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DOES FORMAL EDUCATION AT ALL LEVELS CAUSE ECONOMIC GROWTH?
EVIDENCE FROM GREECE

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Abstract: *This study empirically investigates the link between the levels of formal education and economic growth in Greece during the period 1960-2009. The paper applies the Lucas approach (1988) and employs cointegration, error-correction models and estimates the effect of each educational level on economic growth. The empirical analysis reveals that there is a long-run relation between educational levels and gross domestic product. The overall results show that secondary and higher education has had a statistically significant positive impact on growth, while primary has not contributed to economic growth. The findings also suggest that there is evidence of unidirectional long-run causality running from primary education to growth, bidirectional long-run causality between secondary and growth, long-run and short-run causality running from higher education to economic growth.*

Keywords*: formal education levels; human capital; enrolment rates; economic growth; VAR; Greece*
JEL classification: *O40; O41; O47; I21; I25*

1 INTRODUCTION

Since 1960, the interaction between education and economic growth has been investigated with micro-approaches (Psacharopoulos 1995; Bouaissa 2009) and macro-approaches (Pereira and Aubyn 2009; Odit, Dookhan, and Fauzel 2010). Existing economic literature accepts education as one of the primary components of human capital. Human capital refers to the stock of competences, knowledge and personality attributes embodied in the ability to perform labor so as to produce economic value (Bashir, Iqbal and Zaman 2011). According to macro-

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economic literature the two main approaches are: the augmented Solow neo-classical approach and the "new or endogenous growth theories" (Sianesi and Van Reenen 2003). The augmented neo-classical model [Mankiw, Romer and Weil (1992), (hereafter M-R-W (1992))] simply extends the basic Solow's (1956) model with education/human capital as an additional production factor. On the other hand, endogenous growth models distinguish between those which directly relate education/human capital with economic growth (Lucas 1988) and others introduced by Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992), who have emphasized the key role of R&D efforts and innovations in driving technical progress, productivity and economic growth. Various studies have focused on that topic (Arnold 2002; Strulik 2005; Bucci 2008, etc). While education has no role in traditional neo-classical theories of economic growth, these new approaches have explicitly brought the role of education to the fore. A key difference between new growth theory and the neoclassical growth theory involves the distinction between increasing and decreasing returns to scale. The basic underlying assumption of neoclassical theory is that diminishing returns to capital operates in the production process, while endogenous theory supports the assumption that the production function does not exhibit diminishing but increasing returns to scale. While there is a large amount of evidence on the link between education and economic growth, the effect of formal education levels on economic growth with macro-economic approaches has been studied in the last two decades. The fact that different levels of formal education may have different effects on growth has been addressed in a small set of recent papers.

The period 1960-2009 was particularly important for Greece. In that period, three major events took place influencing the economy and education. a. The association-for-entry agreement with the European Economic Community (EEC). Commencement of negotiations started in September 1959 and the validity of agreement connection finished in November 1962. b. The accession to the EEC. The induction agreement came into force in January, 1981. Greece, as an EEC member participated in all stages of European integration, including the single European Act and the signing of the Maastricht Treaty. c. The accession to the European Monetary Union (EMU) and the adoption of the new Eurocurrency (1 January, 2001). During this period, a number of structural and functional reforms and adjustments, in both economy and education had been implemented with varying success. Economic activities have moved from primary to secondary and especially to tertiary sector of the economy. Also, in this period an educational expansion took place in Greece, especially in secondary and mainly in higher education.

The purpose of this study is to empirically investigate the causal relationship between the levels of formal education and economic growth. Moreover, it estimates the effect of each level of formal education on economic growth in Greece over the transition period 1960-2009. The study uses the time series analysis, the endogenous approach of Lucas (1988) and the enrollment rates as a proxy of human capital. Additionally, it examines the consistency of findings of empirical analysis with the findings of the study of Pegkas (2014), who investigated the relation between the levels of formal education and economic growth in Greece for the same period by using the neoclassical approach of M-R-W (1992). The results may improve the decisions of policymakers about education and its contribution to economic growth.

The rest of the paper is organized as follows: Section 2 provides a brief review of empirical literature; Section 3 discusses the methodology, presents sources and data and reports the empirical results based on econometric analysis, Section 4 discusses the results. Finally, section 5 summarizes the main findings and conclusions of the study.

2 REVIEW OF EMPIRICAL LITERATURE

The existing empirical literature initially investigates the interaction between education in terms of quantity or quality and economic growth as well as the effect of education on economic growth. Various studies have used different variables as proxies of human capital (Tsamadias and Pegkas 2012). The main studies that have investigated the impact of the educational levels on economic growth are presented below: Liu and Armer (1993) found that both primary and junior-high achievement variables enhance economic growth in Taiwan, but senior-high and college education did not exert any significant effects on growth. Tallman and Wang (1994) showed that higher education has a greater positive impact on growth in relation to primary and secondary education for the case of Taiwan. Mingat and Tan (1996) for a sample of 113 countries found that higher education has a positive statistically significant impact only in the group of developed countries, while the primary has a positive effect in less developed and the secondary a positive effect in developing. Gemmell (1996) for OECD countries concluded that primary education most affects the less developed countries, while secondary and higher education the developed. Mc Mahon (1998) investigated the effect of the three levels of education on economic growth for a sample of Asian countries and concluded that primary and secondary level have a significantly positive effect on economic growth, while higher is negative. Abbas (2001) for the countries of Pakistan and Sri Lanka showed that the primary has a negative effect on economic

growth, while secondary and higher education have a positive and statistically significant impact on economic growth in both countries. Petrakis και Stamatakis (2002) found that the growth effects of education depend on the level of development; low-income countries benefit from primary and secondary education while high-income developed countries benefit from higher education. Self and Grabowski (2004) for the case of India showed that except higher education the primary and secondary education had a strong causal impact on economic growth. Villa (2005) investigated the effect of the three levels of education on economic growth for Italy and found that the higher and secondary education has a positive effect on economic growth, while the primary has no significant effect. Gyimah-Brempong, Paddison, and Mitiku (2006) found that all levels of education have a positive and statistically significant impact on the growth of per-capita income in African countries. Lin (2006) for the case of Taiwan found that primary, secondary and tertiary have a positive impact on economic growth. Chi (2008) showed that in China higher education has a positive and larger impact on GDP growth than primary and secondary education. Pereira and Aubyn (2009) showed that in Portugal primary and secondary education has a positive impact on GDP, while higher has a small negative effect. Loening, Bhaskara, and Singh (2010) for the case of Guatemala found that primary education is more important than secondary and tertiary education. Shaihani et al. (2011) for Malaysia concluded that in the short run only secondary education has a positive and statistically significant coefficient, while the primary and tertiary exhibit negative and statistically significant results. Unlike in the long run only higher has a positive and statistically significant effect.

In case of Greece, a few studies have investigated the impact of education on economic growth. Magoula and Prodromidis (1999) showed that in Greece the relative contribution of secondary and higher education to growth in relation to the contribution of primary education has risen: from the 1960's to the 1980's. Asteriou and Agiomirgianakis (2001) showed that the growth of enrolment rates in primary, secondary and higher education positively affected the GDP in Greece for the period 1960-1994. Tsamadias and Prontzas (2012) used the M-R-W (1992) model and found that economic growth had been positively affected by enrolment rates in secondary education for the period 1960-2000. Tsamadias and Pegkas (2014) used the M-R-W (1992) model and found that economic growth had been positively affected by enrolment rates in higher education for the period 1960-2009. Pegkas (2014) used the M-R-W (1992) model and found that the enrolment rates in secondary and higher education have a positive and statistically significant impact on the growth while the primary had a negative one for the period 1960-2009.

3 EMPIRICAL ANALYSIS

This section presents the methodology, the data and sources and the econometric analysis (stationarity properties of the data, cointegration tests, vector error correction models and causality, the generalized impulse response functions and the generalized variance decomposition analysis).

3.1 Methodology and Model

The empirical analysis of this paper uses the methodology of new growth (endogenous) theory. Lucas model (1988) assumes that there are two production sectors, both perfectly competitive: One goods sector (equation 1) and one education (human capital) sector (equation 2). Both productions functions have constant return to scale. The production function in the goods sector is given below[1]:

$$Y_t = A\left(K_t\right)^a \left(uh_t\right)^{1-a} \quad (1)$$

Assuming no externalities and a zero depreciation rate of human capital, the creation of human capital is determined by the following linear function:

$$\Delta h_t = B\left(1 - u_t\right) \quad (2)$$

Equations (1) and (2) are the final expressions for the production functions in the two sectors. Y_t represents the total quantity of the final good produced at time t, A represents the constant technological level in the goods sector of this economy, while k_t and uh_t denote the aggregate quantities of factors used in the production process, again at time t (respectively physical and human capital). Parameter α is the elasticity of output with respect to physical capital (strictly comprised between zero and one). Human capital (h_t) consists only of educated individuals, for the entire economy and Δ represents the growth rate. A fraction u_t of human capital ($0<u<1$) of non-leisure time devoted to goods production is used at time t, while its complement to one ($1-u_t$) is the proportion of time devoted to production of new human capital.

The proxy of human capital is a key issue in the empirical growth model, as it would improve the performance of the growth model. Many researchers tried to approach human capital using proxies, as flow or as stock. The proxy of human capital that was used in this study is the gross enrollment rates (flow) for the three educational levels (primary, secondary and higher). Also this kind of proxy (flow) has been used from other empirical studies, which have employed the model of Lucas (1988). Specifically, Asteriou and Agiomigrianakis (2001) have used the enrolment rates for the case of Greece, Gong, Greiner and Semmler (2004) have used the public expenditures for education for the case of USA and Germany and Haldar and Mallik (2010) have used the public expenditures for education and

primary enrolment rates for the case of India. An elementary formula used by most countries to calculate the gross enrollment ratio is that, the country divides the number of individuals who are actually enrolled in schools by the number of children who are of the corresponding school enrollment age. In Greece, gross primary, secondary and higher school enrollment ratio considers children between the age of 6 – 11, 12 – 17 and 18-23 respectively. The measure of this variable is achieved by using the following function (World Bank 2012):

$$GHER^t = \frac{E^t}{P^t} * 100 \tag{3}$$

where $GHER^t$=Gross Enrolment Ratio in school year t for each educational level, E^t = Enrolment for each level of education in school year t, P^t = Population in age-group which officially corresponds to each level of education in school year t. This proxy is reported as quantitative measurement of human capital. The quality of education cannot be taken into account. Given the availability of the data, it is not possible to consider wider definition of human capital investment compassing on-the-job training, experience and learning-by doing, the number of repeaters and dropouts in each grade and ignoring its depreciation.

The model needs an approximation for the time spent to build up human capital accumulation, (1-u). In constructing the series for (1-u) is necessary to make a compromise. It is known that the time devoted to human capital accumulation includes many years of schooling, training on the job, etc. but only the earned university degrees are used here as a fraction of the employment. Therefore, we define (1-u) as follows [see, Gong, Greiner, and Semmler (2004); El-Mattrawy and Semmler (2006)]:

$$1 - u_t = \frac{\text{university degrees}}{\text{employees}} * s \tag{4}$$

with s=6 as approximated time (years) at university. The university degrees include diplomas and doctoral degrees. Equation (4) states that the time spent in education $1-u_t$ is equal to the number of college graduates at time (t) divided by the labour force and multiplied by the school years.

3.2 Data and Sources

Data on Gross Domestic Product (GDP) and physical capital investment series are annual and were taken from the AMECO database. GDP measured at 2005 constant prices and investments is the gross capital formation at 2005 constant prices for the total economy. Data for constructing human capital proxy

were taken from the Hellenic Statistical Authority (HSA) database. All variables are expressed in logarithmic form.

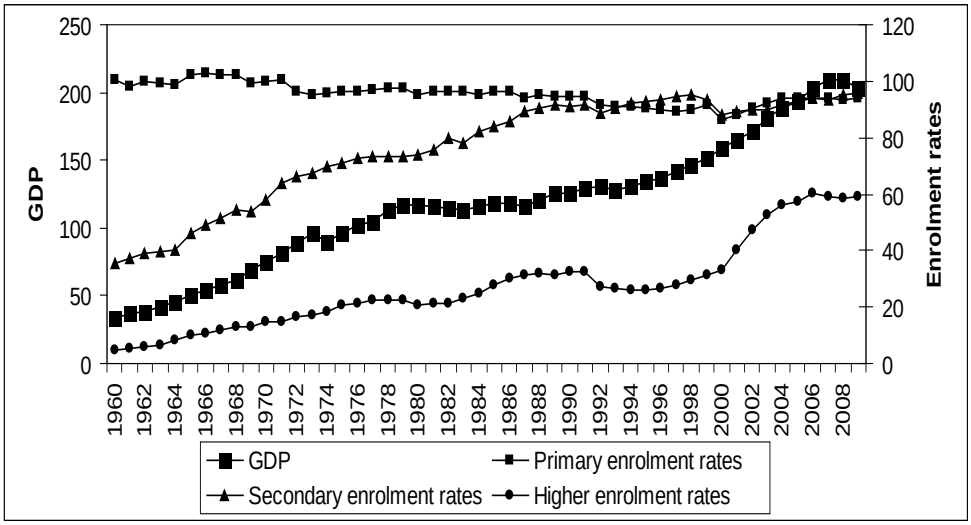

Figure 1: GDP (2005 as base year) and Primary, Secondary and Higher enrolment rates (1960-2009)

Source: AMECO database and Hellenic Statistical Authority (EL.STAT.)

During the period 1960-2009 Greek GDP indicates a significant increase as well as a radical increase in the share of secondary and higher education. The primary education is represented by a very small (almost stable), negative slope over the whole period (Figure 1).

3.3 Estimation of the human capital sector

If the assumption of constant returns in the second sector holds, the marginal effect of (1-u) on the growth of human capital equals B (Monteils 2004). If B is positive and statistically significant (increasing scale returns) then increasing stock of human capital is the engine of long run growth (endogenous growth). In the opposite direction if B is negative or statistically insignificant there must be decreasing scale returns (no endogenous growth). By using the OLS method the results of the estimated equation (2) for each educational level are given below on the table 1. The regressions were estimated consistently as for the existence of the Serial Correlation and the Heteroskedasticity, by using the Newey-West (1987) estimator.

Table 1: Returns to Scale results

Δht	**1-u**
Primary	0.00003
	(0.630)
Secondary	-0.006
	(-4.036)***
Higher	-0.017
	(-3.818)***

Note: The t-statistics are presented in parentheses. The asterisks indicate significance at the 1% level.

The results show that the link between the time devoted to education (or the duration of training) and growth of human capital is negative. The coefficient of 1-u yields negative and statistical significant results at 1% level for the cases of secondary and higher education and statistical insignificant results for the primary education. The human capital grows in such a decreasing rate, so the endogenous character of the economic growth suggested by Lucas is not verified. Consequently, all findings point to the conclusion that human capital is a factor like the others to the production function and it does not break the law of diminishing returns. So, the application of this model would be accompanied by similar predictions as the neoclassical growth model introduced by Solow (1956) and Mankiw, Romer, and Weil (1992). Potential explanations for these results may be the following:

a) Lucas model may not be compatible with the time series analysis, b) our approach of the variable 1-u may be biased as to the measurement used method, c) the assumption of linear relationship between growth rate of human capital and the time devoted to learning may be incorrect, d) the short period of the time series data.

3.4 Estimation of the production sector

This section focuses on the effect of primary, secondary, higher education and investments in physical capital on economic growth by using a VAR methodology. We estimate three different VAR models. Each model includes the variables of economic growth, investments and one of the three educational levels. Using education data by levels may be preferable for a number of reasons. In particular, the growth impact of different forms of educational levels may vary. Also, including primary, secondary and higher education into the same equation is a procedure which may provide invalid results due to strong multicollinearity between the variables (Loening, Rao, and Singh, 2010). First, the order of integration is checked and then cointegration tests are used in order to check the existence of long run relationship between variables. Second, the causality tests based on vector error correction approach were applied and third, in order to investigate the dynamic relationships

between the variables of the models the impulse response functions and variance decomposition are plotted and calculated respectively.

Stationarity test

Initially, the stationarity of the variables GDP, physical capital investments and education is checked. The stationarity of the data set is examined using Augmented Dickey-Fuller (ADF) (1981), Phillip-Perron (PP) (1988) and Perron (1997) structural break tests. We test for the presence of unit roots and identify the order of integration for each variable in levels and first differences. The variables are specified including intercept and including intercept and trend. The optimal lag length of the ADF regressions is determined by Schwarz criterion (1978). The PP statistics are obtained by the Bartlett Kernel and the automatic bandwidth parameter approach as suggested by Newey and West (1994). For the Perron structural break test, the maximum lag length is specified by the user to be equal to 4. For the ADF, PP tests the null hypothesis is non-stationary and for the Perron test is non-stationary with a structural break. Unit root test results are given in Table 2.

Table 2: Results of unit root tests

Variables (in levels & first differences)	**ADF test**		**PP test**		**Perron test**	
	With intercept in equation	**With intercept and trend in equation**	**With intercept in equation**	**With intercept and trend in equation**	**With intercept in equation**	**With intercept and trend in equation**
q_t	-4.695***	-2.310	-3.886***	-2.879	-3.526	-3.566
Δq_t	-4,749***	-4.848***	-5.572***	-5.443***	-7.484***	-7.445***
k_t	-3.604***	-3.042	-3.605***	-3.040	-3.840	-3.265
Δk_t	-6.350***	-6.366***	-6.605***	-6.591***	-7.989***	-7.804***
$uh1_t$	-1.375	-1.318	-3.013	-2.959	-3.763	-4.130
$\Delta uh1_t$	-8.267***	-8.267***	-8.173***	-8.173***	-8.585***	-8.748***
$uh2_t$	-4.991***	-5.281***	-1.991	-1.933	-2.382	-3.354
$\Delta uh2_t$	-5.017***	-5.149***	-6.625***	-6.625***	-7.786***	-7.686***
$uh3_t$	-2.279	-2.401	-2.610	-3.796**	-4.050	-4.179
$\Delta uh3_t$	-3.515**	-3.496**	-3.736**	-3.725**	-4.818	-4.772

Note: ***, ** indicates the rejection of the null hypothesis of non stationarity (ADF) and (PP) at 1% and 5% level of significance respectively. For ADF and PP tests MacKinnon (1996) critical values have been used for rejection of hypothesis of a unit root. For structural break test critical values are those reported in Perron (1989).

The results in Table 2 showed that for all the tests the null hypothesis couldn't be rejected at 5% for every variable in their level. The null hypothesis could be rejected at 5% for all variables in their first differences. So the variables from combination of the criteria under study are stationary in their first differences on 5% significant level.

Cointegration test

Stationary tests show that all the variables which are non-stationary in levels become stationary in first differences. They are in fact integrated of order one. So there is the possibility that the variables of GDP, physical capital investments and primary, secondary, higher education are cointegrated. In order to account for influences on the GDP, two dummy variables are added to the VARs model. The first dummy variable involves the year 1974, when the international oil crisis took place and GDP had a significant fall. The second dummy variable involves the year 2001, when Greece became a member of the Euro zone. To determine the lag length of the VARs, three versions of the system were initially estimated: a four, a three and a two-lag version. Then, the Akaike information criterion (AIC) is used to select the optimal lag length. The cointegration test was conducted by using the reduced rank procedure developed by Johansen (1988) and Johansen and Juselius (1990). The Johansen multivariate cointegration approach is used to examine the long-run relationship between the variables. The estimation procedure assumes intercept and no trend in the VARs estimations. This cointegration method recommends two statistics to check the long run relationship: the Trace and maximum Eigenvalue tests. The results of the cointegration tests are presented in the tables 3, 4 and 5.

Table 3: Cointegration test: GDP, physical capital investments and primary education

Series: q k uh1					
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**5 Percent Critical Value**	**Max-Eigen Statistic**	**5 Percent Critical Value**
None*	0.887	126.38	35.192	106.90	22.299
At most 1	0.254	19.481	20.261	14.424	15.892
At most 2	0.098	5.0569	9.1645	5.0569	9.1645

Note: [a] r indicates the number of cointegrating relationships. Trace and Maximum Eigen test statistics are compared with the critical values from Johansen and Juselius (1990). *Trace and Max-Eigen tests indicate 1 cointegrating equation at the 5% level.

[b] Lags interval: 0 to 0

Table 4: Cointegration test: GDP, physical capital investments and secondary education

Series: q k uh2					
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**5 Percent Critical Value**	**Max-Eigen Statistic**	**5 Percent Critical Value**
None*	0.9054	134.96	35.192	115.55	22.299
At most 1	0.2479	19.409	20.261	13.965	15.892
At most 2	0.1051	5.443	9.1645	5.443	9.1645

Note: [a] *r* indicates the number of cointegrating relationships. Trace and Maximum Eigen test statistics are compared with the critical values from Johansen and Juselius (1990). *Trace and Max-Eigen tests indicate 1 cointegrating equation at the 5% level.

[b] Lags interval: 0 to 0

Table 5: Cointegration test: GDP, physical capital investments and higher education

Series: q k uh3					
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**5 Percent Critical Value**	**Max-Eigen Statistic**	**5 Percent Critical Value**
None*	0.6184	59.579	35.192	46.252	22.299
At most 1	0.2115	13.326	20.261	11.409	15.892
At most 2	0.0391	1.9170	9.1645	1.9170	9.1645

Note: [a] *r* indicates the number of cointegrating relationships. Trace and Maximum Eigen test statistics are compared with the critical values from Johansen and Juselius (1990). *Trace and Max-Eigen tests indicate 1 cointegrating equation at the 5% level.

[b] Lags interval:1 to 1

The null hypothesis in the Trace and maximum Eigenvalue tests is that there is no cointegrating vector. The null hypothesis of one co-integrating vector in the Trace test could be rejected at 5% and could not be rejected at 5% for more than one co-integrating vectors, which implies that there is only one cointegrating vector in all the cases. The finding of one co-integrating vector was further supported by the results of the maximum Eigenvalue test, in which the null hypothesis that there is no cointegrating vector could be rejected at 5% only for one co-integrating vector. Thus, the results lead to the conclusion that the GDP, physical capital investments and each of the three educational levels are cointegrated and there is a long-run relationship between them. The estimated cointegration relationships are presented in the following table 6:

Table 6: Long Run Relationships

Levels of Education	**c**	**k**	**uh**
Primary	2.37	0.77	-0.96
	(0.15)***	(0.05)***	(0.45)***
Secondary	3.42	0.50	0.52
	(0.20)***	(0.05)***	(0.07)***

Levels of Education	c	k	uh
Higher	3.05	0.67	0.20
	(0.38)***	(0.09)***	(0.06)***

Note: The standards errors are presented in parentheses. The asterisks indicate significance at the 1% level.

From the above-estimated equations it can be concluded that in the long run the coefficients of secondary and higher education are positive and statistically significant at the one-percent level. The elasticity of GDP with respect to secondary and higher education is 0.52 and 0.20 respectively. This means that a one percent increase in secondary and higher education enrolment rates will foster economic growth by about 0.52 and 0.20 percent respectively. The role of secondary and higher education level on economic growth seems to be important and significantly explains economic growth. The elasticity of GDP with respect to primary education is -0.96. So the primary education has had a negative effect on economic growth. Also, it can be concluded that in the long run, physical capital investments have a significant positive effect on economic growth in all the equations.

Error Correction Models

Having verified that the variables are cointegrated, the vector error-correction model (VECM thereafter) can be applied. The VECM can give the correction term that reflects influences of the deviation of relation between variables from long-term equilibrium upon short-term changes. The size and statistical significance of the error-correction term measures the extent to which each dependent variable has the tendency to return to its long-run equilibrium. For the VECMs including primary and secondary education the Akaike information criterion identified no lags for the VECMs with primary and secondary education and one lag for the VECM with higher education as optimal lag length. Therefore, it can be concluded that there is not a short run but only a long run relationship between the variables which included in the VECMs with primary and secondary education. The vector error-correction models pass all the standard diagnostic tests for residual serial correlation, normality and heteroscedasticity. The results[2] of the vector error-correction models showed that the first dummy variable has a negative and statistically significant influence on GDP. The second dummy has no influence on GDP as the coefficient is not statistically significant, except the VECM with secondary education which is significant positive.

The t statistic on the coefficient of the lagged error-correction term represents the long-run causal relationship and the F-statistic on the explanatory variables represents the short-run causal effect (Narayan and Smyth 2006). More specifically, the Wald-test applied to the joint significance of the sum of the lags of each explanatory variable and the t-test of the lagged error-correction term will imply statistically the Granger exogeneity or endogeneity of the dependent

variable. The non-significance of ECT is referred to as long-run non-causality, which is equivalent to saying that the variable is weakly exogenous with respect to long-run parameters. The absence of short-run causality is established from the non-significance of the sums of the lags of each explanatory variable. Finally, the non-significance of all the explanatory variables, including the ECT term in the VECM, indicates the econometric strong-exogeneity of the dependent variable that is the absence of Granger-causality (Hondroyiannis and Papapetrou 2002).

Table 7: Causality test for primary education based on VECM

	Long-Run Causality
Variables	**ECT**
DQ	- 0.138*** [-11.03]
DK	-0.152*** [-2.96]
DUH1	0.008 [1.09]

Note: The asterisks of the lagged ECTs are distributed as t-statistics and indicate rejection of the null hypothesis that the estimated coefficient is equal to zero (weak exogeneity) and no causality. The asterisks indicate significance at the 1% level.

Table 8: Causality test for secondary education based on VECM

	Long-Run Causality
Variables	**ECT**
DQ	- 0.191*** [-11.91]
DK	-0.244*** [-3.54]
DUH2	-0.100*** [-5.92]

Note: The asterisks of the lagged ECTs are distributed as t-statistics and indicate rejection of the null hypothesis that the estimated coefficient is equal to zero (weak exogeneity) and no causality. The asterisks indicate significance at the 1% level.\

Table 9: Summary of causality test for higher education based on VECM

	Short-run dynamics non-causality			**Weak exogeneity**	**Tests of Granger non-causality (joint short run dynamics and ECT)**			**Test for strong exogeneity**
Variables	DQ	DK	DUH3	ECT	DQ and ECT	DK and ECT	DUH3and ECT	All variables and ECT
DQ	-	1.72 (0.18)	5.39** (0.02)	- 0.10*** [-2.99]	-	24.28*** (0.00)	22.59*** (0.00)	42.48*** (0.00)

	Short-run dynamics non-causality			Weak exogeneity	Tests of Granger non-causality (joint short run dynamics and ECT)			Test for strong exogeneity
DK	2.28	-	4.43**	0.12	1.96	-	4.46	6.18
	(0.13)		(0.03)	[0.93]	(0.37)		(0.11)	(0.11)
DUH3	0.11	0.04	-	-0.086	1.92	23.10***	-	24.80***
	(0.73)	(0.83)		[-1.22]	(0.38)	(0.00)		(0.00)

Note: The Wald test statistics reported are distributed as a chi-square distribution with degrees of freedom the number of restrictions. The p-values are presented in parentheses. In the short-run dynamics, asterisks indicate rejection of the null hypothesis that there is a short-run non-causal relationship between the two variables. The asterisks of the lagged ECTs are distributed as t-statistics and indicate rejection of the null hypothesis that the estimated coefficient is equal to zero (weak exogeneity). The t-statistics are presented in brackets. Finally, in the tests for Granger non-causality and strong exogeneity, asterisks denote rejection of the null hypothesis of Granger non-causality and strong exogeneity respectively. The asterisks indicate the following levels of significance: **5% and ***1%.

Table 7 reports the findings for the endogeneity between the variables of GDP, physical capital investments and primary education. Estimates of the parameters show that the error-correction term is negative and statistically significant for the GDP and physical capital investments equations. The t-test for the error-correction term indicates the significance of the long-run causal effect at the one percent level. Therefore, GDP and investments are not weakly exogenous variables. These results imply that in the long run, there is a unidirectional Granger causality running from primary education to GDP and bidirectional causality between physical capital investments and GDP. Table 8 reports the findings for the endogeneity of GDP, physical capital investments and secondary education. Estimates of the parameters show that the error-correction term is negative and statistically significant for the three equations. The t-test for the error-correction term indicates the significance of the long-run causal effect at the one percent level. Therefore, GDP, investments and secondary education are not weakly exogenous variables. These results imply that in the long run, there is a bidirectional Granger causality running between secondary education, physical capital investments and GDP. Table 9 reports the findings for the endogeneity of GDP, physical capital investments and higher education. Estimates of the parameters show that the error-correction term is negative and statistically significant only for the GDP equation. The t-test for the error-correction term indicates the significance of the long-run causal effect at the one percent level. Therefore, GDP is not a weak exogenous variable. In addition, the t-tests of the error-correction term for the physical capital investments and higher education enrolment rates are not statistically significant. These results imply that the physical capital investments and higher education are weakly exogenous variables. In the long run, there is a unidirectional Granger

causality running from higher education and physical capital investments to GDP. In the short-run dynamics, the Wald tests indicate that there is a unidirectional Granger causality running from higher education enrolment rates to GDP. Finally, the significance levels associated with the Wald tests of joint significance of the sum of the lags of the explanatory variable and the error-correction term provide more information on the impact of physical capital investments and higher education on economic growth and vice versa. Finally, the empirical results reveal that for the GDP and higher education variables we can reject the hypothesis of strong exogeneity supporting the proposition that there is a relationship between physical capital investments, higher education and economic growth in Greece.

Impulse Response Functions

In order to study the dynamic properties of the VAR models, impulse response functions analysis (IRF thereafter) is employed using the Cholesky decomposition. The time period of impulse response functions spreads over ten years, which is a long enough period to capture the dynamic interactions between education and physical capital investments growth rates to economic growth. The IRF derived from the unrestricted VARs are presented in figures 2, 3 and 4.

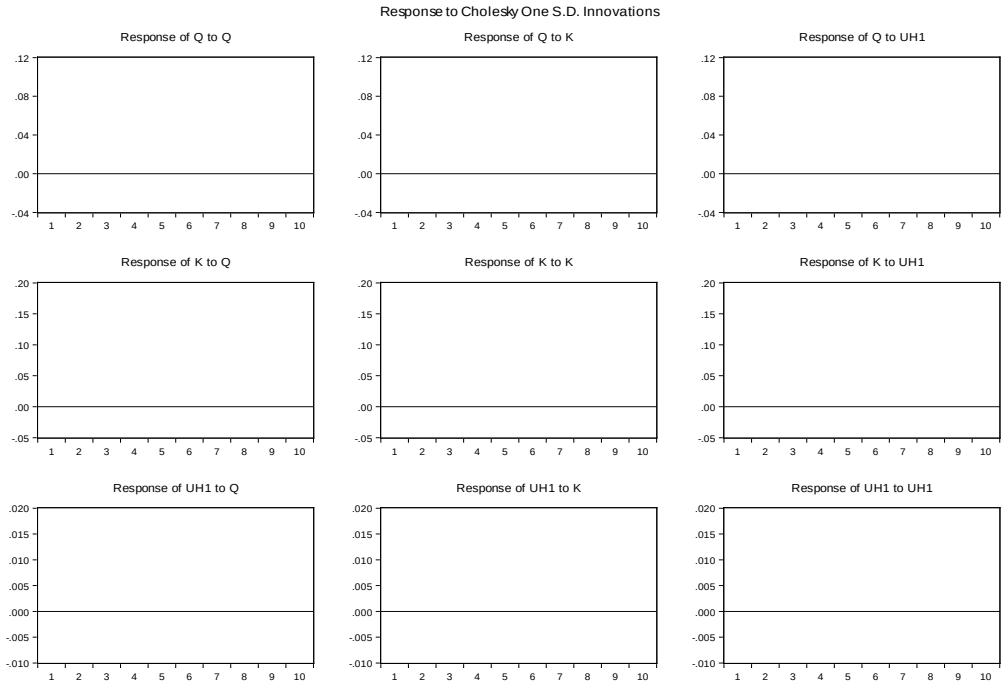

Figure 2: IRF with primary education

The variables of the first VAR order as following: GDP, physical capital investments and primary education (Q, K and UH1).

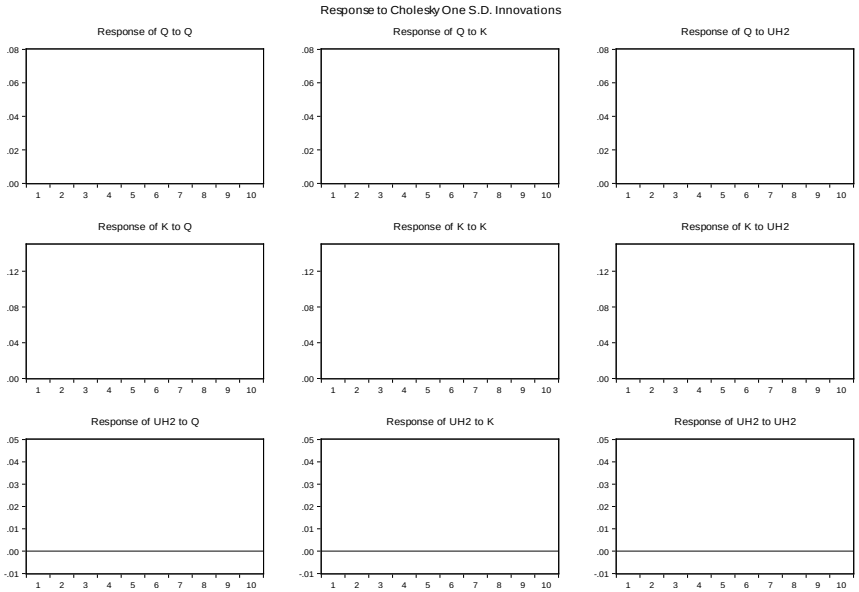

Figure 3: IRF with secondary education

The variables of the second VAR order as following: GDP, physical capital investments and secondary education (Q, K and UH2).

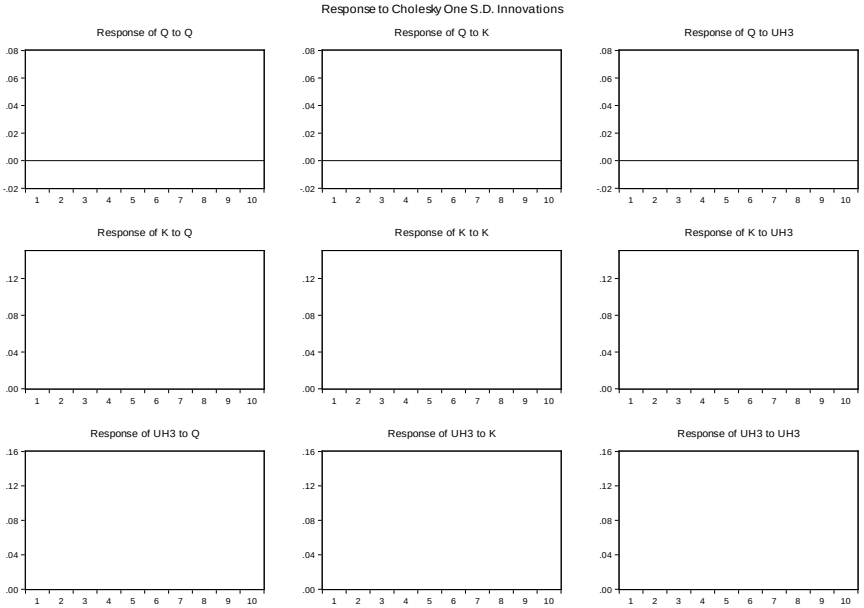

Figure 4: IRF with higher education

The variables of the third VAR order as following: GDP, physical capital investments and higher education (Q, K and UH3).

From the first row of figure 2, it becomes apparent that one standard deviation shock of primary education has a negative impact on economic growth. Similar, a one standard deviation shock to economic growth variable has negative impact on primary education. Figure 3 reports that a one standard deviation shock to secondary education has a positive impact on economic growth. In other words, a one percent increase in secondary education's innovation causes a 0.02 percent increase in economic growth. Similar, a one standard deviation shock to economic growth variable has a positive impact on secondary education after the second year. Figure 4 shows that the response of economic growth from one standard deviation shock in higher education is positive and significantly bigger than secondary education. A one percent increase in the innovation of higher education causes a 0.06 percent increase in economic growth. Similar, higher education response to economic growth innovation is positive. A one standard deviation shock to physical capital investments has a positive impact on economic growth, but the strongest positive impact arises from economic growth to investments in all the figures.

Variance Decomposition Analysis

The variance decomposition (VDC thereafter) is estimated for each variable in the VAR models for a period of ten years. The VDC estimation results are presented in tables 10, 11 and 12.

Table 10: Variance Decomposition for Primary Education

	Variance Decomposition of Q				Variance Decomposition of K				Variance Decomposition of UH1			
Periods	S.E.	Q	K	UH1	S.E.	K	Q	UH1	S.E.	UH1	Q	K
1	0.02	100.00	0.00	0.00	0.11	20.05	79.94	0.00	0.01	97.69	1.79	0.51
2	0.04	98.37	1.37	0.25	0.17	20.60	79.36	0.02	0.02	97.44	2.16	0.38
3	0.06	95.85	3.49	0.64	0.22	21.12	78.80	0.06	0.03	97.14	2.55	0.29
4	0.08	93.21	5.72	1.05	0.26	21.60	78.27	0.12	0.03	96.79	2.98	0.22
5	0.10	90.73	7.81	1.44	0.31	22.04	77.75	0.20	0.04	96.38	3.44	0.17
6	0.12	88.50	9.70	1.78	0.35	22.45	77.26	0.28	0.04	95.92	3.91	0.15
7	0.15	86.54	11.36	2.09	0.39	22.83	76.79	0.37	0.04	95.43	4.41	0.14
8	0.17	84.81	12.82	2.36	0.43	23.18	76.35	0.46	0.05	94.90	4.93	0.16
9	0.20	83.29	14.10	2.60	0.48	23.51	75.92	0.55	0.05	94.33	5.46	0.20
10	0.22	81.95	15.23	2.80	0.52	23.82	75.53	0.64	0.06	93.73	6.01	0.25

The variables of the first VAR order as following: GDP, physical capital investments and primary education (Q, K and UH1).

