under scrutiny. Their findings indicate the presence of a strong co-movement in the performance of these institutions, reflecting a higher perception of rising global systemic risk amongst financial market participants. This fact ultimately reflected these institutions' unsound exposure to potentially 'toxic' securitised products.

More importantly, the preceding authors further ascertain that there were direct spillovers from the CDS spreads of major U.S. banks to their European counterparts[54]. These findings thus validate the international financial contagion processes underlying the initial financial shock to U.S. mortgage and credit derivatives markets through the global dispersion of securitised products and the subsequent repricing thereof (Eichengreen, Mody, Nedeljkovic and Sarno, 2009:3 to 5).

Therefore, these findings do indeed suggest that the massive creation and global dispersion of securitised products – in strict accordance with the credit risk transfer hypothesis - , which had been hitherto facilitated by the 'originate-to-distribute' banking paradigm -, subsequently gave way to the rapid deterioration of financial institutions' loan portfolios, once residential real estate prices started to falter. *This global uncertainty surrounding the financial soundness of major financial institutions - especially of those most exposed to potentially 'toxic' securitised credit derivatives products - ultimately unleashed an equally massive deployment of public resources in order to countervail the impending paralysis of national banking markets and institutions and the subsequent recessionary effects of a global financial shock.*

4.2.3. THE ROLE OF MONETARY POLICY IN THE AFTERMATH OF THE GLOBAL FINANCIAL CRISIS

The expressive global macroeconomic uncertainty pervading international financial markets in the aftermath of the global financial meltdown precipitated the need for a proper set of massive macroeconomic policy responses to the said global financial

[54] The fact that certain European financial institutions (in particular, of German extraction) became quite exposed, through financial exposures comprised of securitised assets of subprime extraction, to the U.S. Subprime shock might ultimately contribute to the CDS spillovers in question.

shock. As shall be seen in the following paragraphs, the present crisis has been quite unique insofar as a massive experimentation involving quite idiosyncratic and heterogeneous policy responses has taken place in order to address both general (e.g., the economic downturn) and specific financial frailties (e.g., persistent liquidity shortcomings in the financial sector).

Adopting the taxonomy proposed by Mishkin (2010) in reference to U.S. macroeconomic policy in the aftermath of the U.S. financial shock, this author classifies monetary policy responses to the Subprime Crisis as either conventional or nonconventional responses[55] (Mishkin, 2010:11).

Conventional responses essentially comprise setting an expansionary central bank interest rate, namely, by structurally lowering these key interest rates in the wake of a financial shock. The latter interest rate constitutes monetary policy's main policy instrument, and this shift aims to restore growth to the debilitating real economy in the aftermath of such an expressive shock.

On the other hand, nonconventional responses comprise three innovative policy measures – liquidity provision, asset purchases and management of expectations[56]. The first two of these policy measures have also been colloquially termed as 'quantitative easing' (Mishkin, 2010:12).

Liquidity provision is aimed at stabilizing financial markets by expanding central bank lending to financial institutions in need of liquidity. This is needed in order to countervail the quite damaging post-crisis short term scarcity of market funds which had been hitherto available prior to the onset of the crisis.

[55] The same macroeconomic policy reasoning is generally applicable to European monetary policy responses, as shall be seen in the following sub-sections; nevertheless, it should be noted that the ensuing European sovereign debt dynamics has been quite distinctive, in light of the heterogeneity of fiscal policy responses amongst Euro Area Member States.

[56] This third nonconventional policy measure is inconsequential to the intended goals of the present document, and will therefore not be herein addressed; nevertheless, we would like to observe that we do not entirely concur with the view that this policy measure is unique to the aftermath of the present crisis, as Mishkin (2010) seems to suggest; in our view, some degree of macroeconomic management of expectations has always been present in previous episodes of financial crises.

Asset purchases involve the acquisition of specific types of securities (including mortgage-backed securities), in order to halt the adverse feedback pricing loop which deeply strained financial market prices associated with mortgage-backed securities, as described earlier in this section.

The latter nonconventional measures were intensely pursued once the more conventional measure of setting central bank interest rates reached a zero-bound lower limit. This boundary effectively constitutes a severe impediment to the subsequent effectiveness pertaining to the use of this policy instrument as an unlimited expansionary policy instrument. In fact, as both the examples of the Euro Area and the U.S.A. quite effectively illustrate, it is widely acknowledged that the latter macroeconomic constraint ultimately inhibited conventional policy measures and further prompted the concomitant use of the above-mentioned nonconventional instruments (Mishkin, 2010:11 to 15).

Overall, monetary policy strategy responses in the wake of the Global Financial Crisis may be aptly characterized as a "massive experimentation in an unprecedented [crisis] situation" (Mishkin, 2010:11), through the deployment of a significant number of innovative policy measures, the final implications of which have yet to be fully ascertained.

Where the potentially hazardous consequences associated with these innovative policy measures are concerned, Allen and Carletti (2010) point out that quantitative easing has not been subjected to an appropriate 'checks and balances' macroeconomic governance procedure. This is due to the fact that quantitative easing has seldom been used before as a policy instrument in the aftermath of previous crises[57], prompting a great uncertainty as to its unintended side-effects (Allen and Carletti, 2010:18).

These authors further observe that a proper appraisal of both the potential benefits and costs pertaining to the use of these innovative monetary policy measures has yet to be fully ascertained. They further point out that the massive use of

[57]According to these authors, Japan effectively exemplifies the uncertainty surrounding the deployment of these innovative quantitative easing measures, insofar as the latter have yet to resolve the structural issues affecting the Japanese economy during the past decade (Allen and Carletti, 2010:18).

quantitative easing measures during the present financial turmoil might indirectly lead to the build-up of strong inflationary pressures, stagflation or even currency crashes (Allen and Carletti, 2010:18 and 19).

In the short term, the intensive use of these innovative nonconventional policy measures has inevitably led to an expansion of the corresponding monetary base and to an easing of tensions in the credit markets. *Notwithstanding, this has been achieved thorough an equally massive expansion of central bank balance sheets*[58]*, in view of the latter entity's direct acquisition of securitised assets*[59]. Given the uncertainty surrounding the pricing of these assets over the long-term, it is still not feasible to ascertain the precise amount of central bank losses ultimately associated with the purchase of these securities.

Therefore, countercyclical monetary policy (both in its conventional and nonconventional forms alike) had to be complemented by the implementation of equally ambitious, but distinctively idiosyncratic, government interventions under the auspices of equally countercyclical fiscal policy measures. The latter policy's implementation has inevitably compromised the fiscal outlook of the advanced economies most affected by the Global Financial Crisis, as shall be seen in the following section.

4.2.4. THE ROLE OF FISCAL POLICY IN THE AFTERMATH OF THE GLOBAL FINANCIAL CRISIS

The recent global financial shock has not only warranted central bank interventions in support of expansionary monetary policies, but has also elicited the implementation of fiscal policy measures in support of respective debilitated real economies. The said fiscal measures have constituted a substantive countercyclical

[58] At the end of 2008, Mishkin (2010) estimates that the balance sheet of the Federal Reserve has balloned to over a trillion United States Dollars, mainly derived from the acquisition of mortgage-backed securities with maturities of ten or more years (Mishkin, 2010:13 and 15).

[59] Where the present Euro Area sovereign debt turmoil is concerned, the European Central Bank has yet to pursue a monetary response based on the direct acquisition of sovereign securities, but has indirectly sustained the said acquisition through its refinancing operations (or 'repos'), by extending the maturity of the latter operations (up to 36 months), and widening the quality of collateral assets posted by its counter-parties (European Central Bank, 2011b, 8 and 9, Box 1). Both measures were intended to support the supply of credit to the Euro Area economy and relieve the funding pressures of financial institutions.

expression of financial support, not only to countervail rising unemployment and feeble consumer spending through automatic stabilizing measures, but also to counterbalance the deep frailties pertaining to the banking sectors of the advanced economies most affected by the global systemic shock.

In fact, Claessens, Kose and Terrones (2008) consider that aggressive countercyclical fiscal policy in the wake of previous episodes involving housing price busts and subsequent credit crunches have usually been more accommodative and flexible than monetary policy alone. This finding suggests that the former might be more effective than the latter in dealing with such episodes (Claessens, Kose and Terrones: 2008:29 and 30). This seems to confirm the above-mentioned zero-bound-related limitations imposed upon monetary policy during the occurrence of these extreme events, which are noticeable in the present episode. However, we will observe that the harshness of the recessionary impact brought about by the present global financial turmoil has indeed strained the resourcefulness of *both* monetary and fiscal policy alike.

In the context of research performed using different historical samples involving major postwar banking crises, Reinhart and Rogoff (2009) conclude that asset market collapses are quite prolonged and deep, with real housing price declines averaging 35% over a six-year period. In addition, they estimate that real economy variables are quite impacted by the said crises, with output falling by an average of 9% (from peak to through) and the unemployment rate rising to an average of 7% over the downward phase of the cycle. On average, output decline lasts for about two years while unemployment lags over four years (Reinhart and Rogoff, 2009:224).

Furthermore, using a more chronologically widened twenty one-year window surrounding selected global and country-specific historical events, Reinhart and Reinhart (2010) conclude that real *per capita* GDP growth rates - the latter constitute a proxy for the standard of living - are significantly lower during the decade following the occurrence of a severe financial crisis. The median post-financial crisis decline in the specific case of advanced economies is approximately 1%. The same historical pattern is observable with the unemployment rate, which rises structurally during the following

decade after the shock has taken place and with historical housing real price cumulative declines which can be as large as 55% (Reinhart and Reinhart, 2010:2 and 3).

Accordingly, a dynamical analysis of the role played by fiscal policy following financial crises should inevitably take into account the prospective performance of the economy in the aftermath of such episodes. That is, the scope of realistic fiscal policy responses should take into account not only the trajectory of the above-mentioned explosive budget deficits due to expanding government expenses sustaining and financing extensive support packages (e.g., to the banking sector); but also, and more importantly, *it should take into account the immediate medium term prospect of the corresponding decreasing tax revenue collection in view of post-shock dampened economic growth*.

Reinhart and Rogoff (2008) also conduct comprehensive research referring to the recessionary impact of banking crises on government tax revenue using a sample of selected banking crises during the 1945 – 2008 period. They ascertain that real government revenues (deflated by consumer prices) consecutively fell in the tree-year period following a given financial crisis, thus exposing the frailty associated with fiscal policy instruments in the aftermath of financial crises (Reinhart and Rogoff, 2008:41, Figure 8b). In fact, the impact on government revenues for the sub-group of the most advanced economies for the more extensive 1815 – 2007 period continues to confirm the decrease in annual government revenue growth in the two-year period following a banking crisis (Reinhart and Rogoff, 2008:42, Figure 8c). In both cases, government revenue growth had been positive in all of the three preceding years before the occurrence of the crisis in question. The authors further report that advanced economies exhibit a very persistent tendency to embrace aggressive countercyclical stimulus measures in order to soften the impact of banking crises on the real economy than do emergent market economies (Reinhart and Rogoff, 2008:41).

That is, historical examination dictates that increasing government spending is simultaneously accompanied by decreasing taxing revenue collection, due to the lack of output growth in the aftermath of financial crises. The full use of countercyclical fiscal policy response measures supported by taxing revenue collection instruments is

therefore constrained by the very extent of the output gap. Inevitably, this limitation enhances the role of public debt policy (in detriment of government tax revenues) as a crucial and decisive fiscal policy instrument in order to support fiscal policy-related state interventions in the aftermath of financial crises.

Where the design of generous state-supported fiscal packages to flailing banking sectors inscribed within the most advanced economies affected by the Crisis is concerned, the said fiscal packages are generally comprised of three quite distinct measures: financial guarantees in support of ailing financial institutions, the reinforcement of deposit insurance schemes and direct capital injections in troubled financial institutions.

Accordingly, and for the purpose of funding the said country-specific fiscal packages, governments have made extensive use of sovereign bond markets and corresponding instruments - as the fiscal instrument of choice - , thus originating a significant increase in the debt-to-world GDP ratio. The latter has risen from 62% in 2007 to 85% in 2009, and the same figure is projected to rise, in 2014, to 118% for G20 countries (Candelon and Palm, 2010:14). This deep connection will be the object of our wholesome attention in the following sub-section.

In the specific case of the Euro area, Alessandri and Haldane (2009) state that government support packages have totaled more than1,99 trillion Euros, more than 1,68 trillion Euros of which in financial guarantees alone and the remaining 310 million Euros in direct capital injections, for the year 2009 alone[60] (Alessandri and Haldane, 2009:Table 1, column entitled 'Euro' and grouping entitled 'Government').

Indeed, the overwhelming scope and impact of these government interventions in the Euro Area alone has also been confirmed by the OECD (2009). Gross financial liabilities in connection to the emergency measures in response to the global financial meltdown have been estimated to have risen from 71,2% of nominal Gross Domestic Product (GDP) to over 84,4% of Euro Area GDP from the years 2007 to 2010,

[60] The authors consider that deposit insurance schemes did not burden the national budgets of Euro Area Member States.

representing a rise of 18,53% throughout the said four-year period (OECD, 2009:73, Table III.8).

Notwithstanding, it should be observed that short-term country-specific government responses within the Euro Area differ significantly in both scope and degree. Petrovic and Tutsch (2009) provide an insight into the heterogeneity surrounding these short-term interventions in the aftermath of the Global Financial Crisis, but, regrettably, their research is strictly confined to an eight-month period between October, the 1st, 2008 and June, the 1st, 2009 (Petrovic and Tutsch, 2009, entries for EU Member States).

Inevitably, these government interventions by individual Member States have also taken quite a toll on the corresponding fiscal balances of the countries in question, which have been seriously jeopardized in the aftermath of the present global financial shock. This fiscal deterioration has been most manifest in the following five nuclear issues (that will be presented hereafter), some of which might have to be reversed in the following years, in order to safeguard the continuity of the European project (OECD, 2009:73).

First, government interventions have unleashed persistently massive, but nevertheless unsustainable budget deficits, in blatant contravention of the European Stability and Growth Pact (SGP), which theoretically caps annual budgets up to 3% of GDP for each and every individual Member State.

Second, the said interventions have also quite blatantly placed pre-crisis public debt positions on unsustainable trajectories, once again in clear contravention of the SGP, which stipulates that European national debts should be lower than or equal to 60% of corresponding Member States' GDP[61].

Third, government support packages to the credit markets have been funded by significant amounts of outstanding government and central loans, in which the

[61] Both the annual budget and public debt caps constitute the cornerstone of the set of Nominal Convergence Criteria instituted by the historical Maastricht Treaty (Leão, Leão e Lagoa, 2009:338 and 339); in our judgment, they are still quite decisive to the wholesome prosecution and stability of the Euro Area as an optimal common currency area.

respective governments have become interested counterparties. This raises the possibility of socializing private moral hazard-related costs should the loans in question not be fully repaid.

Fourth, some of the financial guarantees issued in support of ailing financial institutions are equivalent to public debt, while others constitute contingent liabilities originating financial exposures which will have to be subsequently unwound.

Fifth, government interventions within their respective banking sectors have, in some instances, fundamentally altered the structure of banking systems by partly nationalizing some troubled financial institutions. Governments have therefore become either controlling or significant shareholders in the said financial institutions, a fact which might in itself originate uncompetitive distortions in corresponding national banking sectors.

Notwithstanding, financial crises (and specially those of systemic nature) are quite protracted and highly complex events. Taking into account the severity of the global financial shock under scrutiny, post-financial shock recessionary effects to the real economy have been quite severe. *By deeply inhibiting economic growth and thus jeopardizing the collection of tax revenues in the aftermath of the present Global Financial Crisis, the latter event has inevitably made the public debt instrument stand out as the preferred fiscal instrument of choice, notwithstanding the blatant contravention to pre-shock European commitments (such as, for example, the Growth and Stability Pact).*

The following sub-section will further analyze the link between output and sovereign debt, detailing the nature of this intricate relationship and placing it in its appropriate historical context.

4.3. THE SOVEREIGN DEBT–OUTPUT NEXUS: ESSENTIAL CONCEPTS AND CURRENT RESEARCH

In the present sub-section, we will introduce and describe several nuclear concepts – including the sovereign debt Laffer curve - which are fundamental to understand the main issues surrounding the impact of public debt on economic growth. We will also provide a brief synopsis of the recent developments in this theoretical field.

4.3.1. THE TWO FACES OF SOVEREIGN DEBT: THE SOVEREIGN DEBT LAFFER CURVE

The severity of the economic impact associated with the present Global Financial Crisis has highlighted the need for the proper pursuit of sustainable and coordinated macroeconomic policy responses in order to countervail the corresponding negative impact, with the firm intent of restoring output growth and eradicating unemployment.

In the specific case of fiscal policy, public debt – as the fiscal policy instrument of choice - has been particularly strained in the aftermath of the present Global Financial Crisis, in view of its strategic importance as an effective budgetary financing instrument. Intensive use of this instrument inevitably gave rise to upsetting sovereign financial stress presently affecting financial market soundness in the Euro Area in the aftermath of the current financial turmoil.

We will first proceed by presenting a circumscribed definition of the concept of sovereign debt (which is by itself a rather elusive concept), mainly taking into account the nature of its composition. In the context of the present document, we will thus embrace the set of definitions proposed by Reinhart and Rogoff (2009), which will serve as a foundation to the final sub-sections of the present document.

Total government debt comprises "total debt liabilities of a government with both domestic and foreign creditors" (Reinhart and Rogoff, 2009:9, Box 1.1). The term 'government' includes the central administration, provincial and federal governments,

as well as all other remaining entities possessing borrowing power endorsed with an explicit government guarantee (Reinhart and Rogoff, 2009:9, Box 1.1).

On the other hand, total government debt comprises domestic debt and external debt. The former represents liabilities issued under and subjected to national jurisdiction, regardless of the creditor's nationality or underlying currency denomination of the entitlement. While the latter represents public and private liabilities placed with foreign creditors and subjected to the latter's jurisdiction or to international law (Reinhart and Rogoff, 2009:9, Box 1.1).

From a creditor's perspective, there arises the possibility that the underlying sovereign credit entitlement might not be repaid (either fully or even partially) under the initial conditions set forth at issuance. That is, sovereign debt might be susceptible to sovereign default risk, thus resulting in a loss (partial or total) of the underlying credit as a result of this uncertainty.

Nevertheless, it should be noted that sovereign risk is presently liable of being hedged against. In the past decade, new financial products and markets have been developed, which allow for the possibility of insuring against the prospect of credit default (e.g., sovereign debt default). Credit default swaps (CDS) constitute an over-the-counter financial contract between two counterparties in order to exchange the credit risk underlying a specific reference entity (in our case, a sovereign debtor) in exchange for a stream of premium payments. Thus, once these contracts are agreed upon, the insurance buyer's position is immune to the prospect of credit default (should such a credit event occur) and the only associated cost is the insurance premium, known as the credit spread (Felsenheimer and Gisdakis, 2008:76).

Accordingly, the recent rise in CDS spreads pertaining to European sovereign debt market instruments has become the focal point of sovereign stress, in light of the latter instrument's signaling abilities. In fact, one of the fundamental justifications for the present rise in sovereign debt spreads associated with the latter instruments has been the perceived significant discrepancy in the economic performance among Euro Area Member States in the aftermath of the systemic breakdown. The main determinants

associated with this most troublesome rift will be presented in the following sub-section.

