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Innovative Activity and Development: Analyzing Firm Data from Eurozone Country-Members

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***Abstract*—**In this work, we attempt to associate firm characteristics with innovative activity. We collect microdata from listed firms of selected Eurozone Country-members, after the beginning of 2007 financial crisis. The following literature, several indicators of growth and performance were selected and tested for their ability to interpret innovative activity. The main scope is to examine the possible differences in performance and growth between innovative and non-innovative firms, during a severe recession. Additionally to that, a special focus will be held on whether macroeconomic performance and national innovation system, determines the extent of innovators' performance. Preliminary findings, through correlation matrices and non-parametric tests, strongly indicate the positive relation between innovative activity and most of the measures used (profitability, size, employment), confirming that even during a recessionary period, innovative firms not only survive but also seem to succeed better economic results in almost all indexes relative to non-innovative. However, even though innovators seem to perform better in all economies examined, the extent of that performance seems to be strongly affected by the supportive mechanisms (financial and structural) that their country provides. Thus, it is clear, that the technologically intensive 'gap' between European South and North, during the economic crisis, became chaotic, due to the harsh austerity measures and reduced budgets in those countries, even in sectors with high potentials in economic activity and employment, impairing the effects of crisis and enhancing the vicious circle of recession.

***Keywords*—**Eurozone, innovative activity, development, firm performance, non-parametric tests.

I. Introduction

INNOVATIVE activity is considered to be one of the most crucial factors of prosperity and growth, directly (improving turnover and profitability) or indirectly (increasing employment, diffusing innovation etc.) [1]. Active Research and Development appeared in various surveys to be a major factor for technological and economic progress (for a short literature review, [2]-[5]. Reference [6] find that investment in innovation activities, affect positively the innovation output (sales of new products) resulting also in better productivity. In the line of that, [7, p.990] claim that R&D increases the level of sectoral and national economic performance, diffusing innovative products, while [8, p.492] finds that R&D process is positively correlated with productivity growth and sales, especially in high-tech sectors. In their research, [9] highlight the ability of those firms to survive and grow even during economic crises. In regard to European firms, [7] concludes that the innovators are more likely to grow than non-innovative firms.

Apart from financial performance, innovative activity seems also to affect positively firms' competitiveness indoor and internationally, increasing exporting activity (see indicatively [6], [10], [11]). As a result of its strong impact in economic development and dynamism in firm and country level, policy makers attempt to encourage and support innovative firms, establishing the necessary infrastructure (science parks, better educated scientific personnel, allocation of public funds to innovative activities, and other policy measures towards the fostering of innovativeness and entrepreneurship).

Adversely to empirical findings that confirm the importance of innovative activity, in Eurozone, no common strategy seems to exist on that field. More specific, the countries of European south, after a period of prosperity and growth (until 2005), present poor performance, decreasing the (already low) R&D expenditures and the high-tech exports, while two of them (Portugal and Greece) are in the last place. Due to the dramatic cuts in public spending and the austerity measures, those countries suffer from various economic restrictions in liquidity, exports, imports of intermediary goods, etc. On the other hand, countries affected less by current crisis (like Germany and France), continue to increase investment in R&D, they establish national systems of innovation focused on technologically intensive sectors, and support production of high-tech products and services. As a result the existed technologically intensive gap between those two groups, after the current financial crisis seems to increase further. Fig. 1 presents the average percentage of high-tech exports, and Fig. 2 the R&D expenses the last 20 years in EURO-15 countries[1], in the two groups of countries analyzed and in selected representative large developed economies (Germany, US, China and Japan).

As it is clear, from both figures, innovative activity is rather low in countries of European South. The stability or even slight increase appeared after 2007, it is not the real picture, as in actual values, both R&D expenses and high-tech exports have been dramatically reduced. As a percentage of GDP however seem to be stable, due to the very large reduction in GDP in those countries. The adversely happens in countries of European North where GDP increases the last years.