Table 11: Variance Decomposition for Secondary Education

	Variance Decomposition of Q				Variance Decomposition of K				Variance Decomposition of UH2			
Periods	S.E.	Q	K	UH2	S.E.	K	Q	UH2	S.E.	UH2	Q	K
1	0.02	100.00	0.00	0.00	0.11	21.64	78.35	0.00	0.02	98.30	0.92	0.77
2	0.04	97.91	1.64	0.44	0.16	22.89	77.05	0.04	0.04	97.53	0.44	2.01
3	0.05	94.30	4.49	1.20	0.21	24.08	75.77	0.13	0.05	95.98	0.38	3.62
4	0.07	90.16	7.75	2.07	0.25	25.21	74.52	0.25	0.06	93.85	0.65	5.48
5	0.08	86.04	11.00	2.95	0.29	26.26	73.32	0.40	0.07	91.34	1.17	7.48
6	0.10	82.18	14.04	3.76	0.33	27.26	72.15	0.57	0.08	88.60	1.86	9.52
7	0.11	78.67	16.81	4.50	0.36	28.19	71.04	0.76	0.09	85.75	2.67	11.56
8	0.13	75.53	19.28	5.17	0.40	29.06	69.98	0.95	0.10	82.89	3.56	13.54
9	0.15	72.74	21.49	5.76	0.44	29.87	68.96	1.15	0.11	80.07	4.48	15.44
10	0.17	70.26	23.44	6.28	0.48	30.64	68.00	1.35	0.12	77.33	5.41	17.24

The variables of the second VAR order as following: GDP, physical capital investments and secondary education (Q, K and UH2).

Table 12: Variance Decomposition for Higher Education

	Variance Decomposition of Q				Variance Decomposition of K				Variance Decomposition of UH3			
Periods	S.E.	Q	K	UH3	S.E.	K	Q	UH3	S.E.	UH3	Q	K
1	0.02	100.00	0.00	0.00	0.10	22.03	77.96	0.00	0.05	92.35	7.31	0.33
2	0.04	95.25	0.01	4.73	0.15	14.54	81.94	3.50	0.10	91.19	7.89	0.90
3	0.05	89.48	0.53	9.97	0.19	12.56	80.11	7.32	0.15	89.94	8.74	1.31
4	0.07	84.30	1.34	14.35	0.23	11.61	78.05	10.33	0.19	88.71	9.62	1.65
5	0.09	79.94	2.20	17.84	0.27	11.10	76.20	12.68	0.23	87.52	10.49	1.97
6	0.11	76.35	3.02	20.62	0.31	10.83	74.63	14.52	0.27	86.36	11.35	2.27
7	0.14	73.38	3.77	22.83	0.35	10.68	73.28	16.02	0.31	85.24	12.18	2.56
8	0.16	70.92	4.44	24.63	0.38	10.61	72.12	17.25	0.35	84.17	12.98	2.83
9	0.18	68.84	5.02	26.12	0.42	10.59	71.09	18.30	0.39	83.14	13.75	3.09
10	0.21	67.08	5.54	27.36	0.46	10.59	70.18	19.21	0.42	82.16	14.48	3.34

The variables of the third VAR order as following: GDP, physical capital investments and higher education (Q, K and UH3).

As the years pass primary, secondary and higher education gradually affect more the variation of economic growth. More precisely, 2.80, 6.28 and 27.36 percent of economic growth forecast error variance in a ten years period is explained by disturbances of primary, secondary and higher education, respectively. Higher education innovation explains much more than primary and secondary the variation of economic growth. Overall, this figure is quite substantial, underlying the importance of higher education on economic growth. Also, as the years pass physical capital investments affect the variation of economic growth in all figures. From the first year a substantial part of the forecast error variance of economic growth from 5.54 to 23.44 percent, is affected by the disturbance of the physical capital investments. On the other hand, the variation of

physical capital investments is largely explained by economic growth. The overall results from VDC seem to be in agreement with those of IRF, providing evidence in favour of the importance of secondary and higher education to explain variation in economic growth.

4 DISCUSSION OF THE RESULTS

The results of the econometric analysis show that secondary and higher education have had a positive contribution to economic growth in Greece during the period 1960-2009. These results are consistent with most of the previous studies mentioned above. Specifically, the results are in line with the studies, such as Tallman and Wang (1994) for Taiwan, Lin (2006) for Taiwan, Loening Bhaskara, and Singh (2010) for Guatemala, Abbas (2001) for Pakistan, Shaihani et al. (2011) for Malaysia, Villa (2005) for Italy, Chi (2008) for China, Gyimah, Paddison, and Mitiku (2006) for African countries. In the case of Greece, the results are in line with the studies of Magoula and Prodromidis (1999), Asteriou and Agiomirgianakis (2001), Tsamadias and Prontzas (2012), Pegkas and Tsamadias (2014) and Pegkas (2014). The result that primary education has had a negative impact on economic growth is consistent with less of the previous studies mentioned above. Specifically, the results are in line with the studies, such as Abbas, (2001), Villa, (2005) and Shaihani et al, (2011), Pegkas (2014). As Romer (2001) noted, primary education might not show short run results in the economy, but has indirectly long term effects on it. As primary is the first and basic level of education it is very important for the other two levels of education, which make up the productive sector of the country. In addition, in the case of Greece, possibly due to the fact that primary enrollment rates were already high, during the period under review they had declined in some subperiods. So, for the examined period which the GDP has grown significantly, the primary education had a negative significant effect on economic growth. During the period 1960-2009 Greek economy was transformed from the primary to the tertiary production sector. Furthermore, Greece was transformed from a less developed to a developed country. That may explain the findings of the study that secondary and higher education have had the most significant positive impact on growth in Greece, while primary education had not contributed to growth. This conclusion is supported by the research of Gemmell (1996), Mingat and Tan (1996) and Petrakis and Stamatakis (2002), who concluded that primary education affects more less developed countries, while growth in more developed countries depends mainly on secondary and higher education.

Another main result of the study reveals the rejection of the increasing returns to scale. This finding is consistent with other studies that applied the Lucas model such as: Monteils (2004) in the case of France, Gong, Greiner, and Semmler (2004) in the case of U.S. and Germany, Van Leeuwen (2006) in the cases of India and Japan. So, the endogenous character of the economic growth suggested by Lucas is not verified. As a result the application of this model would be accompanied by similar predictions as the neoclassical growth model introduced by Mankiw, Romer, and Weil (1992). Probably that explains the similarity with the results of the study which has applied the neoclassical growth model for the case of Greece (Pegkas, 2014).

5 CONCLUSIONS

The study empirically investigates the causal relationship between each level of formal education and economic growth. Moreover, it estimates the effect of each level of formal education on economic growth, in Greece during the time period 1960–2009. In order to estimate the contribution of education to economic growth, the paper used the endogenous approach of Lucas (1988) and the enrollment rates as proxy for human capital. The empirical analysis reveals that GDP, the three levels of education and physical capital investments are cointegrated. The elasticity of GDP with respect to primary, secondary and higher education, is -0.96, 0.52 and 0.20 respectively. The results also suggest that there is evidence of unidirectional long-run causality running from primary education to growth, bidirectional long-run causality between secondary and growth, long-run and short-run causality running from higher education to economic growth. These results are supported by the generalized impulse response functions and the generalized variance decomposition analysis. Overall, the conclusion of the study indicates that the quantity of secondary and higher education has had a positive contribution to economic growth. In Greece, the quantity of education has increased during the last five decades (Pegkas and Tsamadias, 2014) whereas the quality of education remains low as many reports indicate (PISA 2012 Results-OECD). In Greece, many important structural reforms in various sectors of the educational system need to be implemented, in order to further improve the quality of human capital. This way the contribution of education to economic growth in Greece will be increased. Future research could focus on the investigation and evaluation of the quality of education, efficiency, effectiveness and productivity of higher education institutions and schools. Another study could investigate synergies among higher education institutions and businesses. We believe that these are crucial factors in

the direction of the country's development in the international competitive and dynamic environment.

Notes

[1] For more details of the model please refer to Bratti and Bucci (2003) and Pegkas (2012).

[2] The results of VECMs are available from the authors upon request.

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EXPLORING PHD STUDENTS' CONCERNS REGARDING DOCTORAL PROGRAMS IN ECONOMICS AND BUSINESS ADMINISTRATION

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Abstract: *Tertiary education involves specific perceived issues among PhD candidates that lead to several self-destructive behaviors regarding the research process and the quality of the doctoral thesis. Studying the emotional mechanisms behind the process of doctoral research offers useful insights for both PhD candidates and PhD supervisors. A qualitative approach involving a concept analysis method was used to investigate the concerns about the doctoral process of a group of PhD candidates enrolled in the first year at the Doctoral School of Economics and Business Administration of Iași, Romania. Both spontaneous and induced responses were considered. The order of concerns and the fact that some of them were mentioned together were also taken into account. Most of the concerns are related to time-management. Results are discussed and several recommendations are made.*

Keywords*: PhD students concerns, economics and business doctoral program, content analysis*

JEL Classification*: A230 Economic Education and Teaching of Economics: Graduate*

1 INTRODUCTION

The starting points of this study are the quality of doctoral research in Romania, the rate of dropout for doctoral studies and the number of requests for extension of the time allocated for doctoral research. Another relevant issue is the large number of changes of the doctoral process in recent years - modification of

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the study period, elimination of distance-learning doctoral studies, changes in funding opportunities, changes regarding the highest number of PhD students allowed per supervisor.

Romanian doctoral students and supervisors perceive the scientific articles published in Romanian journals as inferior to those of other European countries, according to the Research Institute for Quality of Life. Most doctoral researchers and coordinators also consider the doctoral study period in Romania as being too short.

The same Research Institute, in the *Report on the opinions of doctoral coordinators and PhD students in Romania*, provides information about the extent to which doctoral students face difficulties related to conferences participation funding, access to research data, lack of people with whom they can discuss the PhD topic, quality of guidance, difficulties in combining doctoral activity with job responsibilities, personal financial difficulties. PhD students in economics are mostly dealing with conferences participation funding issues and limited access to research data. The same report reveals that 85% of doctoral students in economics were employed when beginning their doctoral studies.

As shown in the quoted report, there are some factors that cause psychological discomfort to Romanian PhD students. Aspects, such as length of the doctoral program, information literacy or administrative issues determine a chain reaction, causing a feeling of inadequacy that ultimately has repercussions over the quality of the thesis and the research process in general. Identifying those difficulties is an important matter for universities in order to be able to offer a higher quality research programs and a comfortable journey throughout the process.

An exploratory research was conducted in order to identify the main concerns of Romanian PhD students in Economics and Business from Iași regarding the doctoral process. A brief literature review is provided in the second section. Third section offers the description of the methodology and the data preparation process. Results are found in the fourth section while the last section provides a summary of the main findings including recommendations, limitations and future research directions.

2 OVERVIEW OF CURRENT RESEARCH

Improving the quality of doctoral programs has been in the attention of educational researchers and administrators for a long period. This section aims to summarize the major findings on the matter of struggles and concerns that doctoral students have to cope with during their doctoral process.

A significant body of literature exists on the topic of doctoral thresholds (Zaiț, 2010) – the main problems that doctoral students confront with along their research program. The main issues previously investigated are doctorateness as a threshold concept (Trafford and Leshem, 2009), challenges of the doctoral journey (McAlpine and Amundsen, 2009), innovation in PhD completion (Kearns, Gardiner and Marshall, 2008), social isolation (Ali and Kohun, 2007), doctoral students' attrition (Ehrenberg, Jakubson, Groen, So and Price, 2007), socialization to academic norms (Weidman and Stein, 2003), (Weidman, Twale and Stein, 2001), (Thorntorn and Nardi, 1975), productive conflict and devil's advocacy (Schultz-Hardt, Jochims and Frey 2002), (Schwenk and Valacich, 1994), (Murrell, Stewart and Engel, 1993), (Priem and Price, 1991), models of marketing doctoral student socialization (Trocchia and Berkowitz, 1999).

A study conducted with the purpose of finding inhibitors and facilitators in a doctoral program revealed that a candidate's success is negatively influenced by financial problems, family problems, administrative and cultural difficulties or isolation (Dinham and Scott, 1999). The same article concluded that most of the candidates did not have role models in the family while pursuing this academic path. When a candidate is the first in the family pursuing doctoral studies, even though relatives can understand the importance of education, they are not truly able to support the candidate through the process. Also, many PhD candidates have a family of their own and a common issue that they have to deal with is managing to maintain a normal family life during the doctorate process (Dinham and Scott, 1999; Rockinson-Szpakiw, Spaulding and Knight, 2015).

The raised concerns about doctoral studies in the '90 led to a study revealing that doctoral candidates do not entirely understand what a doctoral program involves or how to manage to successfully complete it (Golde and Dore, 2001). That problem may result in disorientation, low self-esteem research wise or solitude.

Manathunga (2002) investigated the psychological signs that may lead to failure to complete on time the doctoral program. Several behavioral evidence of a future problem is procrastination, avoiding the supervisor, constantly changing the view on the topic of research or isolation (Trocchia and Berkowitz, 1999; Manathunga, 2002). The same paper underlies three categories of factors which affect doctoral progress – emotional, cognitive and social. Emotional factors include low self-esteem or anxiety towards self-performance. On the same note, emotional and cognitive blocks are crucial factors (Kearns, Gardiner and Marshall, 2008) that inhibit research progress. Researchers developed a psychological skills training program that aimed to help candidates overcome

difficulties that lead to failure to complete the program. The research was based on the Cognitive-behavioral coaching model, a general framework was used for subjects to improve PhD students' performances and achieve their goals. Evaluation of the program shows that students have improved time management skills and were more realistic in their expectations.

A psychological factor that is also often overlooked by the faculty's administration is the issue of socialization among doctoral students. This concept related to professional success was addressed in the study on the importance of peer relationships during the doctoral program (Trocchia and Berkowitz, 1999). Peer relationships and the relationship with the supervisor are playing an important role in achieving an emotional state that leads to overcoming potential isolation problems and successfully complete the doctoral program. Other study (Ali and Kohun, 2007) regarding the link between isolation and attrition of doctoral students has aimed to create a framework for dealing with this issue. The authors created a four-stage social isolation framework. Those stages correspond with the natural phases of a doctoral program, as follows – preadmission, first ,second year and the final period. According to this scheme, doctoral solitude has different causes and different remedies in each stage. There are scholars who state that a low level of socialization among students leads to a high level of stress (Perez and Kutugata, 2013), therefore, a low level of research quality, among other implications. Other scholars (Litalien and Guay, 2015) support the importance of peer and mentor relationships, meaning that the intensions of leaving the program are also influenced by the relationship with the mentor, the administration of the faculty or with other peers. Students strongly rely (Vezoussi, 2009) on other individuals, as mentors or peers in the issue of literature recommendations.

One important barrier in completing a doctoral program is the relationship with the supervisor. The candidate usually has some expectations regarding that relationship which may or may not be fulfilled in the end. Some researchers investigated that issue and developed a scale named Superqual (Hair, 2006), aimed to measure the gaps between expectations and reality in the candidate – supervisor relationship. Such a scale is particularly useful for young supervisors without much experience but it can be modified to be applicable to general expectation about a doctoral program.

Information literacy is another factor that may be a perceived barrier in the process of writing a high-quality thesis. A doctoral candidate has to know where to seek the most relevant information, how to discriminate important findings regarding his area of study and how to use that literature. A paper that aimed to study this issue (Bøyum and Aabø, 2015) has concluded that both Google Scholar

and library databases are widely used, although the literature found in specialized databases is considered more academic, useful and relevant (Vezzosi, 2009; Bøyum and Aabø, 2015). Regular Google appears to be the starting point of searching for simple information (Vezzosi, 2009).

Prior research shows that the candidates in the science-based disciplines are more likely to finish faster the doctoral program (Seagram, Gould and Pyke, 1998; Litalien and Guay, 2015). In economics and business area, studying statistics or accountancy may influence a doctoral thesis written in time. Also, high quality supervision is leading to the same result. A predictive model of doctoral dropout intentions (Litalien and Guay, 2015) was developed. The model is based on Self-Determination Theory which is basically a theory of inner motivation. Briefly, the model states that highly perceived competences are lowering the dropout intentions.

Individual competences in research activities is another issue that candidates encounter. Informative, instrumental and communicative competences (Olehnovicaa, Bolgzdaa and Kravale-Pauliņa, 2015) were analyzed and it has been concluded that as the research experience grows, the informative competences are improving. Overall, instrumental competences are less developed, especially for the first year candidates. Doctoral students' metacognitive profiles are also varying (Cantwell et. al., 2012). These varieties of profiles cause a problematic candidature. Three aspects of that issue are management of affect, management of intellectual demands and management of contingency. All three are considered to be interacting.

The problem of holding down a stable full-time job was also addressed (Dinham and Scott, 1999). In the majority of cases, the candidate needs support for the expenses to complete a doctoral program. The problem of over-education can put into difficulty future PhDs (Gaeta, 2015) as during the tenure they may not be capable to maintain full time jobs. Research education does not prepare them for a future job outside academia and they do not find the gained skills to be useful for a future job.

As it can be observed, there are many issues that doctoral candidates have to face during the doctoral process. This paper aims to explore the concerns of PhD candidates in order to propose several solutions helping the administrative stuff of Doctoral Schools to be able to ensure a higher quality research experience.

3 METHODOLOGY

We conducted an exploratory research (based on unstructured written interview) for collecting the data, followed by a content analysis of the individual

written responses. The aim of this exploratory research is to identify the concerns, fears and anxieties, related to the doctoral process of the first year PhD students in the Doctoral School of Economics and Business Administration of the Alexandru Ioan Cuza University of Iași.

The study involved a sample of 18 PhD students from various areas of study - Marketing, Management, Economics and International Affairs, Finance, Economics, Accounting and Statistics. This study involved a qualitative approach and content analysis of the written responses of the subjects was carried out. PhD students responded to one open question, initially spontaneously, and then assisted:

”Which are your concerns, fears, anxieties, worries about the doctoral process?”

The respondents were encouraged to take their time and identify all their concerns. After doctoral students have written their responses, the operator suggested some general concerns and the respondents were encouraged once again to identify as many personal concerns as possible.

Data preparation

A unique code was assigned to each statement for an easy identification. Each code indicated the subject’s number, the subject’s area of study, the statement order and if the statement was spontaneous or inducted. The statements were reduced to a minimum number of words, in order to be easily processed but still accurately expressed the concern of the respondent. This process was mainly achieved through the elimination of irrelevant information.

The next step was grouping items into categories. There were two coders and each of them assigned independently each item into a category, which were debated afterwards in order to achieve a common set of categories. The coding procedure was an emergent one.

With commonly established categories, the coders repeated the previous step. This step allowed the calculation of the Intercoder Reliability, which was 88,595% agreement between coders (Cohen K coefficient). The sources of the coding differences were identified and then analyzed. There was a number of 12 items perceived differently. After a debate, the coders agreed upon the right categories for 7 items but disagreed upon the classification of 5 items. The reasons of disagreement were either the double meaning of the statement, ambiguous phrases or merely different opinions, resulting in the final Intercoder Reliability of 95,698% agreement.

3 RESULTS

Fifteen categories of concerns resulted from the analysis. They are listed in Table 1, by order of the items' frequencies, from the largest (20 items) to the smallest (1 item).

Table 1: Categories of doctoral concerns by frequencies

Category Name	**Number of items**
Insufficient time for research	20
Poor quality of the thesis	15
Insufficient personal time	13
Difficulties related to research methodology	10
Limited resources for the current job	10
Inability to fulfill the mandatory activities for graduation	10
Limited access to necessary data	9
Limited personal competences	8
Lack of financial resources	7
Lack of support from experts	5
Doctoral School location	3
Difficulties in accessing certain research programs	2
Plagiarism	1
Limited length of the thesis	1
Changing regulations	1

The most frequent concerns are related to time required for research. The majority of subjects believe that time allocated for doctoral research is very short and they do not trust that they will be able to finish it on time. PhD students also have many concerns regarding the added value and usefulness of their thesis. In this case concerns particularly refer to the applicability of the research results, the novelty of the findings and the contribution to the field. Many PhD students stated that they have insufficient time for family and friends in the context of doctoral work. The last three categories each containing one concern may be considered exceptions.

Order of the expressed concerns

Insufficient time for research and poor thesis quality are the first concerns that subjects have expressed. Assuming that the order of expression is influenced by the magnitude or intensity of concerns, we can hypothesize that the most important concerns of the subjects are related to these two issues. The concerns about the future or current job are among the last expressed by the subjects. Therefore, those who expressed concerns about the job have not put this issue first, although it is a factor that they take into consideration. Among the last concerns

expressed are also the ones related to the inability to fulfill the mandatory activities for graduation (e.g. publishing, mandatory classes, conference attendance).

Association between concerns

Two or more concerns were considered to be associated if they were mentioned in the same statement. This provides us the information about the ~~close~~ connection between specific concerns in the respondent`s mind. There is a connection mainly among three categories: insufficient time for research, limited resources for the current job and insufficient personal time. These three categories are ranked 1, 3 and 4 by the number of concerns. Therefore, these three categories account for 43 concerns out of 115 (15 categories).

All three categories refer in some way to the limited time that PhD students have. There are important time management issues signaled not only by the category with the highest number of concerns but also by two other important categories associated with it.

Concerns that doctoral students were initially not aware of

Only 20 statements were written after the operator induced few general concerns. Those worries have existed, but the subjects had not been fully aware of them before these have been suggested.

Students in International Business expressed 5 of 17 concerns the Finance group 4 out of 16 concerns, the accounting group 2 out of 8, the statistics group 3 out of 14 and the management group expressed 5 out of 31 concerns they had not been initially aware of.

The only participants who did not submit their options were the marketing and economics PhD candidates. Overall, most of the concerns expressed after the operator induced general concerns are related to the mandatory activities for graduation, followed by insufficient personal time and limited personal competences.

4 CONCLUSIONS AND DISCUSSIONS

Current issues related to the doctoral research programs in Romania led to this exploratory research which involved 18 doctoral students of the Alexandru Ioan Cuza University of Iaşi and aimed to identify the main concerns related to the doctoral process.

The most frequently expressed concerns by the PhD students by order were: short time for their research, usefulness and overall added value of their thesis, limited personal time. The importance of these issues was confirmed by both frequency and writing order of the concerns.

There are some concerns that PhD students had not been initially aware of, most of them related to the mandatory graduation requirements, insufficient personal time or limited personal competences.

An interesting finding is that three major categories of concerns resulted from the concept analysis referring to time management. PhD students consider that they have insufficient time for research, insufficient personal time and insufficient time for current job. The association of these three categories was visible because the majority of the respondents mentioned this type of issues within the same statement.

It is worth mentioning that the most important concerns have been similar to those identified only for marketing doctoral students, in a previous study for the same doctoral school: time, fear of blockages due to research problems or methodology, mixed and scattered expectations regarding the doctoral research process (Zait, 2010). This means that the concerns have been persistent over time.

Even though this is only an exploratory study, it has some managerial implications. Universities could design workshops and training programs to help PhD students in overcoming difficulties related to the doctoral process. Almost all participants in this study reported time management issues. This data could be useful for the administration of universities and doctoral schools that could organize time management courses. It can be stated that changing the length of the doctoral program from 4 to 3 years has affected PhD students, the time required for the research itself and the insufficient time in general were the main sources of concerns.

These findings could be also used by doctoral advisers and doctoral students. The acknowledgment of the shortcomings associated with specific Romanian doctoral programs could be very helpful in planning and organizing the individual doctoral process.

Limitations and future research

The biggest limitation of this study is the small size and the homogeneity of the sample. Although our qualitative approach did not require a larger sample, the findings cannot be extrapolated. Another limitation could be a possible acquiescence bias that originated from the induced concerns. There is also a bias coming from the coders as content analysis implies a certain amount of subjectivity in the process of coding. Moreover, the distance between the concepts lacks a quantitative measurement and this could be a direction for future research.

A future study could explore the specificity of concerns by field of study. The same study could be replicated for doctoral candidates enrolled in other faculties to verify the convergence of the findings. An extension of the sample and

increasing the number of coders could make it possible to conduct a concept mapping analysis, reducing the coding bias. These findings could be useful for developing a scale based on the identified categories for measuring different types of concerns regarding the doctoral program.

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FROM FEARFUL TO TRUSTFUL – HOW PERCEIVED RISK DIMENSIONS IN E-COMMERCE DIFFERENTIATE BETWEEN CONSUMERS

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Abstract: *The need to segment the market for e-commerce in terms of risk is without doubt of great importance, from a theoretical, but mainly from a managerial point of view. This is why the present study derives a typology of consumers based on six dimensions of perceived risk in online shopping (product, financial, delivery, privacy, social and psychological) and links the resulting risk profiles to several outcome variables. The study is one of the few that offers a new perspective on perceived risk, identifying a two-factor structure: situational risk and individual risk. These two factors were used in a cluster analysis, where four segments were identified: careful consumers, fearful consumers, suspicious consumers and trustful consumers. To offer valuable information for practitioners, these segments are compared in terms of intentions to buy online, online shopping frequency, trust in e-commerce, perceived ease of use, and perceived usefulness of e-commerce.One interesting finding is that suspicious and trustful consumers do not differ in terms of buying intention, even though the difference between them in terms of perceived risk is significant. Implications and further research directions are identified.*

Keywords*: perceived risk, online buying intention, risk profiles, segmentation*
JEL classification*: M3*

1 INTRODUCTION

The interest in perceived risk for marketing dates back to the 1960s, when Bauer (1960) first proposed to analyze consumer behavior as risk taking behavior. Since then, perceived risk has been intensively studied in the marketing literature

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to explain adoption behavior, particularly relating to new technologies such as e-commerce (Featherman&Pavlou, 2003; Li & Huang, 2009; Crespo et al, 2009). Surprisingly, however, little is known about different consumer risk profiles in online shopping and how such profiles can be used for segmentation and targeting purposes. Conchar et al. (2004) specifically suggest that market segmentation efforts should take into account risk characteristics because these can help firms create differentiated strategies to address the needs of specific consumer segments. While, prior research has proposed consumer typologies based on perceived risk dimensions in e-commerce, itdid not link the resulting consumer profiles to outcome variables (Xirong& Yang, 2010); moreover, such typologies were derived based on specific product categoriessuch as electronics or clothing (e.g. Bhatnagar&Ghose, 2004; Zheng et al., 2012). Against this background, the present study (a) develops an empirical typology of consumers based on their perceptions of different kinds of risk associated with e-commerce in general and (b) links this typology to several outcome variables relating to online shopping behavior.

2 CONCEPTUAL BACKGROUND

Cunningham (1967) conceptualized perceived risk in terms of two components: (1) the amount that would be lost if the consequences of an act are not favorable, and (2) the individual's subjective feeling of certainty that the consequences will be unfavorable. Risk is typically approached in the marketing literature as a multi-dimensional construct composed of six dimensions: financial, product, physical, psychological risk, social and time risk (Jacoby & Kaplan, 1972). Financial risk refers to the likelihood of suffering a financial loss due to hidden costs, maintenance costs or lack of warranty in case of faults (Jacoby & Kaplan, 1972). In the context of online shopping, financial risk denotes the possibility of loosing money when paying online (Featherman & Pavlou, 2003; Pires et al., 2004). Product risk refers to the chances of the item failing to meet the performance requirements originally expected of the purchase (Jacoby & Kaplan, 1972). In e-commerce, product risk refers to the fact that the product cannot be touched, tested prior to purchase(Pires et al., 2004; Forsythe et al., 2006). Physical risk measures the probability of the purchase resulting in physical harm or injury (Jacoby & Kaplan, 1972); however, this type of risk is not a real issue in e-commerce as it cannot harm one's health (Cases, 2002). Psychological risk denotes the chances of the specific purchase being inconsistent with the self-image of the consumer (Jacoby & Kaplan, 1972). Social risk gives the likelihood of the purchase resulting in others thinking of the consumer less favourably (external psychological risk) (Jacoby & Kaplan, 1972). Time risk is perceived when some products fail and

consumers waste time, convenience, and effort getting it adjusted, repaired, or replaced (Roselius, 1971). In the case of e-commerce time risk also relates to delivery problems (Pires et al., 2004). A further dimension specific to e-commerce is privacy risk, which refers to personal data that can be hacked and used without the consumer's approval (Featherman&Pavlou, 2003).

Bhatnagar and Ghose (2004) used product risk and security risk to classify consumers who buy electronics online and identified three clusters: high security risk/high product risk; moderate product risk/low security risk and low product risk/moderate security risk. Xirong and Yang (2010) used five dimensions of perceived risk: performance, economic, time, social and psychological and identified five segments: fashionable consumers, individualistic consumers, henchmen, busy-men and money-grubbers. Zheng et al. (2012) analyzed a Chinese consumer sample for the case of shopping online for clothing and also identified five consumer groups: experience risk-taking, self-dependents, personal risk averseness e-shoppers, security sensitive neophytes, and pleasure seeking mature e-shoppers. The five segments were subsequently characterized in terms of risk reducing strategies. Zheng et al. (2012) used ten risk dimensions (product, physical, financial, delivery, privacy, payment, time, source, social, psychological) which resulted in a two-factor model capturing personal (social, psychological and time risk) and non-personal risk. Since the above mentioned studies used specific products to assess perceived risk in e-commerce, the resulting segments are inevitably also product-specific. Moreover, potential differences among distinct risk profiles in terms of outcome variables were not explicitly analyzed.

In this study, perceived risk is conceptualized as the risk of using the Internet as a shopping channel in general rather than with respect to specific products or brands. Moreover, the study examines how different consumer segments differ in terms of several outcome variables, notably trust in e-commerce, online shopping frequency, perceived ease of use, perceived usefulness and intention to buy online.

3 METHODOLOGY

The current study took place in Romania, an emerging market; given that most of the scales measuring perceived risk in e-commerce have been developed in high-income countries (Forsythe et al., 2006; Pires et al., 2004), in-depth interviews were conducted to test the scale items and generate additional ones. This resulted in a pool of 12 new items for perceived risk which were added to 17 items taken from previous studies (Featherman&Pavlou, 2003; Forsythe et al, 2006; Pireset al, 2004). We used established scales for all other constructs: trust,

perceived ease of use, perceived usefulness, intention to buy online (Pavlou, 2003; Featherman&Pavlou, 2003; Crespo et al. 2009; Hernandez et al, 2010).

Two samples of students were used; the first sample (123 students) to purify the measures and the second (426 students) to develop the typology. The choice of students as respondents was supported by the fact that 37% of Romanian online shoppers are between 18-24 years old[1].A questionnaire was used for data collection purposes containing the clustering variables (six dimensions of perceived risk) and the outcome variables (online shopping frequency, trust in e-commerce, perceived ease of use, perceived usefulness and future intention to buy online).

The scales were purified using the first sample, whereby items were dropped on the basis of low reliabilities, insignificant loadings or low squared multiple correlations as revealed by confirmatory factor analysis. Items were not dropped solely on statistical reasons. Content analysis was also used to see if items with poor content validity – calculated as the content validity ratio (Lawshe, 1975), were the same items with poor psychometric properties as yielded by confirmatory factor analysis.The purified scales were subsequently replicated on the second sample and offered satisfactory results in terms of psychometric properties (Table1).

Table 1 – Psychometric properties of scales

Construct	**No. items**	**Cronbach's alpha**	**Composite reliability**	**AVE**
Product risk	5	0.801	0.800	0.671
Financial risk	4	0.747	0.760	0.676
Delivery risk	2	0.766	0.606	0.661
Privacy risk	3	0.683	0.690	0.653
Psychological risk	2	0.701	0.716	0.748
Social risk	2	0.773	0.775	0.796
Perceived usefulness	4	0.802	0.806	0.718
Perceived ease of use	4	0.775	0.798	0.712
Trust in e-commerce	3	0.660	0.666	0.632
Intention to buy online	4	0.936	0.937	0.888

4 RESULTS

To obtain a typology of consumers based on the six perceived risk dimensions, we employed cluster analysis, prior to which a principal components analysis (with oblique rotation) was conducted. This produced a two-factor solution explaining 68.9% of variance, with product risk, financial risk, privacy

[1]GFK report 2011 - http://www.gfk-ro.com/public_relations/press/multiple_pg/009110/index.en.html

risk and delivery risk loading on one factor (situational risk - 49.9%) and social and psychological risk loading on the other factor (individual risk - 18.9%). Subsequently, the resulting factor scores were used as input into a two-step clustering procedure. The first step involved hierarchical cluster analysis and revealed that the sample can be classified into four groups. In a second step, group-centroids were calculated and used as input for a k-means cluster analysis to develop the final cluster solution. The obtained solution was then tested for robustness. Following Sharma (1996), the sample was split into two halves. Hierarchical cluster analysis was done on the first half and a four cluster solution was obtained. Cluster centroids were computed for the six risk dimensions andwere used to perform k-means clustering on the second sample. A second k-means procedure was done on the second sample this time without using the centroids from the hierarchical clustering. Agreement between the assignment of centroids and the separate analysis was of 0.977 (kappa) which indicates a highly robust cluster solution (Table 2).

The four clusters are briefly described below:

- *Careful consumers* (25.6% of respondents) are those who have a moderate level of situational risk and individual risk. While social risk is at a low level, it is the highest of all clusters.
- *Fearful consumers* (17.3% of respondents) have the highest situational risk and moderate level of individual risk; however, social risk has a much lower value compared to psychological risk.
- *Suspicious consumers* (28.2% of respondents) have a moderate level of situational risk and a low level of individual risk. While there seems to be no personal barrier for them to use e-commerce (both psychological and social risk are very low), they assess potential losses in specific situations of online buying.
- *Trustful consumers* (28.7%) are consumers characterized by low levels of both situational and individual risk.

To check the internal validity of the cluster solution, we followed recommendations from Maute and Dube (1999) and performed a multivariate analysis of variance (MANOVA) on the original 18 items representing the scales of risk dimensions. Results yielded a significant result (Hotelling'sT^2=5.063, F37.38, p=0.000) indicating that the clusters differ in terms of perceived risk dimensions in e-commerce.

Table 2 – Consumers segments

Risk dimensions	**Careful consumers**	**Fearful consumers**	**Suspicious consumers**	**Trustful consumers**
	N=108	**N=73**	**N=119**	**N=121**
Financial	4.23	5.47	4.32	2.97
Product	4.90	5.78	4.59	3.17
Delivery	4.83	6.01	5.23	3.59
Privacy	4.32	5.68	4.70	3.28
Psychological	4.35	4.18	1.97	2.08
Social	2.00	1.54	1.28	1.37

were *items measured on a 7-point Likert scale.

External validity of the cluster solution was tested by comparing clusters on a variable not used in the cluster analysis (Singh, 1990). Trust, conceptualized as general belief that online shopping can be trusted (Pavlou, 2003) was introduced in a one-way ANOVA analysis using cluster membership as factor variable. Results showed that the clusters differ significantly in terms of trust in e-commerce (F=64.284, p=0.000). Moreover, the ANOVA confirmed the expected description of clusters; specifically, the fearful consumers showed the lowest level of trust, whereas the trustful ones had the highest level of trust (Table 3).

Table 3 – Trust in e-commerce

Variable	**Segments**			
	Careful	**Fearful**	**Suspicious**	**Trustful**
Trust in e-commerce - mean	4.0449	3.7753	4.7815	5.1884

The four clusters were further profiled on gender, online shopping frequency, perceived ease of use of online shopping, and perceived usefulness of online shopping.

To see if the clusters differ in regards to gender, we first weighted the cases and afterwards used the Chi-square test, which revealed significant differences (χ^2=30.805, df=3, p=0.000). The trustful segment is formed by 68.5% men, whereas the suspicious segment has more women – 62.3% as well as the careful one – 59.6%. The fearful segment is more balanced (45.7% men, 54.3% women). These results are consistent with previous studies that show that women are more risk-averse than men both in general (Finucaneet al, 2000) and with specific reference to online shopping (Gabarino&Strahilevitz, 2004).

Regarding online shopping frequency(Table 4), the careful and the fearful segments have the largest percentage of consumers who have not bought online in the last six months, while the suspicious and trustful consumers have the lowest percentage. The suspicious consumers make an interesting case: 20.2% of them

bought more than four times online in the last six months as opposed to only 13.2% of trustful consumers. Thus, suspicious consumers perceive higher situation risk than trustful ones, yet they seem to buy more often online.

Table4 – Online shopping frequency

Online shopping frequency	Careful	Fearful	Suspicious	Trustful
Never	57.4%	56.2%	22.7%	19.8%
Once	23.1%	20.5%	24.4%	28.9%
Twice	8.3%	13.7%	18.5%	24.0%
3-4 times	7.4%	5.5%	14.3%	14.0%
More than 4 times	3.7%	4.1%	20.2%	13.2%
Total	100.0%	100.0%	100.0%	100.0%

The segments also differ significantly in terms of perceived ease of use and perceived usefulness of online shopping (Table 5). The suspicious and trustful consumers perceive a higher usefulness and ease of use of online shopping; this is consistent with their greater online shopping frequency (see Table 4).The careful and fearful consumers both have moderate levels of perceived usefulness and ease of use; however, they score significantly lower than suspicious and trustful consumers.

Table5 – One-way ANOVA results

Variables	Segments				One-way ANOVA
	Careful	Fearful	Suspicious	Trustful	
Perceived usefulness - mean	4.5785	4.6552	5.5314	5.6931	F= 40.722, p=0.000
Perceived ease of use - mean	5.0024	5.2766	5.9801	5.9960	F= 41.596, p=0.000

Results showed that the segments differ significantly in terms of future intention to buy online (Table 6). However, suspicious and trustful consumers, who have the highest intention to buy online, do not differ (p=0.986). Careful consumers have the lowest intention to buy and are significantly different from fearful consumers (p=0.044).

Table 6 – Intention to buy online

Variables	Segments				One-way ANOVA
	Careful	Fearful	Suspicious	Trustful	
Intention to buy online - mean	3.9211	4.4250	5.8085	5.7519	F= 61.044, p=0.000

5 DISCUSSION, IMPLICATIONS AND FURTHER RESEARCH

The aim of this study was to determine homogenous groups of consumers based on the six dimensions of perceived risk in e-commerce. Data analysis suggested that risk dimensions could be separated in two factors: a situational risk factor and an individual one. Based on these two factors cluster analysis was applied and four consumer segments were identified: careful consumers, fearful consumers, suspicious consumers and trustful consumers. The careful type is represented by consumers who feel a moderate level of risk for all dimensions, except social risk, which actually is very low for all four segments. Careful consumers have small experience with online shopping and exhibit moderate level of trust in e-commerce. Although they find e-commerce to be useful and easy to use, they have to lowest intention to buy online. The next segment has high perceived risk for all situational risk types, moderate psychological risk and low social risk. The fearful segment is also represented by people with low shopping experience and has the lowest level of trust in e-commerce. They perceive usefulness and ease of use in a similar way to careful consumers, yet they have a higher intention to buy. One explanation could be the fact that fearful consumers feel less psychological risk that careful consumers. Suspicious consumers have moderate situational risk and low individual risk. They are experienced consumers with a high level of trust in e-commerce. They perceive e-commerce to be very useful and easy to use and exhibit a high intention to buy online. The trustful consumers have the lowest levels of risk for all dimensions. They are experienced consumers with the highest level of trust in e-commerce. This segment, however, does not differ from the suspicious one in terms of perceived usefulness, perceived ease of use and buying intention.