We have documented, in the previous sub-section, the need felt by governments to abridge the output gap in the aftermath of financial crises by implementing costly fiscal stimulus packages, which heavily bear upon government fiscal deficits. Given the traditional fall in government revenues in the aftermath of such episodes, the arising fiscal deficits are inevitably funded by a corresponding rise in the stock of sovereign debt, the latter often being the only feasible sovereign financing option available.

But is there a link between mounting sovereign debt and subsequent output growth? In the affirmative case, what are the main characteristics of this complex and dynamic relationship? We will herein address this fundamental research topic within the geo-economic framework of the Euro Area, taking into account the period comprised between the introduction of the Euro and the aftermath of the Global Financial Crisis.

Reinhart and Rogoff (2009, 2011) extensively portray the aftermath of financial crises, namely where the performance of public debt is concerned. Notwithstanding the fact that their extensive historical research possesses far-reaching macroeconomic implications, it would be fundamental to mention some of these topics and corresponding implications, insofar as they directly bear upon our own research pertaining to the Euro Area.

First, according to the historical findings presented by the latter authors, one of the defining characteristics associated with the aftermath of financial crises - when output traditionally decreases - has been the massive explosion in public debt, mainly due to the buildup in fiscal deficits. This historical finding is in strict accordance with the evidence heretofore presented pertaining to the present financial breakdown. According to the statistics advanced by these authors, the cumulative increase in public debt in the three years following systemic banking crises in selected post-World War II financial episodes indicates that increments in public debt average 86,3%. That is, the stock of public debt nearly doubles in the following three years after an extreme episode

has taken place[62] (Reinhart and Rogoff, 2009:169 to 171) (Reinhart and Rogoff, 2011:9 and 10). Thus, the latest run-up in public debt in the aftermath of the Global Financial Crisis of 2007 – 2008 is historically validated.

Second, by adopting a more enlarged historical perspective through the analysis of the 1860 – 2010 period, the latter authors scrutinize the performance of gross central government debt as a percentage of GDP. This fundamental ratio traditionally peaked in the aftermath of the World Wars and the Great Depression episodes. That is, the evolution of this ratio throughout these systemic episodes confirms that when output is traditionally retrenching, the public debt stock traditionally soars in order to mitigate the impact of the said episodes through fiscal deployment. That is, this constitutes the most dependable source of funding for countercyclical fiscal policy, and, more specifically, for public debt policy. By historical standards, and taking into account the recent performance of this ratio during the present global financial turmoil, the said ratio is still peaking and has recently reached levels not recorded since the end of World War II. It has even surpassed previous historical peaks reached during World War I and the Great Depression[63] (Reinhart and Rogoff, 2011:8, Figure 1, inset labeled 'Advanced Economies').

Third, by taking into account the impact of the present financial crisis in the countries inscribed within the highest public debt bracket, the latter authors' assessment again confirms a recurrent pattern observed in previous financial episodes. By solely considering the period 2007 – 2009 for this selected set of countries, rising public indebtedness (duly deflated by consumer prices) has been most striking in seven of the countries most affected by the latest financial crisis: Greece, Iceland, Ireland, Portugal, Spain, the United Kingdom and the USA. Herein, public debt levels rose by an average of approximately 134%[64], thus exceeding by a considerable margin the 86,3% historical benchmark (mentioned in the preceding page) connected with prior financial crisis

[62] This specific comparative exercise drawn by these authors focuses on the percentage increase in public debt, rather that recurring to the more common debt-to-GDP ratio.

[63] As a general rule, it should be observed that, prior to World War II, the main driver for public indebtedness was mainly attributable to the cost of financing wars, while, during peacetime, the main driver for rising public debt is attributable to the onset of severe financial crises.

[64] The corresponding figure for countries that did not experience a major financial crisis is approximately 36% in real terms between 2007 and 2010 (Reinhart and Rogoff, 2011:11).

episodes within a larger set of countries (Reinhart and Rogoff, 2011:10 to 12, specially Figure 2, top sub-panel).

Fourth, these authors further conclude that banking crises frequently either precede or coincide with sovereign debt crises, when sovereign stress is rampant and potentially acute and when the creditworthiness of public debt is seriously questioned by the financial markets (this topic will be fully developed when the concept of sovereign default is hereafter introduced). That is, banking crises often constitute efficient predictors of sovereign debt crises. One of the main justifications for this chronological sequencing pattern might be attributable to the contingent liability hypothesis previously expounded in the literature. This hypothesis stipulates that mounting public debt as the main fiscal policy tool in the aftermath of financial crises might undermine (or be perceived to undermine) the very solvency of a given government pursuing such an expansionary policy (Reinhart and Rogoff, 2011:17 to 19). Therefore, the said hypothesis, while suggesting the existence of an expressive trade-off between rising public indebtedness and government solvency, also raises a most fundamental research topic, which will be addressed in the following paragraph.

The above-mentioned findings are quite essential to our through understanding of a most fundamental research topic affecting sovereign debt markets in the aftermath of the present Global Financial Crisis. *The latter research topic pertains to the potential existence of an optimal level of public indebtedness beyond which output growth becomes encumbered by the sheer stock of existing public debt. That is, is there an optimal threshold level of public debt which does not restrain output growth? If so, is such a threshold quantifiable?* This pivotal research issue will constitute the centre of gravity of the present document, which will strive to answer the questions herewith associated within the geographical framework of the Euro Area.

In the course of their extensive research, Reinhart and Rogoff (2010a, 2011) arrive at a central finding concerning the above-mentioned key research topic. The authors scrutinize the relationship between sovereign debt and GDP growth focusing their research on a newly-compiled database consisting of forty-four countries and spanning approximately two hundred years. Subsequently, they group the annual

observations in four distinct clusters or groups, according to their public debt-to-GDP ratio value. The cut-off points for these distinct categories are determined *ex ante* by the authors and vary according to increasing and equally-ranged[65] public debt-to-GDP ratio intervals (namely, less than 30%, between 30% and 60%, between 60% and 90% and above 90%). Their central findings suggest that *the relationship between public debt and GDP growth is quite feeble when considering the first three intervals. That is, the relationship is weak for public debt-to-GDP ratios below 90%, a fact which indicates that, below the 90%, sovereign debt does not constrain output growth. However, the relationship between public indebtedness and output growth is quite significant for the majorant interval containing the highest public debt-to-GDP ratio values. That is, when the latter ratio values are greater than 90%, the corresponding median growth rates fall by one percentage point and average growth rates fall almost by four percent (when the latter values are compared to those associated with lower debt burden categories). Furthermore, the said 90% sovereign debt threshold above which output growth is constrained is applicable to both advanced[66] and emerging market economies and is also uniformly applicable throughout the underlying chronological sample (reaching well back into the* 1800's). *Thus, according to this finding, the relationship between public debt and output growth is therefore deleterious when levels of public indebtedness are above 90% (Reinhart and Rogoff, 2010a:7) (Reinhart and Rogoff, 2011:25 to 27).*

In addition, the existence of public debt thresholds is essentially country-specific, i.e., the said thresholds may vary quite heterogeneously across the countries included in the sample. This is attributed to the fact that national fiscal policies remain quite idiosyncratic, most specially in Euro Area Member States. As such, we cannot strictly speak of a single general threshold value universally applicable to all countries or sets of countries across time. Indeed, Reinhart and Rogoff (2010a) conduct their threshold estimation research within specific sub-sets of their sample (i.e., selected

[65] Except, of course, for the category comprising more than 90% of public debt-to-GDP ratio values, which is unbounded by an upper limit.

[66] The selected advanced economies portrayed by the authors are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zeland, Norway, Portugal, Spain Sweden, the United Kingdom and the U.S.A. (Reinhart and Rogoff, 2010a:7).

advanced economies, selected emerging markets), and the 90% threshold should not be viewed as a universal value. Instead, the said thresholds should rather be viewed as country-specific historical limits. (Reinhart and Rogoff, 2010a:23).

Furthermore, the said set discrimination is quite efficient, insofar as these authors' findings point to the existence of a discrepancy between the thresholds applicable to advanced economies and emerging markets (the latter economies being much more intolerant to debt accumulation). Thus, this discrepancy constitutes the essence of one of the most important findings associated with the latter authors' research, the 'debt intolerance' puzzle. The gist of the latter puzzle's argument relates to the fact that the historical analysis previously conducted by these authors has revealed that public debts associated with emergent market economies tend to default at low levels of public debt-to-GDP ratios that those of more advanced economies. That is, emergent market economies' public debts are more intolerant to higher debt accumulation than those of advanced economies (Reinhart and Rogoff, 2009:121).

This fundamental research topic will certainly bear upon our own research, in view of the fact that the present European sovereign debt turmoil affecting the Euro Area might be conditioned by this puzzle. The latter turmoil has been particularly acute when taking into account the build-up of sovereign stress related to the said Area's southern Member States. That is, as the latter economies' mounting public debts breach historical country-specific thresholds, corresponding risk *premia* have risen quite sharply, further straining these highly indebted economies. Furthermore, the recent rise in Euro Area sovereign spreads might also be conditioned by the existence of disparaging thresholds within the said Area, thus signaling the presence of a higher degree of sovereign debt intolerance in some Member States. That is, these country-specific levels might have been less relevant during the recent European economic convergence process of the last decade, but their importance has certainly resurfaced with the onset of the current Global Financial Crisis (the following sub-section will describe this process more thoroughly).

Moreover, the results pertaining to the existence of noxious effects, above a given threshold, of public debt on output have also been documented by other authors,

namely by Cecchetti, Mohanty and Zampolli (2011), Kumar and Woo (2010) and Checherita and Rother (2010). These authors' findings will also be briefly reviewed herein, insofar as these results constitute the literature's state of the art where this fundamental research question is concerned.

Cecchetti, Mohanty and Zampolli (2011) also analyze the same research topic using a database comprised of 18 OECD countries between 1980 and 2010. Their analysis acknowledges the massive rise in non-financial sector debt (which duly includes both government and private sector indebtedness) as a percentage of GDP for the countries included in their chosen sample.

According to the authors, the underlying upward trend in both public and private indebtedness has been a distinguishing feature throughout the sample data. That is, the recent crisis has only consubstantiated an already rising trend. The authors justify this long-term trend according to the three following factors. First, the removal of barriers on financial market activity from the late 1980's onwards has ultimately consolidated a liberalized global financial framework, thus deeply spurring financial innovation. Second, the onset of the Great Moderation has given rise to both low inflation and low unemployment rates, thus eliminating the great uncertainty associated with the deeply inflationary 1970's. Thus, general economic stability was greatly improved upon, with financial innovation fostering the supply of credit throughout the markets and allowing risk to become a financial commodity in itself. Third, advantageous tax policies on debt have also encouraged not only the very supply of debt, but also the creation of new debt-related financial instruments (e.g., mortgage-backed securities) and collateral markets (e.g., the stimulation of real estate markets through increased homeownership) (Cecchetti, Mohanty and Zampolli, 2011:5 to 8).

The latter authors conduct their research pertaining to the effects of this long-term mounting debt on output growth not only by using several methods to address the research issue in question, but also by disaggregating their analysis into public and private (both corporate and household) debt and addressing the latter's impact on economic growth.

First, the authors also confirm that there is a negative impact of mounting public debt on output growth, insofar as a 10 percentage point increase in the public debt-to-GDP ratio is associated with a 17 to 18 basis point reduction in subsequent average annual growth (Cecchetti, Mohanty and Zampolli, 2011:14).

Second, the authors also conduct their research by dividing their sample into quartiles in the manner of Reinhart and Rogoff (2010a, 2011). Their findings also suggest that high levels of debt dampen output growth, most specially taking into account that when debt is augmented from the third to the fourth quartile, output growth is reduced (Cecchetti, Mohanty and Zampolli, 2011:16), thus confirming the previously described Reinhart and Rogoff (2010a, 2011) findings.

Third, the authors estimated several regressions according to multiple scenarios involving specific debt categories included in their sample. Their findings suggest that public debt is deleterious for output growth when the public debt-to-GDP ratio is beyond the 80% - 100% range (specific thresholds vary according to their adopted model specifications) (Cecchetti, Mohanty and Zampolli, 2011: 3 and 17).

Fourth, the authors also strive to present some of the policy implications associated with their findings. They conclude that the advanced economies' demographic profiles - namely where the existence of ageing populations is concerned - constitute a main driver for the structural deterioration of fiscal gaps, further straining fiscal policy instruments. This fact reinforces the need for governments to substantially and aggressively reduce their mounting public debt exposure. Debt consolidation (or reduction) actions targeting a level of public debt much lower than the calculated thresholds would only enhance the corresponding economies' ability to respond to future economic shocks of uncertain magnitude (Cecchetti, Mohanty and Zampolli, 2011:21).

Furthermore, this debt consolidation effort would be even more desirable in view of the fact that the current expansionary policy being pursued by the European Central Bank might be reversed in the future. Leão, Leão and Lagoa (2009) draw attention to the fact that a prospective rise in key central bank rates in order to curb

future inflationary pressures will most certainly condition the prices pertaining to existing stocks of sovereign debt[67] (Leão, Leão and Lagoa, 2009:151 to 153). This argument is particularly valid for the Euro Area as a whole once the current crisis' economic impact is fully dealt with by the European Central Bank and monetary policy again becomes contractionary. This will inevitably add pressure to Euro Area Member States' existing stock of sovereign debt.

Kumar and Woo (2010) also establish a link between public debt and growth, by using a wide variety of econometric methods applied to a sample of data comprising the 1970 - 2007 period for several advanced and emerging market economies alike. The authors' findings suggest the existence of a negative relationship between high public debt and subsequent real *per capita* GDP growth. On average, a 10 percentage point increase in the initial public debt-to-GDP ratio is associated with a subsequent gradual decrease of 0,2 percentage points in annual real *per capita* GDP growth, although the said impact is smaller when addressing the sub-set of advanced economies included in their sample, where the decrease is around 0,15 (Kumar and Woo, 2010:21).

More importantly, the authors also observe the impact of non-linearities of mounting public debt on output growth, by conducting their research in the manner of Reinhart and Rogoff (2010a, 2011), thus grouping public debt-to-GDP ratios accordingly. They also conclude that the higher the level of initial public debt, the higher the negative impact on subsequent output growth. They also suggest that a given ratio rise has a significantly higher impact on the highest public debt-to-GDP ratio sub-set than in the remaining lower sub-sets. *This fact suggests the presence of non-linear effects when the said ratio surpasses the 90% threshold (Kumar and Woo, 2010:18).*

On the other hand, this further re-enforces the policy recommendations proposed by Cecchetti, Mohanty and Zampolli (2011), whereby public debt levels should be kept quite below the threshold markings. This should be pursued, at the very least, as a

[67] This argument is made much more resounding when taking into consideration the strong degree of association between central bank key interest rates and bond prices, insofar as monetary policy has traditionally been the most important determinant to the said bond markets (Leão, Leão and Lagoa, 2009:154); the other determinant – credit rating announcements – has been deemed less fundamental to advanced economies prior to the onset of the Global Financial Crisis, but has certainly gained importance since the occurrence of the global systemic event, as shall be seen hereafter.

precautionary measure, in order to avoid incurring in the said non-linearities, once the potentially deleterious 90% threshold has been surpassed.

Notwithstanding the merit and validity of the argument in support of a persistent link between sovereign debt and subsequent output growth that has been heretofore presented, some cautionary notes pertaining to the said argument's underlying line of research should also be observed. Criticizing the main findings associated with the line of research pursued by Reinhart and Rogoff, Irons and Bivens (2010) sustain that the estimation of the 90% threshold is based on a simple correlation between high debt levels and slower growth. That is, the said threshold is endogenously determined in accordance with the initial groupings proposed by the former authors. In addition, no particular evidence on causality between public debt and output growth has actually been provided (Irons and Bivens, 2010:2 to 4).

Although we acknowledge the validity of the claims inscribed in this counterfactual line of research, we must also acknowledge the truly innovative spirit of Reinhart and Rogoff's main line of scientific enquiry, which is nevertheless at an earlier critical stage of refinement. Furthermore, the subsequent pursuit of analogous empirical and theoretical research lines should yield more precise and substantiated findings. This is specially the case when taking into account that the full assessment of the impact of the present sovereign debt turmoil, which is still unfolding, has yet to fully acknowledged.

Should we accept the validity of the aforementioned innovative line of reasoning (as documented by the research herein expounded), the impact of rising public indebtedness on output growth prompts a further question concerning the channels through which the said output growth might be diminished. Although it is not the purpose of this paper to present an extensive review of the said channels, it is nevertheless important to provide a brief overview of how output growth might be encumbered by a rising public debt burden.

A most simple connection between public debt and output growth is based upon research conducted by Robert Barro, which has been cited in Reinhart and Rogoff

(2010a). The latter authors refer that future debt sustainability strongly depends on rising taxes. In view of the fact that, in the aftermath of financial crises, governments traditionally follow expansionary fiscal policies (thus expanding public debt-financed fiscal deficits), taxes will ultimately and inevitably end up being raised in the long-term. This will inevitably originate a subsequent distortionary impact on long-term output growth, ultimately straining the ensuing redemption of existing public debt (Reinhart and Rogoff, 2010a:6).

Kumar and Woo (2010) provide a more comprehensive (although brief) review of other growth-distortionary channels established in the literature. Besides the simple (but quite effective) distortionary taxation channel expounded in the previous paragraph, other additional significant channels documented by previous literature include: the adverse effect of public debt on capital accumulation[68] and growth (through higher long-term interest rates), the onset of future inflation corroding growth, the prospect of greater macroeconomic uncertainty affecting growth, the constraints imposed by high levels of debt on the scope of countercyclical fiscal policy and, finally, the 'debt overhang' channel (which will be subsequently discussed in the following paragraphs) (Kumar and Woo, 2010:5 and 6).

Furthermore, a most pertinent research issue to which full attention must also be drawn refers to the implications regarding *the potential existence of a threshold for public debt*. In reality, should the latter constitute a macroeconomic reference point (or interval), and given the existence of potential non-linearities involved once the said threshold has been breached, the relationship between public indebtedness and growth might be characterized in accordance to the precepts suggested by the 'debt Laffer curve' literature, a concept which will be forthwith introduced.

[68] In a prior study conducted before the current financial turmoil, Pattillo, Poirson and Ricci (2004) observe that the negative impact of high debt on output growth stems from a strong negative effect on both physical capital accumulation and total factor productivity growth; in addition, they also find that doubling debt reduces output growth by about 1%, through the reduction in both *per capita* physical capital and total factor productivity by almost as much; this thus highlights the importance of this channel of growth distortion (Pattillo, Poirson and Ricci, 2004:19).

The existence of a sovereign debt Laffer[69] curve has been initially suggested by Krugman (1988) and Sachs (1990), in the wake of the resounding debt crises episodes of the 1970's and 1980's. The latter episodes launched a stern debate concerning the effectiveness of debt reduction programs for over-indebted governments and respective economies, in order for the latter to both re-gain financial creditworthiness and restore output growth. The sovereign debt Laffer curve stipulates that the accumulation of sovereign debt leads to a diminishment of economic output above (or beyond) the said threshold. That is, public debt levels above the threshold actually compromise a given country's debt repayment capabilities by encumbering economic output. This sovereign financial repayment stress is mainly attributed to the fact that, in light of the disincentive to expand capital accumulation due to existing high levels of public indebtedness, the expected debt-servicing costs associated with an already massive level of public debt further discourage subsequent domestic and foreign investment (a quite typical adverse feedback loop). This line of reasoning sustains that the threshold represents a maximum point of public indebtedness which maximizes economic output.