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[1] We excluded countries that joined euro zone after the beginning of economic crisis

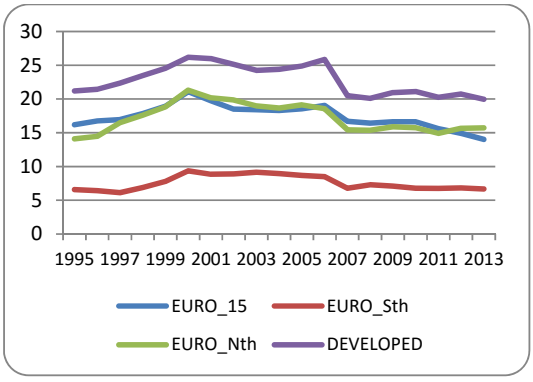

Fig. 1 High-tech exports (% of GDP), Source: [12], [13] and personal calculations

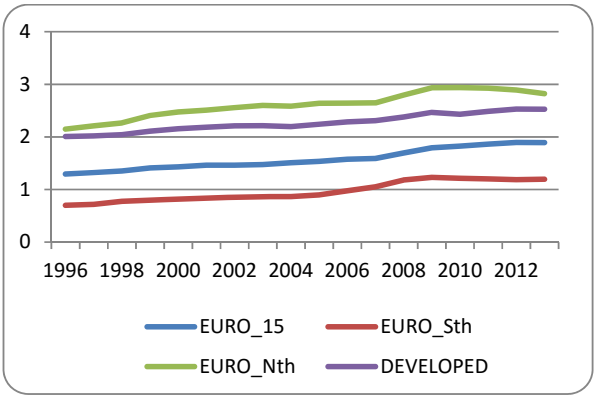

Fig. 2 R&D expenses (% of GDP), Source: [12], [13] and personal calculations

In this work, we attempt to examine the role of innovative activity in hindering the impact of economic crisis. Characteristics of firms performing active Research and Development are compared with those of non-innovative firms, from selected countries of two different groups of Eurozone; The southern European countries (Greece, Italy, Portugal and Spain), that were (and still are) heavily affected by current crisis, and the most representative countries of central Europe (also called as ''European North''), Germany and France, which 'manage' recession in a much different way. Our main scope is first to identify possible differences between innovative and non-innovative firms and then to attempt to disclose similar differences between innovative firms (only) from different countries. The main scope is not only to confirm the (prospected) significant effect of innovation in development but also to highlight the different impact (if any) of macroeconomic performance and infrastructure, in R&D outcome.

II. R&D Trough Recession

As official data [1] demonstrate, is R&D financed by the business sector is particularly affected by the business cycle and reflects changes in financing constraints and aggregate demand. In order to balance that, public spending in R&D seems to increase during economic distress and vise versa, in most developed countries, establishing an anti-cyclical policy. In the United States, R&D expenditure (GERD) has been on a downward trend since 2008, due to the fall in business R&D, but that was partly offset by increasing R&D in the higher education and government sectors. The EU28 performance has been more robust, mainly owing to the recovery of business R&D the last 5 years. This is principally due to growth in Germany's business R&D, which has more than offset reductions in other countries. In China, R&D expenditure has nearly doubled in real terms in the space of five years, principally boosted by the business sector. From 2009, R&D growth in the government and higher education sectors began to slow down but R&D levels continued to increase at a time when other countries were beginning to implement R&D budget cuts. Adversely, in Japan, it has still to recover its 2007 level, largely owing to the poor performance of the business sector

Focusing on euro zone, a period of slight convergence in the field of innovation and R&D intensity takes place after the beginning of common currency project (2002-2005). However, since financial crisis begin after 2007, expenditure in R&D differs significantly across economies and sectors, resulting in different policy measures, performance and development, both in firm and macroeconomic level.