Profiling the segments on different variables helps marketers in creating strategies that better address each consumer type. In this case, the purpose was to obtain groups of consumers that differ in relation with perceived risk dimensions. Even if the analysis yielded a four cluster solution, further testing showed that two of the segments – suspicious and trustful – which differ in terms of risk, do not differ as far as behavioral and outcome variables are concerned. This could be explained by the fact that in some cases perceived benefits may account for more than perceived risk in influencing online shopping behavior. Forsythe et al. (2006) found that perceived benefits make the difference for how often consumers purchase online. These findings show that it is not sufficient to identify which risks are more salient for which consumers, but it is as important to relate risk profiles to behavior as well.

Results obtained in this study are in line with Zheng et al (2012) that also found a two-factor structure for perceived risk which was subsequently employed to perform cluster analysis. However, they used ten dimensions for perceived risk and they analyzed the case of clothing. This might show that the two-factor model is consistent across different buying situations. Three of the segments identified in our study (worried, suspicious and trustful) were consistent with results from Zheng et al. (2012).

As far as limitations are concerned, it is essential to mention that cluster analysis does not assume inference to the population. Results are mainly sample-dependent and it is possible that using a sample from the same population the solution could be different. We also recognize that the use of students may be a limit as they are known to have high technical skills and to be among early adopters of technology. However, students represent a large segment of the market. Furthermore, perceived risk is a situational construct. In this study we aimed to address a general perception of consumers towards online shopping; however, decision to buy online can depend on several other factors such as product, brand or price. Perceived risk is also a dynamic construct expected to change along with the gained online shopping experience. This issue could be addressed by further research. Moreover, each dimension of perceived risk could be longitudinally studied. Further research should also attempt to replicate this study on a different consumer sample and link risk profiles to other outcome or behavioral variables.

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ANALYZING THE IMPACT OF FIRM'S EMBEDDEDNESS IN A CENTRALIZED SUPPLY NETWORK STRUCTURE ON RELATIONAL CAPITAL OUTCOMES

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Abstract: *This research looks at the different effects of firms' network structural positions in an upstream supply network upon the firms' level of relational capital outcomes. Previous research largely focused on the context of decentralized network structure. However, the supply network is a centralized network because of the existence of the focal firm. The existence of the focal firm may influence the impact of relational capital outcomes. Hence, the objective of this research is to determine the type of network structural positions required to obtain a reasonable relational capital outcome in upstream supply network. This study found that network structural positions, i.e. degree centrality contributed to firms' level of relational capital trust. Hence, a firm embedded in upstream supply network benefits differently in terms of relational capital through different degree of embeddedness. The firm resources should be re-aligned to match the benefits of the different network structural positions.*

Keywords: *Supply Chain Management, Network Studies, Inter-Organizational Relations*
JEL Classification:

1 INTRODUCTION

The last decades have seen an increase in managerial concern regarding the complexity of the supply chain, more specifically the upstream supply network. The upstream supply network refers to the firms that reside in the upstream flow of the supply network. The upstream supply network has become more complex due

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to the increased interactions and interrelations among the suppliers' firms as well as the number of the firms. These firms which are the suppliers of materials and services to the focal firms are connected or deal with each other directly or indirectly through the supply of materials to the focal firms or manufacturer.

The traditional reductionist arguments state that supply chain firms opted for the removal from the complex upstream supply chain of partners who are not meeting the performance requirements of the supply chain in an attempt to manage the complexity arising from extensive inter-firm relationships (Choi and Kim, 2008). These strategies may prove to be effective in the short term, but may negatively impact the focal firms in the long run. These negative effects may emerge as firms' involvement in a network of inter-firm relation, creates an important element of intangible capital, which is the relational social capital. This involvement among the firms in the upstream supply network is essentially the firm embeddedness in the upstream supply network structure. However, recent arguments suggest that simply removing these underperforming firms may not be the best way, as firms may remove partners who are resourceful or more influential, but these characteristics are not visible through good accounting measures. Cockburn and Henderson (1998) in addition to Putnam (1993; 2000) posited the approaches that value and appreciate these complex inter-firm relations may be better alternatives. This is because, firms have been found to benefit through embeddedness with other firms in a network structure.

Network embeddedness constitutes an important element that Putnam (1992) identifies as being the relational capital (Cousins et al. 2001). Cousins et al. (2006) stated that relational capital was the configuration of relationships within the network structure, as well as with the broader network structure of the firm. It has been documented that the level of embeddedness increases relational capital such as trust and motivation from the interactions (Cousins et al., 2006). More specifically, organizational researchers have confirmed that organizational involvement in a decentralized network structure impacts on organizational relational capital outcomes such as the level of trust (Gulati and Gargiulo, 1999; Podolny and Page, 1998). Thus, a firm's embeddedness in the network structure may produce relational capital such as trust that may then have the potential to generate other benefits such as reduced costs and greater flexibility (Reagans, Zuckerman and McEvily, 2004). Nevertheless, in the decentralized and horizontal communication structure of networks causes opportunistic acts to become an imminent threat. Opportunism may emerge when parties in the network relationship have issues of goal incongruence. In addition, connectivity may have its costs too, as a firm may lose some control of its operations and administrations.

Naturally, in a supply network context, to guard against the instability of the network structure and threat of opportunism, while at the same time acquiring high levels of integration among firms in the supply network structure, stakeholders in the network structure often introduce a focal or central firm to administer and manage the activities in the network structure (Huang, 2007). This is the case that that the study is investigating.

The upstream supply network is essentially a centralized network structure. It is a centralized structure through the existence of the focal firm that monitors and administers transactions in the upstream supply chain for the production of the finished goods and services. This centralized coordination often involves a focal firm or manufacturer, typically operating in the center of the transformation process (Choi and Krause, 2006). Since relational capital outcomes emerge through interactions in a free flow, decentralized, network structure application (Gulati and Gargiulo, 1999; Podolny and Page, 1998) of the integrated network to the issues of centralized upstream supply network complexity may require deeper understanding of the impact of the centralized network structure. This study raised this concern following the argument of Putnam (1992) which posited that relational capital emerged largely in a decentralized network structure. This is because; a centralized coordination such as the focal firm in the upstream supply network may introduce effects unknown, or remove potential benefits to the firms in the upstream supply network. For example, since the central coordinator (i.e. the focal firm), is often the most powerful firm in the supply base having arms-length control that monitors actions of the network member, it is also a profit-driven entity with the most investment in the supply network. Occasionally albeit unintended, a Machiavellian portrayal may affect the level of relational capital among the firms in the centralized network structure. In addition, the centralized nature of network governance has been found to reduce the horizontal connection which is prominent for the creation of relational capital in a network structure (Poppo and Zenger, 2002). Since these horizontal connections are significant for generating the relational capital mentioned by Putnam (1992), a key question would be: will firm involvement or embeddedness in the centralized upstream supply network produce the same relational capital outcomes?

2 LITERATURE REVIEW

"…*firms are no longer structured like a medieval kingdom, walled off and protected from hostile outside forces...but....involved in an intricate lattice work of collaborative ventures with other firms, most of whom are ostensibly competitors"* (Powell, 2003, p. 113)

Powell's statement described the overall transition of organization form over the years as follows: The adoption of network firms in the upstream supply network structure relates to the assertion of network forms of organization in an inter-organizational or inter-firm relationship as conducted by an organizational study researcher. Integrated network refers to the notable structure of the inter-firm relationship. Globalization has made the study of inter-firm relations increasingly important, as the resources needed to undertake the task of organizational management have grown in scale. Hence, this limits the potential of independent action by any single organization (Kauffman, 1993). A holistic understanding of the inter-firm relationship would catapult organizations into providing better service as well as cost reduction (Faems, Van Looy and Debackere, 2005; Krauss, Mueller and Luke, 2004; Lawson et al., 2009; Stuart, Hoang and Hybels, 1999). This situation arises because a network, argued Powell (1990), facilitates the exchange of efficient and reliable information. This is due to the relational capital developed through the firms' level of embeddedness in the network structure.

2.1 Embeddedness

Granovetter (1985) advanced the concept of embeddedness as an effort by which to explain economic behaviour of an organization. According to Granovetter (1985), embeddedness refers to the level of involvement of a firm in the network of inter-relations. A firm's levels of involvement have an impact upon its actions or behaviour in the network. Granovetter (1985) posited that transactions between actors in a network are embedded in a social context economic decisions and outcomes are affected not only by the actor's isolated relations with other individuals or firms in the network but also by the structure of the overall network of relations within which the actor resides. Economic behaviors are embedded in the network of relations that provide the context for economic processes (Granovetter, 1985). As every behaviour materializes through some form of outcome, almost all economic processes are presumed to be embedded in the networks of relations.

Thus organizational performance is influenced by the pattern of embeddeness of the organization in the network. Since in the upstream supply network, firm embeddedness relates to the degree of the interaction that a firm may has with other firms in the network which are a direct reflection of the firm degree of inter connectivity with others in a network. Hence, one may conclude that organization performance in the supply network may also be influenced by the organization embeddedness pattern such as its centrality and connection (Scott, 1998) with other organizations in the supply network (Mueller, 2000).

Structurally, supply network is virtually formed by the connectivity or links between firms where the integration progressively forms the ultimate structure, which is the supply network itself. The relationship is also known in the literature as the buyer-supplier relationship (Beamon, 1999). According to Choi and Kim (2010), a buyer–supplier relationship represents a dyad, or two nodes and one link, in network terms. Each node can be conceptualized as an actor performing activities for generating value Choi (2008). The firms need resources from its supplier organization, and the supplier needs contracts and payments from the buyer. On top of that the firms also interact with each other to share information regarding market opportunities and new threats (Choi, 2008). As a consequence, these phenomena create a link and form a dyad or a buyer–supplier relationship. Because a firm in the supply network often has links to other firms, the firm is then impliedly linked to the new indirectly connected organizations. Similarly, with the supplier organization, this will also bring to the dyad their links with other organizations either directly or indirectly (Lamming et al., 2000). Conclusively, a buyer–supplier relationship is not only a dyad. It is also part of a network that has come to bear on individual nodes to the relationship through each other's extended business relationships. This form of inter-firm relations or connectivity created the complexity in the supply network structure.

Research applying the embeddednes theory lens to supply chain relationship is beginning to appear since the last decade. Recent studies have emphasized the impact of embeddedness in driving improve supply chain performance. For instance, the embeddedness in social interaction between firms in the supply network were found to be an important factor in solving problems and reducing total costs (Stuart, 1997). Choi and Kim (2001) present the initial platform for operations and supply chain management researchers to adopt the embeddedness concept into the supply of supply input in the supply network. Using the Social Network approach, the authors present the embeddedness concept from the perspective of the supply chain. The authors posit the importance of framing organizations in the supply network (i.e. suppliers) as being embedded in a larger supply network than in isolation. Such framing provides organizations in the supply network with better basis in developing policies and long-term strategies. The authors went on to posit that the embeddedness of organizations in the supply network influence its performance, a statement in tandem with previous network research findings that found the configuration of network of relations can facilitate or impede an organization's behaviors and performance (Granovetter, 1985; Burt, 1992; Nohria, 1992). Krause, Handfield and Tyler (2007) also documented that embeddedness in the supply network of information sharing is an important means

for transferring appropriate practice. The findings on embeddedness and relational capital are not particularly new. Nevertheless, the theoretical elements' underlying firm's embeddedness and relational capital in the supply network have little theoretical underpinnings. A more systematic study into the extent to which embeddedness of the different inter-firms relationships network contributes to the creation of relational capital is warranted.

Although there has been increase number of research regarding firm's embeddedness in network, the literature is silent about the relationship between organizational embeddedness and organizational social capital in a centrally governed supply network that is a network governs by a strong focal organization which enforces and monitors the supply and demand of materials by other sub organizations in the network. Network scholars have found a strong relationship between organizational embeddednes in network structure and organizational social capital in a decentralized network form of organization (Wasserman and Galaskiewicz, 1994, Ter Wal and Boschma, 2009, Chang, 2003a, McEvily and Zaheer, 1999, Ahuja, 2000, Anderson et al., 1994, Provan et al., 2007, Galaskiewicz and Marsden, 1978, Johnson and Mareva, 2002, Haibin, 2004, Breschi and Lissoni, 2005, Hite et al., 2005).

In this study, although undoubtedly the organizational social capital emerged in network forms of organizations, we argue that the presence of a central actor of or dominant power such as the focal organization in a supply network, may change the pattern of inter connectivity and ties among organizations in the network hence influencing the organizational social performance. At the minimum, the flow of information has to go through the central actors before it can be disseminated to other actors in the network. Furthermore, the formal power of the central organization may add new perspectives to the informal, social control mechanism operating in the network.

2.2 Relational capital outcomes and supply network structure

Trust increases connectivity among the organizations in the network. For example, Uzzi (1997) shows how firms have embedded ties with each other in addition to the arms' length relationship. Uzzi (1997) refers to the arms' length relationship as an opportunistic relationship; while embedded ties induce cooperation, and coordination among network organizations. The author further emphasized three features of embedded ties, which include: fine grained information exchange, joint problem-solving and trust (Uzzi, 1997). The findings of Powell (2003) and Uzzi (1997) all point to the competitive advantage for organizations in a network form of relationships.

Trust also plays an important role in franchising for outlets of a retail chain. Ou, Abratt and Dion (2006) conducted a survey among 356 grocery store shoppers to study the effects of individual retailer reputation on their store choice patterns. Using the Structural Equation Modeling (SEM) approach, the authors found that retailer reputation affects purchase frequency, travel time and expenditure levels. Podolny (1993) added that visible network ties to a highly reputable firm are a sign of quality. Consequently, bestows status upon an organization.

The author found that reference to trust through ties to other prominent actors in the network allows for the provision of higher products and service's prices. Trust capital is posited to contribute to reduced costs, ease of recruitment as well as increased employee loyalty (Carmeli and Tishler, 2005; Fombrun, 2008; Helm and Salminen, 2010; Luoma-aho, 2007).

Goins and Gruca (2008), Yu and Lester (2008) applied social network analysis to give a theoretical perspective to elucidate how the spill overs effects can take place in a network structure. Based on a study that adopted industry as a network, the authors investigated how both proximity and structural equivalence impact upon spill over effects on firms in the network. The authors (using social network analysis terminology) noted that actors in a network who interact frequently with each other in a network have a tendency to occupy similar network positions and types of network ties between these organizations. These conditions, according to Goins and Gruca (2008), increase the likelihood of the actors to resemble one another and share common perceptions of reputation from stakeholders. Thus, interdependence in the network would depend on the organizational network position.

In social network analysis, network positions with other organizations with high network centrality not only provide peripheral organizations with access to capital, these ties also provide other organizations with relational capital spill-over benefits. For example, network centrality refers to an organization's position in the network relative to others (Scott, 1988). As one of the most important properties of network structure, network centrality evaluates an actor's status, prominence and power (Knoke and Kuklinski, 1982). Knoke and Kuklinski (1982) further stated that actors who are the most important or prominent in the network are usually located in the most central positions within the network. Being central means the actors or organizations are connected to almost all other actors in the network. The connections can be in the form of informal ties, such as information-sharing and referrals, as well as formal ties, which include contractual relationships. Exchange of resources occurs between actors who are tied together either formally or informally.

Thus, extensive contacts or associations with the central organizations in the network increase the availability of information and inflate the reputational spill over benefits (Luoma-aho, 2007). Hence, the embeddedness in the exchange network not only begets tangible returns, it also warrants the accumulation of other intangible ones such as the relational capital outcomes.

It is instructive to know that, scholars have argued that as organizational performance information is difficult to obtain, relational capital becomes an important element for the survival of the organizations (Ferris et al., 1998; Kramer, 1999). Relational capital is generated in the network of inter-firm relations. This argument can be promptly adapted to the upstream supply network. Because of the difficulties involved in analyzing the profiles or intentions of firms in the network, relational capital items such as trust is often applied by the stakeholders in order to make resource allocation/partnership decisions (Poppo and Zenger, 2002). One implication of this dependency on relational capital is that a firm's high level of involvement may result in increased relational capital outcomes upon it.

However, despite the various impacts of embeddedness found in the literature, many of these inter-organizational network outcomes studies have been focusing on the decentralized network structure. Little to no research has paid attention to firms' embeddedness in centralized networks with focal firms, such as in the upstream supply network. In the upstream supply network,. Choi and Krauuse (2008) argued that an upstream supply network is likely to be a centralized network structure. What affects firms' embeddedness in such a centralized network structure has upon network relational capital outcome as per a decentralized network structure is not certain. One important element that may result in diverse relational capital effects is the nature of the network governance between a decentralized network and a centralized network structure.

Even though an integrated network of services and flows may be the best solution to the problem of complexity driven by inter-firm relationships in the upstream supply network, the question remains, will the effects of a firm's embeddedness on reputation, trust and influence to be similar when firms are embedded in a centralized network such as the upstream supply network? This question is valid because the existence of a powerful focal firm in the upstream supply network may introduce an unknown impact on relational capital outcomes in the context of the upstream supply network structure. This is because the introduction of the focal firm may alter the overall network positions of the network members. Thus, the first main research question for this research seeks to investigate the relationship between firms' embeddedness in the centralized upstream supply network and firms' relational capital outcomes and reads:

Is the embeddedness of firms in the centralized upstream supply network related to the firms' relational capital outcomes?

2.3 Research hypothesis

Extensive interactions generate trust among firms. For example, Uzzi (1997) found that, in order to obtain information regarding a potential partner before collaboration activities can be carried out; firms resort to trusted firms for information. The trust between the firms, argued (Uzzi (1997) is the result of multiple exchanges in the past. In the same vein, Gulati (1995) highlighted that years of inter-firm relationships generate trust among them. In addition to that, Gulati and Gargiulo (1999) found that negative gossip by third parties about another party's uncooperative behaviour significantly reduces the likelihood of direct relations; whereas positive gossip strengthens the likelihood of direct relations among firms in the network. What this literature shows is that, in a network relationship, a firm will sometimes refer to its partner's previous experience and information with potential partners before agreeing to short-term or long-term business commitments. Extensive interactions are a catalyst for trust in networks of inter-firm relations. Similarly, Eccles (1981) found that extensive interactions among a network of homebuilder firms also create trust among network members. The authors found that exchanges of information among the contractors regarding materials prices create stronger inter-firm relationships and thereby facilitate the creation of trust.

Trust also materializes in the long run through the contract relations among firms. For example, Brown and Troutt (2004) found that trust emerged through extensive contracts and social relations between government organizations and non-profit organizations. McEvily, Perrone and Zaheer (2003) found that an important structural condition in a network of inter-firm relationship is trust. A firm that loses the trust of its network members may see that some of its ties are removed and the firm itself is pushed into the periphery from the core network position. Consequently, this will create a new firm that will take the central figure and become the core firm in the inter-firm network. Thus, the literature indicates that firms in a network having an extensive relationship with other firms in the network may be perceived as trustworthy by others. Since extensive relationships in network analysis can be pictured based on the level of firms' coreness in the network structure, this research hypothesizes that:

Research Hypothesis: Firm's embeddedness following their centrality position in the upstream supply network through different inter firm relations impact the level of trust that the firms may acquire from other network members.

3. METHODOLOGY

Align with the objectives of this study; the design and methodology of are based on the theoretical and analytical framework of the Social Network Analysis (SNA). In SNA, the relationships or ties between the actors in the network are the primary data collected while the actor attributes or characteristics serve as the secondary data. Graphically, an actor of the social network is represented in the network diagram by a node or a point. Given a collection of actors, social network analysis can be used to study the structural variables measured on actors in the set. The relational structure of a group or large social system consists of the pattern of relationships among the collection of actors. The concept of a network emphasizes the fact that each individual has ties to other individuals, each of whom in turn is tied to a few, some, or many others, and so on. The phrase "social network" refers to the set of actors and the ties between them. The network analyst would seek to model these relationships to depict the structure of a group. One could then study the impact of this structure on the functioning of the group and/or the influence of this structure on individuals within the group.

There are several key concepts at the heart of network analysis that are fundamental to the discussion of social networks. These concepts are: actor, relational tie, dyad, triad, subgroup, group, relation, and network. The definition and descriptions of these concepts are given in the table in Appendix 1.

For this study, an upstresam supply network of a small maritime industry seems to be an ideal setting. A supply network in the maritime industry is a material-intensive enterprise. Much of the activities and activities are highly dynamics and are widely dispersed throughout the network. Materials and information flow are transferred through interactions among different firms. Since firms in supply network operate in an environment of high degree of complexity (Bozarth et al., 2009) and uncertainty (Wilding, 1998a), firms seek an edge through connections or interactions with the members of the network. Lambert and Cooper (2000) stated that the key to these issues is the on-going relationship with the other partners. They stressed on the importance of investigating the relationships that suppliers and customers have. Johnston et al. (2004) suggested that on-going relationship among members increases efficiency and effectiveness of the supply network.

The site of this study is located in the country Malaysia. The researcher profiles different supply networks critically to determine the most suitable network for study. One of the networks, here labelled as APMMHQ-1 supply network, was found to be the appropriate site for this exploration. APMMHQ-1 supply network was found to have good performance indicator, and considered one of the best

supply system in the region through its Integrated Logistic Support (ILS) programs. Accordingly, these signs were assumed to be good pointers for the suitability of the site. The top level managements were approached for possible participations in the study. After several communication about the goal of this study and the potentials benefits for the APMMHQ-1 supply network, positive commitments were received from the top managements to participate and granting participations to this study.

The first step of social network analysis is to determine the population of the study to be surveyed. There are two sampling units in this study: the firms that occupy the APMMHQ-1 upstream supply network for the product RHIB and the ties or relationship between them. The sampling frames for the firms and for the connections between them are nested. In network studies, the method used to sample relations is part of the survey instrument.

In network studies, all the actors that are located within the naturally occurring boundaries are included for analysis. Consequently, network studies do not use samples as in the conventional sense, rather, it seek to include all of the actors in some population or populations (Hanneman and Riddle, 2005). The research population for this study consists of the firms in the upstream supply network of APMMHQ-1. More specifically this study investigates the firms operating in the upstream supply network of APMMHQ-1 for the supply of parts and materials for the production of Rigid Hull Inflatable Boat (RHIB) to the APMMHQ-1. In APMMHQ-1 production, the RHIB is the small fast craft that received highest demand from the market. It contributes to up to 43% of the company return in 2010, 2009, and 2008.

As mentioned in network studies, all the actors that are located within the naturally occurring boundaries are included for analysis. Consequently, network studies do not use samples as in the conventional sense, rather, it seek to include all of the actors in some population or populations (Hanneman and Riddle, 2005). Defining and locating the boundaries of a network is utmost important in a network study. To identify and define the target population within the APMMHQ-1 upstream supply network for RHIB, the author combines the realist and the nominalist approach.

A survey instrument was used to collect majority of the information needed for this study. Surveys and questionnaire are traditional tools to help network researchers to obtain data on inter-organisational relationships (Wasserman and Faust, 1994). Leading network researcher such as Galaskiewicz and Marsden (1978), Knoke and Kuklinski (1982), Burt (2004), and Borgatti and Li (2009a) established the credibility of this technique for the collection of network data on inter-organisational transactions such as information transfer, resource transfer and

joint activities. Survey is suitable for this type of study because it allows the researcher to tap into the participants' subjective perceptions of interactions rather than objective measure of interactions, which many situations are hard to get access to for confidentiality reasons (Diani, 2002).

The survey instrument in this study followed standard survey design features such as asking general information questions at the beginning, followed by more specific questions, and lastly the most probing questions at the end. The survey questionnaire consisted of closed ended questions and open ended questions. In general, the questionnaire were framed following the standard of Choi and Hong (2002), Provan and Milward (1995), Stone (2001), Corteville and Sun (2009) and Cross and Parker (2004).

3.1 Network Ties Questions

The first category of questions seeks demographic information of the network actors. The second category investigates the network ties between the organisation/unit in the MMEA supply network. In this section, the respondents were given a grid with each of the buyer-supplier organisations in sample on the vertical axis. Respondents were asked to go through the list and indicate (with a check) which buyer-supplier organisations that the respondents' organisations have been involved with for each of the four types of relationship listed. These four types of ties are important to understand both formal and informal relationships among organisations (Provan and Milward, 1995, Choi and Hong, 2002a, Corteville and Sun, 2009). The four types of ties investigated, which were contracts, information sharing, referral made and received ties. The contractual questions shows how formally linked an organisation/unit is with another in the supply network. The survey instrument asked the key informants to indicate on the roster the list of organisations that they have formal service contracts with (Choi and Hong, 2002a, Provan and Milward, 1995). The shared information category illustrates the norm of collaboration and cooperation between the organisation/unit that is asserted on formal links or ties. Network data on information and communication ties reveal collaboration in a network. Information sharing was assessed in the network survey by asking key informants to indicate on the rosters which the buyer-supplier organisations listed below that might have exchange of information to accomplish their work (Cross & Parker, 2004). Referral made and received illustrates the patterning of service links or ties and the overlap with the other two links as referral links can be either formal or informal. Respondents were asked to indicate with a check on the rosters the list of buyer-supplier organisations to which they made referrals. Similar actions were asked from respondent for referral received ties. Key informants from each buyer-supplier organisations were asked to select organisations

to which they received referrals. Referral made and referral received ties followed the work of Corteville and Sun (2009).

Another important source of network ties data were gathered indirectly during the surveys. For example, key informants were likely to mention existing information, contract, or referral relationships that they had formed outside of the known boundary. The researcher also invites the respondents to name other organisations that may have participate in the MMEA supply system but is not listed as one of the 37 buyer-supplier organisations. The researcher, however, did not receive any additional named to be included into the network data.

3.2 Definitions and Operationalization

There are two types of variables that are included in the network data of this study. First is the embeddedness variable. Embeddedness variables are the main independent variables of the social network data set. The second set of variables is the relational capital performance variables which form the outcome variables of this study. Degree centrality measures the number of other actors in the network to which the focal organisation or ego is tied to. In a directional graph degree centrality is recognized by adding the number of connections flowing to the focal organisation or the ego to the number of connection flowing from ego and subtracting the overlap. In the case of non-directional graph, the degree centrality of an actor or organisation is defined as,

$$DEGREE\ CENTRALITY = d\ (ni) \tag{1}$$

where d (ni) refers to the degree of the node i. An actor or organisation degree centrality score is bound by the number of actors in a network other than ego (n-1) (Wasserman and Faust, 1994).

3.3 Relational Capital Performance Variables

There are many forms of trust that can exist in an organization from what is referred to as blanket trust which translates to a trust of another individual in any action they take to a focused trust on a specific topic. In the context of the Social Network Model, trust is considered when an individual believes that another individual will take actions that are mutually beneficial and not solely to one's own advantage.

Trust measures the quality of relationship between two organisations. In this study, although respondents were asked to report their multiples types of relationship with other organisations, a global measure of relationship quality is adopted to measure the overall quality of the relationships between two organisations or actors. Operationally, the actor's ratings of relationship quality

with other buyer-supplier organizations are organized in a matrix of reported relationship quality. The horizontal and vertical axes represent each buyer-supplier organization. The respondents were listed on the vertical axis and the target buyer-supplier organizations for reported relationship quality were listed on the horizontal axis. This places each response along the rows of each matrix. The rating given by the respondent buyer-supplier organizations (1-4, 1 = poor relationship to 4 = excellent relationship) was recorded in the appropriate column of the relationship matrix. The trustworthiness of buyer-supplier organizations is calculated by the ratio of the column total of the matrix (the sums of all reported relationship quality rating of a target actor of organisation) to the number of organisations which reported a quality rating.

3.4 Analysis Method

The analysis was divided according to the types of analysis technique applied. First, the researcher performed exploratory social network analysis (visual analysis) of buyer-supplier organisations network by exploring the network maps and the network structural measures. For this purpose, this study adopted a spring-embedding visualization method in the UCINET program whereby a network layout is computed using force directed algorithm. More specifically, the algorithm place nodes based on node repulsion and equal edge length bias. When so configured, the placement of nodes in the sociogram is based on forcing the nodes apart and tending to select placements that lead to equal edge lengths (i.e., equal length lines between nodes). This particular layout has the advantage of detecting network centrality patterning (Polites and Watson, 2008). For these routines, this study applied the network imaging software within the UCINET (Borgatti et al., 2002) i.e. the NetDraw, which is equipped with sophisticated visualization techniques. Visual representation of supply networks can provide useful direction for researchers, and starting point to developed subsequent quantitative analyses (Choi and Hong, 2002b).

Then, the researcher tested the research hypotheses using innovative statistical network modeling known as the Exponential Random Graph Modeling (ERGM, or p* model; Robins et al., 2007b). Robins, Elliott et al. (2001) suggested that in social network analysis, the network structure need to be searched not assume from previous other related literature.

In general, the exponential random graph models (ERGM) have the following form:

$$P_r\left(Y = y\right)(\ 1/k)\exp\left(\sum nA(g)\,A(y)\right) \qquad (2)$$

where:

(i) The summation is over all configurations A;

(ii) ηA is the parameter corresponding to the configuration A (and is nonzero only if all pairs of variables in A are assumed to be conditionally dependent)

(iii) gA(y) is the network statistic corresponding to configuration A; gA(y) = 1 if the configuration is observed in the network y, and is 0 otherwise

All ERGM models are of the form of equation (1), which describes a general probability distribution of graphs on n nodes. The probability of observing any particular graph y in this distribution is given by the equation, and this probability is dependent both on the statistics gA(y) in the network y and on the various non-zero parameters ηA for all configurations A in the model.

Consequently, different network analysis routines were applied to explore patterns of connectivity among the buyer-supplier organisations that are embedded in the MMEA supply network and examine the structural characteristics of these entities. These analyses were performed using the software package UCINET (Borgatti et al., 2002).

Scholars of social network have consistently confirmed that the fundamental theoretical insight of the social network analysis rest on the importance of the ties between actors (Lusher, 2011, Lusher and Ackland, 2010, Lusher et al., 2012, Carrington et al., 2005, Nahapiet and Ghoshal, 1998). In social network, the embedded nodes or actors are interdependent, making them related unit of analysis (Lusher et al., 2012, Snijders et al., 2006). Consequently, it is not best assessing network member's relations in a quantitative manner through the normal series of traditional statistical analysis (Shumate and Palazzolo, 2010). One chief reason for this argument is that as the normal series of traditional statistical techniques consider each node or actors of a network to be unrelated or independent (Robins et al., 2012, Igarashi et al., 2006). Many leading network scholars claimed that traditional statistical analysis disregard the possibility of relations between the individual nodes or actors through the assumption of independence of observation (Bamber et al., 2010, Lusher et al., 2012, Robins et al., 2009, Shumate and Palazzolo, 2010), when in fact, in social network node and actor are an interdependent, related, unit of analysis (Knoke and Kuklinski, 1982). It is for this interdependency and relatedness argument that a special class of statistical models is preferred when investigating social relations phenomena, in particular the Exponential Random Graph Model (ERGM) (Shumate and Palazzolo, 2010).

4 RESULTS

4.1 Exploratory Network Analysis: Visual Analysis of Social Network Trust Network Map and Degree Centrality

From Figure 1, there are several sub-groups or cliques of trust relationship in the network structure. In addition in the almost all sub-groups or cliques, there

exists one firm that has high trust attribute compare to other nodes. Furthermore, nodes that are periphery in the network are mostly low in their trust score. This network map implies that nodes that are embedded in the core position may experience high level of trust while nodes on the periphery have mostly low trust level. Together, the positioning of the nodes of the trust network indicates the tendency towards a degree based core-periphery structure. Borgatti and Everett (2000) stated that the core periphery structures imply the existence of two distinct regions in the network, i.e. one that includes dense and cohesive subsets of nodes, and another where connections are looser and sparse. Borgatti and Everett (2000) posited that these particular structure may form in two ways, i.e. one as a result of high centralization process, indicated by the presence of hubs and spokes nodes, for example when prominent firms attracts most of the other firms, and another, due to high triangulation, which suggest the presence of large number of overlapping cliques.

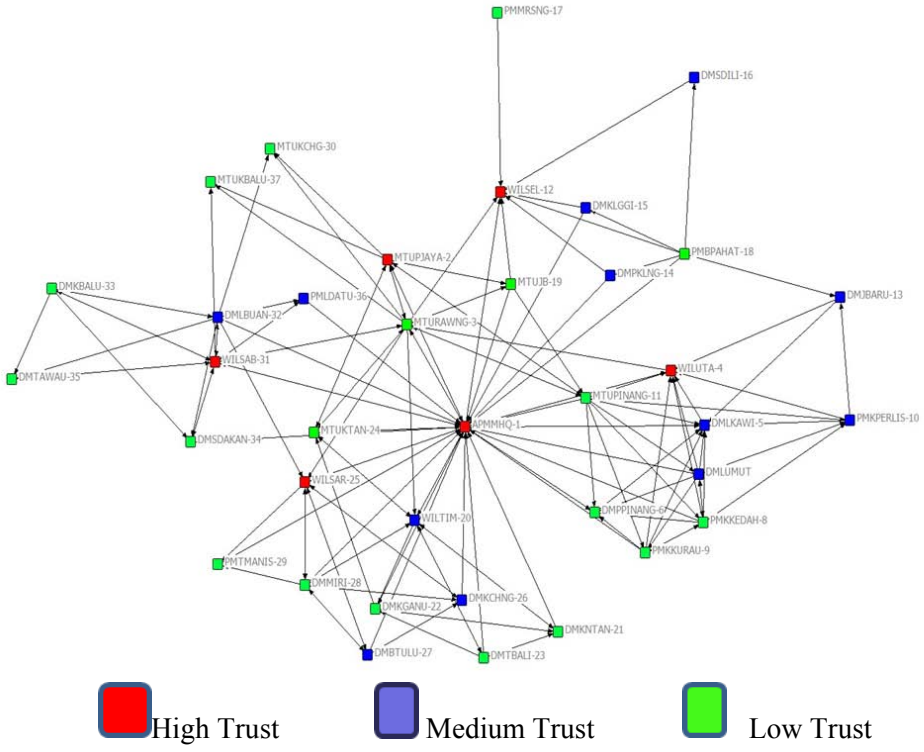

Figure 1: Trust network with color on the nodes representing high and low trust score.
Source: Author

4.2 ERGM Analysis of Trust Network and Embeddedness Based on Degree Centrality

To test the effects of nodes embeddedness attribute in a more systematic way, this study performed a series of ERGM analysis, which allow the researcher to determine statistically the effects of organizations measures of network embeddedness upon trust network (Snijders et al., 2006, Robins et al., 2009). For the ERGM analysis this study adopted Shumate and Palazzolo (2010) Pure Structural Effects and Pure Attribute Effects model analysis. In the initial analysis, the researcher conducted the Pure Structural Parameter Effects model ERGM analysis to determine the relevant structural formation of the trust network. Following this, the researcher conducted another ERGM analysis with the buyer-supplier organizations measures of network embeddedness or node attributes included into the model. This model is called the Pure Attribute Based Network Effect model. The outcome of this model will enable the researcher to see the impact of the attribute upon the ties structural formation propensity inside the relevant network and more importantly upon the node attribute parameters. The relevant node attribute parameter to test for these effects is the Sum of Continuous Attribute and supplemented by the Difference of Continuous Attribute parameters. Using these parameters the researcher will be able to tell the individual effects of the attributes upon the buyer-supplier organizations in the network. Following Robins et al. (2007a), the researcher analysed the MLE (Maximum Likelihood Estimate), and the standard error. The parameter is significant when absolute value of estimates exceed twice the standard error outcomes of each models. The sign of the MLE ("+" or "-") provides an indication of whether the particular network structure occurs more or less likely than predicted by chance. For a model to be considered well converged the parameters t-ratio must be less than 0.1 is absolute value. All of the parameters included in this study models are under the convergence threshold, indicating that the models fit the data well. In the following section this study discuss the analysis results of ERG model for trust network and embeddedness attributes measured based on degree centrality in the formal contract tie, information sharing tie, referral made tie, and referral received tie.

4.3 MMEA Trust Network with Organization Network Embeddedness Degree Centrality (ONEDC)

In this section, the researcher discussed the ERGM analysis results involving embeddedness of firms measured based on the ONEDC across four supply ties. For reason of constraints place on this study report, the researcher will only discuss the

Pure Structural Effects model results followed by the model effects of the embeddedness attributed as represented by the Sum of Continuous Attribute and the Difference of Continuous Attribute parameter of each supply ties. The parameter estimates (MLE), and standard error are presented in Table 1.

Table 1: ERGM Results

Parameter	ML Estimates	Standard Error
Trust Network Pure Structural Effects		
Arc	-1.101	0.082*
Reciprocity	1.478	0.401*
A-in-S	-1.350	0.429*
A-out-S	0.128	0.399
AT-T	1.096	0.259*
AT-C	-0.273	0.109*
AT-D	0.469	0.212*
AT-U	-0.089	0.131
A2P-T	-0.163	0.045*
A2P-D	-0.124	0.075
A2P-U	0.084	0.027*
Trust Network Pure Attribute Effects		
Section 1: ONEDC in Contract tie		
Sum of continuous attributes	0.071	0.026*
Difference of continuous attributes	-0.036	0.017*
Section 2: ONEDC in Information sharing tie		
Sum of continuous attributes	- 0.064	0.017*
Difference of continuous attributes		0.014*
Section 3: ONEDC in Referral Made tie	0.028	
Sum of continuous attributes		0.017
		0.001*
Difference of continuous attributes		-0.027
Section 4: ONEDC in Referral Received tie		0.001*
Sum of continuous attributes		0.012*
	0.031	
Difference of continuous attributes		0.022*
	0.046	

Asterisk indicate effects where absolute value of estimates exceed twice the standard error

In Table 1, to obtain a converged Pure Structural Effects model for trust network, the structural parameters are included conditionally until the model is converged i.e. until the t-ratio of each relevant parameter is less than 0.1. Consequently, the parameters that are included in the Pure Structural Effects model of the trust network are as follow: Reciprocity, A-in-S, A-out-S, AT-T, AT-D, AT-

U, AT-C, A2P-T, A2P-U, and A2P-D. Structurally these parameters reflect certain form of ties structural formations in the trust network. These parameters reflect density (arc), reciprocation (reciprocity), degree based or centralization (A-in-S, A-out-S), and multiple transitivity (AT-T, AT-D, AT-U, AT-C, A2P-T, A2P-U, and A2P-D) (Robins et al., 2009, Wang et al., 2006b).

