Do the Troika's financial assistance programs reduce systemic risk? Evidence from Eurozone countries

Konstantinos A. Moutsianas and Kyriaki Kosmidou*

Department of Economics,
Division of Business Administration,
Aristotle University of Thessaloniki, Greece
Email: kmoutsia@econ.auth.gr
Email: kosmid@econ.auth.gr
*Corresponding author

Abstract: The European sovereign debt crisis has forced many countries in the Eurozone to request financial assistance from the European Central Bank (ECB) and the International Monetary Fund (IMF) to prevent the contagion of the crisis to national banking systems. In the framework of providing large-scale financial rescue packages, the Troika, a unique institutional construction that consists of the ECB, the IMF and the European Commission (EU), has developed economic policies in combination with economic adjustment programs that aim to reinforce financial stability and reduce systemic risk. Our research focuses on the estimation of systemic risk in the countries that have implemented the Troika's bailout programs. The main objective is the evaluation of systemic risk in Greece, Ireland, Portugal, Cyprus and Spain 'pre' and 'post' the Troika's financial rescue programs to examine whether the Troika's bailout programs reduce systemic risk and financial fragility.

Keywords: financial stability; systemic risk; value at risk; conditional value at risk.

Biographical notes: Konstantinos A. Moutsianas is a PhD candidate with particular interest in banking finance, international financial markets and financial stability issues. He received his Master's degree in Management Information Systems from Aristotle University of Thessaloniki and Master's degree in Banking Finance from International Hellenic University. He received his BSc in Economics from Aristotle University. He is, currently, working as a credit risk analyst in special asset unit of a systemic financial institution in Greece.

Kyriaki Kosmidou is an Associate Professor in Banking Finance at the Department of Economics, Aristotle University of Thessaloniki, Greece. She holds a PhD in Banking Management, MSc in Finance and Economics and BSc in Mathematics. She has published more than six books as well as many papers in issues relevant to banking management, financial risk management and banking performance evaluation, in well known journals such as *Journal of Banking and Finance*, *International Review of Financial Analysis*, *European*

Journal of Operational Research, *Omega*, *Applied Financial Economics*, and *Journal of Multinational Financial Management*. She has presented various topics in banking finance and risk management to over than 50 national and international conferences.

1   Introduction

The current European sovereign debt crisis has forced many euro-area countries to formally request financial assistance from the European Central Bank (ECB) and the International Monetary Fund (IMF) with the aim of reinforcing financial stability and restoring market confidence. In the framework of providing large-scale financial rescue packages, the Troika, a unique institutional construction that consists of the ECB, the IMF and the European Commission (EU), has developed economic policies and funding programs that aim, among other objectives, to reinforce financial stability and reduce systemic risk. The analysis of systemic risk in banking systems has become an issue of great importance for supervisory authorities and central banks especially because of the repeated banking crises during the last two decades (Haq and Heaney, 2012) and systemic crisis effects (Helwege, 2010). In this context, the new regulatory framework of Basle Agreement III aims to the reduction of negative impact of systemic risk (Bratis et al., 2015). Because systemic risk is closely related to social and economic costs, its assessment and monitoring is important for governments, investors and financial market participants. The crises that occurred within the euro-area can be characterised as 'exceptional' due to specific attributes and restrictions in the European Monetary Union's operating policy framework. According to Pisani-Ferry et al. (2013), economic restraints related to the fixed exchange-rate system, the single monetary policy, the free movement of capital, the high degree of interconnections between the national financial systems, the prohibition of monetary financing and the lack of experience in crisis management in combination with policy and legal constraints led to an unprecedented crisis.

The present paper focuses on the evaluation of systemic risk in the Eurozone countries that implemented the Troika's bailout programs. We estimate systemic risk in the following euro-area countries that became involved with the Troika's innovative stabilisation mechanism: Greece, Ireland Portugal, Cyprus and Spain. Considering that a sovereign debt or financial crisis can evolve into a systemic crisis if many banks collapse simultaneously or if a bank's failure spreads to other banks in the financial system (Acharya, 2009), the estimation of systemic risk is crucial for financial stability and the smooth functioning of financial systems. The main objective of this work is the evaluation of systemic risk in the aforementioned countries 'pre' and 'post' the Troika's bailout programs to examine whether the Troika's financial assistance programs reduce systemic risk and financial fragility.

For the measurement of systemic risk, we employ a methodology that was first proposed by Adrian and Brunnermeier (2011) and that is based on the *CoVaR*. *CoVaR* is defined as the value at risk (*VaR*) in a financial system conditional on a financial institution (or a set of financial institutions) being under financial distress. The financial institution's contribution to systemic risk is defined as the difference ΔCoVaR between the *CoVaR* conditional on the institution being under financial distress and the *CoVaR* in the institution's median state. '*Co*' stands for conditional, co-movement, contagion and

the contribution of a bank to systemic risk. To examine whether the Troika's bailout programs have a positive effect on systemic risk, we compare the risk measure of systemic risk *CoVaR* in two time periods:

1 the *pre*-Troika period, which includes a period without any institutional assistance

2 the *post*-Troika period, which includes the period after the implementation of financial assistance programs.

The recent financial crisis has demonstrated the importance of analysing and assessing systemic risk and systemic events (Duca and Peltonen, 2013). Additionally, the consequences of the sovereign debt crisis have renewed interest in systemic risk (Billio et al., 2012) and highlighted the need for development of tools to detect systemic risk. Mendoza et al. (2010) note that because of the current financial crisis, the analysis of systemic risk has gained more importance. Moreover, they argue that systemic risk is related to negative shocks suffered by individual financial institutions that can easily propagate and affect other financial intermediaries. Systemic risk is related to financial instability that becomes so widespread that it causes malfunctions in the operational framework of a financial system (Hartmann et al., 2009). The concept of systemic risk underlies the understanding of financial crises (De Bandt and Hartmann, 2000). It should be noted that financial systems are more sensitive and present more vulnerabilities to systemic risk than do other sectors of an economy because of the structure of bank balance sheets, the interconnection channels among banks and the nature of financial contracts (ECB, 2009).