Accordingly, the public debt – output relationship resembles a concave function where the maximum point of this function represents the maximum economic output attainable as a function of the level of public indebtedness. Below the threshold, adding debt leverages economic output, while above the same threshold, adding public debt de-leverages economic output. This is essentially achieved through the said capital accumulation channel, notwithstanding the fact that other channels might also play a significant role.

Furthermore, whenever levels of public indebtedness surpass the appropriate thresholds, a sovereign debtor might also be liable to suffer from the so-called 'debt overhang' paradox. Debt overhang is typically associated with the 'perverse' portion of the sovereign debt Laffer curve, insofar as the corresponding over-indebtedness is equated with a debt service surcharge on the economic fabric that typically undermines

[69] The original Laffer curve – named after U.S. economist Arthur Laffer - constitutes a theoretical representation of government revenues as a function of the taxation rate (namely, as a percentage of taxable income) and suggests the existence of an optimal rate of taxation which maximizes government revenues.

the expansion of economic output through the capital (dis-)accumulation channel. That is, as a greater share of output is needed to service mounting public debt repayment, there is a reduced incentive for debtor nations to adopt structural reforms in order to correct their initial excessive dependency on public debt. This ultimately suggests the occurrence of a potent and vicious negative debt cycle – a sovereign adverse feedback loop, as a variant of the type of pricing mechanism initially proposed by Mishkin (2010) - , whereby the quality of existing sovereign debt is seriously jeopardized by adding subsequent un-serviceable debt that might ultimately compromise the very solvency of underlying debtor nations. This implacable sovereign loop can only be reversed through a Pareto-improving debt consolidation process, thus restructuring the initial conditions under which the initial debt burden was agreed upon. More importantly, the said debt consolidation is Pareto-improving to both debtors and creditors alike, in view of the fact that it strengthens the incentives for debt repayment and avoids massive default-induced losses (Roubini, 2001:9 and 10).

In effect, the existence of a potential sovereign debt Laffer curve, subject to quite a distinctive dynamics, will warrant the introduction of additional nuclear concepts which are ultimately related to the sovereign debt meltdown process affecting the financial markets in the wake of the Global Financial Crisis. These additional concepts will be introduced in the following section, which will deal with the basic tenets of sovereign debt meltdowns and are intimately related to the vulnerability pertaining to public indebtedness levels *above* the estimated threshold values that are typically associated with the perverse section of the sovereign debt Laffer curve.

4.3.2. THE PERILOUS JOURNEY FROM DEBT VULNERABILITY TO SERIAL DEFAULT

As stated in the previous sub-section, the sovereign debt Laffer curve is generally comprised of two quite distinctive sections. In the first section, debt is a benign determinant for economic output, while in the second section, debt becomes a malign determinant for economic output. The recent sovereign stress turmoil currently

affecting the Euro Area's sovereign debt markets in the aftermath of the Global Financial Crisis suggests that some of the Member States more critically affected by the said stress are already suffering from the malign effects of public debt accumulation, exhibiting debt levels that have already started to encumber economic output. But prior to addressing the idiosyncrasies of the Euro Area's sovereign debt problems, it would be useful to introduce some concepts related to the different degrees of sovereign affliction induced by the over-accumulation of public debt. These are deeply useful in our discrimination of the severity of the impact of the events taking place once public debt-to-GDP ratios are well above the said optimal thresholds. Moreover, these concepts will also be useful to fully grasp the complexity of the sovereign distress currently affecting the Euro Area's sovereign debt markets.

The perverse section of the sovereign debt Laffer curve is thus implicitly associated with the concept of debt vulnerability, whereby *the accumulation of debt beyond the optimal threshold strongly reduces the incentives for complying with the underlying set of debt liabilities.* That is, the vulnerability concept relates to the possibility incurred by debtors (of sovereign extraction, in our case) of not complying (willfully or otherwise) with the initial terms of the accrued debt agreements or contracts.

Nevertheless, it should be pointed out that there are several gradative distinctions before non-compliance (or, in the extreme case, default) occurs. That is, there are various degrees of non-compliance whereby the original debt contracts might be partially or fully breached. The latter will be described once an important source of vulnerability is properly addressed.

An important source of vulnerability stems from the 'illiquidity *vs.* insolvency' debate within the literature. Debt illiquidity refers to the specific episodic circumstances under which a given sovereign debtor's short-term debt compliance schedule might become affected by the onset of a liquidity crisis (e.g., as in the aftermath of a systemic financial crisis of deep magnitude which deeply constrains available liquidity). Under these circumstances, the said schedule – which includes not only the financing of interest payments, but also the potential rolling over of the accrued principal – is

compromised by the debtor's short-term inability to fund these schedules. That is, the said sovereign debtor is faced with a financial short-term debt repayment non-compliance, but is otherwise fully willing and capable of financing the said schedule(s) in the long-run (Reinhart and Rogoff, 2009:59 to 61).

On the other hand, debt insolvency stands in clear contrast to the preceding situation insofar as it reflects the market perception upheld by financial market creditors that a given sovereign debtor is either unwilling or financially unable to honor its compromises over the long run. In these extreme circumstances, the trajectory of existing public debt is manifestly structurally unsustainable over a long time frame or is, at the very least, perceived to be so by financial market creditors (Reinhart and Rogoff, 2009:60).

It should be observed that, in practice, it is often quite difficult to distinguish between the more temporary state of illiquidity from the more structural state of insolvency, insofar as both are inherently dynamic concepts and are typically associated with macroeconomic uncertainties. Ultimately, distinguishing illiquidity from insolvency constitutes an intricate and daunting economic task that ultimately requires a profound and complex analysis sustained by a very broad range of indicators, factors and assessments (Roubini, 2001:11).

Furthermore, it should be pointed out that these two quite distinct states may require equally distinct conciliatory approaches to solving the underlying debt-related issues. Should a sovereign debtor be facing illiquidity issues, a process of debt rescheduling (equivalent to a very mild restructuring) might suffice to correct the temporary ailments and restore creditworthiness. On the other hand, should a sovereign debtor suffer from a more structural insolvency condition, the proper solution might come in the form of a through debt reduction program. In either case, both prescriptions are Pareto-improving, insofar as they reduce the incentives for debt profligacy and restore the necessary trust in the creditor - debtor relationship (Roubini, 2001:3).

Considering the severity of this later insolvency state, it should be further observed that there are no simple rules for assessing whether a given sovereign debtor is

insolvent or not. One of the approaches suggested by the literature states that a sovereign debtor's solvency requires the discount value of its foreign (i.e., external) debt to be non-zero in the infinite limit of its inter-temporal budget constraint. Implicitly, the growth of its foreign debt must necessarily be inferior (or equal) to the underlying real interest rate paid on this debt. Accordingly, if a sovereign State is running primary deficits and has an initial stock of debt, this solvency constraint requires the said State to run primary surpluses over the (theoretically) infinite timeline. Notwithstanding, and taking into account the infinite trajectory paths that might ensure compliance with the inter-temporal solvency criterion and its infinite timeline budget constraint, the latter condition constitutes a very loose criterion to assess fiscal sustainability (Roubini, 2001:3 to 5).

In view of what has been mentioned thus far, *it would be quite relevant to ascertain, in the aftermath of the present global financial turmoil, whether public indebtedness trajectories in advanced economies (as the epicentre to the said turmoil) have indeed been set on an unsustainable path.* In order to further delve into this question, it is quite decisive to take into consideration the governmental recapitalization effort of ailing financial institutions and the introduction of costly macroeconomic stimulus packages. In the context of our paper, *this research line will allow us to specifically investigate whether sovereign debt thresholds have been eventually breached in the Euro Area, most specially in the aftermath of the global systemic shock.*

Taking into account the case of the world's most advanced economies (and addressing the vast majority of the Euro Area's economies), Cecchetti, Mohanty and Zampolli (2010) address the post-crisis fiscal situation and short-term fiscal prospects of these economies. Their empirical findings confirm the rapid deterioration of the public purse, namely where the intricate correlation between the fiscal outlook and government debt is concerned, insofar as the rapid deterioration of the former is duly accompanied by mounting governmental indebtedness. For example, in the case of the German economy (as the Euro Area's biggest economy), the fiscal balance deteriorates from a surplus of 0,2% of GDP in 2007 to a (estimated) deficit of 4,6% in 2011. Analogously, government debt is set to rise from 65% to 85% of GDP. This dual deterioration is also

extensible to all of the Euro Area's economies included in these authors' research (Cecchetti, Mohanty and Zampolli, 2010:3, Table 1).

Furthermore, and considering the long term 30-year projections for the trajectory of the public debt-to-GDP ratio for a dozen advanced economies (including nine of the Euro Area's economies[70]), the latter authors' forecasts unequivocally point to an untenable public debt situation, even taking into account subsequent mitigating gradual (but not radical) fiscal consolidation plans (Cecchetti, Mohanty and Zampolli, 2010:3, Graph 4).

Thus, one of the major risks posed by these long-term public debt forecasts is the ensuing higher (or rising) risk *premia* demanded by investors for holding the corresponding public debt, particularly in the case of the most indebted economies of the Euro Area. This indeed reinforces the fact that these economies' public debt profiles are presently associated with the perverse section of the sovereign debt Laffer curve, and are correspondingly set on unsustainable trajectories.

Should this less optimistic long-term scenario materialize for the set of the Member States of the Euro Area, this raises the prospect of a menacing obstacle for the wholesome prosecution of the European project: as risk *premia* keep rising in view of unsustainable public debt trajectories, investor market differentiation among Euro Area Member States might give rise to the onset of episodic (but quite damaging) episodes of outright default on the corresponding national public debts. This extreme scenario is particularly applicable to the economies exhibiting a weaker fiscal outlook, *thus prompting the need to a quicker return to sound fiscal and public debt rectitude (through debt consolidation), as soon as possible*. In the context of our research question, the Stability and Growth Pact still constitutes an excellent historical reference point for the whole of the Euro Area.

In fact, and taking into consideration its original purpose, the Stability and Growth Pact tried to curb excessive budget deficits by imposing penalties to prospective profligate Member States, even taking into account the occurrence of recessionary states

[70] This group includes: Austria, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain.

(Leão, Leão and Lagoa, 2009: 322 and 323). That is, implicitly, the promotion of economic growth was already envisaged in the Pact, even taking into account a prospective post-crisis scenario. Rising public spending in the aftermath of a crisis might have constituted a powerful and forceful countercyclical instrument, should the Pact have been fully enforced in its intended original framework. We will further address this topic when introducing Euro Area's sovereign debt tensions, most especially taking into account the sovereign financial stress associated with southern Member States' debt profiles, and subsequent policy recommendations.

On the other hand, persistently rising risk *premia* on sovereign debt might constitute a forewarning as to the potential occurrence of an impending credit event (in our case, a sovereign default). The latter might reflect a given sovereign debtor's increasing probability of non-compliance with contractual obligations previously agreed to under the pre-default terms of the debt contract. The said non-compliance may refer to the non-payment of principal and/or accrued interest payments. Nevertheless, what are the manifestations of sovereign default, as a non-compliance event?

According to the taxonomy proposed by Reinhart and Rogoff (2009), sovereign defaults may comprise an outright default or a rescheduling. In the former case, the sovereign debtor simply announces its intention to dishonor its existing public debt schedule and disengage itself from the correspondent contractual obligations. An outright default may be further classified as complete (when the sovereign debtor's intentions extend to the totality of its debt commitments) or partial (when the said intentions comprise a fraction of its debt commitments) (Reinhart and Rogoff, 2009:61 to 63).

On the other hand, a rescheduling should be contextualised within a more dynamical bargaining framework, whereby a sovereign debtor seeks to impose upon its creditors a longer repayment schedule and/or interest rate concessions (some rating agencies regard reschedulings as negotiated partial defaults). This is pursued in order to soften the profile of existing cumbersome debt schedules.

It should be further pointed out that, in practice, most defaults are typically partial in nature and, accordingly, the ensuing bargaining *equilibria* typically involve partial re-negotiated repayment schedules most suited to the interested parties. This empirical bargaining framework quite often blurs the thin line between outright defaults and reschedulings (Reinhart and Rogoff, 2009:61 to 63).

Another key concept that merits further attention is sovereign serial default. The latter term refers to a sovereign debtor's sovereign default(s) on either external or domestic debt (or both), regardless of the (higher or lower) default frequency associated with the historical sequence of corresponding default episodes in question. On the other hand, serial default might also involve either wholesome default or partial default through rescheduling, regardless of the time needed to obtain the often negotiated partial exaction to creditors (Reinhart and Rogoff, 2009:14 and 15).

But why do sovereign debtors default (serially or otherwise)? There are basically three incentive mechanisms associated with the pursuit of this extreme course of action. First, and contrary to other non-sovereign debtors (e.g. private entities), sovereign debtors cannot be liquidated and there are neither national nor international judicial institutions capable of enforcing the original terms of a contractually agreed upon public debt contract which might ensure the forced transfer of assets from sovereign debtor to sovereign creditor.

Second, defaults or restructurings enable sovereign debtors to reduce the volume of debt and/or lengthen the maturity of their repayments, with the intention of providing a temporary boost to current consumption expenditures, notwithstanding the fact that the latter rise might be obtained at the expense of future declining consumption expenditures (De Paoli, Hoggarth and Saporta, 2006:3).

Third, should the financial costs of servicing existing sovereign debt within the originally agreed contractual terms exceed the financial costs associated with the restructuring of those very terms, a 'default point' might have been reached (Borensztein and Panizza, 2008:4). That is, once this point is surpassed, sovereign

debtors have a strong incentive not to comply with the initial debt schedules and seek a bargaining equilibrium more suited to their vested interests.

Nevertheless, it should be observed that this process entails several economic costs to those sovereign debtors engaging in this consequential course of action. In general terms, there are five types of impactful economic costs associated with sovereign default episodes (whether serial or otherwise). First, there are short-term reputational costs to corresponding credit ratings and interest rate spreads associated with the default-prone sovereign debtor. Nevertheless, default episodes do not seem to have a long-term impact on credit ratings. Second, there are international trade exclusion costs impacting more export-oriented economies. Third, there are short-term costs to domestic growth in the sovereign debtor's economy through the financial repression of the banking systems of the said economies. Fourth, there are significant political costs accruing to the sovereign debtor's political authorities pursuing the default course of action[71] (Borensztein and Panizza, 2008:5). De Paoli, Hoggarth and Saporta (2006) add a fifth reason (which is indirectly connected to the first of the above-mentioned) pertaining to a sovereign debtor's loss of access to borrowing from the financial markets, once a default decision is undertaken. However, as is pointed out by these latter authors, the theoretical evidence in support of this latter cost has been quite mixed (De Paoli, Hoggarth and Saporta, 2006:3).

Taking into account the afore-mentioned concepts needed to understand the complexity of the research topic under analysis, our research should now be in a position to carefully examine the more recent findings associated with the historical incidence of past sovereign debt crises. Contrary to what might be expected, sovereign debt crises do not constitute a historically unprecedented or sporadic phenomena. Quite the opposite, sovereign default episodes are quite adamant throughout history. Using a dataset covering more than 90% of world GDP and spanning a long historical period from 1800 to 2009, Reinhart and Rogoff (2009,2010b) extensively document sovereign

[71] It should be noted that the conventional wisdom linking the pursuit of expressive fiscal adjustments (e.g., profound budget reductions) to significant political costs to the political agents pursuing such a drastic course of action is currently being challenged. Alesina, Carloni and Lecce (2011) do not find supporting evidence to sustain this traditional perspective in the context of their research addressing 19 OECD countries within the 1975 – 2008 period.

default cycles throughout the last 210 years. Their unprecedented findings may be summarized as follows.

First, there have been extensive periods where a significant percentage of all the countries included in these authors' sample have been in either a default or a restructuring state. Taking into account only the most severe global sovereign default (or near-default) episodes, the authors conclude that there have been five pronounced global peaks or default cycles throughout the said period. The last two global defaults (in fact, the only two episodes of the last century) refer to the post-World War II and to the emerging market debt crises of the 1980s and 1990s. Thus, the historical frequency of default episodes is quite high (Reinhart and Rogoff, 2009:68 to 73) (Reinhart and Rogoff, 2010b:10 to 12).

Second, public debt traditionally follows a lengthy and repeated two-stage boom-and-bust cycle, the latter typically constituting the phase where a markedly higher incidence of sovereign debt crises takes place. In fact, these crises commonly occur in the wake of the peak of public indebtedness. Globally, public debts continue to rise after a default has taken place, in light of the accumulation of debt arrears and subsequent sharp GDP contractions (Reinhart and Rogoff, 2010b:11 and 12).

Third, serial default is a most pervasive financial phenomenon, affecting both advanced and emerging market economies alike, across all continents (Reinhart and Rogoff, 2010b:13). In particular, the economies of the European continent have been, historically, quite affected by this phenomenon.

Where the European continent is concerned, these authors comprehensively comment on the early history of serial default of medieval Europe during the period 1300 – 1799. Notwithstanding the necessary distance and prudence needed to establish such a long historical comparison, this examination does suggest that the present sovereign financial turmoil in the Euro Area does not constitute a historic anomaly, in light of earlier sovereign default episodes taking place on this continent during the medieval period. During this latter period, France and Spain exhibited the greatest

number of defaults (8 and 6, respectively) (Reinhart and Rogoff, 2009:87, Table 6.1, column entitled 'Number of defaults').

Furthermore, where the first half of the authors' dataset is concerned (comprising the nineteenth century), a majority of European sovereign default and restructuring episodes taking place during the said century involved major world powers of European extraction, such as Austria-Hungary, France and Germany (the latter considered as a set of powerful regional states). Even a newly formed State, such as Greece[72], defaulted four times during the nineteenth century since its independence date (in 1829) (Reinhart and Rogoff, 2009:91, Table 6.2, entry 'Europe').

Where the second half of the authors' dataset is concerned (comprising the twentieth century and up to 2008), the authors' assessment of the default and rescheduling episodes for the European continent are also quite unequivocal as to the high incidence of sovereign debt crises, most of which clustered in the second and fourth quarters of the last century. The first cluster is mainly attributed to World War II-related financial strains, while the second cluster is mainly attributed to countries belonging to Central and Eastern Europe (Poland, Romania, Russia and Turkey) (Reinhart and Rogoff, 2009:96, Table 6.4, entry 'Europe').

Therefore, the main conclusion to be drawn from this historical synopsis refers to the hitherto unsuspected high incidence of historical sovereign debt crises of varying severity across Europe[73], which shatters the perennial myth associated with the invulnerability of European sovereign debt to financial predicaments.

The cognitive dissonance arising from the latter differential contrasting rigorous historical analysis to entrenched misconceptions concerning the imperviousness of public indebtedness (specially within advanced economies) constitutes the very base of the *'this time is different'* syndrome proposed by Reinhart and Rogoff (2009, 2010b).

[72] According to the authors, Greece has spent more than a century (expressed as a cumulative tally) since its independence in a state of default or rescheduling (Reinhart and Rogoff, 2009:99, Table 6.6, entry 'Europe', first column).