First, in the structural effects section, the Arc ML estimate is a significant and negative parameter, suggesting fewer trust relationships are expected it the MMEA supply system are observed than would have been expected by chance. In other words, firms of the MMEA supply network forge trust relationships to only a few of the potential other firms in the network. This phenomenon is expected as trust relationships are build overtime and relies on other endogenous variables such as size of the participating firms and the length of the relationships (Jiang et al., 2011, Laaksonen et al., 2009, Doney and Cannon, 1997). Firms' size encompasses the firm's overall size and its market share position. Firms' size provides a signal to other firm its level of trustworthiness. Overall size and market share indicate that many other businesses trust this firm enough to do business with it. This suggests that the firms consistently deliver on its promises to others or it would not have been able to maintain its position in the industry.

Second, there is a significant and positive effect of reciprocity for trust network model. This indicate that firms are likely to nominate each other in trust relation i.e. if Organizations APMMHQ1 trust WILSEL4 there is also a high likelihood that WILSEL4 trust APMMHQ1 in return. Reciprocity is an important feature of many other social networks studies, and it is expected in trust relationships (Lusher, 2011, Lusher and Ackland, 2010, Lusher et al., 2010, Lusher et al., 2012, Bamber et al., 2010, Robins et al., 2012, Robins et al., 2009).

Third, the model shows that the A-in-S parameter is significant but negative A-in-S parameter is an indication of the presence of highly nominated firms within the trust network. What can be taken from this parameter estimates is that in the trust network, controlling for other effects, although there is a significant parameter estimates for A-in-S, the negative MLE score indicate that it is unlikely that trust ties relationship will be forge based on the degree based structural formation. On top of the structural parameters, Table 1 also shows the effects of the continuous attributes upon the ties formation propensity between the embedded buyer-supplier organizations in the trust network in the attribute effects sections. The first section shows the results for ONEDC in contract tie. The Sum of Continuous Attributes is significant and positive. This shows that in the trust network, firms that have high ONEDC in contract tie forge trust ties with others with similar high embeddedness level and with low embeddedness level more frequently. Because the

embeddedness score is related to the number of connections that firms has in the network, we could also relate this parameters to the location of these firms in the network structure. Structurally, we would find these firms to be located in the center of the network, as there are the nodes that has the most connections or ties to other nodes in the network. The Difference of Continuous Attribute is significant and negative suggest that the firms with differing level of embeddedness levels are less likely to forge ties together. What can be taken from the findings of the ERGM analysis outcome is that, ONEDC in contract tie influences the propensity for trust ties to be forged between the embedded firms. Thus, firms with high ONEDC may appear more trustworthy to the other network members.

In the second section, there is a negative and significant Sum of Continuous Attribute parameter indicating that firms with high ONEDC in the information sharing tie have low tendency to trust others with high or low ONEDC firms. A significant and positive Differences of Continuous Attribute shows that there is a strong tendency for firms in the observed network to forge ties or trust other network members when their ONEDC differences are small. When compared to the attribute effects in contract ties, the Sum of Continuous Attribute effects are non-significant but Difference of Continuous Attribute effects are positive and significant. The distinctions in the attribute effects may relate to the type of type of ties in question. A formal tie such as the contract tie is governed by terms and regulation. Such condition may lead to focal organizations becoming dominant in the network. For example, Toyota is the focal organization in the Toyota supply chain with few tier one organizations also considered focal, as they functions as the main supplier to the Toyota production facility. The flow of supplier between upstream suppliers to the focal suppliers and subsequently to the manufacturer itself is governed by agreed rules and regulations with the contracted organizations are bounded to the demands and needs of the ordering authority (i.e. focal organizations). This phenomenon may create a few focal organizations that become core nodes as indicated by the positive Sum of Continuous Attribute effects in the model. On the other hand, positive and significant Difference Continuous Attributes may be attributed to the informal nature of the information sharing tie whereby in such network, communication is not based and bounded by any official regulatory. The third section of trust network model in shows the attributes effects results for ONEDC in referral made tie. There is a significant and positive Sum of Continuous Attribute effects for the observed network indicating that firms with high ONEDC in the referral made tie tend to forge ties with others. The negative and significant Differences of Continuous Attribute show that when the difference

in their ONEDC is small, there is low tendency for the firms of the observed network to forged trust ties with other firms.

Finally, the fourth section shows the result of attributes effects, ONEDC in referral received tie. The Sum of Continuous Attribute is found to be positive and significant. This is an indication that firms that possessed high ONEDC in referral received tie are likely to form ties with other network members. However, the positive and significant Difference of Continuous Attribute shows that trust relationship are more likely to be forged between network nodes when the difference in ONEDC in referral received tie is small.

5 DISCUSSIONS

The exploratory analysis and the ERGM analysis revealed that there were significant, positive effects of firm's embeddedness based on centrality network positions and trust. For example, firms that are highly embedded in the information-sharing tie network, based on their degree centrality network structural position, have a high likelihood of being perceived as trustworthy by other network members. The results are similar in the referral made ties, and the referral received ties. This also indicates that, as firms are more embedded in the centralized upstream supply network based on the degree centrality network structural position, their level of trustworthiness as well improves. However, the Maximum Likelihood Estimate (MLE) is significant but negative when firms are highly embedded in the contract tie. What this means is that the more embedded a firm is in the upstream supply network based on the formal contract tie, the less is the likelihood that it will be perceived as trustworthy by other network members.

This suggests that the study hypothesis can be accepted. As a firm becomes more embedded in the upstream supply network structure, it will experience varying levels of relational capital depending on the type of activity that the firm is involved in. Thus, the more embedded a firm is in the supply network based on degree centrality network position, the more likelihood there is that the firm will be perceived as trustworthy by other firms embedded in a similar network structure. This implies that firms in an upstream supply network relationship trust the firms that occupy the central position in the supply network structure; alternatively, by definition, the firms that receive the most ties or connections from other firms.

Overall, it appears that firm's embeddedness in the supply network structure contributes to the level of trust that one firm may receive from other network members. Moreover, the trustworthiness level that a firm receives from other colleagues may be helpful in the collaborative development of a new-product innovation or services. The level of trust can also influence the development and

training of personnel; for example, to qualify them to deal with the partners' or customers' technology or system. The results of the parameter estimations are in line with the results of the trust network visual analysis (Figures 1). In this case, this study also found that, in the sociogram of trust network (Figures 1), firms that have a high level of embeddedness based on degree centrality are also the central firms in the trust network structure.

This finding is consistent with Uzzi (1997). Uzzi (1997) found that, in inter-firm relationships, active relational governance such as information-sharing is associated with trust. Further, it was found that firms resort to trusted firms in the network with whom they have dealt multiple times in the past to obtain information regarding a potential partner before collaboration activities can be carried out. More importantly, Zaheer et al., (1998) confirm that this leads to improved performance of inter-firm exchanges. An important implication of this study is that the findings provide support that firm's commitment into information-sharing activities enhances the perception of trust that the firm may receive from other network members. In addition, referral relationships are regarded as being a firm's high level of goodwill (Anderson, 1998). Referral relationships often involve sending human resources, or participating in programs to make certain of issues regarding clients or processes. As receiving referrals can be interpreted as receiving resources from other network members, others may regard the act of sending referrals to other firms as an act of goodwill. Consequently, firms that receive a high number of referrals will also be perceived as highly trustworthy by other firms in the network structure. Thus, the findings of ERGM analysis for the hypothesis lend support to the argument that firms are more embedded in the centralized upstream supply network.

6 CONTRIBUTION

Achieving success in a supply network is essential. Understanding how and why some business relationships succeed and why others fail is perhaps among the most critical issues facing firms in the supply network. Thus, from a manager's standpoint, it is important to know how to improve firms' overall performance. Based on the findings of this research, the following implications are highlighted. First, the researcher could demonstrate that firm network involvement, or its embeddedness in the centralized upstream supply network or supply base, is extensively related to the firm's key relational capital resources (ERGM analysis of Table 1). More specifically, it is beneficial to know that firms which become aware of, and are involved in the centralized upstream supply network relations, will widely experience increased levels of trust. Even though it is not the goal of this

study to explore the impact of network involvement on accounting or financial indicators, it is, however, important to note that Reagans et al. (2004) argued that relational capital such as trust facilitates transactions. As a result, it could reduce costs, as well as increase performance and innovativeness of the related parties. What this means for managers of the supply network is the ability to identify and capitalize on the important network structural position that can contribute to increase relational capital outcomes. The findings of this study have indicated the relevant position or degree of involvement for the generation of trust; it is the initiative of managers to determine their respective positions in the centralized upstream supply network structure and make the necessary adjustments.

In addition, the findings of this study also showed that the relationship between network involvement and relational capital is reasonably high, even in the highly centralized upstream supply network structure. Thus, managers of firms in the supply network should not be discouraged from involving themselves with other firms in the supply network structure. The relational capital resources still flow to other firms despite the existence of a central focal firm managing and administering transactions between firms in the network structure. This highlights the needs for managers and firms to have the ability to examine and understand other firms' patterns of embeddedness as this may be the key to capturing the dynamics of inter-firm relationships that might be beneficial or lead to future concerns. As firms are able to understand this concept, it might help the firm to avoid the danger of dismissing a certain firm based solely on poor accounting measures, when, in fact, this firm is connected to other highly powerful or resourceful ones. The quantitative analysis results of this study may shed light on the type of relations that may have influence upon firms' relational capital and become the knowledge needed for managers to comprehend the dynamics. In addition, the findings of this study may shed light on the 'myth of downsizing' in the context of inter-organizations. Choi (2011) described the upstream supply chain complexity or supply base complexity as being a 'beast' that requires understanding in order to tame it. Rather than by harsh actions such as removal of a part or elements that formed the whole network. This study attempted and succeeded to investigate and provide others with an additional lens through which to comprehend the complexity and consequently, bring new means to tame the beast. Since it has been a known empirical fact that downsizing does not improve performance of intra-organizations, the findings of this study may prove similar effects. It may also explain in part why, in the context of inter-organizations, a 'reductionist' approach (based on accounting measures) to suppliers' management may not be the answer. It follows that it seems ill-guided reductionist may remove

the influential, resourceful firms that do not appear on the firms' radar of good accounting measures (Choi et al., 2006).

This study also indicates the importance for firms and more specifically, managers of the firm operating the supply chain management functions to be able to understand and analyze the embeddedness of other firms in the supply network structure, as well as their own. To understand the nature of other firm's embeddedness in the supply network structure, managers need to have the ability to determine the direct and indirect ties that the firms have with other network members. Thus, firms must possess potent network awareness in order to manage the complexity resulting from multiple direct and indirect ties. For example, a firm with heightened network awareness ability should not simply cut ties with low performing partners in the network merely assuming low accounting returns, as these partners may actually be connected to a more influential network of members. Network theorists refer to this phenomenon as the strength of weak ties (Granovetter, 1973; Ruef, 2002). This study also contributes to the resource allocation and management strategy in the supply chain. Resource allocation problems in supply chain management may take place during portfolio management optimization. Owing to the complexity inherent in these systems, the search for optimal solutions can be a difficult task. Since sharing of information is central to the resource allocation activities in supply chain management, understanding the pattern of the resulting network structure can help managers to use this preliminary finding to channel the resources for relationship management based on the type of both organizations and relationships. More focused relationship management would ultimately improve cost savings and performance of the supply chain. Thus, overall, on top of the normal accounting measures commonly applied to the management of the supply network structure, results from this study can add to the much needed tacit, intangible knowledge of complexity arising from inter-firm relations. Accordingly, the knowledge of embeddedness of firms in the upstream supply network structure can be another strategic tool for managers when dealing with the complexity in the supply network that arises from inter-firm relations. The researcher posited that by understanding and knowing firms' patterns of embeddedness in the different network ties, managers will be equipped with an additional tool when evaluating current and potential partners, as well as determining optimum resource's allocation strategy and forecasting purposes.

7 FUTURE RESEARCH

As for future research opportunities, the framework of this study could also be tested in other industries, i.e. in a more dynamic, fast cycle industry such as the electronics industry. The heightened degree of uncertainty and rate of innovation in the electronics industry may influence the pattern of strategic behaviour of the embedded organizations and the appropriate network configurations. Firms embedded in rapidly changing networks may achieve competitive advantage through different forms of network embeddedness from firms in a more stable environment such as the shipping industry. In the volatile, rapidly changing environment, the level of uncertainty will also be higher compared to the more stable industry. With this increased volatility and uncertainty, organizations are expected to make decisions that are based less on economic parameters but more on relationships and resources at hand. Hence to see if the findings of this study would also hold in different industry, it would be an interesting undertaking and would add to the generalizability of this study.

8 CONCLUSION

This study has presented a view of the supply network as a social system and has pointed out that network embeddedness plays a prominent role. Our results suggest that embeddedness impact upon the organizational level of social capital. This implies that the supply management function can, to some extent, shape the supply network structure around particular organizations. More research is needed to determine the extent, to which embeddedness of an organization can control, or more likely influence, the development of networks and how much leverage the supply network has in this process. The results also suggest that supply network embeddedness may have much to contribute towards strategy development. In conclusion, by considering the overall implications of the study, it may conclude that complexity is not all bad. Managers need to consider their firm's existing embeddedness in order to exploit the competitive advantage of supply network inter-organizational relationships. Firms that fail to understand the underpinnings of these relationships stand to face more difficulties within the network itself. For this reason, managers that intend to obtain competitive advantage from the network must engage with other partners more effectively. No doubt some firms are at an adequate standing, while others are struggling in some areas. The framework of this study can be applied by managers who are committed in engaging other network members.

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APPENDIX

Concept	Description/Description
Actor	Social entities of the network. Actors are discrete individual, corporate, or collective social units
Tie	A linkage between a pair of actors. Actors are linked to one another by social ties. Common examples of ties employed in network analysis are: • Evaluation of one person by another (for example shared values) • Transfer of resources (such as communications, giving information and receiving information) • Behavioural interaction (such as knowledge exchange)

Concept	Description/Description
Dyad	A tie between two actors. A dyad consists of a pair of actors and the (possible) tie(s) between them. Dyad is frequently the basic unit for the statistical analysis of social networks.
Triad	A subset of three actors and the (possible) tie(s) among them
Network Data	Network data consists of at least one structural variable measured on a set of actors
Graph	Graph theory has been useful in social network analysis for many reasons. • provides a vocabulary to label and denote social structural properties • gives mathematical operations with which many of these properties can be quantified and measured • gives us the ability to prove • gives theorems about graphs, and hence, about representations of social structure • gives a representation of a social network as a model of a social system consisting of a set of actors and the arcs between them

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IMPACT OF THE TRANSITION TO IFRS FOR THE ROMANIAN LISTED COMPANIES IN FINANCIAL DISTRESS

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Abstract: *The transition to IFRS of the Romanian listed companies enables us to provide a comparison of some accounting data reported in the same period and that have been obtained according to different accounting regulations: RAS vs. IFRS. The aim of our paper is to establish if the listed companies in financial distress report a trend of changes due to the transition to IFRS that is different to the one established for the performant companies. Based on the data corresponding to the 2011 financial year (with available RAS and IFRS information), we have calculated Gray's comparability index (for a series of financial indicators) in the case of the two groups of companies (one in financial distress and a performant one) and we have statistically tested the existence of significant differences between the values of the index for the two company categories. We have found out that some indicators evolve in the same manner (especially the balance sheet structure indexes), others maintain the same trend, but the significance of the variances are different (ROS, ROA, ROE and OI), and, finally, for another series of indicators, the trend of the change caused by the IFRS transition is different for the two groups of companies (leverage and equity).*

Keywords*: Impact of IFRS, Gray index of comparability, Romanian listed companies, companies in financial distress*
JEL Classification*: C51, C58, G33, M41, M42*

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1. INTRODUCTION

The financial year 2012 has been an important moment for the Romanian listed companies from the financial reporting point of view – the transition to IFRS in their individual financial statements. If until 2011, Romanian regulation was used (RAS – OMFP 3055/2009) and IFRS were mandatory only in the case of consolidated financial statements, starting with 2012, the Romanian standard setter also chose to impose the use of IFRS in the individual financial statements of the listed companies. Among the reasons mentioned by the Romanian standards setter for this decision we can find "the need to follow the international practice", but also the recommendations of the international organizations (WB and IMF). We have to mention that Romania is not the only state in the EU which extends the commitment to the IFRS implementation in the individual financial statements, but even though the number of countries that impose this commitment is not very large – in 2014 several countries in the EU had regulations that imposed (2 countries) or allowed (11 countries) the use of IFRS in other cases than the consolidation of the listed companies (EU, 2014).

From the point of view of the accounting research, the mandatory transition to IFRS represents a very important event which allows to measure the difference between the Romanian standards (RAS) and the international ones (IFRS). Besides, alongside the transition to IFRS of the European listed companies (in the consolidated financial statements), the premises of an extremely rich literature on the impact of the IFRS have emerged.

In case of Romania, analyses have already been carried out in order to discover the impact of the IFRS on the financial statements of the listed companies. For the studies that aim to sum up the effects of IFRS, two categories of accounting figures are available for the 2011 period: a series of values according to the RAS (issued in the 2011 financial statements) and another one according to the IFRS – issued as comparative information in the 2012 financial statements.

Săcărin (2014) analyses the effects of the IFRS transition for the non-financial Romanian listed companies, excluding the insolvent companies and analyses the impact on the assets, shareholders' equity, liabilities, net income and on certain financial indicators (return on equity, solvency, leverage). For a sample of 68 companies, Istrate (2014a) found that the impact of the IFRS on some accounting figures is important but not in the line of the hypotheses he poses – his results confirm in general those of Săcărin (2014). For our study, we will keep the Săcărin's (2014) values as references, we will test these values by applying a different comparability index (as in Istrate, 2014a and Istrate, 2014b), and we will then analyze the impact of IFRS on the companies that had been

between 2011 and 2012 in financial distress – insolvency or other negative shareholders' equity companies.

In fact, our research evaluates the differences between the companies with financial distress and the other listed companies in terms of the impact of the transition to IFRS on the accounting values. We carried out this research as many companies had been affected by the global financial crisis which began in 2008 and we tried to identify the differential effects of the crisis on Romanian listed companies in financial distress as well as the manner in which financial reporting standards influenced the financial reporting of these companies.

In our analysis, we compare the impact of IFRS on distressed companies compared with the impact on the non-distressed listed companies. From our analysis, we have found that some financial indicators evolve in the same manner for the two groups of companies, other indicators maintain the same trend, but the significance of the variances is different and, finally, for other series of indicators, the trend of the change caused by the IFRS transition is different for the two groups of companies.

The reminder of this paper contains a review of the relevant literature (section 2), the methodology and the sample (section 3), the presentation of the main results (section 4) and the conclusions (section 5).

2 LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The literature on the impact of the IFRS transition is significant and analyses numerous aspects of such a transition. Clarkson *et al*. (2011) analyses the transition to IFRS in 2005 for a sample of nearly 3.500 European companies and observes a clear differentiation of the effects on country groups: *common law* vs. *code law*. Many other studies focus on the individual statements of some countries or country groups (Jermakowicz & Gornik-Tomaszewski, 2006; Hung & Subramanyam, 2007; Haller and al., 2009; Fifield and al., 2011; Aubert & Grudnitski, 2011; Callao Gastón and al., 2010).

The first section of the literature that we consider looks into the impact of IFRS in Romania. In the second part, we will focus on the financial description of companies in financial distress and also on the indicators that are used in diagnosing this state, and, finally, on the use of Gray's comparability index to assess the impact of different accounting frameworks on the accounting figures. We will add information related to mandatory requirements of financial statements under IFRS to be audited and the impact of the auditor's affiliation to the Big 4 group on the accounting figures for the listed companies.

2.1 The use of IFRS in Romania

The transition to IAS/IFRS in Romania has generated some interesting studies. Awe can find an excellent list in Ionaşcu *et al*. (2014). Although there are relevant analyses and descriptions of Romanian's transition to the international regulations, Ionaşcu *et al*. (2014) believe that the literature is in its incipient stage and especially consists of studies regarding the IAS/IFRS perception, which were added several articles that detail and empirically analyze the actual consequences of the IFRS. Albu *et al*. (2014) found a low level of conformity with the IFRS in Romania, even though there are also companies that use excellently the international regulations.

A very useful study for the establishment of our pool of articles has been published by Săcărin (2014). The author analyses the quantitative impact of the Romanian listed companies' transition to the IFRS with comparative data regarding the beginning and the end of the 2011 financial year. The main results reported by Săcărin (2014) show us that the IFRS impact was relatively moderated, the most affected structures being the shareholders' equity. Săcărin's (2014) analysis has been conducted on the sample of the listed companies (from which insolvent companies and the ones with unavailable data were excluded) – with 56 remaining companies. The indicators used by Săcărin (2014) are the total assets, shareholders' equity, liabilities, the net income, return on equity, solvency and the indebtedness ratios. Istrate (2014b) analyzed the impact of IFRS on some accounting figures of three Romanian listed banks and found that there was a significant increase in equity and a moderate increase in net income. Istrate (2014b) compared these results with the averages of the modifications for the others Romanian listed companies: there are significant differences between the impact on banks and the impact on the other companies. For the Romanian listed companies, with non-financial activities, the impact was rather limited (results according to the ones reported by Săcărin, (2014)): a slight increase of the shareholders' equity, a significant decrease of the result. Istrate (2014a), using Gray index of comparability and assuming that Romania is a *Code law country*, found a slight increase in equities, a significant decrease in net income, in return on equity (ROE) and in return on assets (ROA) and an increase in financial leverage (FL).

2.2 Relevant indicators for the analysis of companies with financial distress

The emergence of an uncertainty mood associated with the financial stability of companies displays significant effects on the socio-economic environment which integrates them by modifying the organizational or individual

strategies that are specific to a large category of partners, either the current (investors, creditors, clients, suppliers, personnel etc.) or future ones. On this basis, Brédart (2014) signals the importance of identifying the predictors of the financial distress situations, a process which is highly researched in the literature. The author though supports the interpretation of the significance of the financial indicators only correlating them to the features of corporate governance, the last one being a fundamental factor that conditions the application of the ongoing concern of businesses.

To this extent, Gounopoulos & Polemis (2012) use, in order to determine the symptoms of the financial distress status of the companies in the UK, just composite financial indicators related to the financial structure and company performance, non-financial factors being excluded due to the difficulty of gaining credible information, especially from the companies dealing with insolvency. Only 4 out of the 10 tested indicators prove their relevance for the analyzed context, namely: Working Capital to Market Value (MV) plus Total Debt (DT); Working Capital to Market Value (MV) plus Total Debt (DT)); (Pre-Tax Earnings to Market Value plus Total Debt) and Earnings Before Interest and Tax (EBIT) to Market Value (MV) plus Total Debt (TD).

Lieu *et al*. (2008) notice that financial indicators related to the financial structure, solvency, profitability and the ones based on cash-flow remain the main variables of the early discovery of financial distress, but the analyses have high relevance if they involve the contribution of some non-financial factors resulted from the structure of the shareholders or the components of the management board. Trussel (2013) correlates, with the same purpose, the financial indicators to the qualitative variables such as size, age and the field the company operates in.

The significant impact of financial distress status of companies on the multiple fields of the economic horizon has led to the perpetuation of scientific debates on the topic, the diversity and variability of the environment conditions though limiting the possibility to identify a limited series of relevant indicators.

2.3. Research hypotheses

In 1980, Gray proposes a *conservatism index*, subsequently becoming the comparability index. This index was used to compare the accounting values from the application of different accounting regulations. Gray (1980); Weetman & Gray (1991), Street *et al*. (2000); Balsari *et al*., (2009), Gray *et al*. (2009), Liu (2009), Liu *et al*. (2010), Fifield *et al*. (2011) use Gray's index of comparability to analyze the differences between various sets of accounting regulations; most of the times, it is about the American vs. various European regulations (British, French, Netherland or Swedish ones), but lately, the comparison has been between the IFRS and other

regulations (American, European ones, etc.). We found an extensive literature review on the use of this index in Istrate (2013) and Istrate (2014a).

According to the Romanian Accounting Law 82/1991, annual financial statements of companies meeting a series of criteria, having the size and the performance provided by law have been the subject of the mandatory financial audit. At the same time, Romanian companies that use the IFRS are the BSE (Bucharest Stock Exchange) listed companies and are implicitly the subject of mandatory audit. Moreover, the literature specifies that the audit engagement carried out by audit companies that are included in the Big 4 are qualitatively better than the ones carried out by the companies that are not included in the Big 4 (Lawrence *et al*., 2011). The increase of the quality of the audit engagement can have a direct impact on the audit opinion and implicitly on the application manner of the IFRS by the Romanian BSE listed companies.

Starting from the results seen in the literature, regarding the existence of significant differences between the obtained values of some financial indicators calculated for the performant companies and the ones in financial distress, the study proposes the testing and validation of the following general and working hypotheses:

General hypothesis*: In Romania, the transition from RAS to IFRS has led to the emergence of significant differences between the reported accounting figures of the performant companies and the ones in financial distress.*

Working hypotheses

H_1: *For the Romanian BSE listed companies which are performant, comparability exists at the level of financial statements, providing the transition from the use of the RAS to the use of IFRS.*

H_2: *For the Romanian BSE listed companies in financial distress, there is no comparability at the level of financial statements, providing the transition from the use of RAS to the application of the IFRS.*

H_3: *The auditing of the financial statements by the auditors affiliated to the Big 4 leads to an increase of the information comparability in the financial statements, providing the transition from the use of RAS to the application of IFRS.*

3 METHODOLOGY AND DATA

The evaluation of the difference between the RAS and the IFRS will be made using Gray's comparability index. There are more versions of this index – we will use the version *in equation (1).*

$$Index\ of comparability\ (IC) = 1 - \left(\frac{NumbersIFRS - Numbers\ RAS}{|NumbersRAS|}\right) \quad (1)$$

The interpretation is simple: *a value of the index higher than 1 shows a decrease of the values in IFRS compared to the RAS, while a sub unitary index shows the opposite – an increase of the values due to the transition to IFRS.*

The transition to IFRS in 2012 within the individual financial statements was available for 69 Romanian listed companies. The starting point in establishing this sample was the list published in September 2012 by the monitoring body of the Stock Exchange (Romanian Securities and Exchange Commission – CVNM – *Comisia Națională a Valorilor Mobiliare* , included now in Financial Supervisory Authority - ASF - *Autoritatea de Supraveghere Financiară*- (http://www.cnvmr.ro/pdf/diverse/Lista-societati-incidente-OMF-2012.pdf, consulted on April 5th 2013). There were not included in the transition some businesses whose activities were highly intermediated on the financial market (SIF, the stock exchange itself and the Proprietatea Fund). From the CNVM, we have selected companies that had been declared in insolvency during 2011 (we found this information in their financial reports and on their websites), as well as companies with negative net assets on 31st of December 2011 (if not insolvent) – we have considered that their financial situation allows us to separate them from the other companies, based on the existing uncertainties regarding the ongoing concern assumption (besides, in most cases, the auditors showed their worries regarding the assurance of their ongoing concern). We thus reached a sub sample of 14 companies, all with the most varieties of non-financial activities.

The data were manually collected from the 2011 and 2012 financial statements of the Romanian listed companies – we compared the figures issued in 2011 (RAS) with the ones corresponding to 2011 (IFRS) found in the 2012 IFRS financial statements. Considering the specific situation of the companies in distress, we chose a series of 11 indicators to be analysed based on the principal structures of the financial statements:

- *NcA/TA = Non-Current Assets/ Total Assets*
- *CL/TL = Current Liabilities/ Total Liabilities*
- *ROS = Operating Income/ Sales (%)*
- *ROA = Operating Income/ Total Assets (%)*
- *ROE = Net Income/ Equities (%)*
- *FL = Total Liabilities/ Equities*
- *OI/OCF = Operating Income/ Operating Cash Flow*
- *PBT/TCF = Profit before Tax/ Total Cash Flow*
- *TA = Total Assets*

- *EQ = Equities*
- *OI = Operating Income*

Our choice for two indicators based on cash-flow is justified by our empirical findings of differences between the numbers according to RAS and the IFRS numbers concerning total cash-flow and operating cash flows - in 22 observations out of 69, there are such differences. This is explained by different definitions of cash equivalent in RAS vs. IFRS and also different criteria for the classification of cash-flows in operating, investing and financing.

In order to emphasize the specific elements of the impact caused by the first IFRS application on the companies in distress, we will compare the specific results of these companies with the same average indicators calculated for the other companies that had to move to IFRS. This comparison will be made in two steps: first, we will retain the other listed companies (55 companies) out of which we will exclude the ones with financial activity, keeping only the ones with non-financial activity for the analysis (51 companies).

Our analysis can continue with the verification of the profiles of the 14 companies in the sample before the 2011 period and after, in order to emphasize the possible premises of the distress in 2011, as well as for the identification of the possible effects (favourable or not) of the straightening activities in 2012 and 2013. Therefore, the total sample of the analysis includes a total number of 65 companies (51 performant and 14 in financial distress).

Testing the existence of significant differences between the values of the calculated indexes for the considered variables in the case of performant and non-performant companies has been made by using the analysis of variance - ANOVA (Jaba *et al.*, 2011). In order to test the influence of the audit company affiliation to the Big 4 on the decrease of the financial information comparability in the case of the performant and non-performant companies, the study uses the generalized linear models – GLM – (Field, 2005).

The generalized linear model used to test the influence of the company status (performant or in financial distress) as well as the affiliation to a certain auditor (Big 4 or not) on the calculated Gray's indexes for the proposed variables will be:

$$Gray\ Index\ (Variable) = \beta_0 + \beta_1 Status + \beta_2 Auditor + \beta_3 Status \cdot Auditor + \varepsilon \qquad (2)$$

where, β_1 measures the status' influence (*Performance* group being a reference point) on *Gray's index*, β_2 measures the influence of the affiliation to a certain auditor (*Big 4* being a reference) on *Gray's Index*, and β_3 measures the combined influence of the status and the affiliation to a certain auditor on *Gray's Index.*

In order to increase the accuracy and precision of the results, the *smoothing* procedure was used (Filip and Raffournier, 2010), where the outliers were replaced with the values of the 5 and 95 percentiles.

Data processing and the research results have been obtained using the SPSS 20.0 statistical software.

4. RESULTS AND DISCUSSIONS

Considering the research aims of this study, firstly, the main obtained results aim to estimate the descriptive statistics for Gray's indexes calculated for the variables that were proposed in the study. Descriptive statistics are calculated at the level of the whole sample as well as in groups depending on the company status (*Performance* or *Distress)* or on the affiliation of the auditor to the Big 4. In the second stage, the existence of significant differences on the variation of Gray's index was estimated using ANOVA, separately calculated for each variable, depending on the company status or the affiliation of the auditor to the Big 4. In the third stage, for indexes displaying significant differences the company status influence and the influence of the auditor's affiliation to the Big 4 (separately and combined) on the Gray's index variation were estimated, calculated for each variable that was used for the analysis.

Subsequently to the calculus of the comparability index for all variables in the analysis, a series of descriptive statistics was estimated for the whole sample but also for groups of financial performance, depending on the company's status. The obtained results are presented in Table 1.

Table 1: Descriptive statistics for Gray Indexes estimated for the proposed variables, for firms with financial performance and financial distress

Gray Index	Firms status	N	Mean	Std. Deviation
NcA/TA	Performance	51	0,9795	0,13429
	Distress	14	0,9920	0,09704
	Total	65	0,9822	0,12661
CL/TL	Performance	51	1,0441	0,15597
	Distress	14	1,0198	0,16324
	Total	65	1,0389	0,15658
ROS	Performance	51	1,2599	0,98298
	Distress	14	1,5107	1,20338
	Total	65	1,3139	1,02948
ROA	Performance	51	1,1705	0,54842
	Distress	14	1,3196	0,80890

Gray Index	Firms status	N	Mean	Std. Deviation
	Total	65	1,2026	0,60967
	Performance	51	1,3711	0,90900
ROE	Distress	14	1,4803	1,02743
	Total	65	1,3946	0,92844
	Performance	51	0,8991	0,19125
FL	Distress	14	1,0084	0,08775
	Total	65	0,9226	0,17941
	Performance	51	0,8377	0,95831
OI/OCF	Distress	14	0,6487	1,22949
	Total	65	0,7970	1,01520
	Performance	51	0,9398	0,79480
PBT/TCF	Distress	14	0,7281	0,94932
	Total	65	0,8942	0,82721
	Performance	51	1,0003	0,07456
TA	Distress	14	0,9890	0,07779
	Total	65	0,9979	0,07479
	Performance	51	1,0169	0,17006
EQ	Distress	14	0,9834	0,39690
	Total	65	1,0097	0,23406
	Performance	51	1,2152	0,77837
OI	Distress	14	1,4589	1,07536
	Total	65	1,2677	0,84759

Source: own processing in SPSS 20.0

Based on the data in Table 1, we can notice that the means of Gray's indexes that were calculated for the *CL/TL, ROS, ROA, ROE* and *OI* show supra-unitary values both for the performing companies and the ones in financial distress. This shows that the accounting figures have decreased after the implementation of IFRS, compared to the ones reported in the case of RAS use. For the *Nc/TA, OI/OCF* and *PBT/TCF* variables, the values of Gray's indexes are sub-unitary for both company categories, which show an increase in the accounting figures resulted from the use of IFRS, compared to the ones obtained after the use of RAS. But, a particularity is represented by the *FL, TA* and *EQ* indicators, for which the values of Gray's indexes display supra-unitary values in the case of performant companies (the values diminished after the use of IFRS, as a sign of prudence, at least in the case of assets recognition and net equity), while for the companies with financial distress, the calculated indexes reported sub-unitary values (the increase of the accounting figures as the result of the IFRS use in the case of total liabilities shows the use of prudence in financial reporting).

Depending on the affiliation of the auditor that audited the financial statements of the companies in the sample, to the Big 4 or Non Big 4, Table 2 displays a series of descriptive statistics, on auditors' categories and on the whole sample.

Table 2: Descriptive statistics for Gray Indexes estimated for the proposed variables, for firms audited by Big 4 or by Non Big 4 auditors

Gray Index	Auditor	N	Mean	Std. Deviation
	Big 4	18	1,0003	0,02662
NcA/TA	Non Big 4	47	0,9752	0,14786
	Total	65	0,9822	0,12661
	Big 4	18	0,9954	0,12898
CL/TL	Non Big 4	47	1,0555	0,16414
	Total	65	1,0389	0,15658
	Big 4	18	1,5724	1,40229
ROS	Non Big 4	47	1,2149	0,84361
	Total	65	1,3139	1,02948
	Big 4	18	1,3564	0,82786
ROA	Non Big 4	47	1,1437	0,50106
	Total	65	1,2026	0,60967
	Big 4	18	1,7300	1,08946
ROE	Non Big 4	47	1,2662	0,83653
	Total	65	1,3946	0,92844
	Big 4	18	0,9596	0,08755
FL	Non Big 4	47	0,9085	0,20301
	Total	65	0,9226	0,17941
	Big 4	18	0,8163	1,13710
OI/OCF	Non Big 4	47	0,7896	0,97770
	Total	65	0,7970	1,01520
	Big 4	18	0,7757	0,89761
PBT/TCF	Non Big 4	47	0,9396	0,80416
	Total	65	0,8942	0,82721
	Big 4	18	0,9936	0,03216
TA	Non Big 4	47	0,9995	0,08597
	Total	65	0,9979	0,07479
	Big 4	18	1,0169	0,24570
EQ	Non Big 4	47	1,0069	0,23213
	Total	65	1,0097	0,23406
	Big 4	18	1,5225	1,23599
OI	Non Big 4	47	1,1701	0,63231
	Total	65	1,2677	0,84759

Source: own processing in SPSS 20.0

Based on the data in Table 2, we can notice that for the *ROS, ROA, ROE, EQ* and *OI*, the values of the calculated Gray's indexes display supra-unitary values, irrespective if the auditor is affiliated to the Big 4 or not. These results emphasize the fact that the auditor's affiliation or not to the Big 4 did not influence the decrease of the accounting figures after the use of IFRS. For the *FL, OI/OCF, PBT/TCF* and *TA* variables, the values of the calculated Gray's indexes report sub-unitary values for the companies that are audited by auditors who are affiliated to the Big 4 as well as for the ones that are not affiliated.

Significant differences can be seen in the case of *Nc/TA* and *CL/TL*. Companies audited by the auditors in Big 4 display supra-unitary values of the calculated Gray's index for the *Nc/TA* variables, and the ones audited by non-Big 4 auditors display sub-unitary values of the calculated index of the same variable. Supra-unitary values of the calculated index for the *Nc/TA* emphasize a decrease of the accounting figures after the IFRS use, which is imposed by the Big 4 auditors, according to the principle of prudence. For the companies that were audited by Non Big 4 auditors, we can notice a supra-evaluation of the current assets after the use of IFRS.

In case of *CL/TL*, the values of the calculated Gray's index show an increase of the accounting figures (current liabilities) after the use of IFRS, for the audited companies by Big 4 auditors and an increase of the same figures for the companies that are audited by Non Big 4 auditors. Based on these results, we may conclude that the Big 4 auditors enforce the use with a higher strictness of the principle of prudence in the case of the IFRS use compared to the non-Big 4 auditors.

Testing the existence of significant differences between the values of Gray's indexes, calculated for different firms categories (determined depending on the status and the auditor's affiliation to the Big 4) has been carried out using ANOVA.

Table 3 shows the influences of the company's performance (on the two categories: *Performance* and *Distress)* on Gray's indexes of comparability, calculated for the variables proposed in the analysis.