Policy authorities and governmental institutions provide different definitions and interpretations of systemic risk. According to the ECB (2009), systemic risk is "the risk that the inability of one participant to meet its obligations in a system will cause other participants to be unable to meet their obligations when they become due, potentially with spillover effects (e.g., significant liquidity or credit problems) threatening the stability of or confidence in the financial system)". The IMF, the Bank for International Settlements (BIS) and the Financial Stability Board (FSB, 2009), in their report to the G-20 Finance Ministers and Governors (2009) about the evaluation of systemically important financial institutions, markets and instruments, define systemic risk as a "risk of disruption to financial services that is caused by an impairment of all parts of the financial system and has the potential to have serious negative consequences for the real economy".

There are two main motivations for this research. First, the unfolding crisis in the euro-area is 'exceptional' because it began as a sovereign debt crisis and evolved into a banking crisis that damaged national banking systems and, subsequently, the real economy. According to Shambaugh (2012), the crisis in the Eurozone has been transformed into different types of crises. It began as a financial crisis, evolved into a liquidity crisis, which led to a debt crisis and a solvency crisis, and currently is a systemic crisis in an international financial framework. Furthermore, the nature and characteristics of the euro-area and Europe in general make the crisis in the Eurozone and its study unique, including structural and functional deficiencies in the Euro system, the common monetary policy, the monetary integration of country-members with different economic and monetary policies that led to divergent perceptions on addressing the crisis, the restricted ability of member states to implement countercyclical macroeconomic policies and the absence of a crisis management framework (Kotios et al., 2011; Papastamkos and

Kotios, 2011; Shambaugh, 2012; Kotios and Roukanas, 2013; Pisani-Ferry et al., 2013) as well as the different sources of problem in each country such as bubbles in real estate markets, excessive public debt and banking fragility (Sarafrazi et al., 2014). In addition, the crisis in the European Monetary Union has been accompanied by serious fiscal and structural problems and reduction of the economic activity with impact to long-term sustainability (Antonakakis and Vergos, 2013). Most of the euro-area countries are characterised by excessive public debt and fiscal deficits.

Second, the construction of the Troika, which was developed to implement financial assistance programs to shield financial stability and reduce systemic risk, is a new and innovative institutional collaboration. The Troika originated in 2010 when Greece made the decision to seek international financial assistance. The Troika of the IMF, the ECB and the European Commission act as a stabilisation mechanism that jointly provides large-scale funding programs and that also acts as a vehicle for economic and financial evaluation and for negotiation (Pisani-Ferry et al., 2013). In addition, the impact of the funding programs on the countries that have experienced financial crises and requested financial assistance from the IMF is hotly debated (Kutan et al., 2012). A large number of studies address whether the IMF's programs and their implementation produce positive effects for the recovery of financial markets and investor confidence. The empirical evidence and views regarding the success of the IMF are ambiguous (Arpac et al., 2008; Wei et al., 2010; Kutan et al., 2012).

To the best of our knowledge this is the first study that

1   examines the impact of Troika's financial rescue programs on systemic risk using codependence risk measure

2   analyses the effect of financial assistance provided by the tripartite committee which became known as 'Troika'.

In contrast to other studies which consider the impact of purely IMF lending programs by using individual risk measurement of financial institutions. In this context we should note that the development of Troika originated in 2010 and constitutes an innovative institutional collaboration of international lenders. Our empirical research differs from other related works. Previous studies investigate the impact of IMF financial rescue programs on the value of bank stocks and capital markets. Additionally, some studies focus on the impact of IMF announcements on bond market returns, stock market returns and volatility and financial asset prices. This study evaluates the impact of the Troika's programs on the systemic risk that is directly related to the stability of a financial system. The evidence of our research provides useful information to policymakers and institutional authorities regarding the design of financial assistance programs and their impact to financial stability because they focus on the importance of systemic risk measurement. Besides, this research contributes to highlight the systemic risk concept in the framework of financial assistance programs. Finally, it is important to mention that the results of our research can be used in the design of stress testing exercises and especially on the evaluation of banks' capital adequacy. Given the fact that financial assistance programs affect the levels of systemic risk in a financial system, the policymakers which are responsible for the design and the implementation of stress testing exercises should take into consideration this assumption in order to adjust stress testing scenarios and customise stress testing programs within European Union.

The paper is organised as follows: the second section provides an overview of the financial assistance programs in Greece, Ireland, Portugal, Spain, and Cyprus. In the third section, we describe the *CoVaR* methodology that is applied in our empirical research, and in the fourth section we analyse the empirical results. In fifth section, we summarise the study's conclusions.

2 Overview of financial assistance programs

2.1 Greece

Greece sparked the sovereign debt crisis in the EMU (Arghyrou and Kontonikas, 2012). In May 2010, Greece became the first country in the euro-area to formally request financial support from the European Union and the IMF through an Economic Adjustment Program. The Greek government requested €80 bn in bilateral lending support from euro-area member states and €30 bn under a three-year Stand-By Arrangement from the IMF. An important incentive for the financial assistance was the fear of contagion due to the high exposure of German and French banks to Greece (Mink and de Haan, 2013).

The Greek economy was characterised by fiscal and external imbalances that led to a high level of debt, excessive private credit, weak competitiveness and a decline in the real GDP. Additionally, high domestic demand led to an adverse current account deficit. The global financial crisis highlighted the weaknesses of the Greek economy and caused a deterioration of public finances, such as reduction of revenues and an increase in the general government deficit. According to IMF Report[1], the deficit increased to 13.6% of GDP and the public debt to 115% of GDP in 2009. Regarding the financial and banking system, Greek banks experienced high borrowing costs. The deterioration of macroeconomic fundamentals and the real economy led to an increase in non-performing loans and a reduction in banks' profitability. Moreover, the situation in bond markets was adverse because the rating agencies proceeded to downgrade Greek government bonds which resulted in increase of their spreads (Kosmidou et al., 2015), pressure on all EMU periphery bond yields spreads (Philippas and Siriopoulos, 2013) and substantial losses for banking institutions. The exposure of the entire Greek banking system to government liabilities is estimated at €40 billion, of which €32 billion was in bonds.

The main objective of the large-scale rescue program was the maintenance of financial stability and to restore confidence in the country's credibility for private investors. The implementation of the Economic Adjustment Programme aimed to establish fiscal sustainability, develop structural reforms, boost growth, restore market confidence and repair the fiscal and external imbalances. Additionally, one of the main goals of the program was the development of liquidity conditions for the Greek banks because their limited access to international money markets caused turbulence within the banking system and the real sector of the economy due to restrictions on funding.