[73] We are mainly interested in the European continent's debt crisis episodes, but the authors' results span a wide variety of non-European episodes which we will refrain from reviewing; notwithstanding, the overall conclusions relating to the ubiquity of public debt crises are valid across continents.

The said syndrome essentially expresses a stringent collective belief (or rather, a collective misconception) that financial crises (including those episodes involving sovereign debt crises) do not happen to 'us', but solely to 'other people'. That is, these shocks *simply cannot happen* to advanced economies, essentially due to one or several of the following reasons: the said 'advanced economies are immune to shocks', 'our collective learning curve allows us to quickly learn from past mistakes', 'the old rules of valuation no longer apply to the current boom' or simply because 'the present boom is actually built on very sound fundamentals, contrary to past episodes' (Reinhart and Rogoff, 2010b:9 and 10).

Focusing our attention on the origins of the current sovereign debt crisis, one of the misconceptions that fuelled the underlying boom in debt instruments relates to the fact that increased global financial integration actually enhanced global capital markets. This allowed countries to deepen their sovereign debt exposures on an unprecedented scale without, apparently, any consequent side-effect. Furthermore, the very buoyancy of a financial globalization process based on the innovative design of new financial instruments (e.g., securitised products) - but whose structural demerits were not duly scrutinised in the event of a massive financial shock - should not constitute a source for subsequent worry (Reinhart and Rogoff, 2009:214 and 215).

Needless to say, the latter idiosyncratic misconceptions were entirely shattered in the wake of the present Global Financial Crisis, most especially taking into consideration the magnitude of the Euro Area sovereign debt turmoil. Notwithstanding, the gist of this self-renovating cyclical syndrome possesses a very powerful and effective (albeit simplistic) explanatory power.

In the following sub-section, we will provide a thorough assessment of the determinants of European sovereign debt dynamics in the aftermath of the Global Financial Crisis.

4.4. A REVIEW OF THE MAIN DETERMINANTS OF EURO AREA'S SOVEREIGN DEBT SPREADS IN THE AFTERMATH OF THE GLOBAL FINANCIAL CRISIS

The Euro Area presently constitutes an economic and monetary union currently comprised of 17 European Union Member States, the Euro being the latter Area's common sole legal tender. The said Area thus shares a joint monetary policy, but does not contemplate, under its present format, a joint fiscal policy.

As previously noted, the current Global Financial Crisis has deeply strained both monetary and fiscal policies pertaining to the advanced economies most affected by this systemic event. The latter policy has been particularly encumbered by massive government-sponsored interventions that have been implemented in order to countervail the severe financial distress brought about by the said systemic crisis.

Concomitantly, Euro Area sovereign debt issuance – as the preferred fiscal policy instrument of choice in order to fund post-crisis interventions - , while remaining profoundly idiosyncratic in the absence of a common European fiscal policy, has thus exhibited quite a heterogeneous behavior prior to and after the onset of the financial crisis, when taking into account the ensuing fiscal profligacy of each Member State.

Accordingly, the behavior of yield spreads pertaining to the public debt of Euro Area Member States may be generally classed in two quite distinctive stages (Barrios, Iversen, Lewandowska and Setzer, 2009) (Attinasi, Checherita and Nickel, 2009).

The first stage, comprising the period since the inception of the Euro up until the onset of the Subprime Financial Crisis of 2007 – 2008, is characterized by an expressive yield convergence process. During this period, the said convergence process reflects the increasing economic and financial inter-connectedness among Euro Area Member States. Within this stage, there are two points that deserve our attention. First, the benchmark for this convergence process is directly linked to the sovereign quality of German bonds, thereby having enabled the dissemination of a sound fiscal policy from Germany to the other Member States. Second, this convergence process is also connected to the widespread compliance with the Stability and Growth Pact. This stage

is traditionally perceived as the hallmark of successful economic and financial integration within the Euro Area.

The second stage[74], which essentially began with the onset of the Global Financial Crisis and ensuing fiscal profligacy, is characterized by a strong divergence of yield spreads in relation to those of benchmark German bonds. This is especially the scenario involving the more fiscally prodigal Member States (Greece, Ireland, Portugal, Spain, and Italy). *This persistent spread divergence is inextricably linked to the post-crisis massive build-up in European sovereign debt, thus pushing the overall levels of certain Member State's stock of public debt into the perverse section of the Laffer curve, all the while subsequently hindering corresponding output growth.* Figure 1 quite effectively illustrates this latter dynamics in the context of a selection of Euro Area Member States, insofar as the inflection points described in most of the scatterplots herein included not only overwhelmingly depict the non-linear association between sovereign debt and economic output schedules in the aftermath of the Global Financial Crisis, but also potentially point to the existence of a maximum level of tolerance for sovereign debt stock.

Where the reaction of sovereign debt market participants is concerned, this unprecedented upsurge in sovereign bond spreads reflects mounting concerns by the said participants in relation to certain European governments' capacity to fulfill future debt-related obligations (Attinasi, Checherita and Nickel, 2009:7).

More importantly, the post-crisis divergence instability, when compared to the pre-crisis convergence stability, thoroughly signals the onset of investor market discrimination in the European sovereign debt markets in the aftermath of the Global Financial Crisis. This constitutes an attempt to reassess and differentiate individual Member States' idiosyncratic country risks (Attinasi, Checherita and Nickel, 2009:7 and 8). In our judgment, this instability signals investors' lack of confidence in certain Member States' prospective growth performance.

[74] According to Mody (2009), the demise of Bear Stearns seems to have been a decisive turning point associated with this phase (Mody, 2009:5 and 6); we will return to this topic when addressing international risk aversion as one of the main determinants for the behavior of Euro Area's bond spreads.

The most worrisome short-term impact associated with this investor discrimination process pertains to the cumbersome marginal sovereign funding cost for those Member States already facing mounting financial pressures on their national public accounts.

The regime shift in European sovereign spreads prior to and after the onset of the global financial shock might also be simultaneously (but quite simplistically) explained as both a 'flight-to-safety' and a 'flight-to-liquidity' courses of action pursued by market investors (Sgherri and Zoli, 2009:4) (Barrios, Iversen, Lewandowska and Setzer, 2009:7) We will fully explore the implications surrounding these two courses of action when the determinants of European sovereign spreads are fully introduced. However, it should be noted that this behavior conceals a very complex dynamical macroeconomic framework, which we will try to portray in the following paragraphs.

An important question introduced by the above-mentioned yield spread divergence stage concerns the possibility of the mispricing of spreads. That is, during crises, are bond yield spreads faithfully guided by the basics of economic principles, or are market valuations of spreads being driven by irrational behavior? Schuknecht, von Hagen and Wolswijk (2010) examine this issue and conclude that, even in times of financial turmoil, economic rationality still largely explains the said behavior, so that the more recent bond spread divergence is not easily interpreted as a financial market oddity or singularity sustained by irrational market behavior.

While the relationship between public debt and economic output is essentially captured by the dynamics of the sovereign debt Laffer curve, the more recent rise in sovereign bond spreads reflects a more intricate dynamics involving a complex sovereign adverse feedback loop operating in the sovereign debt markets. This dynamical framework should be briefly described prior to addressing the determinants of European sovereign spreads, due to the fact that the said framework might provide a more complex extension of the previously mentioned Reinhart and Rogoff's (2010a,2011) main findings.

In this context, Mody (2009) proposes a prototype of a financial accelerator mechanism whereby the recent turmoil in the sovereign debt markets is reinforced by the frailties connected with the real economy in such an adverse loop involving lack of growth, financial sector stress and mounting sovereign risk.

According to the basic tenets of this proposal, weaknesses in the financial markets and the real economy reinforce each other, most specially in the case involving countries with a constrained competitiveness schedule. The countries most vulnerable to this type of adverse sovereign debt market feedback cycle are those whose competitive performance was most conditioned over the upswing of the previous economic cycle. This lack of competitiveness-based growth perpetuates the severity of the said adverse sovereign debt cycle, by entailing increasing spreads on European sovereign debt. That is, those Member States with a low economic competitive profile are trapped in a self-reinforcing adverse cycle involving higher sovereign debt schedules needed in order to countervail the nefarious real economy impact of the crisis, subsequent low growth prospects in view of the public debt burden and ever-rising sovereign debt *premia* (Mody, 2009:5).

Mody (2009) further dissects the econometric relationship between country financial vulnerability and corresponding sovereign spreads. The author's findings confirm the existence of a statistically significant link between these variables, when taking into account the differentiation of competitiveness among Member States (Mody, 2009:16).

A potential source of disruption justifying this entrapment cycle might be found in the differentiated performance of national banking sectors. Gerlach, Schulz and Wolff (2010) acknowledge that, during the ascending phase of the business cycle, large banking sectors constitute a driver for Member States' economic growth and an important source of government revenue; while during the descending phase of the said cycle, banks constitute a source of significant financial risk to their corresponding governments (Gerlach, Schulz and Wolff, 2010:2 and 12).

Furthermore, Mody (2009) also examines the influence of excessive sovereign debt stocks on rising sovereign spreads following the rescue of Bear Stearns[75]. This event has been hailed by the author as the moment after which the markets' assessment of individual Member States' financial sector prospects drove the process of spread differentiation (Mody, 2009:11).

On the other hand, the latter author observes that a higher level of public debt in countries with lower growth potential will further encumber the public purse. In addition, the author's findings also point to a significant statistical relationship between these variables, most specially taking into consideration those countries exhibiting a large or moderate loss of competitiveness. That is, within the later two categories of countries, Member States have been differentiated both by their perceived financial sector frailties and by their public debt-to-GDP ratios (Mody, 2009:17).

Mody (2009) extends the Reinhart and Rogoff (2009) findings by suggesting (but not demonstrating) that there is a dynamic multiple *equilibria* framework involving sovereign spreads, the health of the financial sector and subsequent growth prospects. In the aftermath of a financial shock to the system, the passage from a 'good' equilibrium point to a 'bad' equilibrium point necessarily entails self-reinforcing larger sovereign spreads, coupled with weaker prospective economic growth. This process thus perpetuates financial sector frailties (or the perception thereof) associated with the original shock. Accordingly, transitions between *equilibria* are much slower where the passage from a more stressed regime ('bad' equilibrium) to a more balanced regime (good' equilibrium) is concerned (Mody, 2009:19 and 38, Figure 8). This constitutes a promising research lead to future developments in the literature, notwithstanding the present lack of empirical evidence in support of such a highly complex assertion.

Thus, taking into account the line of reasoning pursued in the last sub-section, it is quite decisive to ascertain whether Euro Area Member States might thus be trapped

[75] While Mody (2009) considers the demise of Bear Stearns as the defining moment inaugurating the present sovereign debt turmoil, Schuknecht, von Hagen and Wolswijk (2010) point to Lehman's demise as the decisive moment in the said turmoil (Schuknecht, von Hagen and Wolswijk, 2010:14 and 15); we will refrain from commenting the validity of each of these claims, only observing that both demises are deemed to have precipitated the markets' perception of Euro Area's governments' fiscal profligacy.

within the perverse section of the sovereign debt Laffer curve. *In this specific case, the only sound and viable option out of this entrapment (and back to the benign section of the said curve) would be the acquiescence to a credible and thorough debt reduction restructuring program.* The milder process of debt rescheduling might constitute a less credible option, in light of the structural competitiveness issues presently affecting certain beleaguered Member States belonging to the Euro Area.

Having described a very complex and evolving macroeconomic framework, we are presently in a position to address the main determinants of European sovereign spreads. A general review of the said determinants should be extremely useful in addressing the causes of the present sovereign debt turmoil, in order to ascertain the most appropriate policy recommendations to the current sovereign distress.

Attinasi, Checherita and Nickel (2009) observe that there are essentially four sets of factors affecting long-term government bond yield spreads: a sovereign Member States' credit risk profile, sovereign bond market liquidity risk, the overall degree of international risk aversion and, lastly, the financial effects of macroeconomic announcements reflective of fiscal policy events[76] (Attinasi, Checherita and Nickel, 2009:13). Notwithstanding, it should be observed that disentangling and isolating these determinants from the evolution of spreads has proved to be quite a daunting task within the sovereign debt literature. Nevertheless, the above-mentioned determinants have been quite established within the said literature.

Where the credit risk determinant is concerned, a Member State's credit risk specifically reflects not only its current fiscal standing, but also its prospective creditworthiness and fiscal outlook. The credit risk component thus constitutes the required investor premium in order to offset a given (non-zero) probability associated with a scenario commensurate with other than the full repayment of the debt conditions initially agreed upon. That is, the credit risk component encompasses all situations where the sovereign debtor would not be able to fully comply with the initial terms of

[76] The authors rightfully treat this fourth determinant as an offshoot of the credit risk determinant, taking into account the underlying fiscal nature of the macroeconomic announcements in question (Attinasi, Checherita and Nickel, 2009:13).

underlying debt contracts. The corresponding credit assessment might critically depend on investor expectations as to how the sustainability of a sovereign debtor's fiscal standing is interlinked with the sustainability of corresponding sovereign debt (Haugh, Ollivaud and Turner, 2009:6).

Within the scope of the credit component, Barrios, Iversen, Lewandowska and Setzer (2009) further distinguish three types of credit risk: default risk, credit spread risk and downgrade risk. The first is defined as the probability that the sovereign issuer fails to meet its contractual obligations on either coupon repayment or the integral repayment of principal on maturity. The second is defined as the risk associated with the financial performance of the bond, in view of the probability that the corresponding market value might decline more than the value of other equally compatible and comparable bonds. The third reflects the possibility of a ratings downgrade by a qualified credit rating agency (Barrios, Iversen, Lewandowska and Setzer, 2009:6).

In the context of previous literature on European sovereign debt, the most analyzed indicators pertaining to a country's fiscal standing are the government stock of sovereign debt and the government deficit[77] (Barrios, Iversen, Lewandowska and Setzer, 2009:6). In the preceding sub-section, we have described how these variables have deteriorated quite significantly in the aftermath of the Global Financial Crisis, and how this massive deterioration has deeply impacted institutional investors' portfolio allocation decisions.

In turn, this massive deterioration and corresponding investor discrimination have precipitated a 'flight-to-quality' effect, whereby sovereign bond holders preferred to either hold less risky sovereign bonds (e.g., the German Bund[78]) in detriment of the more credit risk-prone debt of certain European sovereign debtors, or demand increasingly higher *premia* for holding the latter sovereign debt, or both (Attinasi,

[77] A third variable which is also observed by the literature (albeit less frequently) is the current account balance (Barrios, Iversen, Lewandowska and Setzer, 2009:9 and 10).

[78] According to Barrios, Iversen, Lewandowska and Setzer (2009), the German Bund is perceived to be the 'safest haven' within the context of the Euro Area's sovereign bond markets, where both its credit quality and liquidity are concerned (Barrios, Iversen, Lewandowska and Setzer, 2009:7); it is therefore unsurprising that the German Bund constitutes the established benchmark both in the financial markets and within the sovereign debt literature (Gerlach, Schulz and Wolff, 2010:7).

Checherita and Nickel, 2009:16) (Mody, 2009:9). This effect is also known in the literature as the 'flight-to-safety' effect (Barrios, Iversen, Lewandowska and Setzer, 2009:5).

Where the impact of massive bank rescue packages on sovereign bond spreads is concerned, it is important to observe that, although the former have certainly shaped the perceptions and subsequent formation of expectations of sovereign debt market investors, there seems to be no clear link between the size of bank rescue packages announced by individual countries and the post-crisis widening of sovereign bond spreads[79] (Attinasi, Checherita and Nickel, 2009:26) (Candelon and Palm, 2010:17). That is, although a Member States' fiscal standing is quite fundamental to the full assessment of its credit risk profile, the sheer size of post-crisis government-sponsored packages to corresponding ailing banking sectors is not, by itself, a determinant factor.

This significant finding is quite compelling, insofar as it signals that, notwithstanding the size of the said rescue packages, sovereign bond investors are significantly more concerned with the corresponding government's *credible commitment* to provide such a support to the banking sector. This assertion critically depends on the latitude of a given Member States' fiscal resources in the aftermath of the systemic shock.

Indeed, demonstration of this over-riding concern is provided by Attinasi, Checherita and Nickel (2009), who state that Member States whose sovereign debt experienced the largest increase in bond spreads, along with a corresponding elevated volatility on their sovereign debt, are not necessarily the ones that have committed the highest amount of fiscal resources to their banking sector (Attinasi, Checherita and Nickel, 2009:24 to 26); but *those Member States (excluding Ireland) that entered the crisis with already significant high government deficits and public debt ratios (Attinasi, Checherita and Nickel, 2009:16).*

[79] Ireland constitutes an exception to the inexistence of a link between the size of packages to widening spreads, in view of the latter country's massive financial bailout package (Attinasi, Checherita and Nickel, 2009:26); that is, according to the latter authors, there is a correlation between the said variables where the Irish case is concerned, and this fact will also impact the present research's findings, as shall be seen when our empirical results are fully presented.

Where the latter ratio is concerned, previous findings suggest that the cornerstone to the 'credible commitment' perspective held by sovereign bond investors is clearly dependent on a given Member State's infinite inter-temporal solvency equation and its corresponding government budget constraint. Ultimately, *the above-mentioned perspective heavily relies on the said Member States' post-crisis prospective economic output trajectories as the only feasible compliance solution to its sovereign debt commitments. That is, the 'credible commitment' view adequately balances the present precarious state of public finances pertaining to a given Member State with the subsequent prospect of debt repayment, the latter being manifestly tied to attaining prospective sustainable economic growth.*

Furthermore, a final significant finding concerning the credit risk component of sovereign debt spreads should also be addressed. One of the most promising strands within the current literature on sovereign debt is the *sovereign credit transfer hypothesis*. The said hypothesis postulates that the profusion of risk due to major credit derivatives losses parked in the macrofinancial balance sheet of the banking sector(s), most particularly in connection to those of the European economies most stricken by the onset of the crisis, has been transferred to and internalized by the Member States.

That is, *massive private sector losses (specially, those emanating from credit derivatives financial products) have been transferred to the public purse, through the massive bailout packages provided to ailing national banking sectors. In view of the fact that public debt policy has constituted the only feasible policy instrument within an already over-strained fiscal policy toolbox, sovereign debt (in our case, of European extraction) has risen in response to the said credit risk transfer from the private sector to the public sector. Ultimately, private sector losses emanating from the occurrence of a financial innovation-related negative externality in the U.S. financial markets have led to a massive global market failure that subsequently prompted government interventions in the form of cumbersome and sizeable financial sector bailouts.*

Acharya, Drechsler and Schnabl (2011) develop a theoretical model (which is subsequently empirically validated) whereby financial sector bailouts and sovereign credit risk are closely linked. These authors' main findings implicitly address the

existence of the sovereign credit risk transfer hypothesis according to which government-sponsored intervention in the financial sector resolves the latter sector's under-investment problems; notwithstanding, the said intervention is associated with future increased taxation that subsequently undermines the creditworthiness of the sovereign agent. In turn, this originates a two-way feedback which subsequently undermines the government's initial support to the financial sector, by way of the deterioration of the latter sector's sovereign debt holdings, thus giving rise to a complex sovereign adverse feedback loop (Acharya, Drechsler and Schnabl, 2011:38).