Table 3: ANOVA results for testing the differences between Gray Indexes for categories of financial status (performance or distress), and categories of auditors (Big 4 or Non Big 4)

Gray Index	**Financial Status (Performance or Distress)**		**Auditor (Big 4 or Non Big 4)**	
	F	**Sig.**	**F**	**Sig.**
NcA/TA	0,106	0,746	0,507	0,479
CL/TL	0,260	0,612	1,945	[iv]0,168
ROS	0,649	0,424	1,583	[v]0,213
ROA	0,654	0,422	1,599	[v]0,211
ROE	0,150	0,700	3,369	[ii]0,071

Gray Index	Financial Status (Performance or Distress)		Auditor (Big 4 or Non Big 4)	
	F	Sig.	F	Sig.
FL	4,284	[i]0,043	1,056	0,308
OI/OCF	0,377	0,541	0,009	0,925
PBT/TCF	0,716	0,401	0,507	0,479
TA	0,246	0,621	0,078	0,780
EQ	0,222	0,639	0,023	0,879
OI	0,907	0,345	2,296	[iii]0,135

[i] Significant differences for a risk of 5%; [ii] Significant differences for a risk of 10%; [iii] Significant differences for a risk of 15%; [iv] Significant differences for a risk of 20%; [v] Significant differences for a risk of 25%

Source: own processing in SPSS 20.0

We may notice in Table 3, that, for a 5% risk, the financial performance of the company (part of the *Performance* or the *Distress* category) has significantly contributed to the reporting of significant differences only for the Gray's index calculated for *FL*. In this case we can assume that the financial performance of the company has significantly influenced the recognition manner of the accounting figures as a result of the transition from the RAS to IFRS, with direct impact on the indebtedness degree. For the rest of the indicators, we can notice that the values of Gray's indexes have not been influenced by the financial performance of the company (status). In this case, the accounting figures have not been influenced by the performance of the company when the transition from the RAS to the IFRS had been made. *Table 3* also displays the influence of the auditor's affiliation to the Big 4 on the manner of accounting figures recognition, and implicitly on the variation of Gray's indexes. For different levels of risk (5%, 10%, 15%, 20% and 25%), we may observe, based on data shown in *Table 3* that the affiliation of the auditor to the Big 4 has significantly contributed to the reporting of differences regarding the values of the calculated indexes for the two company categories. In the case of the *CL/TL, ROS, ROA, ROE* and *OI* indicators, auditing the financial statements of the company has significantly influenced the manner of accounting figures recognition as a result of the transition from the RAS to the IFRS. For the *Nc/TA, FL, OI/OCF, PBT/TCF, TA* and *EQ* indexes, we can notice that the values of Gray's indexes were not influenced by the auditor when the transition from the RAS to the IFRS had been made.

Testing the influence of the financial performance (depending on the two categories: *Performance* or *Distress*) and the auditor (depending on the affiliation to the Big 4 or Non Big 4) on the variation of Gray's indexes, calculated for the variables suggested in the analysis, was carried out using the generalized linear models (GLM).

After the use of GLM on the calculated Gray's indexes, only the results showing a significant influence of the performance (on categories) and the auditors on the variation of the accounting figures' values after the transition to the IFRS have been retained. The results of the analyses have been presented in *Tables 4,5,6,7* and *8*. The β corresponding to the categorical variables (*Status, Auditor* and their combined effect, *Status Auditor*) show the differences that appear at the level of the Gray's indexes' values for the performant companies and the ones in financial distress (β_1), for the companies that are audited by the auditors in the Big 4, compared to the ones that are audited by the Non Big 4 auditors (β_2), as well as the combination of their effects (β_3, indicates the ratio that the value of the calculated Gray's index for a performant company which is audited by an auditor in the Big 4 is higher that the values of the indexes calculated for the other categories of companies).

Table 4 shows the estimates of the parameters of the model where the influence of the company performance and affiliation to a certain auditor on the Gray's index calculated for the *ROS* is analyzed. Based on the obtained results, we can state that the value of Gray's index, calculated for the ROS, is positively influenced by the financial performance and the auditor's affiliation to the Big 4. It means that a performant company which is audited by an auditor in the Big 4 will report a decrease in the *ROS* value as a result of IFRS use, but the combined effect of the factors will lead to an increase of the *ROS* value.

Table 4: Parameters estimates of the influence of financial status and auditor on the Gray Index for ROS

Dependent Variable: Gray Index (ROS)						
Parameter	**β**	**Std. Error**	**t**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Intercept	-0,706	1,519	-0,465	0,644	-3,744	2,332
Status	2,073	1,131	1,833	[i]0,072	-0,189	4,335
Auditor	1,051	0,862	1,219	0,227	-0,673	2,776
Status * Auditor	-1,113	0,652	-1,706	[i]0,093	-2,418	0,192

R Squared = 0,076

[i] Significant estimation for a risk of 10%

Source: own processing in SPSS 20.0

Table 5 presents the estimates of the parameters of the model that analyzes the influence of the company performance and the affiliation to a certain auditor on Gray's index calculated for *ROA*. Based on the obtained results, we may state that the value of Gray's index calculated for *ROA* is positively influenced by the financial performance and the auditor's affiliation to the Big 4. It means that a performant company which is audited by an auditor in the Big 4 will report a decrease of the *ROA* value after the use of IRFS, but the combined effect will lead to an increase of the *ROA* value.

Table 5: Parameters estimates of the influence of financial status and auditor on the Gray Index for ROA

Dependent Variable: Gray Index (ROA)						
Parameter	**β**	**Std. Error**	**t**	**Sig.**	**95% Confidence Interval** **Lower Bound**	**Upper Bound**
Intercept	-0,275	0,890	-0,309	0,758	-2,055	1,505
Status	1,452	0,662	2,192	[i]0,032	0,128	2,777
Auditor	0,790	0,505	1,563	[ii]0,123	-0,221	1,800
Status * Auditor	-0,793	0,382	-2,076	[i]0,042	-1,558	-0,029

R Squared = 0,096
[i] Significant estimation for a risk of 5%
[ii] Significant estimation for a risk of 15%
Source: own processing in SPSS 20.0

Table 6 displays the estimates of the parameters of the model that analyzes the influence of the company performance and the affiliation to a certain auditor on Gray's index calculated for *ROE*. In this case, we can appreciate that the value of Gray's index calculated for the *ROE* is positively influenced by the financial performance and by the auditor's affiliation to the Big 4. For a performant company which is audited by a Big 4 auditor, we will notice a decrease of the *ROE* value after using the IFRS, but the combined effect of the factors will lead to an increase of the *ROE* value.

Table 6: Parameters estimates of the influence of financial status and auditor on the Gray Index for ROE

Dependent Variable: Gray Index (ROE)						
Parameter	**β**	**Std. Error**	**t**	**Sig.**	**95% Confidence Interval** **Lower Bound**	**Upper Bound**
Intercept	-0,466	1,340	-0,348	0,729	-3,145	2,212
Status	2,105	0,997	2,111	[i]0,039	0,111	4,099
Auditor	1,071	0,760	1,409	[ii]0,164	-0,449	2,592
Status * Auditor	-1,225	0,575	-2,129	[i]0,037	-2,375	-0,074

R Squared = 0,117
[i] Significant estimation for a risk of 5%
[ii] Significant estimation for a risk of 20%
Source: own processing in SPSS 20.0

Table 7 displays the estimates of the parameters of the model that analyzes the influence of the company performance and the affiliation to a certain auditor on Gray's index calculated for *OI/OCF*. In this case, we observe that the value of Gray's index calculated for the *OI/OCF* is negatively influenced by the financial performance and by the auditor's affiliation to the Big 4. For a performant company which is audited by a Big 4 auditor, we will notice an increase of the *OI/OCF* after using the IFRS but the combined effect of the factors will lead to a decrease of the *OI/OCF* value.

Table 7: Parameters estimates of the influence of financial status and auditor on the Gray Index for OI/OCF

Dependent Variable: Gray Index (OI/OCF)						
Parameter	**β**	**Std. Error**	**t**	**Sig.**	**95% Confidence Interval** **Lower Bound**	**Upper Bound**
Intercept	4,051	1,497	2,706	0,009	1,058	7,044
Status	-2,529	1,114	-2,270	[i]0,027	-4,757	-0,301
Auditor	-1,792	0,850	-2,109	[i]0,039	-3,491	-0,093
Status * Auditor	1,400	0,643	2,178	[i]0,033	0,115	2,685

R Squared = 0,078
[i] Significant estimation for a risk of 5%
Source: own processing in SPSS 20.0

Table 8 shows the estimates of the parameters of the model which analyzes the influence of the company performance and the affiliation to a certain auditor on Gray's index calculated for *OI*.

Table 8: Parameters estimates of the influence of financial status and auditor on the Gray Index for OI

Dependent Variable: Gray Index (OI)						
Parameter	**β**	**Std. Error**	**t**	**Sig.**	**95% Confidence Interval** **Lower Bound**	**Upper Bound**
Intercept	-0,478	1,237	-0,386	0,701	-2,952	1,996
Status	1,849	0,921	2,008	[i]0,049	0,008	3,691
Auditor	0,893	0,702	1,272	[ii]0,208	-0,511	2,298
Status * Auditor	-0,983	0,531	-1,850	[i]0,069	-2,045	0,080

R Squared = 0,096
[i] Significant estimation for a risk of 5%
[ii] Significant estimation for a risk of 20%
(Source: own processing in SPSS 20.0)

In this case, the financial performance and the auditor's affiliation to the Big 4 positively influence the value of Gray's index calculated for the *OI/OCF*. For a performant company which is audited by an auditor in the Big 4, an increase of the *OI* will be reported after the use of IFRS but the combined effects of the factors will lead to a decrease of the *OI* value as a result of performant companies that use conservatism during financial reporting.

5 CONCLUSIONS

The comparisons between different accounting standards represent a recurrent issue in the accounting research. The implementation of IFRS in Europe in 2005 has opened new lines of research for a large number of empirical studies which analyze the differences between the IFRS and the national accounting

standards that had been previously *used*. In Romania, the authorities have enforced the implementation of the IFRS in the financial statements of the BSE listed companies starting with the 2012 financial year. It allows us to analyse the gap between the IFRS and RAS. Earlier studies provided data on the listed companies that have a positive status now (Săcărin, 2014; Istrate, 2014a) or about banks (Istrate, 2014b) or on the context and perception of IFRS (Ionaşcu et al., 2014). We have analyzed the same data by using a comparability index, as well as a series of statistical tests, in order to identify the extent to which the impact of IFRS on the companies in financial distress is different to the impact on the others companies. We used Gray's index of comparability, applied on a number of 11 financial indicators, calculated based on the data in the statement of financial position, from the income statement and from the cash-flows statement. We also researched the impact of the auditor's category (big 4 vs. non big 4) on the transition to the IFRS. Our sample includes 14 companies in financial distress (insolvency and/or negative net assets) and other 51 companies.

Our results show us that there are indicators that can be included in the following patterns:

- Indicators for which the sense and dimensions of the change caused by the IFRS transitions are similar: *Noncurrent Assets/ Total Assets, Current Liabilities/ Total Liabilities;*
- Indicators for which the direction of the change is the same, but the change degree is significantly different: *ROS - Operating Income/ Sales, ROA - Operating Income/ Total Assets, ROE -Net Income/ Equity, Operating Income/Operating Cash Flow, Profit Before Taxes – Total Cash Flow, Operating Income,*
- Indicators for which the change direction is opposite but the differences are not significant, integrating in a neutrality gap of IFRS implementation: *Financial Leverage, Total Assets and Equity.*

By using ANOVA, we tested the existence of significant differences between the values of Gray's indexes calculated for different company categories. The financial performance of the company (affiliated to the *Performance* or *Distress* category) has significantly contributed to the reporting of significant differences just for the Gray's index calculated for *FL*. In this case, we notice that the financial performance of the company has significantly influenced the way of recognising the accounting figures as a result of the transition from the RAS to the IFRS, with direct impact on the leverage. For all the other indicators, we observe that the values of Gray's indexes had not been influenced by the financial performance of the company. The affiliation of the auditor to the Big 4 has also

significantly contributed to the reporting of differences within the values of the indexes that were calculated for the two categories of companies.

As a result of applying the GLM on the calculated Gray's indexes, only the results that display a significant influence of the performance (on groups) and the auditor's on the variation of the accounting figures' values were retained as a result of the transition from the RAS to the IFRS. The coefficients that were associated to the categorical accounting variables show differences that emerge within the values of Gray's indicators for performant companies and the ones in financial distress, for the companies audited by Big 4 auditors, compared to the ones that are audited by Non Big 4 auditors, as well as the combining of their effects.

The limits of the study especially consist in the reduced size of the sample but also in the lack of market data that would have allowed us to use different financial indicators. Future research aims to extend the size of the sample by including several financial periods in the analysis, before and after 2011. In this case, we will test the existence of accounting figures comparability in the periods before and after the transition from the RAS to the IFRS. Another line of future research aims to include other control variables in the analysis in order to test the effects of IFRS transition on the accounting figures by industry. It would also be interesting to compare our results with eventual studies that analyse similar situation in comparable states (in Eastern Europe) and evaluate the relevance of the accounting figures before and after the implementation of IFRS.

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A METHOD FOR SYSTEMIC RISK ESTIMATION BASED ON CDS INDICES

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Abstract: *The copula-GARCH approach provides a flexible and versatile method for modeling multivariate time series. In this study we focus on describing the credit risk dependence pattern between real and financial sectors as it is described by two representative iTraxx indices. Multi-stage estimation is used for parametric ARMA-GARCH-copula models. We derive critical values for the parameter estimates using asymptotic, bootstrap and copula sampling methods. The results obtained indicate a positive symmetric dependence structure with statistically significant tail dependence coefficients. Goodness-of-Fit tests indicate which model provides the best fit to data.*

Keywords*: copula, CDS, tail dependence, systemic risk.*
JEL Classification*: C15, C32, C51.*

1 INTRODUCTION

We propose a framework for systemic risk analysis based on a copula-GARCH type of model that allows for separate specification of the dependence structure from the marginal distributions. The empirical part analyses the credit risk dependence pattern, between real and financial sectors, at European level, as reflected by the iTraxx Senior Financial and Crossover CDS indices. These indices are highly representative aggregated indicators of credit risk in their respective sectors. Their most important features can be summarized as: forward looking indicators reflecting both market expectation and fundamentals with high liquidity maintained by a broad investor base and updated composition due to half-year roll-over. In addition to flexibility this set-up allows us to focus on individual risks of each sector as well as on the dependence structure that drives their joint behavior and leverages total risk.

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The literature on copula modeling is growing constantly. For a thorough introduction to copulas we refer to Joe (1997) and Nelsen (2006), the two key textbooks on dependence modeling from a statistical perspective. McNeiletal. (2005) provides a sound implementation of copula models in the context of quantitative risk management, while Embrechts et al. (2002) introduces the static representation of dependence via copulas. Patton (2006) lays down the foundation for multivariate financial time series applications of copulas and complements his research with a comprehensive empirical study in Patton (2012). Choros et al. (2010) presents the parametric and semi-parametric estimation methods for copulas on time series data. Patton (2009) gives an overall survey of copula applications to time series. Genest et al. (2009) and Remillard (2010) are two key references for Goodness-of-Fit tests for copulas.

The seminal finding in the copula modeling literature is due to Sklar (1959) who provides the formal approach to separate a joint distribution into independent margins and a copula. Accordingly, for every p-dimensional distribution F with corresponding margins F_i there exists a copula C such that:

$$F(y_1, \dots, y_p) = C(F_1(y_1), \dots, F_p(y_p)) \tag{1}$$

which is unique if all margins are continuous. Conversely:

$$C(u_1, \dots, u_p) = F\left(F_1^{-1}(u_1), \dots, F_p^{-1}(u_p)\right) \tag{2}$$

where $u_i = F_i(y_i), i = 1, \dots, p$. If F_i is continuous then the probability integral transformation$U_i = F_i(y_i)$is unique and $Unif\ (0,1)$distributed regardless of the original distribution of F_i. If $F$is p-times differentiable then the joint density is given by:

$$\begin{aligned} f(y) &= \frac{\partial^p}{\partial y_1 \partial y_2, \dots, \partial y_p} F(y) \\ &= \prod_{i=1}^{p} f_i(y_i) \frac{\partial^p}{\partial u_1 \partial u_2, \dots, \partial u_p} C\left(F_1(y_1), \dots, F_p(y_p)\right) \end{aligned} \tag{3}$$

The copula-GARCH class of models assumes certain parameters are time varying in an auto-regressive manner and their distributions are conditional on past information. In the context of this analysis we are interested in modeling the cross sectional dependence between time series data and therefore we employ an adapted version of Sklar's theorem introduced by Patton (2006). The distribution of Y_t conditional on$\mathcal{F}_{t-1} = \{Y_l : l \le t-1\}$ is decomposed into its conditional marginsand the corresponding conditional copula in the following manner:

$$\begin{aligned} &F(y|\mathcal{F}_{t-1}) = C\left\{F_1(y_1|\mathcal{F}_{t-1}), \dots, F_p(y_p|\mathcal{F}_{t-1})\right\} \\ &\text{with} \quad Y_{it}|\mathcal{F}_{t-1} \sim F_i(\cdot\,|\mathcal{F}_{t-1}), i = 1,2, \dots, p \end{aligned} \tag{4}$$

Fitting a copula on the unconditional probability integral transform will result in an unconditional copula model for the dependence. In a time series context however, it is necessary to condition on the available past information, which first requires the specification of the margins and then the copula that joins the series cross-sectionally. If we define the probability integral transform$U_{it} = F_i(Y_{it}|\mathcal{F}_{t-1})$, then the conditional copula of $Y_t|\mathcal{F}_{t-1}$ is given by $U_t|\mathcal{F}_{t-1} \sim C(\cdot|\mathcal{F}_{t-1})$. It isimportant to note here that both the margins and the copula have to be conditional on the same data set. Fermanian and Wegkamp (2012) have shown that using different information sets for conditional margins and copulas may result in a function F that is not a valid joint distribution. In empirical studies however, it may happen that marginal distributions are only dependent on their own lags, that is they are dependent only on a fraction of $\mathcal{F}_{t-1}$but this still satisfies the restrictionthat margins and copula must use the same data set. We will use the standard ARMA-GARCH approach to model the univariate distributions by specifying the following general model for each series:

$$Y_{it} = \mu_i(Y_{t-1}) + \sigma_i(Y_{t-1})\epsilon_{it} \tag{5}$$

where, $\epsilon_{it}|\,\mathcal{F}_{t-1} \sim F_i(0,1), \forall\, t$. The functional form of F_i makes the model parametric because the copula is fitted on the conditional distribution of the probability integral transform of the standardized residuals constructed as:

$$\hat{\epsilon}_{it} = \frac{Y_{it} - \mu_i(Y_{t-1})}{\sigma_i(Y_{t-1})}, i = 1,2,\dots,p \tag{6}$$

In general financial time series have fatter than normal tails and asymmetric shape. In particular, the tail distribution of the ARMA-GARCH process is heavier than that of a normal distribution. Thus, the parametric form of F_i has to be able to accommodate thicker than normal tails and possibly an asymmetric shape. With the correct functional form the Skew-t distribution can fulfill these requirements. In this study we tested different forms of skewed distributions and choose the flexible and thoroughly studied Skew-t form of Lambert and Laurent (2001), for its suitability to the data at hand. In addition to the location and scale this distribution has two more shapeparameters: the degrees of freedom $\nu \in (2,\infty)$ controlling the thickness of the tails and the skewness parameter $\gamma \in (0,\infty)$ controlling the asymmetry.

The paper proceeds as follows: Section 2 describes the dependence measures used to analyze the degree and pattern of associativity in data. In Section 3 we present estimation methods for parametric copula-GARCH models and simulation techniques to make inference on estimated parameters. Section 4 reviews the Goodness-of-Fit tests applicable to copula models. In Section 5 we describe the data, present the actual implementation and show the results. Section 6 concludes.

2 DEPENDENCE MEASURES

The literature on multivariate analysis provides a broad array of dependence measures, see Nelsen (2006, Chapter 5) for an in-depth description. In this study we will focus on rank correlation, quantile dependence and tail dependence for their specific property of being scale invariant which is a valuable characteristic providing guidance on the type of copula to use in order to better describe the data at hand.

Linear correlation plays an essential role in finance theory; however it is important to mention that this concept only applies in the context of multivariate elliptical distributions. A detailed discussion of the shortcomings of relying on linear correlation is given by Embrechts et al. (2002) who calls them ”fallacies” and describes their effects to multivariate simulation, a technique which we will intensively use for making inference on parameter estimates. One important property of copulas, namely that the dependence structure as summarized by a copula is invariant under increasing and continuous transformations of the margins allows for the specification of the Spearman's rank correlation directly as:

$$\begin{aligned} \rho_s &= \rho\big(F_1(Y_{1t}), F_2(Y_{2t})\big) \\ \hat{\rho}_s &= \frac{12}{T}\sum\nolimits_{t=1}^{T} U_{1t}U_{2t} - 3 \end{aligned} \tag{7}$$

which is simply the linear correlation of the probability integral transforms. Hence for continuous random variables is the linear correlation of their unique copula.$\rho_s$is constrained in $[-1,1]$with the boundaries being reached only if the variables are comonotonic or countermonotonic. A practical reason for using rank correlation is that it can be used to calibrate copulas to empirical data. Despite its appealing characteristics the rank correlation is only a scalar measure that gives an overall indication about the strength and sign of the dependence.

Quantile dependence measures the strength of the dependence between two random variables in the joint upper and lower tails of the support of their distribution. It can be estimated as:

$$\hat{\lambda}_q = \begin{cases} \dfrac{1}{qT}\displaystyle\sum\nolimits_{t=1}^{T} 1\{U_{1t} \le q \mid U_{2t} \le q\}, & 0 < q \le 0.5 \\ \dfrac{1}{(1-q)T}\displaystyle\sum\nolimits_{t=1}^{T} 1\{U_{1t} > q \mid U_{2t} > q\}, & 0.5 < q < 1 \end{cases} \tag{8}$$

and it provides a detailed description of the dependence at various points across the support of the two variables. By comparing the quantile dependences while moving away from the center towards the tails we gain information about the

asymmetry of the dependence structure and a clear indication about which type of copula is more appropriate to use.

According to Joe (1997) the concept of tail dependence relates to the amount of dependence in the upper or lower quadrant tail of the distribution. The motivation for looking at these coefficients is that they provide measures of extreme dependence and we describe them in terms of limiting conditional probabilities. Due to invariability to monotonic transformations, parametric tail dependence can be expressed directly in terms of copulas. For a bivariate copula the tail dependence coefficients are given by:

$$\lambda^L = \lim_{q \to 0^+} \frac{C(q,q)}{q} \; and \; \lambda^U = \lim_{q \to 1^-} \frac{1 - 2q + C(q,q)}{1 - q} \tag{9}$$

where, is said to have upper tail dependence if $\lambda^U \in (0,1]$ and lower tail dependence if $\lambda^L \in (0,1]$. If $\lambda^L = \lambda^U$then the copula is radially symmetric and if one coefficient is 0 than the copula is asymptotically independent in the respective tail. Calculation of these coefficients is straightforward, if the copula has a closed analytical form, as is the case with most elliptical and Archimedean copulas. Since we are particularly interested in making inference on the asymmetry of the dependence structure we will employ a slightly more involved method introduced by Chen et al. (2010) that allows for the computation of the copula parameter independently for each tail. Under the general censorship method of Chen et al. (2010) if $(U_1, U_2) \sim C$ then the upper tailcopula parameter θ^U conditional on $(U_1 > q, U_2 > q)$ is determined by maximizing the followinglog-likelihood:

$$\begin{aligned} \mathcal{L}(\theta^U) &= \frac{1}{T}\sum_{t=1}^{T} l_t(\theta^U) \\ l_t(\theta^U) &= \delta_{1t}\delta_{2t} \log c\,(\widetilde{U}_{1t}, \widetilde{U}_{2t}; \theta^U) \\ &+ \delta_{1t}(1-\delta_{2t}) \log \frac{\partial C(\widetilde{U}_{1t}, \widetilde{U}_{2t}; \theta^U)}{\partial U_1} \\ &+ (1-\delta_{1t})\delta_{2t} \log \frac{\partial C(\widetilde{U}_{1t}, \widetilde{U}_{2t}; \theta^U)}{\partial U_2} \\ &+ (1-\delta_{1t})(1-\delta_{2t}) \log C(\widetilde{U}_{1t}, \widetilde{U}_{2t}; \theta^U) \end{aligned} \tag{10}$$

where $\widetilde{U}_{1t} = max[U_{1t}, q]$ and $\widetilde{U}_{2t} = max[U_{2t}, q]$that is values less then q are replaces by q. Indicator functions $\delta_{1t} = 1\{U_{1t} > q\}$ and $\delta_{2t} = 1\{U_{2t} > q\}$ are used to retain in the log-likelihood function only the terms that are greater than q. Maximizing $\mathcal{L}$ requires closed forms for copula and partialdensities but these are readily available in most cases.

Inference on the estimated dependence statistics can be conducted either by using their asymptotic distribution or via simulation. We implemented a simulation algorithm based on bootstrapping to construct confidence intervals. Regardless of the computational burden the bootstrapping approach is rather convenient in comparison to the standard method of moments that relies on asymptotic properties. For the parametric case the algorithm is built around the stationary bootstrap of Politis et al. (1999)[Chapter, 3]. Asimilar parametric bootstrap can be found in Genest et al. (2006) for which the asymptotic validity has been established by Genest and Remillard (2008).

Algorithm 1 - Simulation procedure to determine confidence intervals for tail dependence statistics based on parametric marginal distributions:

(1)Estimate the model for margins and obtain the probability integral transforms (U_{1t}, U_{2t})

(2)Compute the dependence statistics $\{\tilde{\lambda}^q, \tilde{\lambda}^L \tilde{\lambda}^U\}$using the probability integral transformsfrom the actual data.

(3)Generate N samples of length T using the stationary bootstrap method to preserve the time dependence of data

(4) Estimate the model for margins on each of the N samples and obtain the probability integral transforms $\{U_{1t}^n, U_{2t}^n\}_{n=1}^N$

(5)Compute the dependence measures on each of the N samples to obtain $\{\tilde{\lambda}_n^q, \tilde{\lambda}_n^L, \tilde{\lambda}_n^U\}_{n=1}^N$

(6)Compute the $\alpha/2$ and $1-\alpha/2$ quantiles of$\{\tilde{\lambda}_n^q, \tilde{\lambda}_n^L, \tilde{\lambda}_n^U\}_{n=1}^N$intervalsto obtain $1-\alpha$ confidence intervals

(7) Compute p-values for the dependence statistics as: $p_n^i = \sum_{n=1}^N 1\{\tilde{\lambda}_n^i \geq \lambda_i\} / N,\ i \in q,L,U$

3 ESTIMATION AND INFERENCE

Estimation for copula models is usually done via Maximum Likelihood (ML). One may attempt to estimate margins and copula in one single optimization, however splitting the modeling into two steps can yield more insight and allow for more detailed analysis of the different model components. When margins are estimated parametrically the model is called parametric and inference about the copula amounts to what has been termed the inference-functions for margins (IFM) approach of Joe (1997). The properties of estimates derived using the single stage versus the IFM method, have both been studied in great theoretical detail in the

literature. In practice, estimation requires numerical optimization of the log-likelihood which in terms requires the derivation of copula density.

When using parametric models for the conditional distributions and the copula the log-likelihood is completely specified and the parameters can be estimated as:

$$\begin{gathered}\hat{\theta}_{ML} = \arg\max \log \mathcal{L}(\theta) \\ \log \mathcal{L}(\theta) = \sum_{t=1}^{T}\sum_{i=1}^{p} \log f_i(Y_{it};\theta_1) \\ + \sum_{t=1}^{T} \log c\big(F_1(Y_{1t};\theta_1), \dots, F_p\big(Y_{pt};\theta_1\big);\theta_2\big)\end{gathered} \tag{11}$$

where $\theta = [\theta_1, \theta_2]$ is the parameter vector for the full model.

In the following we will assume that the regularity conditions of Joe (1997) for parameter asymptotic distribution hold for the multivariate model as well as for all margins. Under these regularity conditions the maximum likelihood estimator exists, is consistent and asymptotically efficient and it has the property of being asymptotically normal:

$$\sqrt{T}\big(\hat{\theta}_{ML} - \theta\big) \to N(0, V_{ML}) \; for \; T \to \infty \tag{12}$$

where $V_{ML}$is the covariance matrix of $\hat{\theta}_{ML}$ which can be estimated by the inverse of the Hessianmatrix of the log-likelihood function using standard methods:

$$\begin{gathered}\hat{V}_{ML} = \hat{A}^{-1}\hat{B}\hat{A}^{-1} \\ \hat{A} = \frac{1}{T}\sum\nolimits_{t=1}^{T} \widehat{H}_t \; and \; \hat{B} = \frac{1}{T}\sum\nolimits_{t=1}^{T} \hat{s}_t \hat{s}_t' \\ \hat{s}_t = \frac{\partial}{\partial\theta} \log f_t\big(Y_t;\hat{\theta}_{ML}\big) \\ \widehat{H} = \frac{\partial^2}{\partial\theta\partial\theta'} \log f_t\left(Y_t;\hat{\theta}_{ML}\right)\end{gathered} \tag{13}$$

The canonical representation for the multivariate density function in (3) permits us to say that, in general, a statistical modeling problem for copulas could be decomposed into two steps: identification of the marginal distributions and specification of the appropriate copula function. Thus, IFM parameters are estimated as in:

$$\hat{\theta}_1 = \arg\max \sum_{t=1}^{T}\sum_{i=1}^{p} \log f_i(Y_{it};\theta_1) \tag{14}$$

$$\hat{\theta}_2 = \arg\max \sum_{t=1}^{T} \log c\left(F_1(Y_{1t};\theta_1), \dots, F_p\left(Y_{pt};\theta_1\right);\theta_2\right)$$

and $\hat{\theta}_{IFM} = [\theta_1, \theta_2]$ is the parameter vector estimated in stages. A critical point here is that asymptotic normality does not hold under model misspecification. This implies that the copula likelihood being maximized is not the true likelihood because it is influenced by parameter estimation error in the margins. The naive approach would be to just use the inverse Hessian of the copula likelihood as an estimate of the covariance matrix of the copula parameters but the result should be used with caution as it fails to account for the additional source of error. In order to incorporate the estimation error that propagates from the margins to the copula the following correct estimator should be used for the covariance matrix:

$$\begin{gathered}
\hat{V}_{ML} = \hat{A}^{-1}\hat{B}(\hat{A}^{-1})' \\
\hat{A} = \frac{1}{T}\sum_{t=1}^{T} \hat{H}_t \ \text{and}\ \hat{B} = \frac{1}{T}\sum_{t=1}^{T} \hat{s}_t\,\hat{s}_t' \\
\hat{s}_t = \left[\hat{s}_{1t}, \dots, \hat{s}_{pt}, \hat{s}_{ct}\right] \\
\hat{s}_{it} = \frac{\partial}{\partial\theta_{1i}} \log f_t\left(Y_t;\hat{\theta}_{1i}\right), i = 1,2,\dots,p \\
\hat{s}_{ct} = \frac{\partial}{\partial\theta_2} \log c\ \left(F_1\left(Y_{it};\hat{\theta}_{1,1}\right), \dots, F_p\left(Y_{pt};\hat{\theta}_{1,p}\right);\hat{\theta}_2\right)
\end{gathered} \tag{15}$$

Hessian has to be adjusted to account for marginal parameter estimation error. Asymptotic theory represents the first choice to estimate the parameter covariance matrix. The alternative is to compute standard errors by simulation in either of two ways: by stationary bootstrap or by simulation from copula.

Algorithm 2 - Simulation procedure to compute parametric ML standard errors

(1) Estimate the parametric model on actual data using the IFM

(2) Simulate via stationary bootstrap

(2.1) Generate N samples of length T using the stationary bootstrap method to preserve the time dependence of actual data

(3) Simulate via copula sampling

(3.1) Simulate N samples of length T by sampling from the copula

(3.2) Generate the standardized residuals by transforming the data using the inverse of the marginal conditional distribution

(3.3) Use the standardized residuals to recursively generate the simulated data using the fitted ARMA-GARCH process

(4) Estimate the same model on each of the N samples

(5) Use the distribution of $\{\hat{\theta}_n\}_{i=1}^{N}$ to obtain the standard errors

It is important to note that both the bootstrapping and copula simulation preserve the cross-sectional dependence of data. Time dependence is implicitly insured by the stationary bootstrap while in the copula sampling case it is induced by the recursive nature of the data generating process at Step (3.3).

4 GOODNESS-OF-FIT TESTS

Goodness-of-Fit (GoF) tests have become standard tools of summarizing model performance. We focused on in-sample Kolmogorov-Smirnov (KS) and Cramer-von Mises (CvM) test to assess the parametric distribution of the standardized residuals and copula performance. These are two of the most powerful test available. Our choice is further motivated by their suitability for copula inference and a broad scientific literature describing their theoretical characteristics. In the univariate case GoF tests provide the proper means to test if a set of observations comes from a completely specified continuous distribution. We use GoF tests to assess if the distribution of the AR-GARCH residuals is well-specified, or more specifically, to test whether the estimated probability integral transformations of the residuals come from a distribution that is statistically different from the cumulative distribution function of $Unif\ (0,1)$. This assessment is carried out by using the KS and CvM tests, as defined below:

$$KS_i = \max\left|\widehat{U}_{it} - \frac{t}{T}\right|$$
$$CvM_i = \sum_{t=1}^{T}\left(\widehat{U}_{it} - \frac{t}{T}\right)^2 \tag{16}$$

where $\widehat{U}_{it} = Skew - t(\hat{\epsilon}_{it}; \hat{\nu}_i, \hat{\gamma}_i)$is the t^{th} order statistic of $\{\widehat{U}_{it}\}_{t=1}^{T}$with $i = 1,2,\dots,p$. Unfortunately, when certain parameters for the distribution have to be estimated the KS and CvM testsdo not follow known distributions and their critical values have to be determined by simulation.In the multivariate case these tests share the same idea by using the empirical copula as a reference. The empirical copula converges uniformly to the underlying true copula and Nelsen (2006) notes that this concept permits us to define the sample version of many dependence measures as well as non-parametric tests for independence. Genest et al. (2009)

uses a simulation study to compare a range of copula GoF tests and concludes that the most powerful is the CvM test applied to the Rosenblatt transforms of the original data. This finding is also supported by Berg(2009) who considers a broader range of tests. Following their findings we conduct inference on model specification directly on the Rosenblatt transforms of the data generated by the fitted copula model. Broadly speaking, Rosenblatt transform represents the multivariate version of the probability integral transformation mapping the original data into a hypercube of mutually independent variables. In the bivariate case if $Z_{1t} = U_{1t}, \forall t$ and $Z_{2t} = C_{(2|1t)}(U_{2t}|U_{1t};\theta)$ where$C_{(2|1t)}$is thedistribution of U_{2t} conditional on U_{1t} then, according to Rosenblatt (1952), $Z_{1t}$and Z_{2t} are iid and $Unif\ (0,1)$ distributed. This approach can be extended to multiple dimensions by considering:

$$Z_{it} = \frac{\partial^{i-1} C(U_{1t}, \dots, U_{it}, 1, \dots, 1)}{\partial u_1, \dots, \partial u_{i-1}} \Big/ \frac{\partial^{i-1} C\big(U_{1t}, \dots, U_{i-1,t}, 1, \dots, 1\big)}{\partial u_1, \dots, \partial u_{i-1}}, i = 2, \dots, p \quad (17)$$

The advantage of this transformation is that $Z_t \sim C_{indep}$ if the conditional copula is correctly specified. Assuming that the empirical copula, as defined in (18), is the closest estimate to the true conditional copula we can use the KS_R and CvM_R, as defined in (20) and (21), to test if the independence copula defined in (19) is statistically different from the empirical copula estimated on the Rosenblatt transforms.

$$\hat{C}_R(z) = \frac{1}{T}\sum_{t=1}^{T}\prod_{i=1}^{p} 1\{Z_{it} \le z_i\} \quad (18)$$

$$C_R\big(Z_t;\hat{\theta}\big) = \prod_{i=1}^{p} Z_{it} \quad (19)$$

$$KS_R = \max\Big|C_R\big(Z_t;\hat{\theta}\big) - \hat{C}_R(Z_t)\Big| \quad (20)$$

$$CvM_R = \sum_{t=1}^{T}\big\{C_R\big(Z_t;\hat{\theta}\big) - \hat{C}_R(Z_t)\big\}^2 \quad (21)$$

In the absence of parameter estimation error GoF test statistics follow some known distribution (i.e.$\chi 2$). However, known parametric distributions are not applicable here because $KS_R$and CvM_R depend on $\hat{\theta}$, that is they are affected by estimation error both in marginal distributions and copula. This is the reason why simulation represents the most suitable method for determining p-values for KS_R and CvM_R tests. In the parametric case the simulation procedure is straight forward as it involves sampling and estimation of both marginal distributions and copula. Algorithm 3 describes the simulation procedure to generate viable p-values for KS_R and CvM_Rtests for parametric models.

Algorithm 3 - Simulation based procedure to determine copula GoF p-values

(1) Estimate the full model (margins and copula) on the actual data to obtain the vector $\hat{\theta}$ of parameter estimates

(2) Compute the GoF test statistics $G = \{KS;\ CvM\}$ on the original data set

(3) Simulate N samples of length T from the full model using the estimated parameter $\hat{\theta}$

(4) Estimate the full model on each of the N simulated samples to obtain $\hat{\theta}^{(n)}$

(5) Compute the GoF test statistics for each of the samples to obtain $G^{(n)} = \left\{KS^{(n)}, CvM^{(n)}\right\}_{n=1}^{N}$

(6) Compute the simulation based p-values as $p_{iN} = \sum_{n=1}^{N} 1\left\{G_i^{(n)} \geq G_i\right\}/N\,, i = 1{,}2$

5 IMPLEMENTATION AND RESULTS

Our goal is to describe the dependence between the iTraxx Europe Senior Financial and Crossover CDS indices as a measure of systemic risk between the real and financial sectors at European level. The study is divided in two phases. In the fist phase, we analyze the dependence pattern between the two series and make inference on their joint tail behavior in order to get an insight on what class of copula would be able to capture the dependency structure. In a second phase, we fit a copula-GARCH model and test for the statistical significance of the estimated parameters. One advantage of the copula-GARCH approach is the possibility to specify the model in stages. The marginal distributions are specified by an ARMA-GARCH model for each univariate time series and then a copula is estimated on the probability integral transforms of the standardized residuals. The result is a valid 2-dimensional joint distribution that is easier to estimate and interpret.