In 2012, the IMF and the Eurozone approved the financing for the second Economic Adjustment Programme, which was a new financial rescue package worth €130 bn, and they also decided to extend the loan duration. The second Economic Adjustment Programme was financed by the European Financial Stability Facility (EFSF), which began operations in 2010. Additionally, the second program was combined with private sector involvement (PSI) that aimed to restructure the Greek debt. The goal of the PSI

was the sustainability of Greek debt through a debt exchange process that resulted in a €197 billion exchange offer.

2.2   Ireland

Ireland officially joined the financial support mechanism in December 2010[2] and completed the program in 2013 by successfully implementing a wide range of policy reforms. Ireland is under a post-program surveillance (PPS), which aims to assess the country's capacity to meet its debt obligations to the EFSM, the EFSF and bilateral lenders. Ireland will remain in the PPS until it repays at least 75% of the financial assistance received. In the context of the PPS, the European Commission in cooperation with the ECB carries out regular assessments of the economic environment, the banking sector and the Ireland's financial situation.

During the pre-crisis period, Ireland's economic growth was mainly based on housing construction, which resulted in significant profits to the state, the overheating of the economy and reduced competitiveness. The growth in the construction industry and the real estate market was accompanied by high credit growth in the banking sector, which, due to the lack of an integrated supervisory framework, led to significant imbalances. It is noteworthy that the annual growth of loans to Irish households during the period 2004–2006 was 30%, which caused significant exposure of banking institutions to property-related lending and funding needs. In addition, the prevailing macroeconomic conditions (high employment and high wage growth) in combination with tax incentives provided by the Irish government led to a housing boom. In 2010, the rapid decline in property prices by 38% resulted in the 'bursting' of the housing bubble and the significant deterioration of banks' loan portfolios, which, in turn, faced liquidity problems.

In September 2008, to support the financial system, Ireland provided a complete two-year guarantee on banks' liabilities, which was the so-called Credit Institutions Financial Support Scheme (CIFS). Moreover, to allow financial institutions to issue debt securities, the Eligible Liabilities Guarantee Scheme (ELG) was commenced in December 2009 by the Irish government. The government provided capital injections for banking institutions' capital needs and to strengthen their capital.

Ireland received joint financial assistance of €85 billion for the period 2010–2013 in the framework of the Economic Adjustment Programme that was formally agreed to in December 2010. The financing package included €22.5 billion and €17.7 billion from the EFSM and the EFSF, respectively, €22.5 billion from the IMF, and a total of €4.8 billion from the UK, Sweden and Denmark.

The main objective of the Economic Adjustment Programme[3] was to restore financial market confidence with a focus on the banking system through restructuring, size reductions and deleveraging. Moreover, the program, in combination with the National Recovery Plan, aimed to return the country to fiscal sustainability through limitations on the deficit and the implementation of growth-enhancing policies.

2.3   Portugal

In 2011, after Portugal's formal request to the European Union, the ECB and the IMF, the European Council approved an Economic Adjustment Programme for Portugal for financial assistance to safeguard the country's financial stability, restore confidence in the

financial markets and boost growth. The memorandum of understanding and the loan agreement covered the period from 2011 to mid-2014. Portugal exited the financial rescue mechanism in 2014 and is under PPS. The financial rescue package amounted to €78 bn and was intended to cover fiscal gaps and enhance the Portuguese banks. In accordance with the IMF Report[4], the European Union through the European Stabilisation Mechanism (EFSM), the EFSF and the IMF through an Extended Fund Facility financed the financial assistance program with €26 bn provided by each.

Regarding the outlook of Portuguese economy, it should be noted that the period before the financial crisis was characterised by low GDP, productivity growth and competitiveness and a high government deficit. It is noteworthy that Portugal's GDP was the second lowest in the European Union. Additionally, structural problems in combination with high external indebtedness worsened the country's economic situation. With respect to the Portuguese banking system, it should be noted that the banking institutions had operated under a more conservative framework without investments in 'toxic' financial products. In the period 2008–2010, the banks showed profitability despite increases in non-performing loans. The fact that the development of the property market remained at normal levels and a housing bubble did not occur helped Portugal's banking system avoid significant mortgage losses. However, Portuguese banks experienced funding pressures due to limited access to the capital markets and the crisis in the sovereign debt market.

The goals of the Economic Adjustment Programme[5] for Portugal were to support economic growth and financial stability. Through the implementation of structural reforms, the program aimed to improve the job market and the boost the country's competitiveness. Regarding the fiscal situation in Portugal, the objective was the development of sustainable fiscal policies that could result in increased revenues and the reduction of the deficit through decreased expenditures and limitations on public sector costs. Moreover, the establishment of market confidence in combination with the gradual deleveraging of the Portuguese banks as well as the safeguarding of bank liquidity constituted another primary aspect of the Economic Adjustment Programme.

2.4 Spain

Spain joined a special financing mechanism by signing a memorandum of understanding (MoU) in 2012 for a period of 18 months[6]. The sole purpose of the financial assistance package was the recapitalisation of Spanish banking institutions under the terms of the Financial Assistance for the Recapitalisation of Financial Institutions by the EFSF[7]. The European Commission, in collaboration with the ECB and the European Banking Authority, had the authority to implement the necessary reforms accompanied by regular advice and support from the IMF. Spain successfully exited the program in January 2014 and is currently subject to PPS. The bailout rescue package for Spanish banks amounted to €100 billion being made available by the EFSF/ESM for the necessary banking recapitalisation and the restructuring of the Spanish banking sector. One of the most significant problems facing the Spanish banking sector was problematic real estate assets that had accumulated because of the housing and construction bubble, which led several banks to suffer from low capitalisation. Spain has only used approximately €38.9 billion for bank recapitalisation and €2.5 billion for capitalising the Spanish asset management company.

With regard to Spain's economic situation before requesting external financial assistance, it should be noted that the country experienced a long period of economic growth that was mainly due to excessive credit growth in the private sector and an over-reliance on external financing. The high degree of credit growth in the banking sector, low interest rates, easy access to financing and the belief that high real estate prices would be maintained fuelled a housing bubble that then caused the accumulation of imbalances. The global financial crisis in 2008 caused an unfavourable correction in construction that was accompanied by a sharp decrease in the investment industry, a decline in property prices and substantial reduction in employment in the construction sector. The aforementioned correction that occurred in the housing market also had a great impact on the stability of the Spanish banking system due to the accumulation of problematic loans.