Countries of southern Europe faced a period of growth and prosperity after joining euro zone (1999-2000), but lately, they were heavily affected by the global financial crisis, mainly due to their inability to manage sovereign debt. The result of debt crisis was the implication of harsh austerity measures and dramatic cuts in public spending resulting in a large reduction in GDP and in a violent burst in unemployment. The vicious circle of recession is generally admitted to be the most crucial problem for those economies and specific policy measures and reforms are necessary in order to spur development and growth. The overall economic condition affects investment in R&D, impairing recession. On the other hand, totally different is the picture concerning the two countries of Eurozone North, which were not affected seriously by financial crisis (especially Germany), and they were not obliged to apply cuts in budgets and high taxes in companies.

III. R&D Performance in Eurozone: North Vs South

Greece after joining euro zone (2002-2005), improves significantly its scientific quality, presenting however low R&D intensity (in public and business level) mainly due to specific structural features of the economy: the small size of the firms and the sectoral composition of the economy (mostly low-tech and medium-low-tech sectors such as food and beverages, textiles and chemicals). Furthermore, Greece suffered a net outflow of students to the United States some years before, and recently to Western Europe, due to the burst in unemployment. In 2011 Greece set an R&D intensity target of 2% of GDP to be achieved by 2020, but this target was cancelled at the end of the same year due to the economic crisis and the budgetary constraints. The bailout agreement with IMF, ECB and the European Commission, resulted in a

consolidation program and deep cuts to public expenditure and investment, reducing the lower (already) relative to EU average public spending in R&D. Total factor productivity (TFP) increased from 2000 until 2007, decreasing however, afterwards and in 2012. Its value was inferior to the one registered more than ten years before, affecting negatively employment. Today Greece is the country with the lowest employment rate in the EU, with more than 30% of the population to be at risk of poverty or social exclusion. At the same time, both private and public spending in R&D has been dramatically reduced, due to the austerity measures and restrictions that country confronts in capital markets [14].

Italian R&D intensity of both public and private sectors increased the last decade, but steel remains very far from those of the countries at the technology frontier, while it suffers a net outflow of students and engineers abroad (mainly to US). Under investment of the private sector in R&D and innovation, is largely due to the fact that the Italian economy is characterized by a large number of SMEs and micro firms in low knowledge intensity sectors (such as footwear, textiles and fabricated metal products and bicycles), as well as the low level of skills and insufficient performance of the higher education system in many regions. The Italian research and innovation system is relatively public-based and has a low level of knowledge transfer from public research institutions to firms. Unfortunately, due to the economic crisis, public funding for R&D as a percentage of GDP has been decreased over the last eight years, after a period between 2000 and 2004 in which a substantial increase was registered. The need to reduce the public deficit has imposed budgetary constraints and because of that, the efforts made in research and innovation to increase the knowledge base of the economy have been cancelled out by a decrease in total factor productivity (-5% since 2000) and by the stagnation of employment in knowledge-intensive activities [14], [15].

Portugal expanded its research and innovation system over the last decade, increasing public and business investment in research at a remarkable average annual real growth rate of 7% between 2000 and 2007, accompanied by a large increase in new researchers and knowledge intensity. Despite that progress however, Portugal remains below the EU average in business enterprise research intensity. Recently, Portugal is lagging slightly behind in terms of orienting its economy towards innovative and knowledge-intensive sectors attributed mainly to the severe economic crisis, along with several structural problems in the economy. Total factor productivity is lower than a decade before, the share of employment in knowledge-intensive activities is also relatively low and R&D intensity is further decreased after 2008, due to the economic recession. From 2009 onwards, the trend remains negative and in 2011, Portuguese R&D intensity had fallen significantly and R&D investment has also decreased, being affected by the difficult national business environment and the contraction of domestic demand due to the economic distress, budget's reduction and difficulties in accumulating finance. At the same time, adversely to the need for public funds in order to balance that gap (as discussed previously) public funding of R&D has been significantly reduced due to the pressures created by public expenditure reduction [14].