Attinasi, Checherita and Nickel (2009) test the sovereign credit risk transfer hypothesis through the impact pertaining to the announcement of bank rescue packages on the spread between sovereign CDS *premia* and European financial corporations' CDS *premia*. Under their formulation of the said hypothesis, the credit risk transfer between the private and public sectors underlying the announcement of European bank rescue packages should unequivocally lead to a widening of the differential between sovereign and corporate CDS *premia*. Their findings are highly statistically significant across all of the proposed model specifications, thus validating the hypothesis under scrutiny. Nevertheless, the sheer size of each individual bank rescue package is not by itself statistically significant (Attinasi, Checherita and Nickel, 2009:19, 26, 27 and 35).

Barrios, Iversen, Lewandowska and Setzer (2009) also address the sovereign credit risk transfer hypothesis, by comparing the co-evolution of Euro Area sovereign bond spreads and general risk aversion. They ascertain that, due to the onset of systemic risk in the banking sector, many governments were called upon to provide the previously mentioned direct capital injections (involving, in extreme cases, outright state ownership) and indirect balance sheet support in the form of guarantees. As such, they state that the announcements of bank rescue packages by Member States in the autumn of 2008 led to a downward shift in the level of the overall risk aversion factor, which was simultaneously accompanied by a significant rise in sovereign risk. The authors arrive at these findings by employing Principal Component Analysis, a methodology which will be further discussed when the international risk determinant is

fully introduced. They also ascertain that the risk transfer is deemed as a permanent influence (Barrios, Iversen, Lewandowska and Setzer, 2009:11 to 13).

Finally, Ejsing and Lemke (2009) also address the sovereign credit risk transfer hypothesis first by noting that the latter's basic tenets were directly observed in the negative correlation between financial sector CDS and sovereign CDS. These authors name this negative correlation as the 'level effect'. Once again, the latter effect reflects financial market participants' perception of banking support packages as a credit risk transfer process between the private to the public sector. Subsequently, the said authors also point to the existence of a 'slope effect' whereby the introduction of the said banking packages entails a structural change in the sensitivity to a potential future deterioration of the crisis. This is initially achieved through the estimation of econometric regressions with structural breaks (by using a common risk factor as the independent variable). Through the subsequent estimation of regressions with time-varying parameters, this structural change in risk sensitivity is then found to exhibit an elevated steepness (it nearly quintupled) in the period between October of 2008 and March of 2009, although it fell back after the latter period. Overall, the latter sensitivity attained a new post-crisis level (i.e., persisting beyond the shock), thus confirming the validity of the previously mentioned credit risk transfer hypothesis (Ejsing and Lemke, 2009:11 to 16).

Where the liquidity determinant is concerned, we should start addressing this concept by stating that the latter is essentially concerned with the depth of the corresponding sovereign debt markets. Market depth is equated with multiple variables, such as trading volumes, amount of bonds outstanding, trading activity and secondary market efficiency. Theoretically, more liquid debt markets are usually associated with lower yields in equilibrium, in view of the fact that more liquid sovereign debt might be traded more readily, thus effectively lowering corresponding transaction costs (Attinasi, Checherita and Nickel, 2009:19 and 20).

It should be noted that, within the context of the sovereign debt literature, the liquidity determinant is deemed to have a less assertive influence on bond spreads, notwithstanding the fact that it remains an influencing factor. Indeed, previously

pursued research describes either a significant statistical influence or a more subdued significance. Sgherri and Zoli (2009) openly recognize the importance of the liquidity determinant in explaining Euro Area bond spreads, all the while acknowledging that the literature has not reached a conclusion as to the magnitude of this influence (Sgherri and Zoli, 2009:4).

In the first case, Beber, Brandt and Kavajecz (2006) consider that, during periods of financial market stress, liquidity becomes increasingly important for bond pricing, most particularly taking into account those periods of heightened flow into the bond market such as those associated with financial market turmoils (Beber, Brandt and Kavajecz, 2006:20 to 22). While in the second case, Favero, Pagano and von Thadden (2010) find that the impact of liquidity factors is only statistically significant when considered in conjunction with other determinants (such as the risk factor), but otherwise when liquidity is strictly considered in isolation (Favero, Pagano and von Thadden, 2010:127 and 131).

It should be pointed out that one of the potential reasons for the existence of disparaging results where the liquidity determinant is concerned might have to do with the recourse to quite distinctive and heterogeneous liquidity measures adopted by the literature. This fact should have some bearing on the research findings associated with the liquidity component. This fact stands in clear contrast with the previously addressed credit risk determinant, where there appears to be more consensus pertaining to the adoption of corresponding credit-related measures. That is, where the liquidity component is concerned, there seems to be no clear common ground amongst researchers as to the most appropriate measures capturing the impact of this determinant.

Where the international risk aversion component is concerned, the onset of the latest global systemic breakdown has strongly highlighted the influence exerted by this determinant on sovereign spreads. In effect, the Global Financial Crisis has been unequivocally associated with a global risk repricing, which has deeply affected not only the supply of sovereign debt, but also the demand thereof, in light of the 'flight-to-quality' factor. Moreover, the latter factor has indeed decisively contributed to a

concomitant widening of bond spreads within this class of securities, whereby more safe bonds (e.g., German Bunds) were sought in detriment of lesser safe bonds (e.g., Greek bonds), thus driving the corresponding *premia* demanded by investors.

The empirical literature addressing the international risk aversion determinant states that this component essentially constitutes the single time-varying common factor driving bond spreads, in contrast to the previously mentioned credit risk and liquidity determinants (both of which are typically associated with country-specific factors).

Attinasi, Checherita and Nickel (2009) find that the international risk aversion component is the largest relative contributor to the widening of sovereign spreads in the period between July of 2007 and March of 2009. According to these authors, this latter period has been marred by an elevated level of international risk aversion and the latter component has particularly penalized Member States with compromised fiscal positions. By estimating the relative contribution of each determinant, the international risk aversion factor is found to contribute up to approximately 56% (on average) of the daily change in sovereign spreads (over German Bunds) (Attinasi, Checherita and Nickel, 2009:29, Table 7, column entitled 'International risk aversion').

Barrios, Iversen, Lewandowska and Setzer (2009) arrive at a similar result by ascertaining that, under the tenets of the sovereign credit risk transfer hypothesis, a generalized rise in international risk aversion translated into higher bond risk *premia*. These authors arrive at this result by first decomposing bond yield differentials (*vis-à-vis* Germany's) into both a common sovereign risk factor and an idiosyncratic factor. This was achieved by employing Principal Component Analysis, thus involving the extraction of a linear combination that captures the common variation in the sovereign bond spreads of each Member State. The authors subsequently relate the common factor to a time series reflective of general risk aversion. Thus, they find that the first principal component – reflective of the common sovereign risk factor – explains 95% of the total variation of the correlation matrix. In the context of their study, this indicates the significant relevance of the risk aversion determinant. Thus, one of the potential explanations advanced by these authors is that the announcement of banking packages might have led to a global repricing of risk, heavily penalizing sovereign risk through

increasing international risk aversion (Barrios, Iversen, Lewandowska and Setzer, 2009:11 to 13).

Gerlach, Schulz and Wolff (2010) demonstrate that high aggregate risk is equated with a greater probability of bank defaults, taking into account the fact that large banking sectors constitute a heavy financial burden when translated into potential government-sponsored bank rescue packages. In turn, the latter packages considerably elevate the risk for public budgets, insofar as the prospect of a higher number of bank defaults triggers the need for higher compensation to existing (and prospective) bond-holders. In turn, this inevitably leads to higher *premia*, most particularly in the context of high risk awareness and heightened economic uncertainty (Gerlach, Schulz and Wolff, 2010:17).

Sgherri and Zoli (2009) identify and estimate a time-varying common factor in the sovereign debt markets of the Euro Area, through the use of a theoretical model that accounts for the shifts in the risk appetite of investors. These shifts are thoroughly analyzed throughout the period addressed by these authors, which essentially spans the entire period relative to the implementation of the Euro; accordingly, significant changes in the behavior of sovereign bond spreads both before and after the global systemic meltdown are adequately identified (Sgherri and Zoli, 2009:5). For this purpose, the authors fit a multivariate GARCH model, thus allowing them to estimate the common factor in the sovereign spreads (over German Bunds) for ten Euro Area countries (Sgherri and Zoli, 2009:10).

The time-varying common risk aversion factor is found to be closely associated with macro-economic expectations, increasing when monetary policy is expansionary (in the wake of economic downturns), and decreasing when monetary policy is contractionary (in the wake of economic upturns). The common factor is not only observed to positively co-move with the widening of spreads, but is also deemed to effectively drive the latter spread divergence process. Moreover, the common factor quite aptly captures four major distinct developments during the last decade, the last of which comprises the global and pervasive risk repricing in the aftermath of the Global Financial Crisis (Sgherri and Zoli, 2009:12).

Overall, financial markets seem to have reacted quite sharply to the latest Global Financial Crisis, not only by pricing in the deterioration of fiscal positions in the aftermath thereof, but also by strongly differentiating across heterogeneous sovereign issuers. Furthermore, international risk aversion seems to encapsulate the influence of global and country-specific factors alike. In fact, heightened sensitivity to both rising forecasted debt levels and the solvency of national banking systems seems to have left a bearing on this determinant (Sgherri and Zoli, 2009:17).

Lastly, where the fourth and final determinant pertaining to the financial effects of macroeconomic announcements is concerned, it should be observed that this component is traditionally deemed to constitute a specific sub-set of the first afore-mentioned credit-related determinant. However, more recent literature on sovereign debt has highlighted the importance of this specific sub-determinant in its own right, and we will also follow this latter procedure, notwithstanding the common ground connecting these determinants.

Arezki, Candelon and Sy (2011) employ econometric methods to investigate whether sovereign rating announcements (e.g., sovereign downgrades) unleash any spillover effects across countries and markets alike, within the framework of Europe's financially integrated market environment (Arezki, Candelon and Sy, 2011:3). The latter authors' main finding states that sovereign rating announcements do indeed possess significant spillover effects over both countries and markets. By observing that rating agencies have not fully anticipated the macroeconomic weaknesses of European economies in the wake of the Global Financial Crisis, these authors thus describe the possibility that these announcements could spur financial instability through contagion[80]. That is, sovereign rating downgrades issued by a given credit rating agency impact not only the financial markets associated with the underlying Member State, but are also liable to affect the financial markets pertaining to other Euro Area Member States. This cross contagion finding deeply reveals the ongoing and (yet) unresolved

[80] One rather obvious bank contagion channel refers to the cross-shareholding and dissemination of European sovereign debt across multiple trans-national creditors, which deeply impacts on the profitability of the financial institutions holding the said debt in the event of a systemic sovereign downgrade (Arezki, Candelon and Sy, 2011:3).

nature of the European sovereign debt turmoil under scrutiny[81] (Arezki, Candelon and Sy, 2011:15).

Notwithstanding, the said spillover effects' sign and magnitude vary in accordance with the type of announcements, the source country experiencing the downgrade and the rating agency from which the said announcements originate. Furthermore, the authors also find that announcements associated with massive rating deterioration (e.g., downgrades to near speculative grade ratings) pertaining to certain Member States (such as Greece) originate systemic spillover effects across the whole of the Euro Area. One plausible explanation for the occurrence of this latter phenomenon might involve the pervasiveness of rating-based triggers widely used within the financial community (e.g., within the banking regulatory framework), which amplify the initial downgrade event.

Afonso, Furceri and Gomes (2011) further extend these results by conducting an event study relating the reaction of government yield spreads to changes in rating notations and outlook. These authors' sample comprises 24 European Union countries and their daily data set starts as early as January, 1995 (for some countries) and ends in October, 2010. Their findings may be summarized as follows. First, there is a statistically significant response of sovereign bond spreads to changes related to credit rating announcements. This influence is particularly pervasive in the case of negative announcements, whereas positive announcements command a more muted reaction from the markets. Second, the authors also ascertain that there has been a heightened sensitivity to negative rating events in the aftermath of the Lehman bankruptcy (dated the 15th of September, 2008). This has been most particularly felt in the CDS markets, where the cost of insuring against sovereign default has increased dramatically. Third, although sovereign announcements have not been anticipated in the previous one or two months prior to the said event, there is significant evidence of bi-directional causality between sovereign ratings and spreads within the framework of the event window

[81] According to these authors, Greece, Iceland, Ireland, Portugal and Spain are the Member States with the highest number of credit rating-related events, with a total of 31 announcements between October, 2006 and April, 2010 (Arezki, Candelon and Sy, 2011:10, Table 3, 'Total' column).

adopted by the authors. Fourth, there is significant statistical evidence supporting the argument that rating announcement spillover effects are particularly relevant from lower rated countries to higher rated countries, and that negative credit rating announcements exhibit a persistency effect, insofar as the corresponding impact lasts approximately six months (Afonso, Furceri and Gomes, 2011:20 and 21).

Throughout the present sub-section, we have addressed the main determinants critically affecting the behavior of sovereign debt bond spreads, most specially within the Euro Area. Although it is quite difficult to pinpoint the precise extent of the influence of each of these determinants in bond spread behavior, the sign of their influence has been quite an established feature in the literature. On the other hand, the influence of these determinants has been quite paramount in the aftermath of the Global Financial Crisis, insofar as their joint effect (notwithstanding the difficulty in ascertaining the precise magnitude of their isolated influence) has inevitably been associated with persistently rising sovereign spreads on sovereign funding throughout the crisis, as expressed in the post-crisis spread divergence process. That is, the joint impact of these determinants has been widely reflected in the overwhelming rise in sovereign funding costs, most specially in the case of the public debt pertaining to the most fiscally fragile Member States of the Euro Area.

Furthermore, rising sovereign funding costs associated with the sovereign debt of Member States of the Euro Area inevitably contribute to an increasingly higher debt service burden, which critically constrains economic output trajectories in the wake of the systemic crisis, insofar as an increasing share of output is destined to service sovereign bond holders. That is, the said determinants' influence in the aftermath of the systemic crisis perpetuates the dynamics of the 'bad' equilibrium associated with the perverse section of the corresponding sovereign debt Laffer curve. This ultimately originates an equally persistent sovereign adverse feedback loop cycle, whereby increasing sovereign debt is associated with more fragile, but obdurate, economic output trajectories, which in turn affects sovereign debt issuance and repayment and so forth.

In the following section, we will arrive at the nuclear finding associated with our research, whereby this close relationship between sovereign debt and subsequent economic output trajectory is closely examined.

4.5. THE EURO AREA SOVEREIGN DEBT – OUTPUT NEXUS

Having presented the main determinants underlying the more recent widening of Euro Area sovereign spreads in the aftermath of the Global Financial Crisis, we will presently address the most pressing predicament affecting Euro Area's sovereign debt markets.

In accordance with what has been heretofore exposed, the said predicament involves analyzing the macroeconomic impact pertaining to the potentially excessive accumulation of sovereign debt beyond a given sovereign debt optimal point. This latter optimal point is typically associated with the maximization of economic benefits accruing from the sovereign debt schedule. Should a given combination of output and sovereign debt (within the schedule) be positioned below this optimal point, the corresponding Member State is located in the benign section of the sovereign debt Laffer curve. In this case, an increase in the stock of public debt still benefits economic output. On the other hand, should the said combination be positioned above the optimal point, the corresponding Member State is already under the influence of the perverse section of the sovereign debt Laffer curve. In this latter case, an excessive accumulation of sovereign debt critically constrains output.

Thus, we will investigate the hypothesis according to which each Euro Area Member States' sovereign debt trajectory might hinder their respective macroeconomic performance, most specially taking into account the pernicious impact of the Global Financial Crisis on corresponding public debt(s). This goal will be pursued and achieved according to a two-stage process.

First, we will investigate whether the said Member States' sovereign debt – output schedules are currently positioned according to the precepts of the sovereign debt Laffer curve framework. By taking into consideration the latter curve's dynamics, our research will gauge whether the accumulation of sovereign debt is still beneficial to a Member State's macroeconomic environment, most specially taking into account the impact of the Global Financial Crisis on sovereign debt schedules.

Second, taking into account only those Member States that are already under the influence of the perverse section of the sovereign debt Laffer curve, we will estimate their respective sovereign debt optimal points. This is applicable to those Member States for which the above-mentioned sovereign debt Laffer curve architecture is deemed fitting.

In the latter case, this finding would imply that the corresponding Member States for which the excessive public debt accumulation hypothesis holds true are already heavily burdened by the weight of their own public debt. That is, the corresponding state of economic output has been thoroughly encumbered by excessive sovereign debt accumulation. As previously exposed, sovereign debt policy, as manifested in the more recent display of public debt accumulation, has constituted the main funding instrument for countervailing impending recessionary scenarios through the implementation of profligate post-crisis fiscal policies in the Euro Area in the aftermath of the Global Financial Crisis.

The first stage of our research process will involve the estimation of econometric specifications in strict accordance to the economic reasoning pertaining to the framework of the previously presented sovereign debt Laffer curve; while the second stage involves estimating sovereign debt optimal thresholds, through the aforementioned econometric specifications. In the following sub-section we will present the most relevant literature related to our research hypothesis (sub-section 4.5.1.); followed by a description of our methodology and data (sub-section 4.5.2.); and, subsequently, by a presentation of our main findings (sub-section 4.5.3.).

4.5.1. LITERATURE REVIEW

In the present sub-section, we will only review the most pertinent academic literature that is directly relevant to our research goals, drawing attention to the fact that sub-section 4.3. of the present document provides a more detailed contextualization of this fundamental research topic addressing the impact of excessive debt on economic output.

Krugman (1988) and Sachs (1990) initially present the overall architecture of the sovereign debt Laffer curve by endorsing the view that excessive public debt accumulation over-burdens economic output, through ever-rising service debt costs to existing debt. This is specially more aggravating when sovereign debtors are operating under the perverse section of this curve. In this case, there is an incentive for both debtors and creditors alike to engage in a debt-reduction bargaining process in order to avoid the 'debt overhang' conundrum, whereby increasing debt service costs (beyond an optimal point) potentially prompt sovereign default on existing debt. It should however be noted that this framework was initially addressed to contemplate sovereign debtor defaults pertaining to emerging market economies.

Reinhart and Rogoff (2010a, 2011) highlight the more recent perception that advanced economies are also quite permeable to the issue of sovereign debtor default by addressing the global historical relationship between government debt and output growth. These authors arrive at a central finding according to which there is an optimal level of sovereign debt leverage that can be assumed before output growth becomes affected by the excessive accumulation of sovereign debt. This level is equated with the optimal 'threshold' point in this relationship. Notwithstanding, it should be pointed out that these authors' study of debt thresholds is endogeneously determined by their conducted historical statistical analysis. In fact, they find the 90% threshold by grouping their sample's countries over their chosen period into pre-determined classes. Furthermore, these authors' research is non-idiossyncratic, insofar as it specifically addresses sets of countries (and not each individual country in their sample).

Checherita and Rother (2010) directly assess the average impact of sovereign debt on *per capita* GDP growth in twelve Euro Area countries (collectively addressed) during the 1970 - 2011 period. For this purpose, these authors employ a quadratic econometric specification in debt. Their main findings suggest that there is a non-linear impact of public debt on growth, and this impact becomes pernicious after a given turning point has been reached. The authors unveil a concave (inverted U-shape) relationship between the variables, with a sovereign debt-to-GDP ratio turning-point between 90% – 100%. Nevertheless, the computation of confidence intervals for their

estimations indicates that the initial effects of the referred deleterious impact become evident at the much lower levels of 70% - 80%. In addition, these authors also conclude that the impact of public debt on economic growth is conveyed through the following channels: private saving, public investment, total factor productivity and sovereign long-term nominal and real interest rates.