The financial assistance program for Spain included three components:

1   identification of the capital needs of banking institutions and asset quality assessments

2   separation of impaired assets and their transfer to an external Asset Management Company (Sareb)

3   recapitalisation in combination with support for the viable Spanish banks.

The program implemented in Spain aimed to strengthen the long-term resilience of the banking sector and restore market access. A key part of the program was the improvement of the banks' loan portfolios, the gradual reduction of exposure of the banking sector to the real estate sector as well as limitations on the dependence of the banks on the central bank for liquidity.

2.5   Cyprus

Cypriot authorities submitted a formal request for financial assistance in June 2012 and reached an agreement with the EC, the ECB and the IMF in April 2013[8]. The financial rescue program, which covered the period from 2013 to 2016, amounted to €10 billion, including €1 billion from the IMF.

According to the committee studying the economy of Cyprus in the period before the crisis, the economy was characterised by high growth, low inflation and a high level of disposable income. Economic growth in Cyprus was a result of high private consumption and private investments as well as a high supply of liquidity from the banking sector. However, the rapid credit expansion by the banks to the private sector fuelled a real estate bubble and created a high loan-to-deposit ratio. Moreover, the substantial exposure of Cypriot banking institutions to Greece, not only through holdings of Greek sovereign debt but also through granted loans, caused significant losses because of the adverse macroeconomic situation in Greece and the imposition of a 74% haircut on the nominal value of Greek government bonds in June 2012. With regard to the fiscal situation in Cyprus, until 2008, the country's fiscal fundamentals could be characterised as good, but from 2009 onwards, the deficit began to increase. In May 2011, the Cypriot economy was downgraded by S&P and Fitch Ratings, thus excluding the possibility of financing from the markets. In December 2011, Cyprus agreed to a loan of €2.5 billion from Russia to cover its financing needs. To ensure the stability of Cyprus' banking system, two banks (the Cyprus Popular Bank and the Bank of Cyprus) were consolidated. The process of

resolution included a bail-in of €1.4 billion of subordinated debt. Deposits that were not guaranteed were subject to a bail-in of 37.5%. To prevent a 'bank-run' that could cause the collapse of the entire Cypriot banking system, the Cypriot authorities announced a limited bank holiday and the implementation of capital controls.

The main objectives of the Economic Adjustment Programme[8] were to enhance the credibility of the Cyprus banking system to enable it to contribute to economic growth, to restore depositors' confidence through the reorganisation of the banking institutions and improvements in the supervisory framework as well as to maintain liquidity for the adequate financing of the economy. In addition, the implemented program aimed to reduce the deficit, strengthen revenue collection for the state and improve public sector operations. The implementation of the program also aimed to develop the necessary policies to support the country's competitiveness and to limit macroeconomic imbalances. Tables 1 to 5 provide information on profitability, liquidity, capital adequacy and asset quality of the banking systems that we examine.

Table 1   Greece: banking system data

	Profitability	*Liquidity*	*Capital adequacy*	*Asset quality*
	Return on average assets % (ROAA)	*Net loans/ Total assets %*	*Tier 1 ratio %*	*Loan loss provisions/ Net interest revenue %*
2007	2.41	63.58	12.83	21.54
2008	1.29	68.01	14.54	17.8
2009	0.38	69.73	16.35	40.56
2010	−1.92	72.51	16.98	57.16
2011	−5.3	75.95	10.72	132.43
2012	−4.86	73.5	14.54	176.47
2013	−0.53	63.44	19.83	60.47
2014	−0.54	63.79	18.25	80.93

Table 2   Ireland: banking system data

	Profitability	*Liquidity*	*Capital adequacy*	*Asset quality*
	Return on average assets % (ROAA)	*Net loans/ Total assets %*	*Tier 1 ratio %*	*Loan loss provisions/ Net interest revenue %*
2007	1.32	42.64	10.55	3.81
2008	0.07	48.55	12.11	56.28
2009	−0.03	45.68	18.44	88.21
2010	−0.19	42.24	54.74	111.87
2011	0.17	42.34	67.82	163.95
2012	−0.85	42.03	22.53	134.2
2013	−0.02	44.11	26.63	115.61
2014	0.76	40.28	27.67	−9

Table 3   Portugal: banking system data

	Profitability	Liquidity	Capital adequacy	Asset quality
	Return on average assets % (ROAA)	Net loans/ Total assets %	Tier 1 ratio %	Loan loss provisions/ Net interest revenue %
2007	1.02	60.65	12.68	24.43
2008	–0.46	62.84	12.03	9.84
2009	–0.14	57.69	12.5	33.56
2010	0.43	54	13.08	24.62
2011	0.28	55.97	17.88	24.56
2012	0.21	52.07	18.88	32.47
2013	–0.23	50.36	20.87	42.4
2014	–0.68	49.77	21.89	26.14

Table 4   Spain: banking system data

	Profitability	Liquidity	Capital adequacy	Asset quality
	Return on average assets % (ROAA)	Net loans/ Total assets %	Tier 1 ratio %	Loan loss provisions/ Net interest revenue %
2007	0.8	66.04	14	13.72
2008	0.29	66.7	13.87	22.09
2009	0.66	60.1	14.52	33.3
2010	0.36	62.29	14.83	28.62
2011	0.48	57.16	15.17	32.51
2012	–0.27	51.75	12.17	70.56
2013	0.72	47.86	15.3	37.83
2014	0.71	47.38	16.75	41.98

Table 5   Cyprus: banking system data

	Profitability	Liquidity	Capital adequacy	Asset quality
	Return on average assets % (ROAA)	Net loans/ Total assets %	Tier 1 ratio %	Loan loss provisions/ Net interest revenue %
2007	1.11	45.53	18.61	21.87
2008	–2.59	48.99	14.5	22.57
2009	4.18	43.23	18.29	29.83
2010	1.61	43.62	14.27	26.68
2011	–0.1	49.23	11.34	38.92
2012	1.52	52.62	12.15	48.93
2013	–0.63	55.89	15.58	90.61
2014	–1.44	49.24	16.31	66.84