Economic impact of innovation in Spain is clearly above that of the reference group of countries with similar industrial and knowledge structure but still bellow EU average performance, due to the dominance of low-tech and medium-tech sectors (such as food, textiles, tourism, leather, and the furniture industry). In order to foster innovation in these clusters and in new areas (transport, ICT and energy), investment in research and innovation (R&I) has grown substantially over the last decade, from public and business sector demonstrating a fair degree of structural change towards a more knowledge-intensive economy. Over the pre-crisis period R&D intensity in most manufacturing industries increased well above the EU average, with public and private R&D funding to reach a peak. However, the economic crisis has hit Spain hard and the government R&D budget has been dramatically reduced. In 2011, the ease of access to loans in Spain was among the lowest in the EU, after a dramatic decrease since 2007-2008 when the economic crisis broke out. Under the obligation to follow the austerity measures imposed, R&D budget between 2010 and 2012 reduced by more than 30% (almost 25% in 2012). Venture capital as % of GDP is also well below most EU Member States, in particular seed and start-up capital. Spanish trade balance has become increasingly negative over the decade, with high-tech and medium-tech products however, to present a much slower decrease, indicating their positive contribution. Over the last decade, Spanish total factor productivity has remained stagnant and the employment rate has fallen dramatically during the economic crisis [14], [15].

Adversely to the R&D investment and performance in southern Europe, in France and Germany, things seem to be different [1].

France is among the research-intensive countries in the world. It has a large, relatively strong and competitive science base, is well equipped in large world-class research infrastructures, and is well connected in Europe and internationally, focused mainly on sectors like pharmaceuticals, motor vehicles, aircraft, spacecraft and communication equipment. However, the level of business R&D intensity remains relatively low in comparison with other R&D intensive countries due to modest share of high-tech manufacturing sectors in the economy. France is one of the rare countries where R&D expenditure of public and business sector progressed during the economic crisis (2007-2009), despite the severe budgetary constraints. Together with a decline in GDP, this progress caused a marked increase in overall business R&D intensity in 2009. In 2010 and 2011, business R&D intensity further progressed, attempting to reach the target of 3% intensity by 2020. The economic impact of innovation in France is slightly above the EU average and the contribution of high- and medium-tech products to the trade balance is particularly high, and remained positive over the whole decade, adversely to the negative trend of total trade balance, indicating the positive contribution of innovative process in macroeconomic performance [1], [14].

Finally, the German economy is strong and has high levels of exports of manufactured goods for an economy of its size (the third largest exporter worldwide, after China and the United States, with the largest export surplus in absolute terms). In real terms, the German trade balance in high-tech and medium-tech products is positive and has more than doubled over the last decade, expanding its research and innovation system. Germany has one of the highest economic impact of innovation in Europe, as the economy is more oriented towards knowledge-intensive sectors than the EU as a whole, based mainly on medium-high technology sectors such as automobiles, electro-technical products, machinery, and chemical products. Germany has come through the current economic crisis relatively well, partly as a result of its strong exporting performance, along with government's financial support in innovative activity. Public funding (1/3 of total investment in R&D), has grown substantially the last decade, assisting firms to enhance R&D. The government increased the public budget on research and innovation even during the 2009 economic crisis as part of a policy of prioritizing spending on education and research. Business enterprise expenditure on R&D also grew as a % of GDP over the period 2000-2010. That increase in public and private expenditure on research and development in Germany has helped to maintain a high innovation capacity and a strong export performance [1], [14].