Cecchetti, Mohanty and Zampolli (2011) also address the existence of public debt thresholds and their implications for economic growth. By using a database comprised of 18 OECD countries for the 1980 – 2010 period, these authors observe that public debt is deleterious for output growth when the public debt-to-GDP ratio is beyond the 80% - 100% range. This finding, once again, prompts the issue of the detrimental impact of sovereign debt on economic growth beyond the said optimal interval.

Finally, Caner, Grennes and Koehler-Geib (2010) address this research topic between public debt and growth, by analyzing a broad sample of 101 countries within the 1980 – 2008 period. These authors employ a threshold least squares regression model involving not only real GDP growth and public debt variables, but also a set of disparate control variables deemed to influence economic growth. The main goal of this methodology is to identify a unique threshold level beyond which public debt starts to impact negatively on economic growth. The authors' central finding postulates that the optimal threshold point is 77.1% (of public debt-to-GDP ratio) for a sub-sample of 79 countries (some data were not available for the remaining countries of their sample). According to the latter authors, each additional percentage point of sovereign debt-to-GDP ratio costs the economy 0.0174 percentage points in annual average real growth (Caner, Grennes and Koehler-Gieb, 2010:5). Furthermore, the authors also perform a subsequent estimation using the sub-sample encompassing the developing countries included in the original sample. This is done in order to account for the idiosyncrasies of this latter group, while the sub-sample of developed countries was deemed too small to perform an adequate estimation. Their results point to the fact that the threshold level for this sub-set of developing countries is much lower (64%), confirming the presence of 'debt intolerance' (Caner, Grennes and Koehler-Gieb, 2010:7).

We should draw attention to the fact that this significant discrepancy further points to the possibility that thresholds might be quite idiosyncratic. This constitutes a most important hypothesis that will be pursued in the context of our own model application, in view of the fact that we will strive to estimate country-specific thresholds for our chosen Euro Area sample.

Although most of the literature herein reviewed has been thoroughly assessed in sub-section 4.3. of the present paper, it should be pointed out that the majority of the literature addressing the link between sovereign debt and output has focused on the long-term relationship between these variables. This has been evinced in the most pertinent literature specifically reviewed in this section. Notwithstanding, we will pursue a slightly different approach, insofar as we will be mainly interested in analyzing a much shorter period, namely that associated with the formation of the Euro Area. That is, we will be mainly interested in contextualizing the sovereign debt – output nexus within the framework of Europe's monetary integration process, and thus adopt a shorter time frame than the research heretofore presented.

4.5.2. METHODOLOGY AND DATA

The present research's main empirical goal is to address the existence of a non-linear link between sovereign debt and GDP in the Euro Area, during the period encompassed between the Euro's introduction as an accounting currency and the aftermath of the present Global Financial Crisis.

Thus, we will circumscribe our research goal within a conjunctural, business cycle-oriented timeline, in order to fully address the impact of Euro Area Member States' accommodative fiscal policies. In accordance to what has been heretofore presented, these policies have been mainly financed through the issuance of public debt in the aftermath of the present Crisis. The overall increase in the sovereign debt burden is ultimately associated with the ensuing impact on the said Member States' economic output schedules.

In order to adequately portray this complex association during this particular timeline, we will employ a specific model class within the classical normal linear regression model, namely a polynomial regression model of order two (i.e., a quadratic specification). These models have been extensively used in econometric research, insofar as they have been applied in the estimation of cost and production functions (Gujarati, 2003:226).

In view of the previously described characteristics of the sovereign debt Laffer curve, the application of the above-mentioned quadratic specification will allow us not only to adequately portray the non-linear relationship between the stock of sovereign debt and economic output; but also to estimate (whenever possible) the appropriate thresholds corresponding to optimal sovereign indebtedness levels.

We will accordingly pursue a two-stage research approach in order to achieve our aim. First, we will estimate the polynomial regression model for each of the Member States included in our data set (and, subsequently, for the Euro Area as a whole). Second, once these regressions have been appropriately estimated, optimal sovereign debt-to-output ratios will be extracted from these regression estimations (whenever such configurations are deemed fit).

There are three main reasons for adopting this particular quadratic specification. First, these estimations will take into account the exclusive impact of sovereign debt on economic output, in strict accordance with the economic precepts pertaining to the non-linear sovereign debt Laffer curve framework heretofore previously expounded. Furthermore, and although some of the research previously reviewed (incorporating longer time frames) has also co-jointly addressed the impact of other long-term structural variables (e.g., literacy variables), we do not deem them entirely appropriate to be included in our short-term analysis. This is due to the fact that such an inclusion would mix variables of differing impact, influence and scope (i.e., conjunctural vs. structural). In addition, such an inclusion would also mix monetary and real economy variables within the same specification, which goes beyond the scope of our financially-oriented research. More importantly, existing literature is not entirely convergent on the specific control variable set to be included in such a variable mix.

Second, our specification will incorporate the non-linear impact of public debt on economic output, namely through the adoption of a quadratic specification most suited to this purpose. The latter specification incorporates both a linear and a non-linear term which, jointly, capture the distinct influences of the impact of sovereign debt on economic output.

Third, the inexistence of a common European fiscal policy framework throughout the Euro Area is thoroughly reflected in the heterogeneous fiscal policies presently being pursued by each Member State. Correspondingly, our adopted model is quite adaptive to national idiosyncrasies and will allow us to capture country-specific thresholds. The present research will thus verify the extent to which these distinct optimal points are indeed quite idiosyncratic. This line of research has not been adopted by current research on this topic, which has mainly focused on computing thresholds for large samples, thus overlooking the fact that fiscal policies have remained quite idiosyncratic, specially in the post-crisis environment. Notwithstanding, findings pertaining to the estimation addressing the whole of the Euro Area will also be complementarily presented. This is in line with the reasoning relating to the literature herein reviewed, which portrays its findings on more regionally aggregated lines of enquiry.

Nevertheless, attention should also be drawn to an immediate shortcoming pertaining to our chosen approach. By focusing our attention on the exclusive relationship between public debt and economic output, we are certainly foregoing the impact of other potential explanatory variables to output. Notwithstanding the simplicity of our approach, we deem that the quality of our findings associated with our methodology application will justify our research options. Moreover, this and other potential shortcomings will be fully reviewed at the end of the next sub-section, once our findings are appropriately introduced and reviewed.

We will thus focus our analysis on the exclusive impact of sovereign debt on economic output for each Member State, in line with the framework of the sovereign debt Laffer curve initially proposed by Krugman (1988) and Sachs (1990). This line of research will be pursued notwithstanding the fact that the potential inclusion of

candidate control variables might, most probably, increase goodness-of-fit measures (such as R^2).

As such, our adopted regression specification will be:

$$Y_{t\,i} = \alpha_i + \beta_i X_{t\,i} + \gamma_i X^2_{t\,i} + \varepsilon_{t\,i} \quad (1)$$

where $Y_{t\,i}$ represents Gross Domestic Product (GDP) for each Member State *i*,

$X_{t\,i}$ the linear impact of sovereign debt for each Member State i,

$X^2_{t\,i}$ the squared impact of sovereign debt for each Member State i,

α_i, the constant term,

β_i, γ_i the estimated coefficients for the linear and squared variable terms,

$\varepsilon_{i\,t}$ the error term,

t the time subscript,

i each Member State of the Euro Area.

Although the above-mentioned specification incorporates a squared term, the basic precepts of the classical normal linear regression model are nevertheless applicable, insofar as the model application requires linearity in the coefficients (and not in the variables) (Gujarati, 2003:343 and 344) Simultaneously, the inclusion of a squared term in the specification will more efficiently capture the pervading non-linearities associated with the dynamics of the sovereign debt Laffer curve, which have been previously documented.

After conducting the said estimations, we expect each γ_i to be negative, so that the fitted curves typically possess an inverted U-shape, each with a corresponding optimal point (i.e., a maximum) separating the ascending phase from the descending phase of the estimated sovereign debt Laffer curve(s). This is in agreement with most of

the economic output – sovereign debt trajectories of the Member States depicted in Figure 1. Thus, *each individual maximum will be equated with the sovereign debt threshold for each Member State*. A further estimation for the entirety of the Euro Area using data aggregated from the individual series herein included will also be subsequently conducted.

On the other hand, we also expect the discriminant of the corresponding quadratic equation – equal to $\beta_i^2 - 4^* \gamma_i * \alpha_i$, for each Member State *i* - to be positive in order for the underlying quadratic equation to yield two real roots. This assumption is necessary in order to ensure that the equation's optimal point possesses two positive coordinates, in strict accordance with the existence of positive values for public debt and output alike. In addition, we also expect β and γ to be different from zero, in view of the fact that, should the former equal zero, the quadratic equation would be fitted across the first and second quadrants of the XY-plane (with a maximum inscribed in the *y*-axis). This would imply that debt could assume negative values, which goes against economic interpretation. Should the latter coefficient assume a zero value, the quadratic specification ceases to incorporate the non-linear effects of public debt on GDP (which is precisely what this research is trying to capture), and essentially turns into a linear specification.

This does not exclude the fact that, should the coefficient associated with the quadratic term be deemed statistically insignificant, this would imply that the corresponding Member State(s) might still be under the influence of the benign section of the corresponding sovereign debt Laffer curve. As such, a purely linear specification might constitute a proxy for the estimation of this benign influence, should a quadratic specification prove to be unsound. This topic will be dealt with, once our country-specific results are duly introduced.

Furthermore, and taking into account that we are dealing with time series variables, we are perfectly aware that this fact will certainly result in the presence of serial correlation in our estimations. This violation will be picked up by conducting a Durbin-Watson Test statistic for each estimation. The statistic will certainly exhibit

values between zero and two, thus signaling the presence of positive first order serial correlation throughout our estimations. We will thus correct the said violation (whenever possible) by adding an equation incorporating a first order (and/or a second order) autoregressive error component to our adopted specification, which will greatly amend this expected violation.

In addition, it is hoped that the degree of severity associated with the said violation will not necessarily lead to the existence of spurious regressions, most specially once the said violation has been adequately dealt with. Nevertheless, it is also expected that the presence of serial correlation will continue to be residually felt, albeit at a lesser degree, once the violation is generally dealt with. This is due to the fact that our adopted specification only addresses the explanatory power of public debt on economic output, omitting other potential explanatory variables.

That is, this violation will be residually aggravated by the omission of other potential explanatory variables, but the ultimate goal of the present research is to estimate optimal threshold points only taking into account the exclusive impact of public debt on growth, in accordance with the framework of the sovereign debt Laffer curve previously expounded. We will thus forego the full enhancement of econometric accuracy obtainable through the inclusion of other control variables in order to test for the existence of sovereign debt Laffer curves for each individual Member States, while subsequently computing their respective thresholds (whenever possible).

Finally, our data set includes the following variables for each Member State: GDP at constant prices (base year: 2000) and gross sovereign debt. We have opted to include the former variable using constant prices in order to extirpate the impact of inflation on growth, thus following the procedure previously adopted by Caner, Grennes and Koehler-Gieb (2010).

The said data set was extracted from the AMECO database, compiled by the European Commission, and collected for the 1999 – 2012[82] period (thus comprising 14

[82] The 2011 and 2012 values constitute forecasts.

annual[83] observations). Although the Euro effectively came into circulation in 2002, the beginning point of our series starts in 1999, the year of the Euro's introduction as an accounting currency to the financial markets.

Moreover, it was also deemed relevant to include in our sample the most recent entrants to the Euro Area, in view of the fact that our series ends in 2012, and should thus include all the Member States up to that point. Therefore, our preliminary sample includes the following Euro Area countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain.

Notwithstanding, this preliminary sample will subsequently be slightly reduced in view of the fact that a small sub-set of these countries is comprised of Member States that are quite a long way from reaching the nefarious public debt-to-GDP ratio levels traditionally associated with the descending phase of the sovereign debt Laffer curve. Therefore, those few Member States operating under the influence of the benign section of the sovereign debt Laffer curve do not constitute an immediate cause for concern and should not be considered by the present paper. Accordingly, they should not be addressed by our estimations, insofar as these countries have yet to attain their respective maximum sovereign debt thresholds and are deemed ineligible for the purpose of extracting these thresholds, which essentially constitutes the purpose of our empirical research. That is, Member States exhibiting very low public debt-to-GDP ratios are thus precluded from our analysis, since it is assumed they are under the influence of the benign section of the sovereign debt Laffer curve.

In the following sub-section, we will address the main options pertaining to the application of our chosen methodology, as well as the empirical results derived thereof.

[83] This was the only official data periodicity available for the period under scrutiny (i.e., quarterly data were not available at the time of the present paper's drafting for the time frame in question).

4.5.3. EMPIRICAL RESULTS

The first stage of our model application involves estimating a polynomial regression model of order two (i.e., a quadratic specification) for each of the Member States of the Euro Area. We will subsequently apply this specification to the Euro Area as a whole.

Prior to applying the quadratic functional form specified in equation (1), a close examination of rising public debt-to-GDP ratio values (most specially in the aftermath of the present Crisis) should provide a clear overview of the underlying problems in Euro Area sovereign debt markets. In the context of our research, the latter ratio has been defined as the quotient of the variables included in our data set for each Member State. The maximum values for these ratios across our country data set for the period 1999 – 2012 have been collected in Table 1.

In view of the fact that our research is mainly concerned with 'toxic' sovereign debt schedules, we exclude from our analysis those countries with maximum public debt-to-GDP ratio values below the 77.1% public debt-to-GDP ratio values proposed by Caner, Grennes and Koehler-Geib (2010). This is done in order to focus our research on the set of Member States with non-optimal and excessive sovereign debt burdens, thus eschewing those few countries where sovereign debt issuance is still in a position to clearly benefit economic output.

In effect, this latter value has been chosen because it constitutes the most conservative (i.e., minimum) general threshold level proposed by the academic research herein reviewed (v*is-à-vis* the 80% -100% range proposed by Cecchetti, Mohanty and Zampolli (2011) and the 90% threshold proposed by Reinhart and Rogoff (2010a, 2011).

Accordingly, the 77.1% value will constitute our sample cut-off point for the econometric estimations pertaining to the adopted quadratic specification. That is, Member States that exhibit maximum public debt-to-GDP ratio values below this proposed conservative value will be excluded from our analysis.

Once again, the introduction of this sample cut-off point is justified by the fact that, in these Member States, public debt levels were mainly well contained prior to the onset of the Global Financial Crisis, in view of the scant values of their corresponding public debt-to-GDP ratios prior to 2007. In these specific cases, sovereign debt levels have yet to achieve an optimal threshold point.

Referring to Table 1, this is the case with Estonia, Finland, Luxembourg, Slovakia and Slovenia. Tacitly, our reasoning assumes that these countries are still under the influence of the ascending (i.e., benign) phase of the sovereign debt Laffer curve. Accordingly, sovereign debt still leverages economic growth.

Notwithstanding, attention must be drawn to the fact that, within this latter sub-set, Finland, Slovakia and Slovenia are already in subdued contravention of the Stability and Growth Pact's 60% public debt limit. These contraventions clearly demonstrate the depth of the Euro Area's travails, insofar as the overwhelming majority of the original sample expressively surpassed the said 60% prescribed upper limit[84]

Taking into account the said cut-off rule, our original sample will thus be abridged to the following 12 countries: Austria, Belgium, Cyprus, France, Germany, Greece, Ireland, Italy, Malta, Netherlands, Portugal and Spain. Considering the purpose of our research, this abridged sample theoretically contains the Member States that are already under the influence of the malign section of the sovereign debt Laffer curve (or are on the verge of entering the said section). In principle, they have thus surpassed an optimal point where sovereign debt best leverages growth.

4.5.3.1. QUADRATIC ESTIMATIONS FOR SELECTED EURO AREA MEMBER STATES

The findings yielded by the first stage of our research process – pertaining to the individual estimation of the quadratic functional form based on our abridged data set – are described in Table 2, which will be presented and scrutinized hereinafter.

[84] That is, taking into account our original sample of 17 Euro Area countries, only Estonia and Luxembourg are *not* in contravention of the 60% upper limit prescribed by the Growth and Stability Pact.

We will first convey a general appreciation of the overall results, which will be subsequently accompanied by a closer inspection of the specific findings pertaining to each individual Member State and the Euro Area as a whole.

We conclude that, across our abridged sample, the quadratic specification is quite effective in capturing both the linear and non-linear effects associated with the impact of sovereign debt on economic output.

This overall goodness-of-fit is manifested in the following supporting evidence: highly significant '*p*-values' associated with the corresponding coefficients for each estimated quadratic regression[85], the quite robust corresponding 'R-squared' and 'Adjusted R-squared' values and the general lack of model violations pertaining to the polynomial regression estimations. The limited individual instances where a violation has occurred will be commented in the paragraphs addressing country-specific results.

Where the quality of the individual coefficients α, β and γ is concerned, the corresponding *p*-values pertaining to the estimated regressions are all highly statistically significant, denoting the importance of public debt (both in its linear and squared impact) as a powerful explanatory variable for GDP. In most estimations (with the exception of France's and Portugal's), the constant term (α) was altogether eschewed, thus indicating that, in the absence of sovereign debt, the corresponding output level would be theoretically void, which seems to suggest that sovereign debt deeply favors economic expansion.

Where goodness-of-fit is concerned, all the R-squared (Adjusted R-squared) values are quite high, denoting the estimated equations' expressive explanatory power. In fact, R-squared (Adjusted R-squared) range from a low value of 68,3071% (65,6660%) for Germany, to a maximum value of 95,9117% (95,5710%) for Greece. Thus, a high proportion of the variation in output is explained by public debt, within the framework of our adopted specification, which seeks to portray underlying non-linearities. Equally, the computed F-statistics (in the few cases where this statistic was

[85] Taking into account a 5% level of significance for regression coefficients; in very specific instances, we will nevertheless adopt a 10% level of significance for the coefficients associated with the autoregressive residual component coefficients.

made available) also indicate the overall quality of the robustness of our adopted quadratic specification, insofar as all the terms (when collectively considered) pertaining to each regression are collectively highly statistically significant.

Where the normality of residuals is concerned, the Jarque-Bera Test Statistic was applied to the residuals resulting from our regression estimations. The said residuals were found to have emanated from a normal distribution in all of the computed estimations, which further strengthens the latter's quality of fitness.

We will also review the major potential violations to our model's application, namely the potential presence of serial correlation, heteroscedasticity and multicollinearity. Of the said three potential violations, we will be mainly concerned with serial correlation, in view of the fact that our data set incorporates time series variables, the latter being traditionally prone to this harmful violation.

Where the potential violation of the assumption concerning the absence of correlation is concerned, an autoregressive residual component was also added to the adopted quadratic specification, whenever serial correlation was initially expressively present. This was done in order to address pervasive serial correlation issues pertaining to our initial estimations. A first-order *or* second-order component was initially estimated (for Austria, Belgium and France), while a second-order was also added to the first-order component, whenever the latter's incorporation into our initial specification failed to fully achieve its intended goal (for Cyprus and Spain). The Euro Area quadratic estimation was also fitted with a second-order autoregressive residual component.