The Markit iTraxx Europe Senior Financial index comprises 25 equally weighted CDSs on investment grade European financial entities whereas the Markit iTraxx Europe Crossover index comprises 50 equally weighted CDSs on the most liquid sub-investment grade European corporate entities. The iTraxx indices are rules-based meaning that the selection methodology ensures they are replicable and represent the most liquid, traded part of the market. Composition of each index is determined by a liquidity poll and certain other criteria set up by the index rules. The constituents are changed every six months, on March 20 and September 20, in a process known as ”rolling” the index. Every time the index in rolled a series is created and for the time until the next roll it is called the on-the-run series. Investors can express their bullish or bearish sentiments related to the credit risk as an asset

class which makes the iTraxx indices very efficient as forward looking indicators. Given their liquidity and actualized composition we believe these indices are representative indicators of credit risk for their respective sectors. When analyzed together they reveal the interdependencies between the credit risk of financial and real sectors and therefore create a good reflection of systemic risk at European level. For the sake of brevity we will refer to these indices as SenFin and CROSS.

We proceed in analyzing the log-returns of the end-of-day quotations for the two indices with 5 years maturity. In order to construct a consistent time series we stitched together the log- returns of Series 5 to Series 19 creating a total of 1880 observations spanning the time period from 2006-03-21 to 2013-06-17. Each index series contributes to the final time series of returns only on the period while it is on-the-run (roughly 6 months). Every time a new series is created not only that it may have different constituents but its actual maturity is 6 months longer then the previously on-the-run series. This difference in maturities alone translates into a spread of about 10-15 bp between the old and new series. In order to avoid breaks the actual switch from one series to the other was made in the week following the roll-over on the day when the difference in returns calculated for the two series was the lowest. The return series time span is long enough to include both pre and post crisis market conditions and therefore it is representative of the long run connection between the credit risk of financial and real sectors. All data was retrieved from the Bloomberg Database.

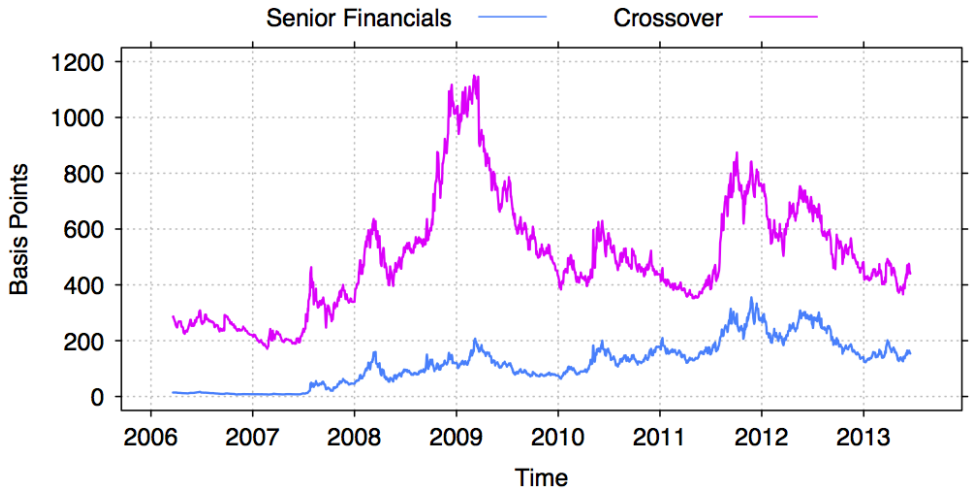

Figure 1: iTraxx Senior Financial and Crossover index levels

Figure 1 depicts the levels of the two indices during the analyzed period. There is clearly more variability in the CROSS index explained by its composition of sub-investment grade CDSs that react more vigorously to changing economic

conditions. Although not as volatile the SenFin index shows a steady upward trend indicating increasing risk in the financial sector. It is interesting to see that selling protection on SenFin was almost worthless up to September 2007 giving the false impression that financial institutions could not default. Another evident aspect form this chart is that the two indices have become more correlated from 2010 onwards. The support received from the European authorities benefited the financial institutions and kept SenFin index relatively stable hovering around 200 bp for the past 2 years. CROSS index followed the same path but with larger swings. An interpretation of this fact would be that systemic risk is not driven by credit risk of financial institutions but rather their inability to finance the real sector.

Table 1. Summary statistics for the returns of the two indices

	Financial	**Crossover**
Mean	0.1083	-0.0348
Std dev	4.7961	2.8720
Skewness	0.3146	0.0488
Kurtosis	10.7897	3.1590
Corr Pearson	0.7804	
Corr Spearman	0.7907	

The summary statistics presented in Table 1 indicate the returns on the two indices have fat tails and possibly skewed distributions. Both linear and rank correlation coefficients give a first indication that risks in the two sectors are dependent. Understanding the dependence pattern is important when choosing the copula to model this dependence. The scatter plot in Figure 2 gives a visual interpretation to the correlation coefficients in Table 1 and clearly reveals an elliptical shape with positive dependence between the returns of the two indices. This pattern is well-suited for the classes of elliptical as well as Archimedean copulas. The visual inspection of the dependence enables us to make several more assumptions that will be statistically tested later on: there is asymmetric dependence with returns more concentrated in the lower tail, there appears to be more mass in the upper tail and extreme returns tend to be correlated.

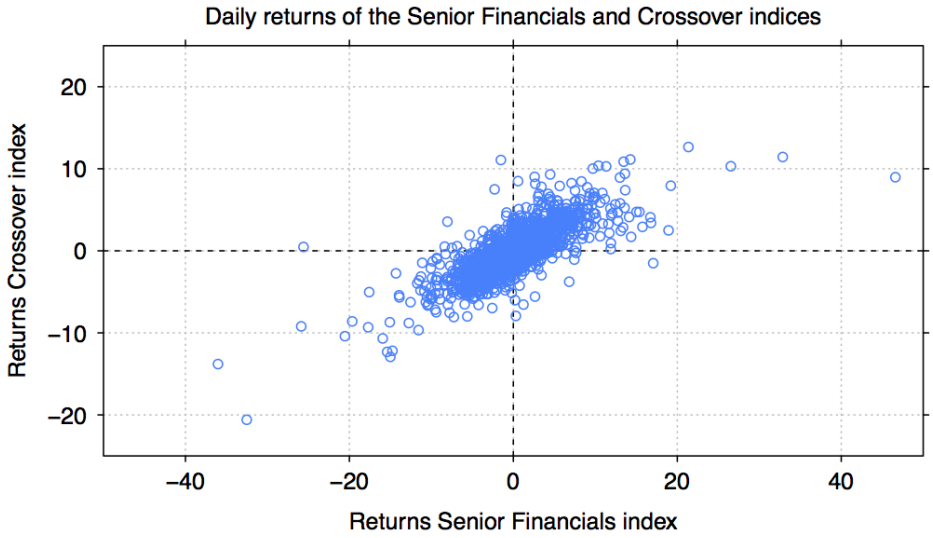

Figure 2. Scatter plot with isometric scales of daily returns of the two indices

Applying an ARMA-GARCH process to the return series of the two indices removes the temporal correlation but preserves the cross-sectional dependence. As most asset returns, our series are not stationary and therefore we followed the standard mean-variance model building approach to make our series temporal independent. The order for the mean equation was determined by comparing the BIC of ARMA models of orders up to 5. An AR(1) process was optimal for both series and this decision has also been confirmed by the partial autocorrelation function of the squared log-returns. Then, we used the squared residuals from the mean equation to test for ARCH effects. Applying the Ljung-Box test on the first 12 squared log-returns revealed p-values very close to zero which gives strong indication of rejecting the null and a motivation to introduce a conditional variance equation. In addition to auto-regressive models we tested for cross-correlation by regressing one series on up to 5 lags of the other series. The coefficients came out not significant at 5% level. This finding together with the shape of the scatter plot in Figure 2 is a strong indication that the two series are not linearly correlated but dependent. Empirical studies have shown that asset returns have fatter tails than the normal distribution can capture. Besides fat tails, empirical distributions of asset returns may also be skewed. To handle these characteristics we used a skewed version of the Student-t distribution. We adopted the specific form of Lambert and Laurent (2001) for its suitability to ARCH processes. Taking all the above into consideration, we implemented this form of mean-variance modeling:

$$r_{i,t} = \phi_0 + \phi_1 r_{i,t-1} + e_{i,t}$$
$$e_{i,t} = h_{i,t}\epsilon_{i,t}, \epsilon_{it} \sim Skew - t(\nu, \gamma) \quad (22)$$
$$h_{it} = \omega_{i,t} + \alpha e_{i,t-1}^2 + \beta h_{i,t-1} + \delta e_{i,t-1}^2 \mathbf{1}\{e_{i,t-1} \leq 0\}$$

where $r_{i,t}$ are the log-returns of the two indices and $\epsilon_{it}$is computed according to (6). Despite the fact that we specified the model in steps estimation was performed in one single optimization using pseudo Maximum Likelihood. Empirical research has also found that returns display alternating periods of high and low volatility with asymmetric impact of innovations. This is why we introduced the asymmetry parameter δ, to capture this kind of leverage effects, however it came out to be insignificant and was dropped from the model. Again, we used BIC to chose among the various AR-GARCH models tested and the results revealed that an AR(1)-GARCH(1,1)-Skew-t model was optimal for both series. Table 2 presents the results of the conditional mean and variance model with standard errors based on Hessian.

Table 2. Parameter estimates for AR-GARCH processes with Skew-t residuals

	Financial		**Crossover**	
	Estimate	**Std.error**	**Estimate**	**Std.error**
ϕ_0	0.1009	0.0581	−0.1596	0.0542
ϕ_1	0.1225	0.0239	0.1137	0.0241
ω	0.2132	0.0836	0.2054	0.0670
α	0.1511	0.0227	0.1184	0.0186
β	0.8562	0.0185	0.8613	0.0204
γ	1.0244	0.0323	1.0109	0.0322
ν	5.9909	0.8274	8.9832	1.6732

A positive mean confirmed by a positive conditional mean for the SenFin returns provides a clear indication that the European financial sector credit risk has been steadily increasing over the analyzed period. On the other hand the conditional mean for the CROSS index indicates an alleviation of credit risks in the real sector. While highly statistically significant γ indicates a very low degree of skewness for both SenFin and CROSS conditional distributions, meaning that both high and low risk situations are equally likely to occur. ν denotes fat tails and its values are consistent with the range of the returns depicted in the isometric scatter plot of Figure 2.The choice for the parametric distribution of the standardized residuals is of crucial importance because it generates the underlying data on which the parametric model is specified. The longer right tails for both SenFin and CROSS indices are consistent with the sign of the skewness parameter in Table 1 and the γ parameter.

As it was pointed out in Section 4 the KS and CvM test statistics follow a known distribution only in the absence of parameter estimation error. In the context of this analysis the conditional distributions of the residuals depend on the parameter estimates of the ARMA-GARCH processes and therefore we resorted to a simple simulation procedure, based on Genest and Remillard (2008), to determine reliable p-values: (1) simulate a sample of length T for each return series using the model with the estimated parameters, (2) re-estimate the model on the resulted sample, (3) compute the test statistics $G^{(n)} = \{KS;\ CvM\}$ on the probability integral transforms of the sample, (4)repeat steps (1)-(3) N times and (5) compute the p-values as:$p - value = \sum_{n=1}^{N} 1\{G^{(n)} \geq G\}/N$. Table 3 presents the results of the GoF tests in (16) applied to the standardized residuals of the two indices. Under the null the test assumes that the distribution is well specified. Analyzing the p-values returned after performing $N = 10^4$ simulations we fail to reject the null hypothesis and therefore we have a strong indication that the Skew-t model is well-specified.

Table 3. p-values for GoF tests for the Skew-t distribution fitted to the residuals of AR-GARCH

	Financial		**Crossover**	
	Test	***p*-value**	**Test**	***p*-value**
KS	0.0265	0.1640	0.0267	0.1120
CvM	0.2487	0.2430	0.1583	0.1870

Our reason for looking at rank correlation is because it provides information on the sign of the dependence between the two indices and gives us a valuable indication on which types of copulas to use. The rank correlation of standardized residuals, calculated according to (7), is 0.7779. Using a simple *iid* bootstrap we computed a 90% confidence interval (CI) of $[0.7597, 0.7952]$. Unlike elliptical copulas, Archimedean copulas can only capture positive dependence and having a statistically significant positive rank correlation justifies the application of these copulas.Of course the parametric copula chosen for the tail dependence must be able to capture tail dependence. Even more so, the copula must provide non-zero tail dependence in the specific tail on which is to be used. The Gumbel copula is also an extreme value copula and according to Caperaa et al. (2000), Archimedean copulas that belong to a domain of attraction are necessarily in the domain of attraction of the Gumbel copula. Hence, in an Archimedean framework, the Gumbel copula seems to be a natural choice regarding tail dependence estimation.

In order to better describe the tail dependence in our data set we have used 2 approaches: the Gumbel copula as representative of the Archimedean class and for the reasons outline above and the Student-t copula as representative of the elliptical

class. The tail dependence coefficients are computed according to (9) parameterized with the Gumbel or Student-t copulas. The parameters for each copula have been computed independently for each tail by maximizing (10). The estimated tail copula parameters are $\theta^L = 1.5469$ and $\theta^U = 1.3557$ for the Gumbel copula and $\theta^L = \{0.6590, 5.49\}$ and $\theta^U = \{0.5475, 5.53\}$ for the Student-t copula. Having a separate parameter foreach tail assures that the parametric copula is calibrated specifically to capture the dependence in that particular tail. The Gumbel copula can only capture upper tail dependency therefore we had to rotate the data to model lower tail dependency. Point-wise CI are computed using the simulation procedures described in Algorithm1. Table 4 presents the tail dependence coefficients together with 90% CI and p-values.

Table 4. Estimates of tail dependence

		Gumbel		**Student-t**	
Lower tail dependence	λ^L	0.4346		0.2885	
	90% CI	0.3368	0.5514	0.2317	0.4151
Upper tail dependence	λ^U	0.3325		0.2123	
	90% CI	0.2151	0.4298	0.1793	0.3537
$p-value\ H_0: \lambda^L = \lambda^U$		0.4414		0.3845	

A word of caution regarding the threshold level q. The threshold q has to be chosen in advance and this introduces a trade-off between variance and bias in the estimator. The closer q is to the boundary of the support the smaller the bias but the larger the variance. In practice, however, this cut-off points are somehow chosen arbitrarily. Our choice is $\{0.025, 0.975\}$.The first conclusion stemming from the results in Table 4 is that there is no asymmetricdependence in the tails. p-values indicate that we fail to reject the null on both cases. The second conclusion is that all tail dependence coefficients are statistically significant. None of the confidence intervals include zero. From a financial point of view these two conclusions provide strong evidence supporting systemic risk. This means that, at the limit, the financial and real sectors credit risks are linked regardless of the direction. Extreme credit risk events, such an economic crisis, cannot happen independently in one sector without affecting the other.

Quantile dependence parameters provide a more comprehensive description of the dependence at various quantiles. We have calculated the quantile dependence coefficients using (8) at quantiles set up at intervals of 0.025 in $[0.025, 0.975]$. Figure 3 presents the results with the gray shaded area representing the CI for the quantile dependence coefficients and the pink shaded area denoting the point-wise CI of tail dependence. CI have been calculated using Algorithm 1. The right side plot present the difference in quantile and tail dependence

coefficients with their respective CI and give a wonderful visual interpretation of the symmetric dependence. It is clear that the CI includes the zero line which indicates that we cannot reject the null $H_0 : \lambda_q = \lambda_{1-q}, \forall\, q$.

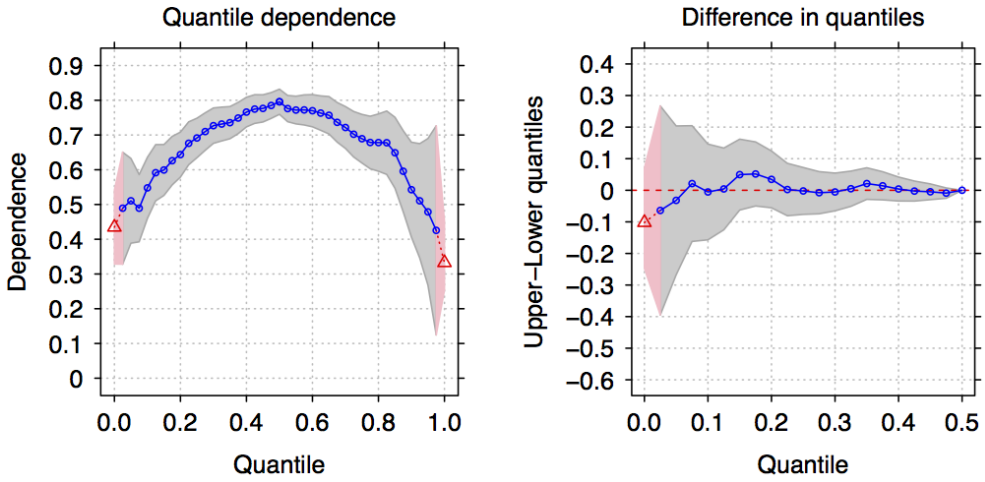

Figure 3. Quantile dependence coefficients and confidence intervals

In order to model the full dependence structure in our data set we use 2 elliptical and 2 Archimedean copulas as follows: 1) The Normal copula has become the standard tool in dependence modeling and despite its inability to capture tail dependence we use it as a benchmark. 2) The elliptical shape of the scatter plot of returns together with the findings about tail dependence lead us to believe that the Student-t copula may be the most appropriate to describe the dependence between the two return series. 3) Even though the upper and lower tail coefficients are not statistically different the quantile dependence computed for lower quantiles are higher than the ones computed for upper quantiles. This is consistent with the data being denser in the lower half of the support. In order to accommodate this empirical pattern we will use the Gumbel copula which has asymmetric contour diagrams with stronger upper tail dependence and shows more variability and mass in the negative tail. Because the characteristics of the Gumbel copula are exactly the opposite to what our data exhibits we used the rotated form.4) Clayton copula has more mass in the upper tail while creating lower tail dependence - which is consistent with larger lower quantile dependence coefficients.

In the multi-stage copula-GARCH framework estimation for copulas is straightforward because the optimization is performed over one or two parameters. One could envisage using the two-stage method to decide on the most appropriate copula family and then estimate all parameters (marginal and copula) in a final fully parametric round of estimation. Given the large sample of our data set we did

not proceed with this approach and relied on multi-stage IFM.Tables 5 presents the estimation results for parametric models using the methods described in Section 3. The first column presents the copula log-likelihood while the second presents the estimated parameters calculated according to (14). The third column presents the Kendall's τ coefficient equivalent to the copula parameters. The Kendall's τexpresses the strength of the dependence in the same units and therefore represents a feasible method of assessing the degree to which the copula is able to capture the dependence. The last four columns present the standard errors of parameter estimates calculated according to the following four methods: 1) the naive method, that is directly from the Hessian of the copula log-likelihood function, 2) the correct multi-stage ML methods described in (15), 3) simulation by stationary and *iid* bootstrap and 4) simulation by copula sampling. The simulations are performed for $N = 10^4$repetitions according to the procedure described in Algorithms 2.According to our *a priori* expectations, based on tail dependence analysis, the Student-t copula performed best as indicated by the largest log-likelihood value. This finding has at least two explanations. First, this copula's characteristics are closest to the pattern exhibited by our data set and in particular it is the only copula that has both lower and upper tail dependency. Second, it is the only copula with two parameters benefiting from the flexibility of a parameter that controls exactly the thickness in the (multivariate) tails.

Table 5. Copula parameter estimates and standard errors

		Parameters		**Standard errors**			
	$\mathcal{L}$	θ	τ	**Naive**	**MSML**	**Bootsrap**	**Simulation**
Normal	899.7	0.7848	0.5744	0.0071	0.0193	0.0184	0.0087
Student-t	948.9	0.7951	0.5851	0.0082	0.0152	0.0182	0.0098
		5.49		0.0261	0.1221	0.0298	0.0332
Rotated Gumbel	889.1	2.2773	0.5608	0.0433	0.1044	0.1037	0.0613
Clayton	727.8	1.7982	0.4733	0.0604	0.1737	0.1441	0.1358

The Normal copula provides the second best fit. This is somehow surprising because this copula cannot capture tail dependence. This is an indication that tail events have a low weight in setting the strength of the dependence. The rotated Gumbel copula performed relatively poor, below the benchmark set by the Normal. This stems from the fact that our data set has both lower and upper tail dependency and this copula can only properly describe one tail at a time. In this context the Gumbel copula is more suitable to describe tail dependence. Kendall's τ values are almost the same with the exception of Clayton copula which has a sensibly lower value. This finding together with the lowest log-likelihood values renders the Clayton copula inappropriate for this data set. Naive standard errors are

significantly lower than the correct multi-stage ML errors giving a false impression of consistency. This is because the naive method ignores the parameters estimation error in the marginal distributions. The results obtained are encouraging because they follow precisely the theoretical guidelines. The bootstrap and copula sampling methods returned standard errors relatively close to the correct asymptotic multi-stage ML. The conclusion is that the easy to implement bootstrapping method is reliable and can be used instead of the cumbersome MSML. However, depending on the implementation and computing power it can be pretty slow.

GoF tests may be considered too strict as they compare relative to the true model. Financial modeling in general and this study in particular relies on estimation and none of the models are expected to be correctly specified. Following this reasoning, the purpose of the GoF test in this study is to determine whether the copula model is different from the true unknown copula and not necessarily for comparison among fitted copulas. The log-likelihood values in Table 5 provide a more appropriate means of comparison between models. Considering the implementation in Genest et al. (2009) we assessed the 4 copula models using the GoF tests presented in (20) and (21) applied to the Rosenblatt transforms of the standardized residuals. Table 6 presents the p-values for the KS_R and CvM_R. Low p-values are evidence against the null that the tested copula is the true unknown copula. Student-t copula is the only one that passes the GoF tests, a result which comes in support of our findings that this is also the best copula, as indicated by the log-likelihood.

Table 5. p-values for GoF tests for selected copula models

	Normal	**Student-t**	**Gumbel**	**Clayton**
KS	0.02	0.13	0.38	0.09
CvM	0.02	0.17	0.16	0.11

6 CONCLUSIONS

We proposed a multi-stage copula-GARCH model to capture the credit risk dependence between real and financial sectors at European level. Our data set is comprised of iTraxx Senior Financial and Crossover CDS indices, highly representative for credit risk dynamics in their respective sectors. In the first part of the study we analyzed the dependence pattern and concluded that the data set has a symmetric dependence structure with statistically significant tail dependence coefficients. These findings are consistent with the existence of systemic risk. In the second part we described the entire dependence pattern by fitting four types of copulas and derived standard errors for the parameter estimates using asymptotic

theory, bootstrapping, and copula sampling. The results indicate the Student-*t* copula as the most appropriate to describe the dependence structure. Our standard error estimates follow precisely the theoretical guidelines. GoF test also indicate that the Student-*t* copula performed as accurately as possible relative to the true copula.

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LOW INTEREST RATES AND BANK RISK-TAKING: HAS THE CRISIS CHANGED ANYTHING? EVIDENCE FROM THE EUROZONE

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Abstract. *This paper examines the impact of monetary policy on bank risk-taking and the influence of the recent financial crisis on this relation. We use a dataset of 571 commercial banks from Eurozone and analyze the relation on the period from 1999 to 2011, with emphasize on the period 2008 to 2011. We use non-performing loans, loan loss provisions and Z-score as measures for bank risk-taking, while for monetary policy the proxies are short-term interest rates (computed using a Taylor rule) and long-term interest rates. We determine the relation between the two by taking into account some specific control variables and analyze it using an entity fixed-effects model and Generalized Method of Moments, alternatively. Empirical results point to a negative relation between interest rates and bank risk-taking. In addition to this, results show that the crisis has led to an additional negative impact on the relation between interest rates and bank risk-taking for the turmoil period 2008-2011.*

Keywords: *monetary policy, bank risk-taking, financial crisis, monetary transmission mechanism*
JEL classification: *G01, G21, G28.*

1 INTRODUCTION

The effects of monetary policy on the banking system have been widely studied during the past years. The recent financial crisis has brought into discussion

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the importance of the relationship between monetary policy decisions (measured through the official interest rates) and the risk-taking behavior of banks.

Various empirical studies (Delis and Kouretas, 2011; Altunbas et al., 2010; Maddaloni and Peydro, 2011) demonstrated that banks are willing to take on more risk when interest rates are low. These papers show that the low interest rate environment of the early to mid 2000s influenced the banking system in the sense that it increased the level of risk assumed by banks. Also, it created the incentives for banks to find new ways of compensating for the low interest rates, as the securitization activity. Maddaloni and Peydro (2011) demonstrated that the influence of low interest rates on the softening of lending standards is amplified by securitization, since higher securitization leads to softer lending standards and higher bank risk.

The low interest rates paradox (Maddaloni and Peydro, 2011) suggests that when interest rates are low the credit and liquidity risk of banks increases and so does the likelihood of a financial crisis. If the crisis unfolds, the monetary authority lowers the interest rate in order to support the economy and the banking system and to avoid new credit turmoil. However, it might be precisely this attitude one of reasons that increases the likelihood of a new crisis.

This study aims at offering an image of the relationship between monetary policy and bank risk-taking in the context of the recent financial crisis. We believe this issue is of interest because this crisis is the most serious financial crisis since the Great Depression, with high economic and social costs. Moreover, although risk is an essential component of the economic system, excessive bank risk-taking has been a key determinant of the global financial crisis.

In our opinion, the risk-taking channel of monetary policy is of interest because it reflects the interaction between finance, behavioral finance and macroeconomics. It relates to finance because it captures the measurement and managing of risk. It relates to behavioral finance because it captures the effects of monetary policy on bank's risk perceptions and incentives. In the end, it relates to macroeconomics because excessive bank risk-taking has effects on the general equilibrium, as the recent financial crisis demonstrates.

The remainder of this paper is organized as follows: the second section revises the key papers regarding the theoretical and empirical insights about the risk-taking channel of monetary policy, the third section presents the variables used in the analysis, while the fourth section explains the data collection process and the descriptive statistics of the data. In the fifth section we present the research methodology, while the sixth section summarizes the key results. The seventh sections concludes.

2 LITERATURE REVIEW

The aim of this section is to review the existing literature about the nexus between interest rate and bank risk-taking, focusing on the theories behind this relation and the empirical work that offers evidence on the existence of the risk-taking channel of monetary policy.

2.1 Theoretical foundations

The majority of the papers that study the impact of interest rates on bank risk have focused on the credit channel of monetary policy. This channel reflects the dual effect of monetary policy on the credit supply of banks. Firstly, through the balance-sheet channel, low interest rates lead to an increase of the collateral and cash-flows of borrowers. Potential borrowers become more creditworthy and this increases the supply of loans. Secondly, through the bank-lending channel, when interest rates are low, banks are faced with the threat of deposit withdrawals. So, they have to search for other financing sources, at a higher cost (Kashyap and Stein, 1994). This extra cost is defined by Bernanke and Gertler (1995) as the external finance premium. As a consequence, the supply of credit would be lowered.

The seminal paper of Borio and Zhu (2008) puts forward the idea that the transmission channel of monetary policy should take into account changes in banks' risk-taking activity. The authors define this as the risk-taking channel of monetary policy. Also, they discuss three factors that support the existence of a risk-taking channel. First, changes of monetary policy affect the perception of risk and the risk position of banks' portfolios. Second, they influence the pricing of assets and have an impact on valuations, income or cash-flows. Third, communication problems regarding the transparency of the decision of the monetary authority may also influence the risk-taking activities of banks.

Additionaly, Rajan (2005) discusses the "search-for-yield" effect as an argument in favor of the risk-taking channel. He explains that when interest rates are low, the yields on risk-free assets are also low. So, banks will tend to invest in risky assets, which offer a higher yield. Moreover, the author argues that the "herding phenomena" (managers try to replicate the investment decisions of their peers thinking that in this way, they will not under perform them) amplifies this behavior.

2.2 Empirical considerations

The access of some researchers to micro-level bank data on the different categories of loans creates the possibility of analyzing the relationship in a deeper manner. Jimenez, Ongena, Peydro and Saurina (2008) analyze the impact of low

interest rates on credit risk, using disaggregated data on bank loans from Spain. They argue that there are three important factors that determine the impact of monetary policy on bank risk taking: the bank itself, the borrowers and the market characteristics. The findings suggest that in the short-term, low interest rates may reduce the total credit risk of banks, while in the medium term, it increase the credit risk of banks. Also, they found that small banks and commercial banks take more risk when interest rates are low.

Different from Jimenez et al. (2008), Ioannidou, Ongena and Peydro (2008) analyze the way in which this rate influence the risk and the price of new granted loans. Their study is conducted on individual loan data from Bolivia, from 1999 to 2003. The study shows that when interest rates are low, banks take more risk and this additional risk is not priced properly. What is more interesting, it is negatively priced.

In the context of monetary policy and bank risk-taking, we argue some thought should be given to the concept of "paradox of low monetary rates". Maddaloni and Peydro (2011) argue that it happens after periods of low interest rates, when banks are encouraged to take more risk, increasing the possibility of a banking crisis. If the crisis starts, the monetary authority will lower the interest rates in order to support the banking system. But lowering interest rates might increase the probability of a future credit crisis. The main finding of their paper is that low monetary rates lead to a softening of the lending standards and short-term rates have a more significant impact on bank risk-taking than long-term rates. This result is also obtained by Diamond and Rajan (2006) and Adrian and Shin (2009).

Additionally, Maddaloni and Peydro (2011) put forward the idea that too low for too long interest rates were a key determinant of the current financial crisis, because they increased the level of risk assumed by banks. The authors discuss three important factors that amplified this effect: the deep reliance of commercial banks on short-term funding, weak supervision concerning bank capital and financial innovation that was largely used in the years before the crisis.

Altunbas et al. (2010) show that a reduction of interest rate below a certain benchmark leads to a negative effect, encouraging banks to take more risk. In order to capture this discrepancy between real interest rates and benchmark levels of them, the authors use a Taylor rule in defining a proxy for the monetary policy stance. We employ the same strategy in our study. Firstly, we compute the country-specific benchmark level of interest rate using a Taylor rule. Secondly, we substract this benchmark from the actual short-term interest rate in order to determine the negative Taylor gaps, that show very low levels of interest rates.

One of the articles that we lean heavily on (Delis and Kouretas, 2011) analyzes the impact of the low interest rate environment of the early to mid 2000s on risk-taking incentives of banks. They found that low interest rate strongly increase bank risk-taking. When analyzing the relation between monetary policy and bank risk, they take into account the endogeneity of bank-level interest rates, but also of some of the control variables.

Empirical papers employ different proxies for measuring bank risk-taking and interest rates. For example, Delis and Kouretas (2011) measure bank risk-taking using two proxies, the risky assets, regarded as a broader proxy, and the non-performing loans (a measure for credit-risk). Monetary policy is proxied by four alternative measures: a short-term interest rate, a long-term rate, a bank-level lending rate and the central-bank rate. However, the conclusions of their analysis are based mostly on the results obtained using the bank-level lending rate.

By contrast, Maddaloni and Peydro (2011) use Taylor rule residuals in order to tackle the problem of endogenous monetary policy, in general and endogenous bank-level lending rate, in particular. The authors argue that positive Taylor residuals correspond to relatively high interest rates, while negative residuals imply what is called "very low" interest rates.

Altunbas et al. (2009) use Expected Default Frequencies and Loan Loss Provisions as alternative measures of bank risk-taking. The Z-score, which is inversely related to the probability of bank insolvency, is another proxy used in the literature for measuring bank risk-taking (Konishi and Yasuda, 2002; Laeven and Levine, 2008).

Overall, the empirical evidence shows a negative relation between low interest rates and bank risk-taking. In our paper, we analyze whether this relation is supported when using a different and unique sample of commercial banks. In addition to this, we study whether the financial crisis has influenced this relation and whether, during the crisis, low monetary policy have had an effect that reduced risk-taking of banks.

3 DATA

The aim of this paper is to analyze the nexus between the stance of monetary policy and bank risk taking in the context of the recent financial crisis. In order to achieve this goal, we first establish the variables used to identify the stance of the monetary policy and the bank risk-taking, but also some control variables that may influence this relation.

3.1 Dependent variables

The existing literature on the topic of our paper documents the use of some alternative measures for risk-taking. We measure the bank risk-taking through three different proxies.

First, we use the ratio of non-performing loans to total loans. It is used as a proxy for credit risk (Delis and Kouretas, 2011; Ioannidou et al., 2008; Ioannidou, 2005). It reflects the quality of the banks' portfolios of loans. Low interest rates may determine a slightly decrease in the level of non-performing loans on short-term for current debtors, because it may ease the interest burden of them. However, on medium and long-term, low interest rates may encourage banks to lower the lending standards and the screening activity and to give loans to some borrowers who would not be eligible otherwise. Hence, in the medium and long-term, the low interest rates may determine an increase of non-performing loans.

Second, we use the Z-score as a proxy for the risk of banks, seen from the perspective of its insolvency risk. We compute Z-score as Laeven and Levine (2008) do, because our sample consists in listed and unlisted banks, while Konishi and Yasuda (2004) only use listed banks. Z-score is computed as the ratio of the return on assets plus the capital-asset ratio to the standard deviation of assets returns. Z-score computed as above represents the inverse of the probability of insolvency: the higher the Z-score, the stable the bank. A low probability of insolvency or a high distance to insolvency points to less risk aversion and to a higher bank risk-taking. We use natural logarithm of this measure as a solution for its highly skewed distribution.

Third, we bring an innovation to our study and use loan loss provisions ratio as a measure for bank risk-taking. When loans become non-performing, banks are faced with the possibility of not recovering the principle and the interest, so they have to use a mechanism through which they create a kind of cushion that protects them against unexpected losses on loans. This mechanism is known as loan loss provisioning. A negative relation between interest rates and loan loss provisions signals a higher risk-taking assumed by banks in the presence of low interest rates.

3.2 Independent variables

Concerning the monetary policy stance, the majority of the existing studies use the three-month Euribor or the overnight interest rates for Eurozone (EONIA rate) as measures of short-term interest rates. They are the same for all countries in our sample and they vary only across time. In order to add variability to the interest rates variable, we employ the technique used in Maddaloni and Peydro (2011) and Altunbas et al. (2010) and proxy it using Taylor's rule residuals. Concerning the

endogenous character of interest rates, we follow Delis and Kouretas' (2011) argument and assume that the European Central Bank do not take into account the bank risk-taking in one particular country when establishing the monetary policy. Also, to support the exogenous character of monetary policy, Jimenez, Ongena, Peydro and Saurina (2008) argue that it is not monetary policy that is reacting to future risk, but banks are actually seeking it.

Turning back to the Taylor's residuals, computing them requires some further notions. First, we need to know the estimated output (or the potential output). Many methods have been used in the literature for estimating the potential output and the output gap (Chagny and Dopke, 2011; Cerra and Saxena, 2000; Almeida and Felix, 2006) - from simple univariate techniques to multivariate structural techniques and stochastic filtering techniques. From all these methods, the Hodrick-Prescott filter approach is the most known and commonly used univariate method. It was proposed by Hodrick and Prescott (1997) and it consists in the de-trending of an economic time series. Basically, it separates the GDP time series into a permanent (smoothed) series which corresponds to the estimate of potential output and a cycle component which represents the difference between real GDP and potential GDP, namely the output gap. A detailed description of the technical features of this technique is beyond the scope of this paper and it is presented in the Appendix B. After estimating the potential output, we use the obtained values and run a regression of EONIA on inflation and GDP, according to Taylor's rule. The regression is implemented for each country because the basic idea of this rule is that, even if countries in Eurozone have a common monetary policy, the macroeconomic conditions differ according to the specificity of each country. In this sense, besides the interest rate, the equation proposed by Taylor includes the GDP and inflation that vary between countries. The residuals from the regression measure the difference between the actual nominal short-term interest rate (EONIA in our case) and the rate computed through Taylor's rule using equal weights on output and inflation and no interest rate smoothing. The mathematics of estimating Taylor's gap can be found in the Appendix A.

The way of computing the measure used for the stance of monetary policy, namely the Taylor gaps, resembles the one used by Altunbas et al (2010) and Maddaloni and Peydro (2011). However, in our study we use only equal weights on output and inflation and no interest rate smoothing, while Altunbas et al. use three different versions of the Taylor's rule.

Having in mind that the interest rate is not the only variable that can influence the risk-taking behavior of banks, we control for some bank-specific characteristics, as capitalization, profitability, size, efficiency and non-traditional

activities. Also, we control for banking regulation, taking into account three indices: capital stringency, official supervisory power index and market discipline, computed using Barth's Database. The last category of control variables concerns the macroeconomic controls, like economic growth, importance and concentration.

3.3 Data collection and descriptive statistics

The bank-level data used for computing variables for the analysis was collected from Bankscope Database. Unlike Delis and Kouretas' (2011) paper, we conduct our analysis on a sample of commercial banks only, because the majority of savings and cooperative banks have many missing values and they are self-eliminating from the sample. Also, we conduct the analysis on commercial banks only due to comparability reasons.

We analyze the sample of commercial banks during the period from 1999 to 2011. We organize it as a panel data in which each bank corresponds to a cross section and each year to the time dimension. The sample consists of commercial banks from EuroArea. Banks from each country are included in the sample starting with the year their country has joined the EuroArea. The panel consists in 571 banks and 13 years (period 1999 to 2011), a total of 6999 bank-year observations. In our data, 75.57% of observations are missing when using non-performing loans as the dependent variable, 42.78% are missing when using loan loss provisions and 42.51% when using Z-score. Despite that, we would rather prefer to use list-wise deletion because eliminating cases that have incomplete observations would significantly reduce the size of our sample.

The sample may be affected by some survivorship bias (because some of the banks might have failed at one moment in time and they are excluded from the sample). Also, we apply our own selection criteria of choosing the sample and the banks included in it. When downloading data from Bankscope, we searched for active commercial banks from EuroZone that have at least five years of available data and that have data for at least one of the following years: 2009, 2010 or 2011. Although Bankscope has the advantages of accounting for almost 90 percent of total banking assets in each country and also of presenting the data in standardized formats, it has the disadvantage of limitations in data availability.