IV. Empirical Analysis

In this work, we attempt to analyze the effects of innovative activity in development and growth in firm level. Thus, data from listed firms of various sectors of the economies of Portugal, Italy, Greece, Spain, France and Germany are collected in order to examine possible differences in performance between innovative and non-innovative firms. The period examined is between 2007 and 2012, including the severe recession that affected most of euro zone country-members. From an initial sample of 600 listed firms from the six countries, after excluding missing values, a final data set of 400 firms randomly selected was created, consisting of 200 firms that invest in Research and Development and 200 that do not perform any innovative activity. The criteria were the continuous R&D expenses for the period examined and whether firms use and/or introduced patents in those years. Through that process, a binary variable was created taking values 1 (innovative firm) or 0 (non-innovative). The number of firms included from each country in the final data set, was attempted to be in accordance with the average number of the listed firms of each one in the period examined, as recorded by world data bank statistics. The sources of the data collected are WorldBank and Worldscope databank. In order to analyze the differences between firms performing innovative activities, we select several widely used characteristics, indicating performance and growth. For most of those indicators (apart from categoricals), percentage change between the period examined were calculated. In the rest of the section, all the variables included in the analysis, are described, along with a brief theoretical justification.

Firm size (SIZE) is one of the most commonly used measures of growth, resulting however in mixed empirical findings. While small businesses are important drivers of growth and innovation, larger businesses typically have competitive advantages owing to economies of scale, cheaper credit and direct access to global value chains. In some researches, smaller firms appeared to grow faster [5], [16]. On the other hand, others indicate that larger firms may affect positively growth. Various measures have been used in literature in order to quantify firm size (number of employees, profitability, total assets etc.) [17]. In this work we select total asset's growth, calculated by the percentage change in total assets (natural logarithm), from the beginning of the crisis and until 2012.

Profitability (PROF) is a crucial factor in regard to firm growth. Firms with strong economic performance could resist in recession, retaining or increasing employment and enjoying less financial and commercial constraints indoor and outdoor. As a measure of profitability, EBIT-to-Total Assets ratio was selected (also called as Basic Earning Power), as it has been included in various similar researches (see indicatively [2], [18]). Due to their competitive advantage, innovative firms are expected to present higher profitability than non-innovative. Thus, a significant effect relation with R&D is expected.

Debt Accumulation (DRBR) is a very important indicator, especially during recessionary periods. It is crucial for a firm to manage successfully and reduce (if possible) liabilities when economic distress appears. A high debt ratio may restrain economic performance, generating worries for firm's ability to make interest and loan payments (see for example [18]). As an indicator of debt accumulation, the financial leverage ratio is used (Total Debt to Total Assets). The fast growth that (according to literature) innovative firms usually enjoy, may affect positively market share and turnover, resulting in a better financial performance and thus a lower debt ratio. A negative relation with R and D activity is thus, prospected.

Liquidity is used as a measure of viability and financial health. Firms presenting high liquidity ratio, are able to reduce liabilities (debt). Furthermore, adequate liquidity during a distress period provides firms with a strong competitive advantage in national and mainly in global market, diminishing constraints from suppliers, financial institutions and creditors. One of the various indicator implying ability of a firm to repay its short-term liabilities is Interest Cover Ratio (ICR = EBIT to Interest expense). A positive relation with innovation is prospected as innovative firms are expected to be more profitable as already discussed.

In this work, we analyze data from two different groups of euro zone that were affected differently by economic crisis and their overall strategy and policy measures applied at that period, were not similar. As a result, an indicator that will divide firms relative to the country they belong to is necessary in order to disclose such divergence. Thus, a categorical country-specific interpreter will be included in the analysis (COUNT), consist of six classes (taking values from 1=poor performance to 6=best performance), relative to

macroeconomic performance (debt accumulation, R&D intensity, GDP growth and unemployment rate). As countries' innovation systems and overall infrastructure differ significantly as already discussed, that factor will be appropriately transformed to a binary dependent variable in the second part of our empirical analysis, in order to disclose possible differences between innovative firms from different countries.