The latter corrections proved highly effective, in view of the fact that spurious regression-inducing serial correlation has been extirpated from all the estimated regressions. This can be attested by conducting the Breusch–Godfrey Serial Correlation LM Test Statistic, which has been specified up to 4 lengths across our sample. These Test results are clearly dismissive of any harmful serial correlation assumption violation in our final estimations.

These corrections have overwhelmingly addressed the above-mentioned violation, but considering that our adopted quadratic specification exclusively addresses the impact of public debt on economic output, it is not feasible that serial correlation might be entirely eliminated. In fact, Gujarati (2003) stipulates that the omission of relevant independent variables might lead to estimation results which are prone to the excluded variable specification bias (Gujarati, 2003:445). In the context of our research, this reflects the persistent, but inconsequential, presence of serial correlation in our final estimations. Notwithstanding, our overall findings suggest that goodness-of-fit is achieved without major breaches to the model's assumptions, once the serial correlation issue is properly addressed (but not entirely dismissed, in light of the referred specification bias).

Where the potential violation of homoscedasticity is concerned, the White Heteroscedasticity Test was applied to all our final estimations. According to the obtained Test results, only Greece's estimation was found to be affected by heteroscedasticity. In this specific instance, the undertaken prescribed remedial measure was the adoption of White Heteroskedasticity-Consistent Standard Errors and Covariances, in order to correct the corresponding t-statistics and properly address this violation.

Where the potential violation associated with multicollinearity is concerned, Gujarati (2003) specifies that the adoption of a quadratic specification does not, strictly speaking, lead to a violation of the assumption pertaining to the absence of multicollinearity. This is due to the fact that there prevails an explicitly functional relationship between X and X^2 that is clearly non-linear. In addition, the model is linear in the coefficients, not in the variables, and that is why we are able to adopt it in the first place (Gujarati, 2003:343 and 344). We will therefore adopt the latter author's guidelines on this matter, most specially taking into account that a widely used method of detecting multicollinearity – the existence of a high R-Squared statistic but few significant *t* Ratios – is not present in any of our estimations (Gujarati, 2003:354). Following this recommendation, we will consider that the combination of the two sovereign debt terms of the quadratic specification quite effectively captures and

isolates both the linear and non-linear impact of public debt on GDP in each and every feasible estimation.

Therefore, we are able to conclude that, taking into account the goodness-of-fit of the quadratic estimations involving our abridged sample data set[86]*, an overwhelming majority of the Member States' public debt and output trajectories are in agreement with our argument sustaining the existence of underlying, country-specific, sovereign debt Laffer curves. This goodness-of-fit applies to the overwhelming majority of our abridged sample, with the notable exceptions of Germany (poor fit) and Ireland (model misspecification). Implicitly, the quadratic estimations test and confirm the hypothesis that the corresponding countries (with the exception of the two latter cases) have been under the influence of the benign section of the sovereign debt Laffer curve prior to the onset of the Global Financial Crisis, taking full advantage of sovereign debt's leveraging power since the introduction of the Euro. Furthermore, the hypothesis sustaining that these countries are currently under the influence of the nefarious section of the sovereign debt Laffer curve is also explicitly tested and confirmed, whereby corresponding levels of economic output are being encumbered by post-Crisis 'toxic' public debt schedules.*

Furthermore, Euro Area Member States' sovereign debt schedules appear to suffer from the condition previously described as debt vulnerability, in view of the fact that, within the scope of our abridged sample, most of the said Member States herein included are already exposed to the malign section of the sovereign debt Laffer curve. Although the more extreme debt insolvency and subsequent sovereign debt default scenarios seem clearly avoidable when the present working paper was being drafted, sovereign debt schedules are nevertheless on an unsustainable trajectory and should be vehemently addressed. These schedules should be properly dealt with within the bargaining resolutory frameworks herein previously exposed, so that the grave economic costs associated with a prospective sovereign default across the Euro Area might be altogether eschewed, and the continuity of the Euro Area might rest assured.

[86] That is, involving the Member States that have already surpassed the 77.1% sample cut-off point proposed by Caner, Grennes and Koehler-Geib (2010).

Turning to country-specific results, we would like to begin by addressing the preceding paragraph's notable exceptions, Germany and Ireland.

Where Germany is concerned, fitting a quadratic specification yields the poorest results in terms of goodness-of-fit across our sample. In fact, observing the scatter plot for our sample's data for this country (Figure 1, sub-figure entitled 'Germany'), a linear specification seems more appropriate than a quadratic one. After having applied such a linear specification, the corresponding goodness-of-fit was superior to the corresponding value for the quadratic specification (89,4103% and 85,4391% for the 'R-squared' and 'Adjusted R-squared, respectively). Notwithstanding, we decided to err on the conservative side and maintain the quadratic specification, reflecting the fact that German sovereign debt's leveraging power has barely surpassed, or might be about to surpass, the corresponding optimal level.

That is, the fact that both specifications are applicable to Germany reflects the fact that the latter country *might still be under the influence of the benign section of the sovereign debt Laffer curve, but be on the verge of attaining its optimal threshold level and thus enter the malign section of the said curve.*

Where Ireland is concerned, the quadratic specification did not yield statistically significant results. In fact, observing the scatter plot for our dataset pertaining to this country (Figure 1, sub-figure entitled 'Ireland'), the quadratic specification does not seem appropriate for this particular case (neither does, for that matter, the linear one). We nevertheless applied both specifications, although the yielded results were not satisfactory for both specifications. We thus conclude that Ireland's public debt and GDP schedules are not related in accordance with the underlying dynamics associated with the existence of a potential sovereign debt Laffer curve for this country. In fact, the said scatter plot also provides a simple explanation for this matter: Ireland's sovereign debt has indeed escalated, but only after the onset of the Global Financial Crisis, having been held at quite moderate levels prior to the said shock. This is clearly observable in the quasi-vertical trajectory prior to the onset of the Global Financial Crisis. According to Whelan (2011), the public debt instrument was indeed decisive in the aftermath of the latter Crisis, most specially when taking into consideration the expressive government

support granted to this country's stricken banking industry. The latter support has severely threatened the creditworthiness of Irish sovereign debt in the aftermath of the systemic shock (Whelan, 2011:53).

Moreover, a quadratic estimation was also performed for the Euro Area as a whole. The variables herein used refer to aggregate sovereign debt and GDP variables for the Euro Area, which were obtained by adding up the variables for all of the Member States currently belonging to the said Area (and not just the 12 countries included in the quadratic estimations described in Table 2).

A quadratic estimation (specification without a constant) with an autoregressive component of second order was fitted, thus producing interesting non-spurious results for the Euro Area. The corresponding Breusch-Godfrey Serial Correlation LM Test was performed (up to 4 lag lengths). According to the latter LM Test statistic result, the estimation for the Euro Area as a whole produces a borderline case, although, formally, the presence of serial correlation is not strictly found at a 5% level of significance.

In our judgment, this latter result might be attributed to the fact that the existing divisiveness and heterogeneity involving the Euro Area sovereign debt turmoil have been thoroughly reflected in our estimations, insofar as there are varying degrees of severity in the economic distortion involving the level of public indebtedness presently encumbering each individual Member State. This heterogeneity ultimately impacts the very estimations involving the Euro Area as a whole. In addition, the event being portrayed by our working paper is still unfolding according to this idiosyncratic pattern, which might contribute to a certain degree of uncertainty at the aggregated European level.

Finally, the estimations seem to be correctly specified. The Ramsey RESET Test was conducted on all pertinent regressions, in accordance with the findings portrayed in Table 2. The null hypothesis of correct specification was not rejected in all cases, except for Belgium and Malta (where the *p*-value for the Test is 0.031090 and 0.011812, respectively[87]). In these two specific cases, a plausible disrupting source of specification

[87] In both cases, however, the null hypothesis is not rejected at a one percent significance level.

error (considering a five percent level of significance) concerns the already mentioned omission of relevant variables. Taking into account that the present section is mainly concerned with testing the existence of sovereign debt Laffer curves in the Euro Area, and given the lack of consensus in the sovereign debt literature regarding the inclusion of potentially relevant variables and the small sample size, the latter two specifications will be nevertheless maintained.

Overall, our final estimation findings are quite satisfactory. In the following sub-section, the latter findings will allow us to derive optimal public debt-to-GDP thresholds pertaining to each individual quadratic regression heretofore estimated for each Member State included in our abridged sample (with the exception of Ireland, of course). In the context of the previously described sovereign debt Laffer curve framework, the latter thresholds constitute the turning point separating the benign and the malign sections of the said sovereign debt Laffer curve for each of our quadratic estimations.

4.5.3.2. SOVEREIGN DEBT – OUTPUT THRESHOLDS

The second stage of our empirical application involves estimating optimal public debt-to-GDP thresholds from the previously estimated quadratic equations.

In order to attain this purpose, we estimate the first and second order conditions for the existence of an optimal point pertaining to the quadratic equations underlying our estimations presented in the previous sub-section. For this purpose, it should be observed that the expected value of the error terms is zero. The latter quadratic estimations clearly point to the existence of an inverted U-shaped association between public debt and output for each Member State. This is expressed in the fact that the coefficient pertaining to the squared debt term is negative in all of our estimations, and thus, the corresponding optimal point is necessarily a maximum. (Table 2, column entitled 'Coefficients of quadratic specification', sub-column 'γ_i').

Accordingly, the optimal threshold maximums are obtained by computing the first derivative to each of the quadratic equations, equaling each of the latter to zero and then finding the optimal sovereign debt – output solutions that satisfy the latter

equations. The coordinates of the optimal (maximum) points are presented in Table 3, for each of the Member States included in our abridged sample, in addition to the whole of the Euro Area. These coordinates represent both the optimal value of sovereign debt (*x*-axis) and economic output (*y*-axis).

Furthermore, by dividing the optimal level of the former by the optimal level of the latter, we arrive at the optimal sovereign debt-to-GDP thresholds for each Member State since the introduction of the Euro. The latter ratio constitutes the turning point separating both sides of the sovereign debt Laffer curve for each Member State's quadratic estimation.

Our findings suggest that idiosyncratic country values are quite heterogeneous within the Euro Area. They range from a lowest value of 74.947462% (Netherlands) to a highest value of 152.752796% (Greece). *These findings clearly indicate a high degree of heterogeneity at a country-specific level that had been masked in the research previously reviewed, which mainly addressed the existence of thresholds at an aggregate macro-regional level.*

A cogent explanation for this fact might reside in the existence of underlying fiscal idiosyncrasies within the Euro Area. *That is, notwithstanding the fact that the latter community shares a common currency, individual Member States are still fiercely heterogeneous where the architecture of their fiscal systems is concerned. That is, while the Euro Area has been successful in implementing a centripetal joint monetary policy, an equally federalist fiscal framework is yet to be designed and implemented throughout the Euro Area.*

Thus, individual Member States are presently solely responsible in the pursuit of their corresponding fiscal policies. Notwithstanding, the most recent 'Treaty On Stability, Coordination And Governance In The Economic And Monetary Union' (a.k.a. the 'European Fiscal Compact') constitutes a fundamental step in addressing this most strategic issue (pending its complete ratification). It stipulates a more disciplined and federalist view of the each Signatory's fiscal position (European Council (2012)).

The latter heterogeneity is, for example, clearly observable in the diversity of composition of government budget balances of the Member States in the aftermath of the present financial turmoil, when taking into account the projected values for these balances as a percentage of Member States' GDP. These balances have been and will continue to distinctively support the individual post-Crisis heavy-handed fiscal responses pursued by each Member State in the aftermath of the present Global Financial Crisis (European Central Bank, 2011a:48).

On the other hand, these distinct fiscal schedules might ultimately reflect the differing impact of the current financial shock upon Member States' economies. Hellwig (2011) states that the difficulty in dealing with the impact of the Global Financial Crisis pertains to the polymorphic nature of the latter global shock, insofar as there co-exist not one but three distinct manifestations of the present crisis, each of which being clearly predominant in a given Member State (Hellwig, 2011:62)[88].

In addition, we also present the deviations from the optimal sovereign debt thresholds previously estimated, which have been collected in Table 3. The latter deviations are obtained by subtracting the said optimal thresholds from the maximum (typically, the post-Crisis lattest) value of public debt-to-GDP ratio values observed in each individual Member State's series, as well as for the Euro Area as a whole. The latter deviations are expressed as a percentage point deviation. They essentially reflect the ensuing public debt corrections needed in order to restore the latter variable's optimal impact on economic output, insofar as these maximum deviations overwhelmingly translate the abusive (i.e., non-efficient) use of the public debt instrument in the aftermath of the Global Financial Crisis.

Within Table 3, it is quite interesting to observe that the countries presenting double digit maximum deviations (France, Greece, Italy, Portugal and Spain) have been under severe pressure from sovereign debt markets. The latter pressure has been quite manifest in both these Member States' post-crisis issuance of corresponding sovereign debt, which has been typically encumbered by higher financing costs, and severe post-

[88] The author distinguishes amongst a pure fiscal crisis (Greece and Portugal), a banking solvency crisis (Ireland and Spain) and a latent (sovereign debt-derived) banking solvency crisis (France and Germany).

crisis sovereign debt downgrades pertaining to existing public debt. On the other hand, the Euro Area as a whole also exhibits double-digit deviation from its optimal threshold point, thus reflecting the fact that a vast majority of its constituent Member States are faced with sovereign debt-related issues that should be structurally solved.

Furthermore, another interesting finding pertains to the fact that the Member States most affected by the present sovereign debt turmoil – those that have been hit by rising post-crisis sovereign spreads and credit rating downgrades - have high sovereign debt thresholds. Taking into account previously mentioned research describing the low thresholds associated with emerging market economies, our finding detailing the higher tolerance of certain over-indebted Member States might be explained by the reputational protection effect granted to the latter Member States through their inclusion in a substantially credible monetary zone (the Euro Area) and their adoption of an equally credible single common currency (the Euro). Notwithstanding, the latter reputational effect hypothesis warrants further research.

Finally, we would like to address the main shortcomings pertaining to our empirical findings. First, the small data set herein included constitutes a limitation to the present research, insofar as it exclusively focuses on Euro Area's sovereign debt's influence on economic output throughout the business cycle encompassing the introduction of the Euro up to the present moment. Second, the research object presently occupying the center of gravity of the present document is quite mellifluous, insofar as the events herein portrayed are still unfolding. This fact deeply strains the underlying research efforts and denies the benefits traditionally accruing to the adoption of a more balanced historical perspective. Third, the presented estimations only depict an association relationship, and do not constitute an attempt to suggest a relationship of causality (either uni-directional or bi-directional) between the variables included in our dataset. Fourth, our estimations only take into account the direct impact of a given Member State's public debt schedule on its own economic output, and not on the output of another Member State (e.g., through the latter's banking sector holding of any other Member's sovereign debt). That is, the referred schedule's impact is exclusively circumscribed to a given Member's sovereign debt on its own output and thus, cross-

contagion is not accounted for. Fifth, should a more widened solution to the Euro Area sovereign debt issues be adopted (e.g., a widened structural debt restructuring), the implementation of such a solution would unequivocally impact the outcome of the present research, by strongly curtailing the level of public debt for each Member State, and, hopefully, reinstating a more vigorous economic output trajectory.

4.6. CONCLUDING REMARKS

The present working paper is comprised of two segments. The first segment conducts an extensive academic survey addressing the relationship between sovereign indebtedness and economic output, most especially taking into consideration the context of the Euro Area in the aftermath of the Global Financial Crisis The second segment of the paper strove to answer a most fundamental question pertaining to the sovereign debt turmoil presently menacing the cohesion of the Euro Area. The said question addresses whether the public debt instrument (as a fundamental fiscal policy tool) has been deeply strained in the aftermath of the Global Financial Crisis, a systemic event which has greatly affected the global financial landscape.

Indeed, by considering the magnitude of the heterogeneous financial rescue packages in support of ailing European banking sectors, most of the Euro Area Member States included in our sample are deemed to have already surpassed an optimal level of sovereign indebtedness, a point beyond which the excessive accumulation of public debt starts to hinder the corresponding economic output levels of the said Member States.

Our findings are thoroughly supported by the architecture and dynamics of the sovereign debt Laffer curve, a cardinal concept that has been previously proposed by the sovereign debt literature. The latter concept was herein applied to address the relationship between sovereign debt and economic output in the Euro Area since the introduction of the common currency. The scope of our research encompasses the majority of individual Member States belonging to the said Euro Area, for which corresponding sovereign debt thresholds were estimated.

Our findings indicate that the overwhelming majority of the Member States included in our abridged sample are already under the influence of the malign section of the afore-mentioned sovereign debt Laffer curve. Notwithstanding, we would like to point out that our research constitutes an approximation to this highly complex sovereign event (which is still unfolding), insofar as the limited data set herein included constrains our research efforts. That is, our research is not allowed to benefit from the existence of a historical retrospective, which would certainly provide a more balanced set of findings embedded with greater insight.

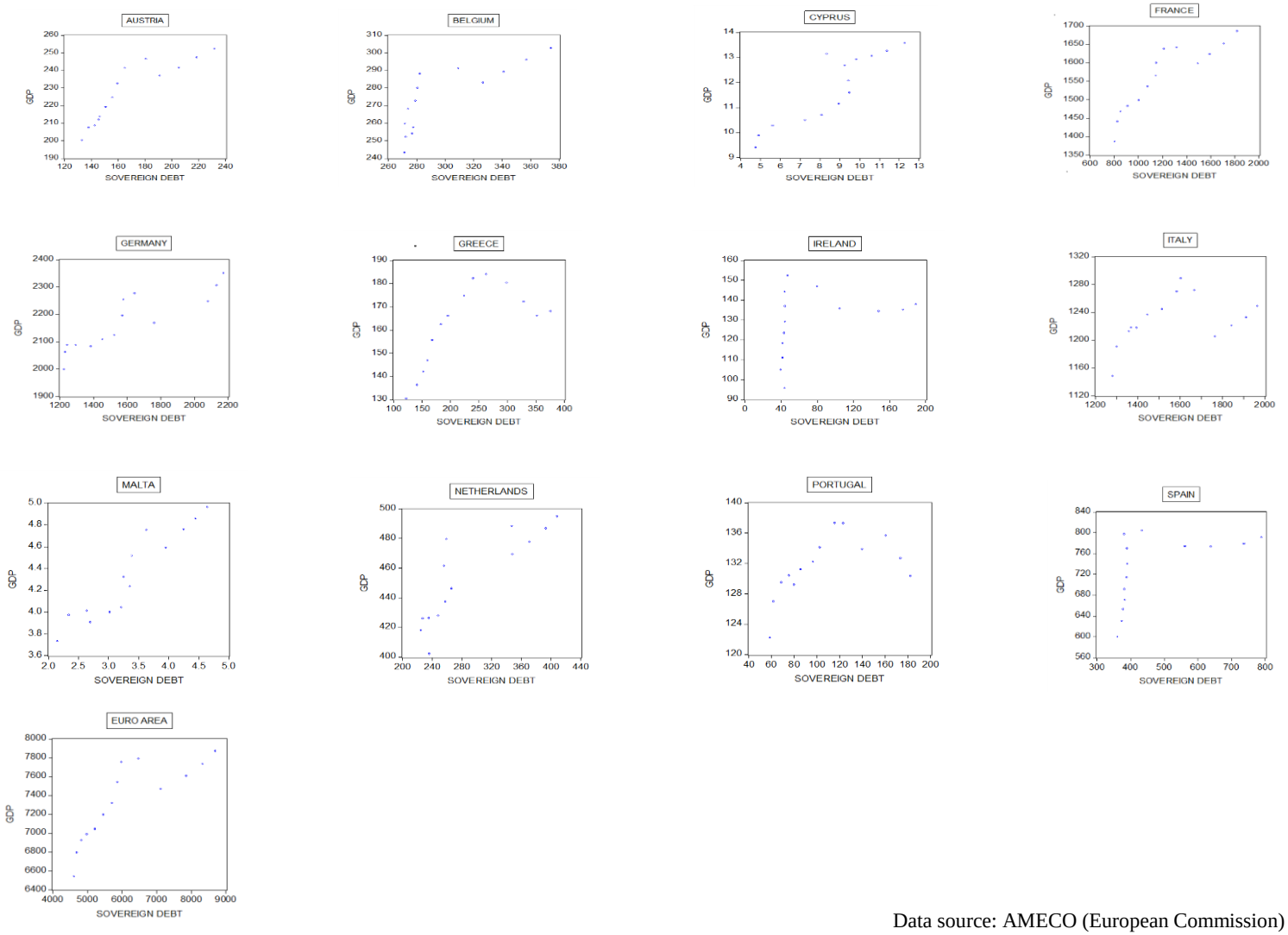
Notwithstanding the said limitation, it is quite safe to assert that the current sovereign debt burden is rapidly becoming cumbersome to the prosecution of the monetary integration process binding Euro Area Member States, through the corresponding constriction of economic output trajectories. Idiosyncratic Euro Area sovereign debt schedules need to be adequately curtailed, in line with the policy recommendations herein reviewed, so that public debt-to-GDP ratios are appropriately brought under control, and economic outputs might resume their corresponding pre-crisis trajectories.