As far as the missing data is concerned, considering that each available information is important for the purpose of the analysis, we do not eliminate banks that have missing observation. Instead, we would rather use the listwise deletion applied in the regression used to analyze the relationship between monetary policy and bank risk-taking. In order to tackle the problem of outliers and also the non-normal distribution, we use the outlier labeling rule (Hoaghin, Iglewicz and Tukey, 1986; Hoaghin and Iglewicz, 1987) as a method for detecting the outliers and we

apply the winsorizing method in order to eliminate them, because trimming would have led to a loss of information. A further explanation about the insights of the outlier labeling rule can be found in the Appendix C.

The descriptive statistics reported in Table 1 enable a better understanding of the variables that we include in the analysis.

Non-performing loans have a mean value of 4.34% of total loans for the period 1999-2011, with a maximum of 14.55% from total loans. Also, from a total of 6999 bank-year observations, only 2183 are available for analyzing the non-performing loans. Regarding the monetary policy, the dynamics of EONIA show a decrease of the mean values of the overnight interest rates in the period from 2008 to 2011. Taylor's residuals, the proxy for monetary policy stance, have a negative mean value of -0.0091%, with a minimum of -5.76% for year 2011 in Estonia and a maximum of 4.81% for year 2009 in Ireland. The dynamics of the mean values of Taylor's residuals for the period 1999 to 2011 show negative values for period 2003 to 2007 and for period 2009 to 2011. These negative values of Taylor's residuals are associated with the concept of very low interest rates (Maddaloni and Peydro, 2011) and they represent the low interest rates which increase the level of bank risk-taking.

As far as the distance to insolvency is concerned, it has a mean value of 0.3784, with a minimum of -3.3126 and a maximum of 4.1637.

A further analysis on the dynamics of the mean values of the bank-level controls and macroeconomic indicators shows that year 2008 has brought considerable changes in the financial situation of banks, but also on the general economic environment. The profitability of commercial banks from Euro Area has mean values which increased in the period from 2002 until 2007, but they show a deep decrease starting from year 2007 to 2011. This evolution reflects the effects of the recent financial crisis on the banking system. Regarding the regulatory environment, the official supervisory power index exhibits an important increase in its mean values that demonstrates the increasing importance of the regulatory requirements for the banking system. Moreover, with a mean value of 1.7243, economic growth has a minimum value of -5.1713 and a maximum of 7.5467. The dynamics of the GDP growth rate show a deep decrease of its mean values. Starting from year 2007 until year 2010 it has registered negative values, corresponding to the recession caused by the financial crisis with extended effects on the general economic environment. After year 2010, it has begun to slightly increase.

The existing literature argues about the positive relation between the distance to insolvency (Z-score) and the bank risk-taking (Borio and Zhu, 2008).

This means that a negative correlation between interest rates and Z-score (in case of our study it has a value of -0.2361) corresponds to a negative relation between interest rates and bank risk-taking.

Table 1 Descriptive Statistics

	Mean	Stdandard Deviation	Minimum	Maximum	Number of observations
Non-performing loans	0.0434	0.0392	0.0000	0.1455	2183
Loan loss provisions	0.0038	0.0046	-0.0068	0.0131	5500
Z-score	0.3784	1.0938	-3.3126	4.1637	5448
EONIA	2.5542	1.2895	0.4377	4.3872	6999
Taylor gap	-0.0091	1.5090	-5.7627	4.8136	6999
Capitalization	0.0852	0.0505	-0.0414	0.1803	6344
Profitability	0.0086	0.0101	-0.0129	0.0307	6214
Size	14.4111	2.2530	7.6401	21.5128	6347
Efficiency	0.3769	0.2033	-0.1259	0.8664	5682
Non-traditional activities	0.1710	0.1648	-0.1054	0.5409	5505
Capital stringency	5.5711	1.5700	2.0000	8.0000	6999
Market discipline	5.5728	0.7010	4.0000	8.0000	6999
Supervisory power	9.8750	2.1807	5.0000	14.0000	6999
Economic Growth	1.7243	2.4668	-5.1713	7.5467	6999
Importance	131.8422	30.3308	55.6995	260.9600	6909
Concentration	41.5830	17.6378	18.9455	90.6350	6999

Source: own computations

This table reports the descriptive statistics used to analyze the sample of the analysis. The average value is described through the mean value. The maximum and minimum represent the highest value and the lowest value that a variable exhibits during the period of analysis. The number of observations refers to the number of complete observations existing in the sample after the listwise deletion of missing observations. The period of analysis is 1999 to 2011. The variables are as follows: non-performing loans is the ratio of non-performing loans to total loans, loan loss provisions is the ratio of loan-loss provisions to total assets, Z-score is the natural logarithm of the ratio of the sum between the return-on-assets and capital-asset ratio to the standard deviation of the return-on-assets, EONIA is the overnight interest rate for the EuroZone, Taylor gap represent the residuals from a regression of EONIA on GDP and inflation and no interest rate smoothing, capitalization is the ratio of equity to total assets, profitability is the ratio of profit before tax to total assets, Size is the natural logarithm of total assets, Efficiency is ratio of overheads to total interest income, Non-traditional activities is the ratio of off-balance sheet items to total assets, Capital stringency is the index of capital requirements,

Supervisory power is the index of the official power of the supervisor, Economic growth represent the real GDP growth rate, Importance is the domestic credit provided by the banking sector as a share of GDP and Concentration is computed as the 5-bank concentration ratio.

4 RESEARCH METHODOLOGY

The paradox of low monetary policy and the recent financial crisis have convinced banks to pay more attention on the level of risk their actions incur. But has the crisis changed the perception of risk by banks? The European Central Banks has significantly lowered the interest rate and the EONIA decreased from 3.87% in 2008 to 0.71% in 2008, 0.44% in 2010 and it exhibits a slightly increase to the level of 0.87% in 2011. The "very low interest rates", measured through Taylor residuals have registered negative mean values during the period from 2003 to 2007 and from 2009 to 2011. Have these low rates led to a further increase in bank risk-taking? Or have banks become more conscious about the consequence of their actions and tried not to take more risk when rates are low? In the end, has the crisis influenced in some way the relationship between monetary policy and bank risk-taking? These are the questions which triggered the existence of this study and we will try to find an answer to them.

Taking into account the above discussion, we will investigate the following research questions: Are low interest rates leading to higher bank risk-taking? Has the crisis influenced this relation? During the crisis, has the low monetary policy an effect that reduced bank risk-taking?

In this paper, we formulate three research hypotheses, as follows:

Hypothesis 1: Very low interest rates lead to higher bank risk-taking for period 1999 to 2011, but also for period from 2008 to 2011. We will investigate this hypothesis using an entity fixed-effects model on three different subsamples.

Hypothesis 2: The relation between low interest rates and bank risk-taking is different before the financial crisis than after it. We will investigate this hypothesis using a Chow test for structural breaks.

Hypothesis 3: The financial crisis has influenced the relationship between interest rates and bank risk-taking for the period 1999 to 2011. We will analyze the coefficient of the interest rate variable in interaction with the slope dummy variable CRIS in order to investigate this hypothesis.

The analysis of the impact of interest rates on bank risk-taking raises two econometrical problems (Delis and Kouretas, 2011). The first one is the endogeneity of some of the control variables and the second one refers to the dynamic nature of bank risk. Besides these two, the literature also discusses the

endogeneity of interest rates, but we argue that the use of Euro Zone interest rate mitigates this problem. The reason is that European Central Bank does not take into account the risk of each Euro Zone bank when establishing the unique monetary policy. Moreover, as Maddaloni and Peydro (2011) argue, the use of Taylor's residuals might also mitigate this problem.

We divide the empirical strategy conducted in our study into two parts. The first one analyzes the nexus between interest rates and bank risk-taking without taking into account the presented econometrical problems, while the second one tackles the two problems.

The basic specification analyzed in this paper takes the following general form:

$$r_{i,t} = \alpha_{i,t} + \beta_0 * r_{i,t-1} + \beta_1 * ir_{i,t} + \delta * ir_{i,t} * CRIS_t + \beta_2 * bc_{i,t} + \beta_3 * rg_t + \beta_4 * ec_t + u_{i,t} \quad (1)$$

In this equation, $r_{i,t}$ represents the bank risk-taking, proxied by the three alternative measures: non-performing loans, loan loss provisions and Z-score, $ir_{i,t}$ represents the monetary policy, measured by two alternative proxies: the Taylor gap and the long-term rate, $bc_{i,t}$ corresponds to the vector of bank-level control variables, while rg_t represents the vector of regulatory controls, ec_t is the vector of macroeconomic controls, and $u_{i,t}$ is the error term. CRIS is a dummy variable and its purpose is to delimitate the period comprising the unfolding of the financial crisis. γ is the coefficient that measures the persistency of bank risk, while δ is the coefficient that measures the impact of the financial crisis on the relationship between monetary policy and bank risk-taking. It represents the additional effect on the level of bank risk-taking that the crisis period (2008 to 2011) brings to the non-crisis period (1999 to 2007).

The basic specification we propose in our study differs from the one used by Delis and Kouretas (2011) and Maddaloni and Peydro (2011) because we take into account the effects of the financial crisis on the relationship between monetary policy and bank risk-taking. In other words, in the papers we lean on, δ=0. Our paper brings an innovation to the existing literature, by introducing the effects of the crisis in the general form of this relationship.

Firstly, we do not take into account the endogeneity of some control variables, the dynamic nature of risk, and the effects of the recent financial crisis. This is equivalent to the analysis of the basic specification under two restrictions: γ = 0 and δ = 0. We study the resulting equation and control for some omitted-variables that may also influence the relation, like CEO compensation or bank governance. Hence, to control for unobserved variables that differ across banks, but

are constant over time and that may influence the impact of interest rates on bank risk-taking, we employ in the analysis an entity-fixed effects model.

To verify if the fixed effects model is indeed better than a random effects model, we apply a Hausman Test for correlated coefficients. The random-effects model requires a more stringent assumption because it can be employed if any unobserved omitted variables are uncorrelated with the included explanatory variables (Brooks, 2008). If the Hausman statistic proves to be statistically significant, we will reject the null hypothesis that the random effects model is the appropriate model. Hence, fixed effects model will be the model to use in our analysis. Furthermore, we test the null hypothesis that the bank fixed-effects are jointly zero using a Redundant Fixed Effects Test. The rejection of the null hypothesis will support the use of the fixed-effects panel model that allows for bank heterogeneity.

We will investigate the first and second hypotheses by analyzing the model on three different samples. The first sample is the full period from 1999 to 2011. The second sample is named "tranquil", it refers to the period from 1999 to 2007. It is characterized by a stable period in the Euro Area, with growing GDP rates and expansion of the bank lending activity. The third sample is named "turmoil" and it corresponds to the period after the unfolding of the financial crisis, from 2008 to 2011. The results are subjected to a Chow test for structural breaks in order to investigate whether the relation between monetary policy and bank risk-taking is different before the crisis than after it. In this study we assume that a possible structural break occurs after the unfolding of the financial crisis, starting with the year 2008.

To investigate whether the impact of monetary policy on bank risk-taking is driven by the effects of the financial crisis, we use only one restriction in the basic specification: the $\gamma = 0$. So, the CRIS dummy variable has a value of zero for the tranquil period and a value of one for the turmoil period.

Going further with the study, we analyze the effects of the impact of the crisis in the context of some endogenous control variables and dynamic nature of bank risk. This is equivalent with the analysis of the basic specification without any restriction.

According to Delis and Kouretas (2011), the bank risk-taking of the previous period may influence the bank risk of the current period. They argue that a reason for this may be the level of regulation. Capital requirements could lead to risky investments with effects over an extended period of time. Also, the bank risk tends to deviate from equilibrium because it might need a certain amount of time to adjust to the effects of macroeconomic shocks.

A dynamic model, including a lagged dependent variable, captures the persistent character of bank risk and provides unbiased results. The Generalized Method of Moments for dynamic panel data is such a model. Moreover, the GMM takes into account the endogeneity of capitalization, lagged profitability and efficiency. As proposed by Arellano and Bover (1995), this method uses the lags of the possible endogenous explanatory variables as instrumental variables.

The results are subjected to a Sargan Test for over-identified restrictions and we also conduct an AR(1) and AR(2) tests on the residuals of the regression in order to establish the validity of the number of lags used as instruments for the list of endogenous variables.

When using the distance to insolvency, measured through Z-score, as a dependent variable, we do not include profitability and capitalization as bank-level control variables in the equation used to analyze the relation between interest rates and the distance to insolvency. The reason is that Z-score is computed using precisely these two variables, so there is no need to control for these two.

5 EMPIRICAL RESULTS

The purpose of this section is to summarize the results of the analysis and comment on their economic interpretation. First, we use an entity fixed effects model to analyze the relationship between monetary policy and bank risk-taking. Afterwards we use the Generalized Method of Moments in order to tackle the econometric problems of this relation: the endogeneity of some control variables and the persistency of bank risk.

An important part of the research question consists in understanding the nexus that can be established between monetary policy and bank risk-taking. The first hypothesis that we investigate in this paper is the existence of a negative relation between interest rates and bank risk-taking. In order to investigate it, we divide the sample according to the purpose of this paper. The analysis on different subsamples enables the investigation of the second hypothesis, with the aim of establishing whether the relation is stable over the period of study.

The results summarized in Table 2 are obtained using the entitiy fixed effects model. The Hausman test and the Redundant Fixed Effects test support the use of cross-section fixed effects. The Chow test demonstrates that the parameters are not stable over time. Hence, we conclude that the relation between low interest rates and bank risk-taking is different before the financial crisis then after it.

Table 2 summarizes the results of this analysis, by using the three proxies for bank risk-taking (non-performing loans, loan loss provisions and z-score) and the Taylor's residuals as proxies for interest rates. In all nine regressions, interest rates have a negative influence on the level of bank risk. This result is in line with the

previous empirical studies. For the full sample 1999-2011, low interest rates lead to higher non-performing loans and also to higher loan loss provisions. Hence, low interest rates lead to high credit risk for banks. The negative relation between Z-score and interest rates shows that low monetary policy lead to high bank stability, hence to a low probability of insolvency. Usually this low probability is associated with a high risk tolerance and a higher propensity for bank risk taking (Borio, 2008).

In Table 2 we also report the results of the analysis conducted on the two subsamples, the one characterized by a tranquil period and the one defined by the financial turmoil. Monetary policy, proxied by Taylor's residuals have a slightly significant impact, at 10% level, in case of loan loss provisions, but the impact is significant at 1% level in case of Z-score. Low interest rates determine high non-performing loans (although the impact is not significant) and high loan loss provisions.

After the unfolding of the financial crisis, for the subsample from 2008 to 2011, the results reported in columns 3, 6 and 9 show that the low interest rates increase the volume of non-performing loans. Banks reacted so that they increased the provisions for loan losses. In addition to this, very low interest rates seem to significantly increase the Z-score of banks, which induce an increase in the risk-taking behavior of commercial banks**.**

To summarize the results presented in Table 2, we reject the first null hypothesis at 5% level and conclude that very low levels of interest rates lead to higher bank risk-taking. Furthermore, we also reject the second null hypothesis about the stability of this relation. Hence, the relation between low monetary policy and bank risk-taking is not stable over time and the impact for the tranquil period 1999 to 2007 is different from the impact for the turmoil period 2008 to 2011.

Going further with the analysis, we want to investigate if the impact of monetary policy on bank risk taking is driven by the effects of the financial crisis and the extent to which this impact is statistically significant. Hence, Table 3 – columns 1, 3 and 5 - summarizes the results of the analysis with the inclusion of a dummy variable which takes the value of 1 for period from 2008 to 2011. The effect of the crisis is not significant for non-performing loans (column 1), but it is highly significant in case of loan loss provisions and Z-score (columns 3 and 5). The recent financial crisis brought a significant positive impact on the relation between interest rates and bank stability. However, the impact remains negative. Furthermore, the coefficient of the slope dummy variable CRIS and its significance show that the impact is lowered for the turmoil period, although it remains

negative. This can be interpreted as a slightly increase in the risk aversion of banks, caused by the effects of the financial crisis.

Table 2 The impact of monetary policy on bank risk: Taylor gaps

	Dependent variable: Non-performing Loans			**Dependent variable: Loan Loss Provisions**			**Dependent variable: Z-SCORE**		
	Full Sample	**Tranquil**	**Turmoil**	**Full Sample**	**Tranquil**	**Turmoil**	**Full Sample**	**Tranquil**	**Turmoil**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TGAP	-.0024*	-.0010	-.003***	-.0002*	-.0001***	-.0002	-.1306*	-.0814*	-.1110*
CAP	-.0944	.0516	-.1619**	.0018	-.0003	-.016***			
PROF(-1)	-.7503*	-.0606	-.6849*	-.0472*	-.0072	-.0186			
SIZE	-.0132*	-.0072	-.0259*	-.000**	-.0009*	-.0001	.2442*	.1510*	.1123**
EFFIC	-.0124	-.0002	-.008	-.0065*	-.0081*	-.0050**	.4623*	.3385*	.4186**
OFFBS	-.0478*	-.0416*	-.0471**	-.0010	-.0008	.0001	.0334	.0734	.3243
CAPRQ	-.0045*	-.0041*	-.0027	-.000***	.0000	-.0013*	-.0483*	-.0868*	-.0079
MDISC	.0001	-.0024	-.001	.0000	.0000	-.0002**	-.0245*	-.0295*	-.0257*
OFFPR	-.0009	.0020	-.003	-.000**	-.0003	-.0003	.2283*	.3146*	-.0908*
EC_GROWTH	-.0014**	.0006	-.0018	-.0003*	-.0003*	-.000***	-.0884*	-.0097	-.0507*
IMP	.0004*	.0002**	.0007**	.0000*	.0000	.0000**	.0039*	.0062*	-.0041**
CONC	.0011*	-.0002	.0008**	.0000	-.0001*	.0000	.0368*	.0579*	.0093**
Entity FE	Yes	Yes	Yes	Yes	yes	yes	Yes	Yes	Yes
Entity RE	No	No	No	No	No	No	No	No	No
Hausman Test	140.588*	57.5092*	68.2391*	87.449*	101.702*	56.647*	436.527*	414.238*	37.4980*
Redundant FE	14.7900*	13.1396*	13.9943*	10.1129*	9.2900*	5.9070*	41.7918*	47.3385*	15.5726*
Observations	1710	876	834	4005	2533	1472	4024	3029	995
R squared	.7737	.8071	.8780	.6080	.6756	.7419	.8718	.8997	.9050
Estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
RSS	.6084	.1742	.1846	.0294	.0139	.0079	545.626	321.405	44.729
Chow Test	Rejects H_0 of stability of parameters over time			Rejects H0 of stability of parameters over time			Rejects H_0 of stability of parameters over time		

(*) Significant at 1% level, (**) Significant at 5% level, (***) Significant at 10% level

We analyze the relationship between monetary policy and bank risk-taking, using Taylor gap as measure for interest rate and three alternative measures for bank risk: non-performing loans (NPLTL), loan loss provisions (LLPTA) and Z-score. As controls we include the bank-specific controls, the regulatory controls and the macroeconomic controls. TGAP is the Taylor gap (computed using the

Taylor rule residuals and described in Appendix A), CAP stands for capitalization, PROF(-1) for lagged profitability, SIZE is the bank size, EFFIC stands for efficiency, OFFBS for off-balance sheet items, CAPRQ for capital requirements, OFFPR stands for official supervisory power index, MDISC for market discipline, EC_GROWTH is the economic growth, IMP stands for importance and CONC for concentration. Important to mention is the fact that in case of Z-score, we do not include profitability and capitalization as control variables, because they are used at computing this measure. The relation is analyzed on the three different subsamples using the entity fixed effects model. The Hausman Test examines whether we should use fixed effects or random effects. The Redundant Fixed Effects Test establishes the need of using fixed effects. The R-squared shows the goodness of fit of the model and the Chow test examines whether the relation is stable over time. *, ** and *** indicate significance at 1%, 5% and 10% level, correspondingly.

We study only the effects of the short-term interest rates (measured through Taylor residuals) on bank risk-taking, since the effects of long-term interest rates are not statistically significant for the sample of our analysis.

We have investigated the influence of interest rates on bank risk and to which extent this impact is driven by the effects of the crisis, but we still do not know if these results change when taking into account the potential endogeneity of some of the control variables and the dynamic nature of risk. Table 3 – columns 2, 4 and 6 - summarize the results of an analysis that tackles these two econometrical problems.

We apply the GMM technique to the basic specification with the aim of investigating if the relationship between monetary policy and bank risk is driven by the effects of the crisis. The results are presented in Table 3. When using this technique, the results are improved in the sense that they show significant influence in case of all three equations for Taylor gap. The Sargan test for over-identified restrictions cannot be rejected for all nine equations, so we conclude that the instruments used are valid. Also, the AR(1) and AR(2) tests are highly significant which is the reason why we did not include the first two lags of endogenous variables in the list of instruments. The results confirm what we observed using the other technique, that short-term interest rates influence the non-performing loans and loan loss provisions in a significant negative way. The explanatory power of the GMM method is higher.

Furthermore, the effects of the crisis bring an additional negative impact to this relation, which increases the magnitude of the coefficients for interest rates in the turmoil period. Hence, when interest rates are low, the non-performing loans

and loan loss provisions increase even more in the turmoil period than in the tranquil period. This corresponds to an increase in the bank risk in the presence of relaxed monetary policy due to the effects of the crisis. A very important result is reported in column 6, where low short-term interest rates, proxied by Taylor's residuals, have an effect that decreases bank stability in the non-crisis period. This would mean lower bank risk-taking in the tranquil period. However, results show an additional negative impact in crisis period. This means a slightly increase of bank stability, followed by higher bank risk-taking. A better bank stability may be explained by the fact that, in crisis times, low interest rates give banks bigger margins.

Regarding the coefficient on the lagged dependent variable, in all three columns they are statistically different from 0, with values between 0 and 1, except for column 6, where it has a value of 1.1516. These results point to the fact that risk is characterized by a significant degree of persistency, according to the discussion proposed by Delis and Kouretas (2011). It means that the bank risk of the previous period influence the bank risk of the current period in a significant way.

As a conclusion, the results from Table 3 investigate the third null hypothesis that the crisis have had no effect on the relation between monetary policy and bank risk-taking. We can reject the null hypothesis at 5% level, so the effects of the crisis have a significant influence on the nexus between interest rates and bank risk-taking. Regarding this influence, we argue that the crisis have had an additional negative impact to the relation, so that the bank risk-taking have increased after the unfolding of the financial crisis.

Table 3 The influence of the crisis on the relation between monetary policy and bank risk-taking:Panel Technique and GMM estimation

	Dependent variable: NPLTL 1999-2011		**Dependent variable: LLPTA 1999-2011**		**Dependent variable: Z-SCORE 1999-2011**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
TGAP	-.0013	-.0017*	.0000	-.0001**	-.1428*	.0483*
TGAP*CRIS	-.0015	-.0019*	-.0003*	-.0003*	.0251**	-.0382**
DEP(-1)		.4749*		.0452***		1.1516*
CAP	-.0971*	-.0632*	.0016	-.0048		
PROF(-1)	-.7428*	-.2930*	-.0447*	-.020***		
SIZE	-.0132*	-.0122*	-.0006*	-.0018*	.2421*	.1519**
EFFIC	-.0121	-.0301*	-.0065*	-.0091*	.4729*	.7224*
OFFBS	-.0476*	-.0569*	-.0009***	.0044*	.0332	.1486
CAPRQ	-.0044*	-.0006*	-.0001***	-.0003	-.0501*	.0127

	Dependent variable: NPLTL 1999-2011		**Dependent variable: LLPTA 1999-2011**		**Dependent variable: Z-SCORE 1999-2011**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
OFFPR	.0002	.0006*	.0000	.0000	-.0208*	-.0010
MDISC	.0000	.0008*	-.0002***	.0003	.2232*	-.0283
EC_GROWTH	-.0016*	-.0028*	-.0003*	-.0003*	-.0855*	.0046
IMP	.0004*	.0002*	.0000*	.0000*	.0039*	-.0031*
CONC	.0010*	.0008*	.0000	-.0001**	.0371*	-.0005
Entity FE	Yes		yes		Yes	
Entity RE	no		no		no	
Hausman Test	136.322*		91.778*		441.784*	
Redundant FE	14.6855*		10.1826*		41.7809*	
AR(1) p-value		.000		.000		0.000
AR(2) p-value		.000		.005		0.000
Sargan Test		.6447		.5659		.6023
Observations	1710	1268	4005	3387	4024	3267
Estimation	OLS	GMM	OLS	GMM	OLS	GMM

(*) Significant at 1% level, (**) Significant at 5% level, (***) Significant at 10% level

We analyze the relationship between monetary and bank risk-taking, using Taylor Gap as measure for interest rate and three alternative measures for bank risk: non-performing loans (NPLTL), loan loss provisions (LLPTA) and Z-score. As controls we include the bank-specific controls, the regulatory controls and the macroeconomic controls. TGAP is the Taylor gap (computed using the Taylor rule residuals and described in Appendix A), CRIS is a dummy variable, DEP(-1) is the lagged dependent variable, CAP stands for capitalization, PROF(-1) for lagged profitability, SIZE is the bank size, EFFIC stands for efficiency, OFFBS for off-balance sheet items, CAPRQ for capital requirements, OFFPR stands for official supervisory power index, MDISC for market discipline, EC_GROWTH is the economic growth, IMP stands for importance and CONC for concentration. In case of Z-score, we do not include profitability and capitalization as control variables, because they are used at computing this measure. The coefficient on the dummy variable "CRIS" captures the effect of the crisis. The relation is analyzed on the full sample 1999 to 2011, using first the entity fixed-effects model (column 1,3 and 5) and, second, the Generalized Method of Moments (columns 2, 4 and 6). The Hausman Test examines whether we should use fixed effects or random effects. The AR(1) and AR(2) tests investigates the existence of autocorrelation of order one and two and the table reports the p-values of these tests. Sargan statistic

represent the test for overidentified restrictions. *, ** and *** indicate significance at 1%, 5% and 10% level, correspondingly.

6 CONCLUSIONS

The aim of this paper is to study the relationship between monetary policy and bank risk-taking, in the light of the recent financial crisis. Using a sample of commercial banks from the Euroarea, we conduct the analysis on two basic directions. The first one is to investigate the impact of interest rates on the risk-taking of commercial banks and the second one is to investigate to what extent this impact is driven by the effects of the crisis in the period 2008 to 2011. An important assumption that we made in this study is that the effects of the crisis can be extended over the period from 2008 to 2011. Hence, we introduce a dummy variable which capture these effects and take the value of 0 from 1999 to 2007 and the value of 1 afterwards.

The overall findings of our analysis point to a negative relation between monetary policy and bank risk-taking, which supports the existence of a risk-taking channel of monetary policy. Our results are in line with the empirical literature on this topic. Maddaloni and Peydro (2011) found that low interest rates soften lending standards, while Ioannidou et al. (2008) argue that relaxing monetary conditions increase the risk appetite of banks. Also, Jimenez et al. (2008) and Delis and Kouretas (2010) show that low monetary policy leads to higher bank risk-taking.

Our study brings novelty to the existent empirical literature by studying this relationship in the context of the recent financial crisis and investigating the existence of the risk-taking channel in times of crisis. The effects of the crisis, extended on period 2008 to 2011, have a significant influence on the impact of interest rates on bank risk taking. The conclusion regarding the nature and the meaning of this impact is quite ambiguous. In case of non-performing loans and loan loss provisions used as dependent variables, low interest rates lead to higher credit risk. Furthermore, in case of Z-score, low monetary policy lead to higher bank risk taking in the turmoil period when using the entity fixed effects model, but to lower bank risk taking when using Generalized Method of Moments. As far as the significance of results is concerned, it is improves when using the latter estimation method.

Our study has some limitations. The results may be sensible to the level of missing data and the data might be affected by the selection bias, since the selection criteria are a subjective decision. Also, the results of this paper are valid for commercial banks only because data for the majority of savings and cooperative

banks in EuroZone is unavailable. Another limit of this study regards the definition of the time frame for the tranquil and turmoil period, since this is also our subjective choice. Finally, the results may be sensible to the measures used as proxies for bank risk-taking, but also to the choice of using Hodrick-Prescott filtering technique in computing Taylor gaps, used to proxy the monetary policy stance.

The main contribution of our paper is the investigation of the existence of a risk-taking channel of monetary policy in the context of the financial crisis. It is of interest for both the regulators and policymakers because we consider that the new monetary framework (which makes extensive use of very low interest rates, hitting the zero-lower bound, and unconventional monetary measures) and its effects can be better understood only if we have a deep understanding of the way the traditional or conventional monetary policy works and the mechanisms through which it is transmitted to the wider economy. Also, studying te effects of low interest rates may help in preventing a future credit crisis.

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APPENDIX

A – Taylor rule

Taylor (1993) proposed a rule which could be used by monetary authorities in policymaking decisions and which argue that it is preferable for central banks to set the interest rates taking into account economic conditions in their own country.

We use Taylor rule in order to compute a proxy that can capture the stance of monetary policy. Basically, Taylor's equation establishes a benchmark for interest rate that can be thought of as the appropriate policy interest rate, from a macroeconomic perspective. The deviation of the real interest rate from this benchmark level is known as Taylor Gap and represents the proxy used in this paper for the stance of monetary policy. We use the standard Taylor rule, with equal weights on output and inflation and no interest rate smoothing. The equation for Taylor rule is formulated as follows:

$$i_t = \alpha + \beta_\pi * (\pi_t - \pi^*) + \beta_y * (y_t - y_t^*) \qquad \text{A(1)}$$

where i_t represents the real interest rate at moment *t*, β_π is equal to β_y and they have a value of 0.5, π^* is the target level of inflation and it has a value of 2% for EuroArea, y_t^* represents the target level of GDP or the potential output and it has unobservable values, so they are estimated values. π_t is the inflation rate and y_t is the real GDP growth rate.

After estimating the potential output, we run a regression of real interest rate on GDP and inflation according to Taylor's equation. The regression is ran for each country in the panel and the residuals obtained from each regression capture the relative stance of monetary policy for each country and they are the Taylor gaps used in the analysis conducted in this paper.

B – Hodrick-Prescott filtering technique

We use this approach as an estimating method for computing potential output, used in Taylor's equation. We have chosen this method because of its advantage of being the most known and commonly used univariate method for estimating potential output and output gap. It is a simple smoothing procedure and it is probably the most popular way of de-trending economic time series in the last recent years.

The potential output (or the trend output) is obtained by minimizing a combination of the gap between actual output (y), the trend output y^* and the rate of change in the trend output for the whole sample of observation, T. The equation used by this technique is formulated as follows:

$$\text{Min} \sum_{t=0}^{T}(y_t - y_t^*)^2 + \lambda * \sum_{t=2}^{T-1}[(y_{t+1}^* - y_t^*) - (y_t^* - y_{t-1}^*)]^2 \qquad \text{B(1)}$$

where λ represent the degree of smoothness of the trend. We use the value of 100 for λ, as proposed by Hodrick and Prescott (1997).

Basically, Hodrick-Prescott filtering technique divide the real GDP growth rate time series into a trend component (the estimate for potential output) and a cycle component (the difference between actual value of output and potential output, or the output gap).

C – Outlier Labeling Rule (Hoaglin, Iglewicz and Tuckey, 1986; Hoaglin and Iglewicz, 1987)

We compute the value of the first and the third percentile (Q_1 and Q_3). The lower bound for the outlier is computed using Q_1-g*(Q_3- Q_1), while the upper bound is computed using Q_3+g*(Q_3- Q_1), where g is the multiplier and it takes the value of 2.2, as proposed by Hoaglin and Iglewicz (1987). The values that are outside these two bounds are considered outliers. We tackle them by using winsorizing method, since trimming would have led to a loss of data, which is a drawback that we want to avoid, taking into account the relative high level of missing data in our sample.

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EVIDENCE ON THE NEXUS BETWEEN ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH THROUGH EMPIRICAL INVESTIGATION OF UGANDA

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Abstract *This paper empirically examines the electricity consumption - economic growth nexus in Uganda for the period 1982 to 2013, with a view to contributing to the body of literature on this topic and informing energy policy design in Uganda. Using capital stock as an intermittent variable in the causality framework, the paper employs Johansen-Juselius (1988, 1995) multivariate cointegration and VECM based Granger causality tests and finds a bidirectional causality between electricity consumption and economic growth in the long-term and distinct causal flow from economic growth to electricity consumption in the short-run, and short-term and long-term Granger causality from capital stock to economic growth, with short-run feedback in the opposite direction. Therefore, it implies that firstly, the Government of Uganda (GoU) can implement conservation policies only through reducing energy intensity and promoting efficient energy use to avoid decline in output and secondly, that the GoUshould intensify its efforts towards capital accumulation in order to realize sustainable economic growth. Lastly, the empirical evidence that electricity consumption influences some short-term capital accumulation supports the GoU's efforts to allow private sector investment in the electricity sector in an effort to increase electricity supply.*

Keywords: *Electricity Consumption, Economic Growth, Multivariate Cointegration and Granger Causality*
JEL Classification Codes: *C22, Q43, Q48*

1 INTRODUCTION

Electricity as a form of energy is considered to be one of the essential driving forces of economic growth in all economies, which directly and indirectly

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complements labour and capital as inputs in the production process (see Pokharel, 2006 and Mulugeta, etal, 2010). It contributes to economic growth through employment generation, and leads directly to value addition associated with extraction and transformation of inputs, technology transfers, marketing and distribution of goods and services. It also reinforces modernization of traditional economic sectors and assists in continuous expansion of secondary and tertiary sectors of the economy, in addition to improving the quality of life of individuals, particularly through heat, light and use of electrical appliances. However, in recent years many countries, particularly in Africa, have been facing serious energy (or electricity) deficiency and have been unable to meet the increasing demand for electricity. In addition to reducing the extent to which countries benefit from the above positive effectsthe shortage in electricity supply consequently raises input prices and prices of other commodities. This in turn contributes to higher overall inflation and dampens aggregate demand and economic growth (Abosedra at al, 2015 and Ouèdraogo, 2010).

The issue of the relationship (and hence direction of causality) between electricity consumption (sometimes used as a proxy for energy more broadly) and economic growth has been a subject of inquiry in economic literature. This is on account of the important policy implications that can be derived from this relationship regarding the course of action that can be done to accelerate economic growth. In spite of a wide discussion in the literature, the issue of the direction of causality between electricity consumption and economic growth still remains ambiguous. This ambiguity is attributed to the use of different data sets, different methods of analysis and different country characteristics (Adom, 2011). In addition, some studies have over-relied on a bivariate causality framework, which may suffer from the omission of variable bias. This is because incorporating the third variable that affects both electricity consumption and economic growth may change not only the direction of causality between the two variables but also the magnitude of the estimates.

This paper joins the debate into the inquiry of the direction of causality between electricity consumption and economic growth in the context of Uganda, with a view to contributing to the body of literature on this topic. In addition, knowledge about the direction of causality between these variables is important for the design of effective energy policy in Uganda. Uganda provides a unique perspective on this issue, being a small, less developed country that is electricity dependent for its growing industrial sector (especially manufacturing, agro-

processing and telecommunication) and commercial sector[2], as well as residential sector (see Shelagh and Tumushabe, 2014).Historical data is shown in Figure 1 in the appendices for the electricity consumption (measured in thousands kWh per capita), economic growth (measured by real GDP per capita) and capital stock per capita (measured by gross fixed capital formation per capita) in Uganda, which all trend upwards over the period 1982 to 2013[3]. In addition, these three variables are highly and positively correlated (see Table 1 in the appendices) suggesting the existence of causality between them.

To investigate the Granger-causality relationship, the authors follow the techniques employed by Odhiambo (2010) who analyzes the direction of causality between the two variables using a trivariate model. In this paper, the authors use capital stock as the third variable that relates to both electricity consumption and economic growth in the same way as Shahbaz et al(2012). This is plausible since capital stock includes electricity infrastructure which affects overall electricity consumption[4].

The rest of the paper is organized as follows: Section 2 provides a brief overview of the electricity sector in Uganda, section 3 briefly reviews the literature; section 4 describes the data and presents the analytical framework; section 5 discusses the empirical results and section 6 concludes.

2 AN OVERVIEW OF THE ELECTRICITY SECTOR IN UGANDA

Uganda is landlocked and resource-rich, yet remains one of the poorest countries globally (in terms GDP per capita) and ranks very low in terms of the Human Development Index (KPMG East Africa Limited, 2013). It has recorded robust economic growth over the last decade. However, in the past two years growth has slowed due to increased financing needs, corruption and inability to address major constraints to economic growth, especially in relation to affordable and reliable energy sources (Shelagh and Tumushabe, 2014). It is endowed with a wide range of natural energy resources such as biomass (fuel wood and charcoal), water and peat, as well as favourable conditions for solar, wind and geothermal power generation. In spite of this, the country's energy sector remains underdeveloped and characterized by low access and coverage by international and

[2]Note that these sectors are also capital intensive.

[3]However, capital stock trends at relatively lower rate than the rest of the series.

[4]There might be other variables in the same boat as capital stock; in particular labour or employment (as used by Odhiambo (2010)), however, formulating and comparing alternative possible models against each other is not within the scope of this paper.

regional standards. For example, approximately 85-90 percent of the country's population lacks access to electricity, and over 90 percent of the rural population depends on biomass for energy. In terms of consumption levels, the bulk of electricity in the economy is used by industrial and commercial sectors while only 30 percent is used by residential sector (Sustainable Energy for ALL, 2012).

The electricity sector in Uganda has been characterized by chronic supply shortages and persistent as well as unpredictable load shedding (rolling blackouts) due to insufficient power generation and underinvestment in energy infrastructure. Moreover, the government's energy policy hasfocused more on the development of large hydropower schemes (which can take many years to commission), which has resulted in partial neglect of the potential of the country's extensive small-scale hydro and biomass energy sources for power generation.Climate change impacts such as droughts and erratic rainfalls have undermined hydropower generation, contributing to supply shortages. Furthermore, theformerstate-owned Uganda Electricity Board (UEB) has suffered from low revenue collection and poor operational and financial performance due to inefficient tariff structures and subsidies, which to a certain extent encouraged wasteful use of electricity by consumers, therebyaggravating supply insufficiency (Shelagh and Tumushabe, 2014).