Employment growth (EMPL) will also be tested for its ability to interpret innovative activity. As already mentioned in theoretical section, many research works conclude in a strong positive effect of innovative performance in employment. According to [1], job creation increasingly determined by a country's ability to access foreign markets. That trend is stronger the last decade in Germany, while European north (especially Greece and Spain) is in the lowest place of whole Europe. Thus, it will provide useful food for thought to test its relation (if any), not only during a severe recessionary period, but also between countries where the impact of economic crisis is different and because of that, policy measures differ too.

Our sample consists of listed firms and because of that one last indicator related to stock performance will be included in the analysis. Earnings per Share (EPS) indicates the available return that a company (stock) offers to its shareholders. It is usually associated with stock preference and because of that with firm's capitalization. Thus, it is prospected to be positively related with innovation as such firms are expected to present higher profitability.

In Fig. 3 some preliminary descriptive statistics are presented for the variables discussed in this section. The average percentage change between 2007 and 2012 is calculated between innovative and non-innovative firms from all countries examined and as clearly demonstrated, in most indicators innovative firms seem to perform better. Specifically in debt accumulation and profitability, differences are more than obvious.

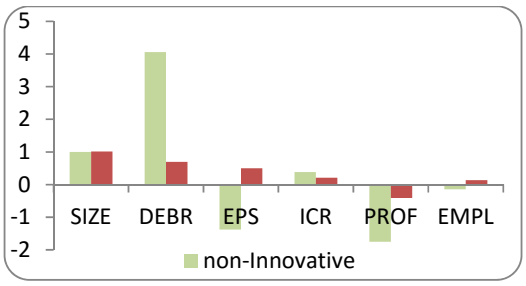

Fig. 3 Performance of Innovative and non-Innovative firms

Those descriptive findings will then be tested through an empirical analysis in order to confirm them or not. For the econometric analysis that will follow, IBM SPSS statistics v.19 will be used.

V. Findings

In this work we attempt to associate several characteristics with innovative process. Thus, a simple correlation analysis will firstly performed, in order to disclose preliminary findings confirming the theoretical background of the impact of R&D during economic distress. As our dependent variable is binary and a categorical variable is also included in the interpreters, Spearman's (rho), is selected as it is considered to be more appropriate for such type of variables. In Table I, correlation results are presented. Additionally, segregation between countries is also presented, disclosing some very interesting findings that will prove to be useful in the analysis that will follow.

TABLE I
Correlation Results

Interpreters (Spearman;s rho)	Innovative Activity (0-1)	Country (0-6)
COUN	.185** (.000)	1
Innov	1	.185**(.000)
SIZE	.201** (.000)	.249**(.000)
DEBR	.004 (933)	-.187**(.000)
EPS	.198** (.000)	314**(.000)
ICR	.168** (.000)	.315**(.000)
PROF	.178**(.000)	.326** (.000)
N=400		

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Findings indicate that innovative activity is significantly correlated with most of the interpreters, but a stronger relation seem to appear with size, profitability (EPS) and employment, and a slightly smaller with country's macroeconomic performance, and liquidity. Even though coefficients' values are not large enough, a clear trend seems to exist, indicating that innovators seem to improve their performance and employment rates, even during an economic recession, confirming findings from other researches and countries, discussed in theoretical section.

As for the prospected effect of countries' economic background in several indicators, results disclose a strong relation with most of the variables used (including R&D), implying that it is not only innovation itself that may hinder the recessionary effects, but the actions that each country will perform to foster innovative entrepreneurship are critical too.

Trying to confirm those findings, we go a step further in the analysis, performing a non-parametric test (due to type of the dependent variable) in order to identify more clear relations among innovation and performance during the economic crisis. For that purpose, the Two-Sample Kolmogorov-Smirnov Test was selected, as it is appropriate for binary dependent variables and it disclose similarities and differences between the populations included in dependent variable: in our case, innovative and non-innovative firms. Findings are presented in Table II:

TABLE II
NON-PARAMETRIC TEST (INNOVATIVE VS NON-INNOVATIVE FIRMS)