3 Methodology and data

3.1 Methodology

The empirical research in this study is based on *conditional value at risk – CoVaR,* which was developed by Adrian and Brunnermeier (2011) (referred as AB henceforth) and relies on the concept of Value at Risk. It represents the maximum dollar loss within an *a* %-confidence interval (Jorion, 2007). *CoVaR* is one of the earliest quantitative systemic risk measures and is perhaps the most well-known co-risk measure (Castro and Ferrari, 2014; Chen and Khashanah, 2014). The methodology of *CoVaR* estimates systemic risk via the conditional value at risk of the financial system, conditional on institutions being in a state of financial distress (Bisias et al., 2012). A financial institution's contribution to the risk in the entire financial system is represented by the difference between *CoVaR* conditional on the institution being under financial stress and *CoVaR* in the normal state of the financial institution. According to Bisias et al. (2012), *CoVaR* does not rely on contemporaneous price movements, and it is used to anticipate systemic risk. In the same study, it is argued that the methodology of *CoVaR* captures externalities such as 'too big to fail' and 'too interconnected to fail' financial institutions. In accordance with Adrian and Brunnermeier (2011), *CoVaR* is a systemic risk measure with a systemic nature. The prefix 'Co' means conditional, contagion, or comovement. In their research, in which the authors develop the meaning of *CoVaR*, financial institution *i*'s *CoVaR* relative to the system is defined as the *VaR* of the entire financial system conditional on institution *i* being under financial distress. The difference between the *CoVaR* conditional on the financial stress of a financial institution and the *CoVaR* conditional on the median situation of the institution is Δ*CoVaR*, which describes the marginal contribution of a financial institution to the overall systemic risk.

The methodology of *CoVaR* and Δ*CoVaR* has several advantages according to study of AB. First, while traditional risk measures focus on the isolated risk of institutions, Δ*CoVaR* provides information about the contribution of each financial institution to overall systemic risk. In other words, it describes the increase in systemic risk due to the financial distress of an institution. Second, *CoVaR* and Δ*CoVaR* can capture the spillover effect among the institutions in a financial system. In addition, *CoVaR* can identify systemic risk from individually 'systemically important' institutions, which due to their interconnection and their size can cause spillover effects on other institutions. Chen and Khashanah (2014) refers to specific studies that apply the methodology of *CoVaR*, such as that by Gauthier et al. (2010) for Canadian financial institutions, Adams et al. (2014), who studied risk spillovers among financial institutions, and White et al. (2010), who analysed the impact of the spillover effect between the *VaR* of a financial entity and the *VaR* of the market.

3.2 Definition of CoVaR

$CoVaR_q^{j|i}$ is the *VaR* of institution *j* conditional on financial event C (X^i) of institution *i* (or the *VaR* of an institution conditional on other institutions being under financial distress). X^i represents the asset returns of financial institution *i*, and X^j represents the asset returns of the financial institution (or financial system *j*). $CoVaR_q^{j|i}$ is defined by the *q*-quantile of the conditional probability distribution:

$$\Pr\left[X^j \le CoVaR_q^{j|C(X_i)} \mid C(X^i) \right] = q \tag{1}$$

The above equation defines the *CoVaR* of the financial institution *j* (or financial system *j*) conditional on financial institution *i* being at its *q%* *VaR* level (*q* is a given quantile of distribution X^j).

VaR_q^i is defined as the *q*-quantile, i.e.,

$$\Pr\left(X^i \le VaR_q^i \right) = q \tag{2}$$

where X^i is the asset return of institution *i* for which VaR_q^i is defined.

The contribution of a financial institution *i* to the risk of financial institution *j* is the $\Delta CoVaR$ and is defined as:

$$\Delta CoVaR_q^{j|i} = CoVaR_q^{j|X^i=VaR_q^i} - CoVaR_q^{j|X^i=Median^i} \tag{3}$$

$\Delta CoVaR$ estimates the contribution of institution *i* to the risk in the whole financial system when financial institution *i* is under financial distress. $\Delta CoVAR^{i|system}$ is a measure of a financial institution's systemic importance that compares the losses in the financial system conditional on the financial institution experiencing large losses to the losses in the whole financial system if the financial institution is in a median state (Castro and Ferrari, 2014).

$$\Delta CoVaR_q^{system|i} = CoVaR_q^{system|X^i=VaR_q^i} - CoVaR_q^{system|X^i=Median^i} \tag{4}$$

3.3   Estimation procedure of CoVaR

The first step of the estimation of *CoVaR* and $\Delta CoVaR$ includes the calculation of the rate of weekly change in the growth rates of the market-valued total assets of individual institutions and the entire financial system. According to AB, the growth rate of the market-valued total assets of financial institution *i* is defined as:

$$X_t^i = \frac{ME_t^i * LEV_t^i - ME_{t-1}^i * LEV_{t-1}^i}{ME_{t-1}^i * LEV_{t-1}^i} = \frac{A_t^i - A_{t-1}^i}{A_{t-1}^i} \tag{5}$$

where

$$LEV_t^i = BA_t^i / BE_t^i, \; A_t^i = ME_t^i * LEV_t^i = BA_t^i *\left(ME_t^i / BE_t^i \right)$$

ME   market value of a financial institution *i*'s total equity

LEV   the ratio of total assets to book equity

BA   book-valued total assets of institution *i*

BE   book-valued equity.

It should be noted that the market value of total assets of a financial institution can be estimated via a structural model of the institution or if we add the market value of equity to the book value of debt. Similarly to AB, our research focuses on the VaR_q^i and the $\Delta CoVaR_q^i$ of total assets of financial institutions because they have a strong relationship

with the supply of credit and liquidity in an economy. In the case of unlisted banking institutions, we use simple asset growth.

The second step of the estimation procedure includes the use of quantile regression. Quantile regression estimates the expected value of a financial system's yield on quantile q of the given financial institution i:

$$\hat{X}_q^{system,i} = \hat{a}_q^i + \hat{\beta}_q X^i \tag{6}$$

The quantile regression on quantile i shows that the expected value $\hat{X}_q^{system,i}$ is the *VaR* of the whole financial system conditional of financial institution's i return. We note that X^{system} represents the asset return of the financial system, and in accordance with AB, it represents the weighted sum of asset returns for each financial institution in the system. Under the condition that the return of the financial institution i is at its *VaR* level, the estimation of X^{system} using quantile regression depicts $CoVaR_q^{system|X^i=VaR_q^i}$. In other words, $CoVaR_q^{system|X^i=VaR_q^i}$ estimates the VaR_q^i of the whole financial system in the event of $X^i = VaR_q^i$.