On the other hand, the continuity of the Euro Area warrants further research on the topic of a common European fiscal framework and its accruing benefits, and, more specifically, on the design of the most adequate sovereign financing instruments and policies that do not expose the referred Area and its individual constituents to encumbered growth in the aftermath of systemic financial episodes. The 'European Fiscal Compact' has constituted a major step in reigning in sovereign over-indebtedness and help restore both confidence in the sovereign debt markets and economic growth. That is, should this over-indebtedness be properly dealt with, a 'soft landing' to the present sovereign debt tensions might be envisaged, whereby sovereign debt ceases to critically encumber economic output.

Furthermore, these innovative sovereign financing mechanisms would dilute individual heterogeneous Member State frailties in the aftermath of the said shocks, making them (individually and collectively) more impervious to these shocks, under the tutelage of a solid common fiscal architecture. This common fiscal framework, along with its monetary sibling already in place, would hopefully ensure the much warranted wholesome stability and cohesion of a historically divided Europe.

APPENDIX C

FIGURE 1 – OUTPUT-SOVEREIGN DEBT SCATTERPLOTS FOR SELECTED EURO AREA MEMBER STATES AND FOR EURO AREA (17)



Data source: AMECO (European Commission)

FIGURE 2 - PUBLIC DEBT-TO-GDP RATIOS FOR SELECTED EURO AREA MEMBER STATES AND FOR EURO(17)

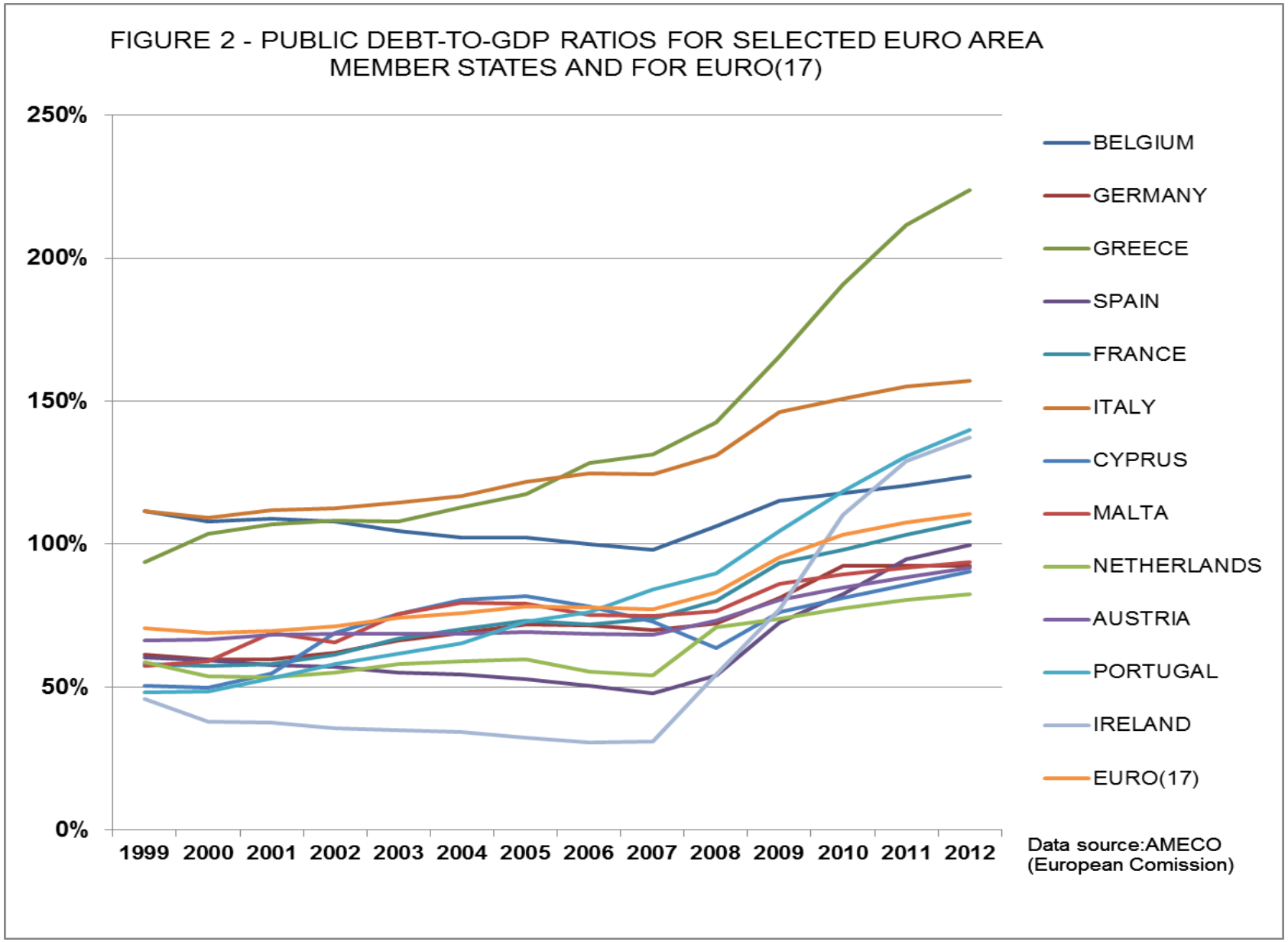


TABLE 1 – SUMMARY STATISTICS FOR PUBLIC DEBT-TO-GDP RATIOS				
COUNTRY	**AVERAGE**	**STANDARD DEVIATION**	**MAXIMUM VALUE**	**ABRIDGED SAMPLE INCLUSION ***
AUSTRIA	73,721220%	8,767335%	91,788860%	**YES**
BELGIUM	109,055768%	7,833072%	123,681608%	**YES**
CYPRUS	72,176587%	12,987098%	90,471468%	**YES**
ESTONIA	7,329004%	2,455150%	11,704512%	NO
FINLAND	46,803691%	7,348945%	62,531496%	NO
FRANCE	76,695079%	17,366465%	107,943447%	**YES**
GERMANY	73,000580%	12,049330%	92,503753%	**YES**
GREECE	138,918864%	42,408628%	223,644948%	**YES**
IRELAND	59,143697%	38,360700%	137,185158%	**YES**
ITALY	127,693173%	17,428158%	157,250352%	**YES**
LUXEMBOURG	12,779583%	8,487848%	28,229585%	NO
MALTA	76,599282%	11,223945%	93,537641%	**YES**
NETHERLANDS	63,770283%	10,859947%	82,444861%	**YES**
PORTUGAL	82,226892%	30,498788%	139,769909%	**YES**
SLOVAKIA	41,131501%	10,827322%	64,409880%	NO
SLOVENIA	40,666625%	14,049271%	70,622001%	NO
SPAIN	64,178098%	16,607399%	99,666468%	**YES**
EURO AREA (17)	*83,106363%*	*14,672918%*	*110,408417%*	**YES**

Data source: AMECO (European Commission)

* Decision rule: should the maximum observed value for the public debt-to-GDP ratio surpass the conservative 77.1% value proposed by Caner, Grennes and Koehler-Geib (2010), the corresponding Member State is included in our sample.

TABLE 2 - QUADRATIC ESTIMATION FOR EURO AREA MEMBER STATES AND EURO AREA (17) SOVEREIGN DEBT LAFFER CURVES

COUNTRIES	COEFFICIENTS OF QUADRATIC SPECIFICATION				GOODNESS-OF-FIT	F-Statistic	Residuals	DW Statistic [1]	Breusch–Godfrey Serial Correlation LM Test up to 4 lenghts YES\NO [p-value]	White's Heteroskedasticity Test YES\NO [p-value]
	α_i (t-ratio) [p-value]	β_i (t-ratio) [p-value]	γ_i (t-ratio) [p-value]	1st and\or 2nd order autoregressive residual component coefficient (whenever applicable)	R-SQUARED ADJUSTED R-SQUARED	(whenever available) [p-value]	JB Statistic [p-value]			
AUSTRIA	without constant	2,184626 (26,33599) [0,0000]	-0,004763 -10,09386 [0,0000]	AR(1): 0,569270 (2,272270) [0,0464]	92.1303% 90,5564%	n\a	1.478673 [0,477431]	1,341645	Do not reject H0 [0,276842]	Do not reject H0 [0,357663]
BELGIUM	without constant	1,648049 (7,073950) [0,0000]	-0,002265 -3,840900 [0,0033]	AR(1): 0,797422 (4,550081) [0,0011]	90,2467% 88,2961%	n\a	1,442321 [0,486188]	1,444203	Do not reject H0 [0,181865]	Do not reject H0 [0,280881]
CYPRUS [2]	without constant	2,145252 (11,60907) [0,0000]	-0,087591 (-4,766356) [0,0014]	AR(1): 0,918271 (3,309190) [0,0107] AR(2): -0,494576 (-1,901892) [0,0937] [3]	83,3927% 77,1649%	n\a	0,398565 [0,819318]	2,421891	Do not reject H0 [0,453412]	Do not reject H0 [0,745255]
ESTONIA	not included (*cf*. sub-section 5.3)									
FINLAND	not included (*cf*. sub-section 5.3)									
FRANCE	722,0598 (6,085038) [0,0003]	1,159171 (5,956791) [0,0003]	-0,000361 (-4,728210) [0,0015]	AR(2): -0,659161 (-1,905053) [0,0932] [3]	89,4103% 85,4391%	[0,000296]	1,091205 [0,579493]	1,581231	Do not reject H0 [0,052667]	Do not reject H0 [0,120847]
GERMANY	without constant	2,375899 (45,14716) [0,0000]	-0,000613 (-20,46013) [0,0000]	not applicable	68,3071% 65,6660%	n\a	0,650558 [0,722326]	1,081683	Do not reject H0 [0,176291]	Do not reject H0 [0,650030]
GREECE	without constant	1,309305 (79,52667) [0,0000]	-0,002344 (-34,29965) [0,0000]	not applicable	95,9117% 95,5710%	n\a	0,689809 [0,708288]	1,530208	Do not reject H0 [0,128480]	White Heteroskedasticity-Consistent Standard Errors & Covariance [4]
IRELAND	not applicable (cf. sub-section 5.3.1)									
ITALY	without constant	1,486528 (50,65509) [0,0000]	-0,000439 (-24,70048) [0,0000]	not applicable	59,5450% 56,1738%	n\a	1,225991 [0,541726]	1,227174	Do not reject H0 [0,299140]	Do not reject H0 [0,137677]
LUXEMBOURG	not included (*cf*. sub-section 5.3)									
MALTA	without constant	2,092023 (25,32943) [0,0000]	-0,228063 (-10,32808) [0,0000]	not applicable	76,6005% 74,6506%	n\a	0,433792 [0,805014]	0,925436	Do not reject H0 [0,391513]	Do not reject H0 [0,221664]
NETHERLANDS	without constant	2,668536 (39,73409) [0,0000]	-0,003646 (-17,74718) [0,0000]	not applicable	76,2182% 74,2364%	n\a	0,563547 [0,754445]	1,186256	Do not reject H0 [0,152974]	Do not reject H0 [0,571522]
PORTUGAL	98,09593 (23,97856) [0,0000]	0,580716 (7,711862) [0,0000]	-0,002204 (-7,043855) [0,0000]	not applicable	87,6136% 85,3616%	[0,000010]	1,032656 [0,596708]	1,944180	Do not reject H0 [0,400185]	Do not reject H0 [5] [0,050283]
SLOVAKIA	not included (*cf*. sub-section 5.3)									
SLOVENIA	not included (*cf*. sub-section 5.3)									
SPAIN	without constant	2,661371 (17,97467) [0,0000]	-0,002127 (-8,507991) [0,0000]	AR(1): 1,126864 (3,833353) [0,0050] AR(2): -0,623837 (-2,371706) [0,0451]	73,0843% 62,9909%	n\a	0,318641 [0,852723]	1,565628	Do not reject H0 [0,157626]	Do not reject H0 [0,336309]
EURO AREA	*without constant*	*2,104737 (97,13550) [0,0000]*	*-0,000142 (-43,20579) [0,0000]*	*AR(2): -0,744193 (-2,462377) [0,0360]*	*85,0899% 81,7766%*	*n\a*	*0,833975 [0,659029]*	*1,744464*	*Do not reject H0 [0,058571]*	*Do not reject H0 [0,108854]*

Underlying data source : AMECO (European Commission)

1 the appropriate DW Test Statistic lower bound for a model without a constant, with two regressors (the linear and quadratic influence) and sample size equal to 14 is 0,783; therefore, the null hypothesis of positive first-order serial correlation should be rejected if the DW Test Statistic yielded a value between 0 and 0,783, which is not the case in any of our regressions.
2 a linear model yielded a better goodness-of-fit, but the sign of the linear coefficient was negative, which goes against economic interpretation.
3 significant at a 10% level.
4 Heteroskedasticity-Consistent Standard Errors and Covariances were adopted in view of the fact that the White Test yielded a value of 0,010080.
5 the adoption of Heteroskedasticity-Consistent Standard Errors and Covariances also yields more robust t-ratios (without altering the initial coefficient estimates) in this specific borderline case of the White's Test.

TABLE 3 - SOVEREIGN DEBT-TO-GDP THRESHOLDS FOR INDIVIDUAL MEMBER STATES AND EURO AREA (17)					
COUNTRY	**QUADRATIC EQUATION**	**OPTIMAL POINT (MAXIMUM) COORDINATES**		**SOVEREIGN DEBT-TO-GDP THRESHOLD FOR EACH EURO ZONE MEMBER STATE**	**MAXIMUM DEVIATION FROM OPTIMAL THRESHOLD (expressed as a % point deviation)**
		PUBLIC DEBT VARIABLE	**GDP VARIABLE**		
AUSTRIA	$AG=2,184626*AD - 0,004763*AD^2$	229,3329834	250,5033991	**91,548851%**	0,240009%
BELGIUM	$BG = 1,648049*BD - 0,002265*BD^2$	363,8077263	299,7864797	**121,355615%**	2,325993%
CYPRUS	$CG = 2,145252*CD - 0,087591*CD^2$	12,24584718	13,13768773	**93,211587%**	-2,740119%
ESTONIA	NOT INCLUDED (cf. Sub-section 5.3)				
FINLAND	NOT INCLUDED (cf. Sub-section 5.3)				
FRANCE	$FRG = 722,0598 + 1,159171*FRD - 0,000361*FRD^2$	1605,5	1652,58432	**97,150867%**	10,792580%
GERMANY	$GEG = 2,375899*GED - 0,000613*GED^2$	1937,927406	2302,159893	**84,178662%**	8,325091%
GREECE	$GRG = 1,309305*GRD - 0,002344*GRD^2$	279,2886092	182,8369862	**152,752796%**	70,892152%
IRELAND	NOT APPLICABLE (cf. Sub-section 5.3.1)				
ITALY	$ITG = 1,486528*ITD - 0,000439*ITD^2$	1693,084282	1258,408596	**134,541697%**	22,708655%
LUXEMBOURG	NOT INCLUDED (cf. Sub-section 5.3)				
MALTA	$MG = 2,092023*MD - 0,228063*MD^2$	4,586502414	4,79753427	**95,601243%**	-2,063602%
NETHERLANDS	$NG = 2.668536*ND - 0,003646*ND^2$	365,9539221	488,2806077	**74,947462%**	7,497399%
PORTUGAL	$PG = 98,09593 + 0,580716*PD - 0,002204*PD^2$	131,7413793	136,3480934	**96,621358%**	43,148551%
SLOVAKIA	NOT INCLUDED (cf. Sub-section 5.3)				
SLOVENIA	NOT INCLUDED (cf. Sub-section 5.3)				
SPAIN	$SPG = 2,661371*SPD - 0,002127*SPD^2$	625,616126	832,4983074	**75,149237%**	24,517231%
EURO AREA	*$EUG = 2,104737*EUD - 0,000142*EUD^2$*	*7411,045775*	*7799,151125*	***95,023749%***	*15,384668%*

Underlying data source : AMECO (European Commission)

CHAPTER FIVE. CONCLUSION

The present Doctoral Thesis strove to answer some critical questions pertaining to the Global Financial Crisis presently under way.

Where the forecasting of the 'Subprime' Crisis is concerned, our findings reveal that the financial indicators scrutinised in Chapter Two forecasted, under the auspices of the EWS 'signals approach and the NPI/NPD methodologies, the impending occurrence of the above-mentioned extreme financial breakdown in the U.S.A.

Where the performance of the global banking industry is concerned, the deployment, in Chapter Three, of a highly innovative model (the HRSM-S) yields very granular findings suggesting that the said industry behaved quite heterogeneously during the economic cycle leading up to the Global Financial Crisis. Moreover, the latter event's deleterious impact propagated in a highly synchronized fashion, revealing a high degree of inter-connectedness amongst banking institutions globally.

Where the excessive sovereign indebtedness of Euro Area's Member States is concerned, an academic survey is first conducted in Chapter Four, revealing the nature and scope pertaining to the said over-indebtedness. In addition, the same Chapter includes a revealing empirical application where the corresponding findings sustain that optimal levels of sovereign indebtedness have been unwisely breached in a vast majority of the Members States included in our sample. The said findings reveal a temporary hindrance compromising the fiscal standing of the European Union.

It is modestly hoped that the present Doctoral Thesis comprised of three essays on the Global Financial Crisis might entail some important lessons for all those involved in the combat against subsequent extreme financial events of similar or greater magnitude, so that the deleterious economic impact brought about by the onset of such impactful financial events might be appropriately curtailed.

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