Test Statistics[a]							
	Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)	Exact Sig. (2-tailed)	Point Probability
	Absolute	Positive	Negative				
Count	,225	,225	,000	2,250	,000	,000	,000
Size	,220	,220	-,005	2,200	,000	,000	,000
Debr	,080	,080	-,060	,800	,544	,544	,079
EPS	,225	,225	,000	2,250	,000	,000	,000
ICR	,175	,175	-,015	1,750	,004	,004	,001
Prof	,170	,170	-,005	1,700	,006	,006	,002
Empl	,205	,205	-,005	2,050	,000	,000	,000

a. Grouping Variable: Innovation

As it is clear, Size, Profitability and Employment are strongly related with innovative activity, with other variables (except debt performance) to follow, confirming correlation's results. What seems to be interesting however, is the very strong impact of country's performance in innovative process, indicating that more prosper countries increase public funding in R&D as already mentioned, improving R&D intensity and performance, while countries of European South in the same period are obliged not only to reduce expenses in general, but also to reduce dramatically funding even in fields with high potentials in performance and employment such as high-tech and medium-tech sectors. Thus, the impact of innovation in firm performance and development is much lower in those countries, impairing their already difficult economic condition.

After confirming the crucial contribution of innovative activity in firms survival and prosperity during severe recessionary periods, we will focus only to innovative firms (group -1-), in order to analyze further the effect of country's macroeconomic performance in micro entrepreneurial data. More specific, do innovators from each country perform similar to those from other countries, or macroeconomic condition and competitiveness determines the degree of the (confirmed) performance? Table III presents the results of the second non-parametric test. The dependent variable is now the group that a firm belongs too (1=countries of European South that were heavily affected by austerity and cuts in spending and 2=countries more prosper, that were less affected by crisis and because of that continue to increase and foster R&D expenses and innovative activity). That segregation is necessary as a binary classification is needed in order to perform the K-S non-parametric test.

TABLE III
NON-PARAMETRIC TEST (COUNTRIES)

Test Statistics[a]							
	Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)	Exact Sig. (2-tailed)	Point Probability
	Absolute	Positive	Negative				
Size	,238	,040	-,238	1,497	,023	,018	,000
Debr	,212	,212	-,041	1,328	,059	,049	,000
EPS	,312	,007	-,312	1,959	,001	,001	,000
ICR	,249	,020	-,249	1,562	,015	,012	,000
Prof	,223	,000	-,223	1,402	,039	,032	,000
Empl	,312	,047	-,312	1,957	,001	,001	,000

a. Grouping Variable: Country

As it is clear, even though innovators seem to perform better in all economies examined, the extent of each innovator's performance is strongly affected by supportive mechanisms and public funding that its country provides. Thus, it is confirmed that it is necessary to foster innovation in countries of European south, in order to improve performance and hinder recession.

VI. CONCLUSIONS

Innovative activity is generally admitted to be a source of development and growth in firm and country level, even during economic recessions. Focusing on current economic crisis, we attempt to disclose differences between innovative and non-innovative firms, and between countries with different macroeconomic performance. Findings of this research work on listed firms from selected countries of South and North euro zone countries, confirm the strong impact of innovative process in most measures of firm performance. Innovators in all countries analyzed, appear to be profitable increasing their assets and employment, even during the severe economic crisis (after 2007). Thus, specific policy measures should be applied, in order to support innovative activity, especially in countries that are heavily affected by economic distress. However, findings also indicate a clear differentiation between firms from European periphery and those of central Europe. From the one hand, France and Germany foster innovative entrepreneurship during current

crisis, while, on the other hand, southern European countries were obliged to reduce dramatically public funds, even in sectors with high potentials. As a result, adversely to what literature and international best practices indicate, the existed R&D investment and intensity gap between those two groups of euro zone, became larger the last years, affecting negatively the overall development and employment. The horizontal cuts in budgets impair the effect of recession, in countries that are heavily affected, and should be reconsidered.

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