$$CoVaR_q^{system|X^i=VaR_q^i} := VaR_q^{system} \mid VaR_q^i = \hat{\alpha}_q + \hat{\beta}_q VaR_q^i \tag{7}$$

$$VaR_q^{system} \mid X^i = \hat{X}_q^{system,i} \tag{8}$$

Quantile regression is an efficient tool for the estimation of CoVaR, which models the relation between a set of independent variables and specific quantiles of the response variable. In contrast to ordinary least squares (OLS), in which a regression coefficient provides information about the change in the mean of the dependent variable if the predictor variable changes by one unit, the quantile regression coefficient estimates the change in a specified quantile of the response variable if the predictor variable changes by one unit. This feature of quantile regression provides the possibility of comparing how different quantiles of the response variable may be affected by the predictor variable. Moreover, OLS is a useful tool for understanding linear information on the mean relationship among independent and dependent variables (Lee et al., 2013), but it does not capture nonlinear effects, resulting in imperfect information on extreme financial events. Koenker (2005) argues that quantile regression is appropriate for the interpretation and understanding of the loss distribution of financial institutions under financial distress by analysing nonlinear effects.

According to Castro and Ferrari (2014), many of the co-risk measures, such as *CoVaR*, that have been developed in the literature are based on quantile functions because they exploit useful properties. One main advantage of quantile regressions is that they do not need extensive information and strict statistical conditions.

3.4   Contributional ΔCoVaR

As we stated earlier, the level of contribution of a financial institution to systemic risk is defined as 'contributional Δ*CoVaR*' and is computed by the following equation:

$$\Delta CoVaR_q^{system|i} = CoVaR_q^{system|X^i=VaR_q^i} - CoVaR_q^{system|X^i=VaR_{50\%}^i}$$

$$= \left(\hat{a}_q + \hat{\beta}_q VaR_q^i\right) - \left(\hat{a}_q + \hat{\beta}_q VaR_{50\%}^i\right) \qquad (9)$$

$$= \hat{\beta}_q \left(VaR_q^i - VaR_{50\%}^i\right)$$

$\Delta CoVaR$ estimates how much financial institution i contributes to the systemic risk of the financial system during stressful periods.

3.5 Time-varying CoVaR

To take into consideration time variation in the joint distribution of returns of financial institution X^i and the distribution of returns of the financial system X^{system}, our research includes the estimation of the conditional distribution as a function of macro-financial (or state) variables. Time-varying $\Delta CoVaR$ provides results of time series during the selected period, in contrast to 'static' $\Delta CoVaR$, which produces only one value during the selected period of examination. The estimation of time-varying $\Delta CoVaR$ requires the estimation of a regression analysis on the conditional quantile of a set of state variables M:

$$X_t^i = a^i + \gamma^i M + \varepsilon_t^t$$
$$X_t^{system} = a^{system|i} + \beta^{system|i} X_t^i + \gamma^{system|i} M_t + \varepsilon^{system|i} \qquad (10)$$

where

X^i return of financial institution i

M_t set of state variables.

In the following, the estimation procedure includes the calculation of time-varying *CoVaR* and *VaR* through the predicted values from the above quantile regression analysis:

$$VaR_t^i(q) = \hat{a}_q^i + \hat{\gamma} M_t \qquad (11)$$

$$CoVaR_t^i(q) = \hat{a}^{system|i} + \hat{\beta}^{system|i} VaR_t^i(q) + \hat{\gamma}^{system|i} M_t \qquad (12)$$

Next, we estimate the contribution of each financial institution to the systemic risk of the financial system $(\Delta CoVaR_{t,q}^{system|i})$:

$$\Delta CoVaR_t^i(q) = CoVaR_t^i(q) - CoVaR_t^i(50\%)$$
$$= \hat{\beta}^{system|i} \left[VaR_t^i(q) - VaR_t^i(50\%) \right]$$

3.6 Data

Our datasets consist of the banking institutions of Greece, Ireland, Portugal, Spain and Cyprus. We have selected banking institutions that have sufficient data for the periods under examination (Tables 6 and 7). The period that we study the banking system and the systemic risk of each country are divided into two sub-periods, the 'pre-Troika' and 'post-Troika' periods; this division is based on the accession of the country to the Troika's bailout programs, which is regarded as a milestone. We study the systemic risk

two years before the country's accession to the financial support mechanism and two years after its accession. For each sub-period, we apply the *CoVaR* methodology to assess whether the financial rescue packages and the implementation of the programs have reduced the systemic risk of the aforementioned countries. The macroeconomic (state) variables consist of GDP growth (GDP), the Consumer Price Index (CPI), the Euro Stoxx 50 volatility index and the log return of a general index of each country's stock exchange. We select the macroeconomic variable GDP growth (GDP) because it shows the economic outlook and performance of the country and we expect that is related with the level of systemic risk. CPI constitutes a basic measure of price inflation and affects the economy in various ways. Additionally, it is related with the cost of living as well as it reflects the changes in the purchasing power. Regarding Euro Stoxx 50 volatility index is one of the most watched European volatility indices and expresses the market expectations at European level of near-term and long-term volatility. In the framework of financial rescue schemes, the market expectations about the completion or not of programs' implementation affect the systemic risk. The return of the general index of each country's stock exchange reflects the performance of the domestic financial markets and expected to affect the systemic risk. Bankscope – Bureau van Dijk, Bloomberg, IMF databases and the European Commission were used as sources of the data.

Table 6 Accession in financial assistance programs and banks of sample

Country	Financial assistance program	Number of banks
Greece	May 2010	4
Ireland	December 2010	21
Portugal	April 2011	31
Spain	June 2012	99
Cyprus	June 2012	11

Table 7 'Pre- and post-Troika' period

Country	'Pre-Troika' period	'Post-Troika' period
Greece	02.05.2008–07.05.2010	14.05.2010–30.03.2012
Ireland	27.07.2007–27.12.2010	12.02.2010–27.12.2012
Portugal	06.01.2009–26.04.2011	03.05.2011–31.12.2013
Spain	31.12.2009–28.06.2012	05.07.2012–19.12.2013
Cyprus	07.06.2010–04.06.2012	11.06.2012–30.12.2014

4 Results

In our empirical research, we apply the *CoVaR* methodology for the five countries that have received financial assistance. More specifically, we apply the time-varying *CoVaR* to estimate the systemic risk in the 'pre-Troika' and 'post-Troika' periods, and we estimate the contributional *CoVaR*, Δ*CoVaR*, to assess the contribution of the selected banking institutions to the overall systemic risk. We have selected banking institutions that have sufficient data for the periods under examination For the proper analysis and interpretation of the results, it should be taken into account that the aim of the study is to

investigate the effect of the Troika's financial rescue plans on the systemic risk of the national financial systems before and after the accession of the countries to the financial support mechanisms, without taking into consideration the implementation of the reforms that are included in the economic programs. In the case of Greece, our research focuses only on the first Economic Adjustment Programme (as mentioned in previous section, a second financial program was approved for Greece in 2012). The results show that the systemic risk measure *CoVaR* in the 'pre-Troika' period is –0.6166, and the Δ*CoVaR* is –0.3718 (Tables 8 and 9). After the first financial assistance package in May 2010 and during the 'post-Troika' period, the respective systemic risk measures are –9.6942 and –0.7653. We note that despite the financial assistance received by Greece, the systemic risk in the financial system increased significantly, as also shown by the increased Δ*CoVaR*, which suggests that the four banking institutions play an important role in the country's financial stability. Sapir et al. (2014) in their study on the request of the Economic and Monetary Affairs Committee argue in different point of view and along the lines of three different criteria that the financial assistance program in Greece was the least successful because of specific factor such as European policy indecision, insufficient program implementation, excessive austerity and late debt restructuring. The reasons that lead to increase of the systemic risk are the deterioration in public finances such as the significant expansion of the debt-to-GDP levels in combination with the negative momentum in the real economy of Greece. Specifically, the sustained reduction in domestic demand, the decrease of GDP growth, the high unemployment rate, the lack of investments and exports contributed significantly to bad performance of the Greek economy. Besides, the deterioration of external macroeconomic environment in euro area as well as the scenarios of a probable exit of Greece from euro area (the so-called Grexit) undermined the success of the financial assistance program. Also, the domestic political environment, the repeated elections and the unstable government apparatus caused the inadequate program implementation. Ireland has successfully completed the Troika's financial assistance program and in accordance with our results, the systemic risk in the financial system during the 'pre-Troika' period is –0.0036. After the accession of Ireland to the financial rescue mechanism of the Troika, the systemic risk decreased to –0.0026 (Tables 10 and 11). Similarly, the contribution of the selected banking institutions to the systemic risk decreased, thus demonstrating the positive impact of the program on the financial stability of the banking system. The reduction in systemic risk is related to the performance of the Irish economy, the restore of trust in public finances and the success in the export sector[9]. Specifically, an increase in industrial production, improvement of the labour market, stabilisation of the property market, surplus in current account balance and reduction of the general government deficit through fiscal adjustment contributed to decrease of systemic risk in Ireland. Moreover, the performance of the Irish banking system seems to be improved through sufficient capital ratios, adequate provisions for non-performing loans and the return to profitability of two of the three large banks. According to aforementioned study of Sapir et al. (2014) the program of Ireland can be considered successful because of the fiscal adjustment, the successful adjustment of financial sector and the improvement in export sector. Portugal exited the financial assistance program in June 2014. According to the empirical results, Portugal's systemic risk declined from –0.0386 to –0.0007 in the periods before and after the implementation of the financial assistance program, and the Δ*CoVaR* index decreased from –0.0054 to –0.0001 in the two respective periods (Tables 12 and 13). The economic situation of the Portuguese economy improved due to the implementation of the Troika's economic

program, but the country still faces problems with competitiveness and a high public debt. With regard to the banking system, Portugal's banks benefited from the improvement in the economy, which allowed them to raise capital from private sources and to improve their capital adequacy ratios and their liquidity. In the case of Portugal, the strict implementation of program in combination with the mutual understanding between the government and the Troika resulted in certainty and satisfaction for the global financial markets. Besides, the reduction of general government deficit and cost competitiveness played an important role in the reduction of systemic risk. Also, the increase in export performance and the record of surplus in current account balance (the first surplus in more than 40 years according to European Commission) contributed to the reduction of systemic risk. One more factor which affected the systemic risk was the increase of domestic demand through the improvement in fixed investment and private consumption[10]. In Spain's case, the results showed that systemic risk increased from –0.0068 to –0.0102 for CoVaR and from –0.0024 to –0.0402 for $\Delta CoVaR$ in the 'post-troika' period (Tables 14 and 15). It should be noted that the mechanism that was developed for Spain is different from that of the other countries because there was no funding from the IMF. Spain also completed the program in January 2014 with the recapitalisation of its banks. Although confidence gradually recovered, it seems that the high ratio of non-performing loans and the high need for capital continue to cause problems in the banking system. The increase of the systemic risk after the implementation of the financial assistance program is due to factors such as large general government deficit and private debt. Also, low productivity of the Spanish economy, the contraction of domestic demand as well as the high level of unemployment played an important role to the increase of systemic risk. In the case of Spain, the adverse developments in banks' asset quality which caused increase of the loan loss provisions[11] undermined the performance of the financial assistance program. In accordance with European Commission 12, the political turbulences in Spain constitute a factor which explains the deterioration in the economy. With regard to Cyprus, we observe that the systemic risk of the financial system increased from –0.0018 in the 'pre-Troika' period to –0.1705 in 'post-Troika' period (Tables 16 and 17). In accordance with EC[12] one of the most important problems for the financial sector remains the level of non-performing loans which results in deterioration of banks' asset quality. Besides, the high unemployment, the tight credit supply conditions, the high private debt led to the increase of the systemic risk. Also, the negative spilllovers from the external environment such as Russia, Ukraine and Greece in combination with the delay of the necessary structural reforms due to political factors contributed to moderate performance of the financial rescue program. The imposition of capital controls during the 'post-Troika' period (2013) played a significant role to the increase of systemic risk. The restriction of free capital movements impaired the functioning of the banking and capital market systems.

Table 8 Greece: 'pre-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	–0.0065	–0.0063	0.0857	–0.1915	0.2617
VaR_t^i	–0.1427	–0.1338	0.0400	–0.2125	–0.0798
$CoVaR_{t,0.05}^{system}$	–0.6166	–0.5923	0.1517	–0.8891	–0.3820
$\Delta CoVaR_{t,0.05}^{system|i}$	–0.3718	–0.3674	0.0464	–0.4570	–0.2812

Table 9   Greece: 'post-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	−0.1163	−0.0174	1.2004	−11.7981	0.9647
VaR_t^i	−0.3450	−0.2521	0.2289	−0.8111	−0.0644
$CoVaR_{t,0.05}^{system}$	−9.6942	−4.9191	9.6259	−28.4868	−0.1266
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.7653	−0.4018	0.6651	−2.0703	−0.0429

Table 10   Ireland: 'pre-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	−0.0024	−0.0033	0.0021	−0.0044	0.0031
VaR_t^i	−0.0052	−0.0055	0.0024	−0.0092	−0.0013
$CoVaR_{t,0.05}^{system}$	−0.0036	−0.0048	0.0043	−0.0111	0.0039
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.0052	−0.0055	0.0024	−0.0092	−0.0013

Table 11   Ireland: 'post-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	−0.0026	−0.0011	0.0141	−0.1446	−0.0009
VaR_t^i	−0.0040	−0.0040	0.0013	−0.0063	−0.0014
$CoVaR_{t,0.05}^{system}$	−0.0026	−0.0027	0.0014	−0.0052	2.42E-05
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.0010	−0.0010	0.0004	−0.0017	−0.0002

Table 12   Portugal: 'pre-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	0.0013	0.0007	0.0061	−0.0127	0.0363
VaR_t^i	−0.0082	0.0002	0.0021	−0.0154	−0.0056
$CoVaR_{t,0.05}^{system}$	−0.0386	−0.1265	0.7619	−1.4603	1.2236
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.0054	−0.0058	0.0283	−0.0575	0.0312

Table 13   Portugal: 'post-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	−0.00301	−0.02472	0.239004	−0.88402	1.12532
VaR_t^i	−2.5E-05	−2.5E-05	1.14E-05	−5E-05	−8.8E-06
$CoVaR_{t,0.05}^{system}$	−0.00071	−0.0008	0.000396	−0.00153	−9.1E-05
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.00019	−0.00015	0.000104	−0.0004	−5.7E-05

Table 14   Spain: 'pre-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	−0.0028	−0.0011	0.0256	−0.3377	0.0248
VaR_t^i	−0.0088	−0.0091	0.0015	−0.0112	−0.0064
$CoVaR_{t,0.05}^{system}$	−0.0068	−0.0063	0.0034	−0.0146	−0.0019
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.0024	0.0026	0.0012	−0.0002	0.0044

Table 15   Spain: 'post-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	0.0037	0.0009	0.0357	−0.0707	0.2954
VaR_t^i	−0.0324	−0.0301	0.0267	−0.0936	−0.0063
$CoVaR_{t,0.05}^{system}$	−0.0102	−0.0074	0.0102	−0.0361	−0.0001
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.0402	0.0513	0.0327	−0.0272	0.0813

Table 16   Cyprus: 'pre-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	0.0036	0.0030	0.0095	−0.0431	0.0889
VaR_t^i	−0.0025	−0.0022	0.0009	0.0014	0.0043
$CoVaR_{t,0.05}^{system}$	−0.0018	−0.0027	0.0022	−0.0022	0.0051
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.0036	0.0030	0.0095	−0.0431	0.0889

Table 17   Cyprus: 'post-Troika' period

	Mean	Median	Std. dev.	Minimum	Maximum
X_i	−0.0017	−0.0015	0.0021	−0.0060	0.0018
VaR_t^i	−0.0020	−0.0015	0.0019	−0.0060	0.0007
$CoVaR_{t,0.05}^{system}$	−0.1705	−0.0014	1.530	−13.86	0.0013
$\Delta CoVaR_{t,0.05}^{system\|i}$	−0.0013	−0.0001	−0.0002	−0.0005	0.0004

5   Conclusions

Systemic crises constitute an integral part of financial crises. The recent global financial crisis represents substantial proof of the ease with which a crisis can become widespread due to the interconnectedness of financial systems and can threaten their viability. Therefore, supervisory authorities, central banks and banking institutions have shifted their interest to the assessment and measurement of systemic risk. In considering systemic risk to be a threat to the stability of a financial system, the development of a supervisory framework that aims to provide macro-prudential supervision makes the estimation of systemic risk of great importance. In this context, it is very important to examine the financial system's behaviour in the case where a financial institution experiences financial distress.

The financial support mechanism of the Troika has provided large-scale financial packages in combination with economic adjustment programs to prevent further crises in the Eurozone. The impact of these programs and the policies that are implemented by the countries that received the financial assistance constitute a controversial issue. Our research focuses exclusively on the impact of these economic programs on the countries' systemic risk, and we particularly examine whether the Troika's bailout programs reduce the countries' systemic risk. For this reason, we apply the *conditional value at risk – CoVaR* methodology, which was developed by Adrian and Brunnermeier (2011), to estimate the systemic risk in two sub-periods: the 'pre-Troika' and 'post-Troika' periods.

Unlike previous study that examined the impact of IMF programs on bank stocks and capital markets, our research outlines the impact on systemic risk of financial systems.

The results of the research show that in the case of Greece, Spain and Cyprus, the systemic risk in the national financial systems has increased. According to the results, the systemic risk in Ireland and Portugal has decreased. With regard to the correct interpretation of the results, it should be noted that our research estimates systemic risk while not taking into account the reforms that a country must implement. Our study shows that the Troika's financial rescue programs do not have the same impacts on the systemic risk in the national financial systems. In the cases of Greece, Spain and Cyprus, although the programs helped the countries avoid more severe crises they do not reduce the systemic risk. We also found that factors such as public finances, the momentum of real economy and the fragility of political environment played an important role on the increase of systemic risk.

The policy-relevant conclusions are related with the measurement of systemic risk change to the countries which have received financial assistance and have implemented the respective financial economic adjustment programs. In particular, the policy implications of our research focus on the impact of the financial assistance programs and provide significant information to policy-makers and institutions such as IMF, ECB and EC regarding the reduction of financial systems' systemic risk which reflects, to some extent, the success or failure of financial assistance programs which accompanied with a range of reforms. In this context, policy-makers may adjust the economic adjustment programs so as to reduce systemic risk and to prevent the risk of contagion. Besides, the findings of this study contribute to the overall evaluation of the programs since so far the assessment of 'post-Troika' period concerns the regaining of market access, the restore of investors' confidence and the enhance of competitiveness.

For further research we could estimate and compare the systemic risk of different sectors of a country's economy which have received financial assistance from Troika (such as insurance sector, industrial sector, real estate sector) in order to evaluate the impact of Troika's programs to systemic risk of different economic sectors.

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