According to projections of electricity demand growth, Uganda is estimated to continue to experience significant power supply shortages from 2015 onwards due to an annual average increase in demand from industrial and domestic sectors of 7 to 9 percent per year (Sustainable Energy for ALL, 2012 and Keibbiehl and Miltner, 2013). This electricity demand-supply gap is likely to widen if large industrial projects are undertaken going forward and if there are delays in the commissioning of forthcoming large hydro projects. Against this backdrop, the Government of Uganda has since embarked on an extensive power-sector reform programme aimed at reducing the burden of subsidies and network losses, improving the quality of service and collection rates and attracting private capital in generation and distribution networks. In this regard, the state-owned Uganda Electricity Board (UEB) has since been unbundled into three entities: Electricity Generation Company Limited(EGCL), Uganda Electricity Transmission Company Limited and Uganda Electricity Distribution Company Limited(UEDCL). These organisations are responsible for generation, transmission and distribution, respectively. In addition, an independent electricity regulator (the Electricity Regulatory Authority or ERA) and the Electricity Disputes Tribunal (EDT) have been established. Further, the Rural Electricity Fund has been established and the Electricity Act has been enacted to create a basis for private sector participation in

electricity generation and distribution. The Government of Uganda (GoU) has also established the Rural Electricity Agency (REA) to promote grid and off-grid private sector-led rural electrification. It has also collaborated with the East African Community (EAC) on regional power interconnection. These reforms have so far improved power systems planning, professionalism and financial transparency as well as mobilizing substantial private resources for investment in the sector so that private operators are now dominant in electricity generation and distribution. Nonetheless, this may change after 2018, when a number of large hydro projects undertaken by Chinese state-owned enterprises are scheduled for completion.(See Shelagh and Tumushabe, 2014 and Tumwesigye et al, 2011).

3 LITERATURE REVIEW

Following the seminal work of Kraft and Kraft (1978), numerous studies in the literature have widely examined the direction of the causal relationship between electricity (sometimes used as a proxy for energy more broadly) consumption and economic growth, and its policy implications based on four main hypotheses, namely; *growth, conservation, feedback and neutrality hypotheses*. The growth hypothesis states that the economy depends on energy consumption for economic growth so that the more energy the economy consumes, the more the economy will grow. Hence energy consumption drives economic growth. In this case, any energy shortage or supply interruption will have a negative effect on economic growth. Under this hypothesis, electricity (or energy) conservation measures aimed at reducing energy consumption may negatively affect economic growth. This hypothesis is supported by studies that find unidirectional causal flow from energy consumption (or electricity consumption) to economic growth (see Odhiambo, 2009a; Narayan and Singh, 2007; Narayan and Smyth, 2008; Narayan and Prasad, 2008; Altinay and Karagol, 2005and Wolde-Rufael, 2004).

On the contrary, the conservation hypothesis asserts that energy consumption in the economy depends on the growth of the economy so that the more growth the economy experiences, the more energy will be demanded and consumed to support that kind of growth. This implies that the economy does not strongly depend on energy consumption for growth. Under this hypothesis, energy conservation policies such as efficiency improvement measures and demand management policies aimed at curtailing electricity use by decreasing wasteful use of electricity can be initiated without negatively affecting economic performance (see Gosh, 2002). This hypothesis is backed by empirical studies that find unidirectional causality from economic growth to energy (or electricity)

consumption. These studies include Kwakwa (2012), Narayan and Smyth (2005), Adom (2011), Mozumder and Marathe (2007) among others.

The feedback hypothesis postulates that energy consumption and economic growth are interrelated and may complement each other. In this case, efficient energy use and energy development policies geared toward increasing electricity generation can impact positively on economic growth. This hypothesis is supported by empirical studies that find bidirectional causality between energy (or electricity) consumption and economic growth. These studies include Aslan(2014), Odhiambo (2009b), Tang (2008), and Masih and Masih (1997).

Finally, the neutrality hypothesis states that there is no causal relationship between energy consumption and economic growth. This hypothesis would imply that neither conservative nor expansive policies in relation to energy consumption have any effect on economic growth. This hypothesis was empirically supported by the works of Payne (2009), Akarca and Long (1980), Yu and Hwang (1984) and Cheng (1995), among other studies.

4 DATA AND ANALYTICAL TECHNIQUES

4.1 Data Types and Sources

This paper uses annual time series data for Uganda covering the period from 1982 to 2013. The data used as a proxy for economic growth is real GDP per capita (US$, 2005 constant prices). Capital stock is proxied by gross fixed capital formation (US$ 2005 constant prices). Data for these two series was obtained from the World Bank Economic Indicators (WEI) database. Lastly, data on electricity consumption per capita (measured in thousands of kWh per capita) was obtained from Uganda Bureau of Statistics (UBOS). For analysis, the data series are transformed into natural logarithms[5] and denoted by the variable names $LRGDP, LK$ and $LEC,$ respectively.

4.2 Cointegration

This paper employs the Johansen-Juselius (1988, 1995) multivariate cointegration procedure to test for long-run relationships between electricity consumption, capital stock and economic growth in Uganda. This technique requires variables to be integrated to the same order, therefore, prior to testing for cointegration between the variables; the paper investigates the presence of unit roots among the variables using Augmented Dickey-Fuller (ADF) and Phillips-

[5]This is done to reduce the possibility of heteroskedasticity.

Perron (PP) unit root tests. If the variables are found to be integrated to the same order, the maximum likelihood estimation of the unrestricted vector autoregression (VAR) model is estimated to determine the existence of cointegration between the variables. The lag length is chosen on the basis of Schwarz-Bayesian information criterion (BIC) and Akaike information criterion (AIC) while the cointegrating rank is determined by means of the trace and maximum eigen value likelihood ratio test statistics.

4.3 Granger Causality Test

According to Granger (1969 and 1988) the existence of cointegration between the variables may imply the existence of causality between the variables at least in one direction. Therefore, the paper employs the Granger causality test based on the vector error correction model (VECM) framework to determine the short-run and long-run causal effects between electricity consumption and economic growth[6]. However, in an attempt to avoid unreliable results on account of omission of variable bias inherent in the bivariate causality framework (see Odhiambo, 2010 and Shahbaz et al,2012), this paper adopts a trivariate causality framework, which includes capital stock as an additional intermittent variable[7].In this regard, the trivariate vector error correction model within which Granger causality is examined is specified, as follows.

$$\Delta LEC = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i}\, \Delta LEC_{t-i} + \sum_{i=0}^{n} \alpha_{2i}\, \Delta LK_{t-i} + \sum_{i=0}^{n} \alpha_{3i} \Delta LRGDP_{t-i} + \alpha_4 ECT_{t-1} + \varepsilon_t \quad (1)$$

$$\Delta LK = \varphi_0 + \sum_{i=1}^{n} \varphi_{1i}\, \Delta LK_{t-i} + \sum_{i=0}^{n} \varphi_{2i}\, \Delta LEC_{t-i} + \sum_{i=0}^{n} \varphi_{3i}\, \Delta LRGDP_{t-i} + \varphi_4 ECT_{t-1} + v_t \quad (2)$$

[6]Granger causality is preferred over other methods owing to its favorable response in both large and small samples.

[7]According to Odhiambo (2010), the addition of this variable may not only affect the magnitude of the relationship between electricity consumption and economic growth, but may also change the direction of causality between electricity consumption and economic growth.

$$\Delta LRGDP = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta LRGDP_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta LK_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta LEC_{t-i} + \beta_4 ECT_{t-1} + u_t \quad (3)$$

where $ECT_{t-1}$is the lagged error correction term derived from the long-run cointegrating relationship ε_t, v_t and u_t are mutually uncorrelated white noise residuals, and the$\alpha's$, $\varphi's$and $\beta's$are corresponding adjustment coefficients. In this test, the short-run causality is captured by the significance of the F –statistics and $t-$ statistics on the explanatory variables. On other hand, the long-run causality is captured by the significance of the $t-$ statistic on the coefficient of the lagged error correction term. Nevertheless, if there is no cointegration between the variables, equations (1), (2) and (3)are estimated without the error correction term and only short-run causality direction can be determined through F-test of significance of the explanatory variables.

5 EMPIRICAL ANALYSIS

5.1 Unit root test

In the first stage, the order of integration of the variables is investigated by employing the standard ADF and PP unit root tests. Table 2 presents the results of ADF and PP unit root tests.vAlthough not presented here, unit root test results on levels of the variables show that electricity consumption, capital stock and economic growth are non-stationary. However, when first differences of the variables are taken, the ADF and PP unit root reject the null hypothesis of non-stationarity for the three variables at the 10 per cent level of significance[8]. Therefore, the paper concludes that electricity consumption, capital stock and economic growth are integrated of order one, $I(1)$,vand hence might be cointegrated.

Table 2: ADF and PP Unit Root Test Results (at first differences)

Variable	ADF Statistic	PP Statistic
ΔLEC	$-8.0156(0.000)^{***}$	$-11.5301(0.000)^{***}$
ΔLK	$-4.2758(0.0105)^{**}$	$-6.4230(0.0001)^{***}$
ΔLRGDP	$-2.9447(0.052)^{*}$	$-3.3363(0.079)^{*}$

Note: Values in parenthesis are p-values while ***, **and * indicate significance at 1 percent, 5 percent and 10 percent, respectively.

[8]The 10 percent level of significance is used for all the variables in this case. Otherwise, the null hypothesis of unit root is rejected at 1 percent for electricity consumption, and 1 percent (PP test) and 5 percent (ADF test) for capital stock.

5.2 Cointegration test

Given that all the variables included in the analysis are$I$ (1), the next stage is to use the Johansen-Juselius (1988, 1995) multivariate cointegration to test for the existence of long-run relationship between them. However, the results of this cointegration procedure depend on the number of lags included in the VAR model, which must therefore be determined beforehand. The number of lags used must seek to ensure that the errors are approximately white noise, while maintaining enough degrees of freedom for estimation. This paper does so by using BIC and AIC criteria, and finds that the appropriate lag length is one. Table 3 reports the trace and maximum eigen value tests for cointegration among electricity consumption, capital stock and economic growth.

Table 3: Results ofJohansen Trace and Maximum Eigenvalue tests for cointegration

Trace test			**Maximum eigenvalue test**		
Null	**Statistics**	**95% critical value**	**Null**	**Statistics**	**95% critical value**
Cointegration between electricity consumption, capital stock and economic growth					
$r = 0$	36.92	29.79	$r = 0$	25.32	21.13
$r \leq 1$	11.60	15.49	$r \leq 1$	10.96	14.26
$r \leq 2$	0.644	3.841	$r \leq 2$	0.644	3.841

Note:1) r stands for the number of cointegrating vectors

These tests show that the null hypothesis of no cointegration against the alternative hypothesis of at most one cointegrating vector is rejected at 5 percent level of significance. Therefore, there exists one cointegrating vector relating electricity consumption, capital stock and economic growth.

5.3 Analysis of Granger Causality Test

The existence of cointegration among electricity consumption, capital stockand economic growth suggests that there must be Granger causality between electricity consumption, capital stock and economic growth at least in one direction. However, it does not show the direction of causality between these variables. Therefore, the paper goes further to investigate the short-run and long-run Granger causality among electricity consumption, capital stock and economic

growth in the context of a VECM framework. Table 4 reports the results of Granger causality test based on the estimated VECM.

Table 4: Results of VECM Granger Causality Test

Explanatory variables	**Dependent variables**		
	ΔLEC	ΔLK	$\Delta LRGDP$
Constant	$0.0028(0.144)$	$0.0725(2.910)$	$0.0162(2.877)$
$\Delta LRGDP_{t-1}$	$2.0168(3.583)^{***}$	$1.2617(1.769)^{*}$	$0.2273(1.409)$
ΔLK_{t-1}	$-0.1310(-0.802)$	$0.3546(1.715)^{*}$	$0.8867(3.896)^{***}$
ΔLEC_{t-1}	$0.0490(0.348)$	$0.3159(1.769)^{*}$	$-0.0398(-0.986)$
ECT_{t-1}	$-0.4488(-4.566)^{***}$	$0.2237(1.797)^{*}$	$-0.1152(4.091)^{***}$
F-test[3]	$7.1295\{0.003\}^{***}$	$2.4483\{0.1069\}$	$2.3662\{0.0045\}^{***}$
R^2	0.5715	0.2206	0.5926
DW	2.098	2.079	2.098
AR	$0.1521\{0.697\}$	$0.3379\{0.561\}$	$0.2137\{0.644\}$
ARCH	$0.1700\{0.680\}$	$0.9068\{0.359\}$	$2.5357\{0.111\}$

Notes: 1) ***, ** and * indicate significance at 1 percent, 5 percent and 10 percent levels. 2) The numbers in parentheses ( ) are t-statistics and numbers in parentheses { } are probability values.3) The F-test measures the joint significance of the independent differenced variables; for example in the case of the equation for ΔLEC the explanatory variables are $\Delta LRGDP_{t-1}$, ΔLK_{t-1} and ΔLEC_{t-1}

The results show that there is bidirectional causality between electricity consumption and economic growth in Uganda in the long-term while causality only runs from economic growth to electricity consumption in the short-term. The long-term feedback hypothesis between electricity consumption and economic growth is supported by the coefficients of lagged error correction terms, which are negative and statistically significant at 1 percent level of significance in the electricity and economic functions, respectively on one hand. On the other hand, the short-term causal from economic growth to electricity consumption is backed up the both coefficient of economic growth and the F-test, which are statistically significant at the1 percent level of significance. This finding provides evidence in support of the proposition that in the long-term economic activity is a result of electricity consumption and vice versa in Uganda. Therefore, electricity consumption and economic growth are interrelated and complement each other. This result is

consistent with Sekantsi (2014) for the case of Uganda[9], Aslan(2014) for the case Turkey, Odhiambo (2009b)for the case of South Africa, and Raza et al (2015) for the case of Pakistan.

This finding is pertinent given that the industrial and commercial sectors, which consume much electricity ,also contribute significantly to economic growth because electricity availability to those sectors might influence their production levels and consequently increase output in the economy. The industrial sector (especially manufacturing, agro-processing and telecommunication) and commercial sector in Uganda currently consume about 70 percent of electricity, and during the period 2008-2012 manufacturing and agro-processing industries contributed 47.0 percent on average to Uganda's GDP, while the manufacturing sector and telecommunication industry collectively contributed on average 27.2 percent in the same period (UBOS, 2013). Thus, one can infer that electricity consumption plays an important role in determining the level economic activity.

In terms of causality running in the opposite direction, Uganda experienced robust economic growth over the last decade due to increased economic activities in financial services, manufacturing and telecommunication, construction, transportation and energy infrastructure. This growth, and associated increased investment, has led to expansion in industrial (especially manufacturing, agro-processing and telecommunication) and commercial sectors, whose demand for electricity has been increasing gradually (Shelagh and Tumushabe, 2014). In addition, in recent years the advancement of the Ugandan economy due to economic growth has witnessed inter-fuel substitution from conventional sources of fuel such as biomass, paraffin and oil to electricity in different sectors of the economy. In particular, higher disposable incomes received by households, particularly in urban areas, have increased their demand for electrical appliances for heating, cooking, lighting, recreation and comfort (Shelagh and Tumushabe, 2014).Given these circumstances, it is also reasonable to expect economic growth to stimulate electricity consumption in the economy gradually. However, the existence of no short-run causal flow from electricity consumption to economic growth might be due to the fact that the low electricity access and persistent load shedding as a result of small electricity sector in Uganda often cause major disruptions to households, businesses and industry (Keibbiehl and Miltner, 2013) and hinder broader investment as well as negatively affecting the country's

[9] The main difference between this paper and Sekantsi (2014) is that this paper includes capital stock as an intermittent variable. Since the results are broadly the same, this paper shows that the results are robust to this change in model specification.

competitiveness and thereby inhibiting economic growth (see Sustainable Energy for ALL, 2012 and Shelagh and Tumushabe, 2014).

From a policy perspective, the verification of bidirectional causality between electricity consumption and economic growth in Uganda has important policy implications for the GoU. They imply that electricity conservation policies have the potential toretard economic growth. Therefore, the GoU should develop energy or environmental policies aimed to reduce energy consumption only through reducing energy intensity and promoting efficient energy use to avoid decline in output. More specifically, the GoU should consider a variety of policies, such as the rationalization of tariff structures and subsidies, efficiency improvement measures, as well as demand management policies aimed at reducing wasteful use of electricity by consumers. These policies offer certain advantages; not only are they cheaper than production but they also avoid the environmental costs associated with additional electricity generation (see Gosh, 2002). In addition, the GoU should also be expanding energy infrastructure to address increased electricity demand to support economic growth.

The empirical results also indicate short-run and long-run causal flow from capital stock to economic growth, which may feed back into capital stock in the short-run. The short-run and long-run causality from capital stock to economic growth are supported by the statistically significant coefficient of capital stock (and F-test) and the statistically significant coefficient of the lagged error correction term at 1 percent level of significance[10] in the economic growth function, respectively. This finding is consistent with Misztal (2010), who finds that fixed capital formation highly explains GDP variances both in the short- and long-run in Romania, and provides evidence of investment-led growth. This suggests that capital accumulation drives at least some of the short-term and long term economic growth in Uganda. This empirical evidence supports the Harrod-Domarmodels and new growth theories, which reconfirm the view that investment is an engine of long-run economic growth (see Barro, 1990; Lucas, 1988 and Romer, 1986). This is because capital accumulation creates production facilities and stimulates economic activities, reduces transaction and trade costs and thereby improving the country's competitiveness as well as providing employment opportunities to the poor (see Sahoo et al, 2010). Hence policymakers in Uganda should formulate macroeconomic policies aimed at enhancing capital investment in order to achieve higher and sustainable economic growth. The finding of short-run feedback causality between capital stock and economic growth is consistent with Shahbaz,et

[10]Note that the coefficient of the lagged error correction term has the correct sign.

al(2012) and Ouédraogo(2010) but contrasts with that of Blomström et al(1996) who argue that causality between the two variables could come from either economic growth or capital investment. It implies that in the short-run economic growth and capital accumulation mutually influence each other, which suggests that high levels of capital accumulation lead to high levels of economic growth and vice versa. This may occur due to the fact that higher levels of economic growth can support more capital accumulation.

Lastly, the existence of short-run causal flow from electricity consumption to capital stock is implied by the significance of the coefficient of electricity consumption in the capital stock function. This weak causality suggests that increased demand for electricity influences some short-term capital investment, particularly investment in electricity infrastructure which affects overall electricity consumption. This result is consistent with Masuduzzaman (2012). This is relevant given that due to increased demand for electricity by different sectors in the economy, the GoU has undertaken measures to increase electricity generation and distribution through private sector investment in the electricity sector. Therefore, this finding implies that policymakers in Uganda should continue to encourage private sector investment in the electricity sector. This policy measure will not only provide much needed private capital in the electricity sector but also foster competition in the sector, providing increased scope for consumer choice (see Shelagh and Tumushabe, 2014).

6 CONCLUSION

This paper studies the causal relationship between electricity consumption and economic growth in Uganda from 1982 to 2013 by using Johansen-Juselius multivariate cointegration and VECM Granger Causality tests. The study finds the existence of cointegration among the variables and bidirectional causality between electricity consumption and economic growth in the long-term and unidirectional causal flow from economic growth to electricity consumption in the short-run. This long-term feedback causality between electricity consumption and economic is plausible given that the major consumers of electricity, industrial and commercial sectors, also contribute significantly to economic growth as electricity availability to those sectors might influence their production levels and consequently increase output in the economy, on one hand. On the other hand, the advancement of the economy has encouraged people, particularly in urban areas, to use electricity dependent gadgets for heating, cooking, recreation and comfort. In addition, increased economic performance over the last decade has increased the expansion

of industrial and commercial sectors, whose demand for electricity has been increasing gradually. This has important consequences for electricity conservation policies as GoU has embarked on an extensive power-sector reform programme aimed at narrowing the electricity demand-supply gap in the country. The results suggest that the GoU can implement conservation policies only through reducing energy intensity and promoting efficient energy use to contain growth of demand for electricity in order to avoid decline in output. Such measures are not only cheaper than production but also avoid the environmental costs associated with additional electricity generation.

In addition, the findings of short-run and long-run causal flow from capital accumulation to economic growth support investment-led growth, which suggests that capital investment drives at least some level of short-term and long term economic growth. This may be due to the ability of capital investment to create production facilities and stimulate economic activity, as well as providing employment opportunities to the poor in Uganda. Therefore, the GoU should intensify its efforts towards capital accumulation in order to realize sustainable economic growth. The analysis also shows short-run bidirectional causality between capital stock and economic growth, implying that in the short-run economic growth and capital accumulation mutually influence each other. Lastly, the finding of short-run causal flow from electricity consumption to capital stock supports the GoU's efforts to increase private sector participation in electricity generation and distribution with ultimate intention to increase electricity supply.

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APPENDIX

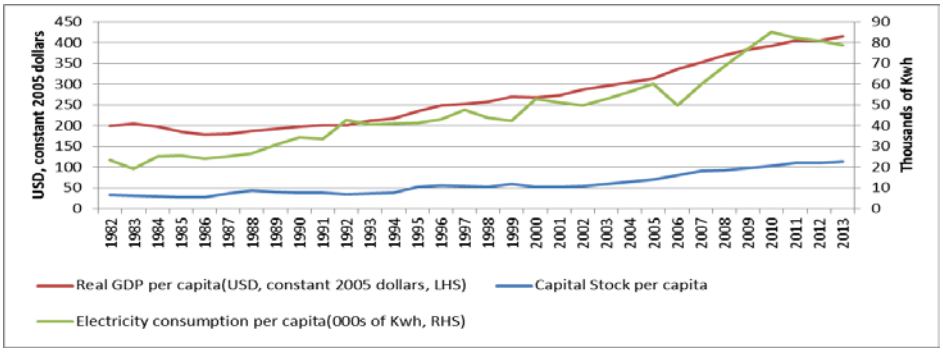

Figure 1: Trend in Annual ElectricityConsumption per-capita, Capital Stock per capita and RealGDP per-capita in Uganda during the period 1982 – 2013.

Source: World Economic Indicators& Uganda Bureau of Statistics

Table 1 The Correlation Matrix for Electricity Consumption per Capita, Capital Stock per Capita and Real GDP per Capita.

Variable	Electricity Consumption	Capital Stock	Economic growth
Electricity Consumption	1		
Capital Stock	0.9444	1	
Economic growth	0.9577	0.9809	1

Source: Own Computations

SURVEY ARTICLE

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UNIVERSITY RESEARCH ECOSYSTEM: A CONCEPTUAL UNDERSTANDING

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Abstract: *The aim of this paper is to propose a new theoretical perspective and a conceptual model to build a sustainable research ecosystem in universities. The paper is conceptual in nature and draws upon existing literature to propose a unique framework on sustainable research ecosystem. This paper borrows the theoretical foundations from natural ecosystem to propose a process and stakeholder view of a research ecosystem in universities and suggests means to achieve sustainability in the long run. A thriving university research ecosystem leads to consistency, efficiency and sufficiency in research output. The ideas proposed in this paper are in the nascent stage and in the emerging market context. Future research is suggested to operationalize and validate the proposed framework in both developing and developed nation context. The insights generated here would therefore contribute to the existing models and frameworks that few universities subscribe to. From an originality point of view present work has conceived and conceptualized a new direction of thinking, i.e. creation of a sustainable research ecosystem.*

Keywords*: research, research ecosystem, sustainability, sustainable research ecosystem, emerging markets, process view, stakeholder view, higher education.*
JEL Classification*: I10*

1 INTRODUCTION

Across various disciplines there has been an increased call to focus on the relationship between university research, its productivity and stakeholder's involvement. The importance of research lies in the fact that research is the

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foundation for knowledge that has made innovation and application possibly resulting in benefits for the society at large (Marginson, 2009). It is also true that all research does not lead to immediate gains and in reality some of it does not lead to any measurable outcome but it is the inquisitive spirit of mankind that expresses itself through research. This gives rise to some interesting questions such as what it takes to produce high quality research, how various stakeholders interact with each other and what could be the possible measures to increase research productivity. In this paper we aim to answer these questions by bringing in a new perspective of University Research Ecosystem (URE) which is analogous to natural ecosystem involving all the potential stakeholders. Paper also advances the body of literature by proposing means to build a sustainable research ecosystem.

This paper is divided into five sections. Section 2 briefly discusses the origin of universities, section 3 discusses the advent of research universities and the university research system, developing on the understanding developed in the previous sections, section 4 presents the definition of University Research Ecosystem (URE). To further substantiate the meaning of University Research Ecosystem subsections also describe the stakeholder and process view of URE. Section 5 discusses the sustainable research ecosystem, and further describes the basis of sustainable research ecosystem; this includes Research Culture (National/ Regional/ Institutional), Disturbance Regime, Research resource management/ Knowledge management and research stakeholders. Section 6 describes the contextualization of proposed model. Discussions, conclusions and future directions for research are presented in the section 7.

2 THE ORIGIN OF UNIVERSITIES

Universities are one of the major contributors of scientific research leading to invention and innovation in the world. Universities not only prepare the labor force, they create the much needed skilled human resource. University is derived from the word "*universitas*" in Latin which means the "whole".[1] The Oxford Dictionary defines university as "a high level educational institution in which students study for degrees and academic research is carried out".[2] In the words of JawaharLal Nehru, the first Prime Minister of India, the central objective of the university is as under (Das, 2007, pp.47):

[1] Latin Dictionary, revised, enlarged and rewritten by Charlton T. Lewis, Oxford, Charendon Press, 1937, pg. 1933

[2] Oxford Dictionary and Thesaurus, edited by Maurice Waite, Oxford University Press, 2007, pg. 1131

"A university stands for humanism, for tolerance, for reason, for the adventure of ideas and for the search of truth. It stands for the onward march of human race towards even higher objectives."

Structured learning at a single place existed in the 7th century BC in the form of the Buddhist monasteries and in the 3rd century AD at Nalanda. Few of these centers were quite large and had several faculties'. Records suggest that there might have been approximately 10000 students and 3000 teachers participating in the process of learning at Nalanda. With students and scholars from Korea, Japan, China, Tibet, Indonesia, Persia and Turkey, the major areas of learning at Nalanda were Buddhist studies, fine arts, medicine, mathematics, astronomy, politics and the art of war (Cochrane, 2009). In the European context, the first so called university originated in the form of a medical school at Salerno, Italy in the 9th century. In the true sense though, the first university originated at Bologna. The first university to be established in northern Europe was the University of Paris, established sometime between 1150–1170 A.D. The University of Oxford, founded in the 12th Century was the most reputed in England. Major part of the curriculum consisted of the seven liberal arts namely: grammar, logic, rhetoric, geometry, arithmetic, astronomy and music. Although the universities in the 12th till 14th Century were controlled by the state, they drew there powers from the church (Ross, 1991). Their autonomy from local government control, in other words, depended upon their subordination to the community of God. In keeping with the Christian order of truth, knowledge was constructed as eternal and scholarship as a matter of interpretation, imitation, and cultivation. During the Reformation, in the 16th century, many universities were freed from the direct control of the Church and came under secular state supervision. In the process, they lost their monopoly over knowledge and science (de Ridder-Symoens, 2003).

Immanuel Kant in his works positioned the university as the embodiment of "thought as action toward an ideal"—the ideal being the production of a national culture and a reasoning subject to serve as its vehicle. He also argued that universities should examine and guide the "inmost thoughts," the "secret intentions," the conduct, and the health of the citizenry through pure disinterested reason (Readings, 1996).

3 ADVENT OF RESEARCH UNIVERSITIES

Today research has become an important function of the university system although its roots can be traced back to the beginning of the 19th century in Germany where the University of Berlin came into existence with scientific research at its core (Ben-David &Zloczower, 1962). In the following centuries till

date, research is of ultimate importance for all universities as the status of universities is based on the research quality and productivity. Many authors have defined research in many ways as regards to the discipline and form in question. Research is primarily defined in different ways by various disciplines and can take many forms. A broad definition of research by Shuttleworth (2008) suggests that research includes any gathering of data, information and facts for the advancement of knowledge.Another definition by Creswell (2002) states that "research is a process of steps used to collect and analyze information to increase our understanding of a topic or issue". It consists of three steps: pose a question, collect data to answer the question, and present an answer to the question.

Research universities are at the zenith of the university system. They serve only the crème of the students and are very few in number (Clark, 1995). However number of such universities has been increasing in the past decade (Altbach & Salmi, 2011). The aim of these universities is to bring research to the core of the university system and apply that research to national economic development. It all started in the later part of the 19th century with the onset of the American Land Grant universities which included direct service to society mainly in agriculture and industry to the objectives of research universities. This brought universities to the limelight and since then universities have been contributing to the society more directly through research and development in almost all countries worldwide (Altbach, 2008).

3.1 The University Research System

Over a period of time, universities world over have developed indigenous science and technology system. The science and technology system comprises of resources available to the university like finance, governance or administrative, human, intellectual, and physical capital that acts as inputs to the productivity through research, education, training, and socialization generating intellectual and human outputs. According to Frischmann (2008), the system comprises of:

I. ***Human Capital*:** Faculty, Researchers, Students, Administrators, Technicians etc;

II. ***Governance Capital:*** Rules, Norms, Policies;

III. ***Physical Capital:*** Land, Facilities and Equipment;

IV. ***Intellectual Capita*l:** Knowledge, Information, Ideas; and

V. ***Financial Capital:*** Research Grant, Funding etc.

Each of these resources is integral to the system. It is interesting to note that the combination in which these resources are put together and the derived behavior

of that combination differs from university to university. The elements of this system, combined within a university structure, together act as valuable inputs in reaching the desired goals of universities like facilitation of research, dissemination of knowledge through education, imparting training and acting for the betterment of the society at large.

University science and technology research systems, like any other system, are invaluable to the society because of the economic activity they generate in addition to the knowledge base that they create for the society. In fact the contributions of the research systems are in the value that is imbibed in final output (Frischmann, 2005). The research results produced by these systems mostly contribute to industrial and social needs by facilitating the production of various private or public goods. The results derived from research not only vary in specifications but also in terms of its use and application to reach desired outcomes towards the benefit of the society (Reichman and Uhlir, 2003).

Allocation of the infrastructural capital of the universities is not a conscious decision to exploit the market potential of research results (Auerswald and Branscom, 2003). Therefore, the majority of the research and development activities resulting in results have not been towards market oriented research. Of course, this is not to say that university research systems have not contributed by way of conducting commercial research or that research results have never been used commercially but rather that this area has not been an area of priority to the universities (Henderson, Jaffe and Trajtenberg, 1998). Historically speaking, as regards to the industry or its need in terms of industry orientation, universities have not allocated enough resources. But the trends are changing with changing times.

In the same way, for a good part of the last century public funding for research in universities have not been towards finding solutions for specific problems of the commercial segment of the society (Fossum et al., 2004). To solve the problems of insufficient research and underutilization of research results by the industry, a re-look at the age old concept of production and utilization of intellectual property was required (Kieff, 2001). An identification of major facilitators of research in universities thus becomes pertinent.

4 DEFINING UNIVERSITY RESEARCH ECOSYSTEM

University Research Ecosystem (URE) can be basically understood as a community of researchers which interacts with one another, their environment and other stakeholders interested in their respective areas of research in such a way that knowledge is transferred between them and system-level processes emerge. For a research ecosystem to evolve, sharing of knowledge is a must as it works like

essential abiotic components of a biological ecosystem. Research ecosystem can be better understood if we analyze it by two views: stakeholder view and process view.

4.1 Stakeholder view of research ecosystem

We conceptualize stakeholders view as collection of interaction of individuals and institutions. The key stakeholders of a research ecosystem of an institution are their faculty, doctoral students, research associates and postgraduate students. Burrows (1999) called these stakeholders, facilitators which included regulatory powers, teaching staff, administrative personnel, competitors, donors, governmental organizations, and various partners among others. Here, it should also be noted that research in isolation is not possible in new age and knowledge economy.Cut throat completion, changing technology and other resource constraints define the context which calls for collaboration with external institutions, industry, central or state government. For research ecosystem to survive, each and every stakeholder has to play a critical and responsible role. Figure 1 below presents the stakeholder view of research ecosystem.

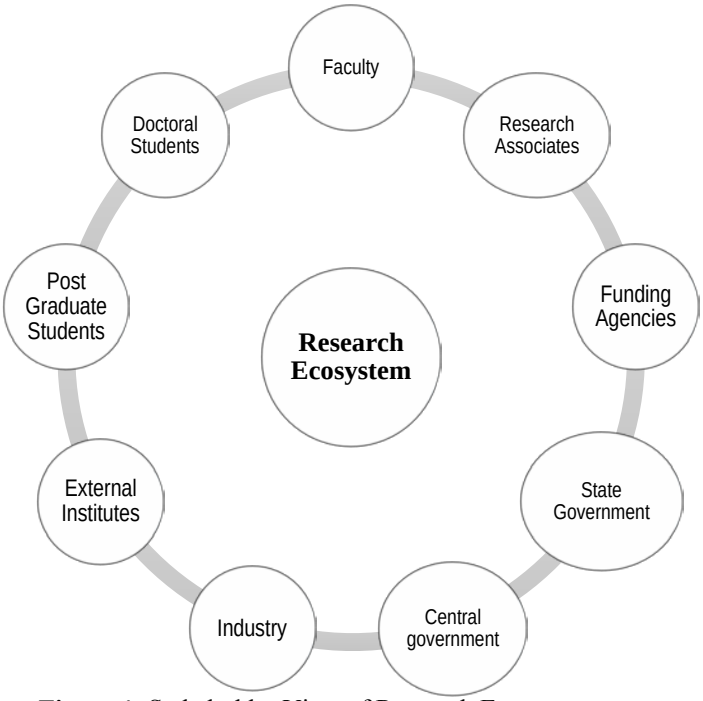

Figure 1: Stakeholder View of Research Ecosystem

4.2 Process view of research ecosystem

The different processes which help the stakeholders of the research ecosystem to share and transfer knowledge among them are shown in the figure 2. The process view is characterized by the processes that can guide a university research ecosystem if managed carefully. These include regular brainstorming in seminars, workshops, conferences and online forums and informal gatherings as well. Technology being a major factor in almost every walk of life cannot be ignored in creation of a research ecosystem. Leveraging on technology available, a library information system and an academic information system can be developed by the institutes to give access to journals, books and audio and video archives as well as making forums and notice boards, etc.

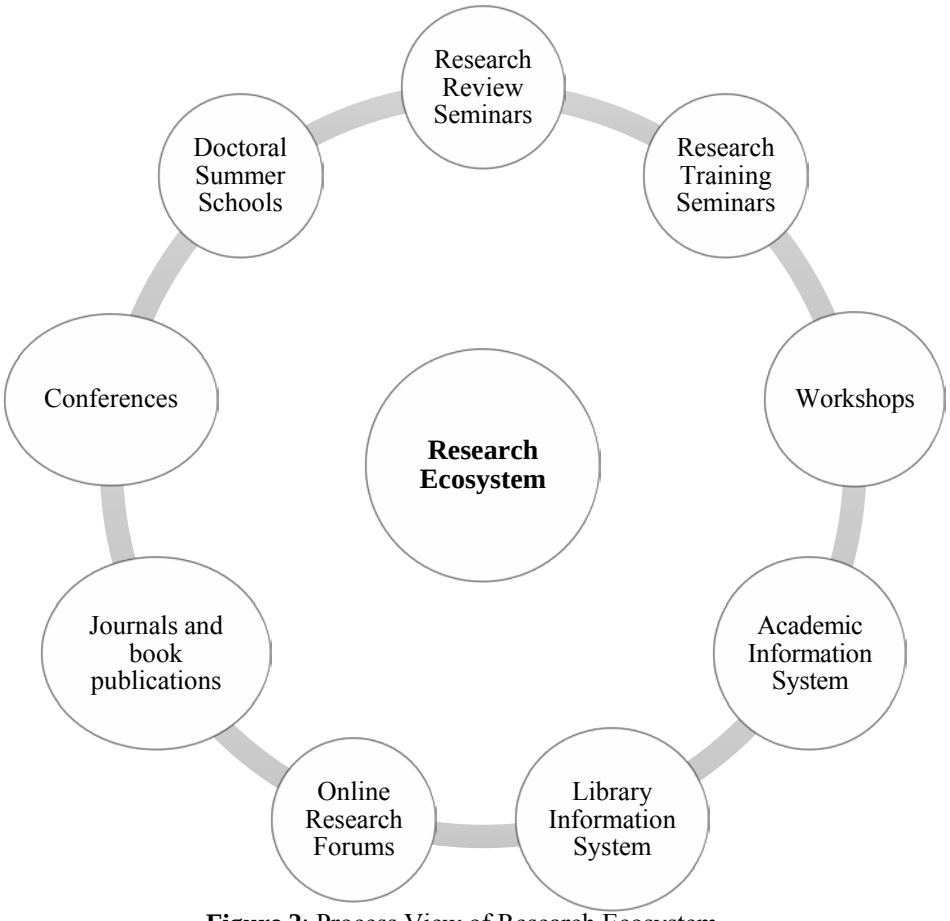

Figure 2: Process View of Research Ecosystem

5 SUSTAINABLE RESEARCH ECOSYSTEM

A sustainable research ecosystem is a system that survives, functions, and updates itself over time; a system in which research community can continue to interact, share, and transfer the knowledge; which can guide the upcoming generations of researchers on its own. If we take the analogy of sustainable natural ecosystem (Chapin III, et.al., 1996), a sustainable research ecosystem can be defined as one that, over the normal cycle of disturbance of events (e.g. economic slowdown), maintains its characteristic diversity of major stakeholder groups, research productivity and its contribution towards the society as a whole.

Few research ecosystems are sustainable and longer than two to three decades, because factors such as research culture, knowledge resources and key stakeholders which shape ecosystems change significantly over these periods of time, as each stakeholder migrates according to its unique knowledge requirement and research capabilities. Like natural ecosystem, it is hard to sustain the current level of research output, composition and structure of stakeholders of any research ecosystem indefinitely. However, sustainability is a relevant and important concept to protect the invaluable knowledge for upcoming generation of researchers.

Research ecosystems are not static. Research stakeholder composition, research productivity, and research processes all change in response to stochastic events and successive change. The specialty of a sustainable research ecosystem is that it maintains these traits within stable bounds.

5.1 The Basis of Sustainable Research Ecosystem

The properties of a research ecosystem are governed by four dynamic elements or interactive controls: regional research culture, research resource management, research stakeholders, and disturbance regime. These interactive controls are constrained by four external factors: global research culture, global research community, and time. A conceptual model of sustainable research ecosystem has been provided in figure 3. From the figure, it is clear that interactive controls must be conserved to sustain a research ecosystem. A new research ecosystem with different properties will evolve with the major changes in any interactive controls. Though each interactive control may change over the time, these controls operate within bounds represented by unique research ecosystem in a way that large changes in interactive controls are prevent

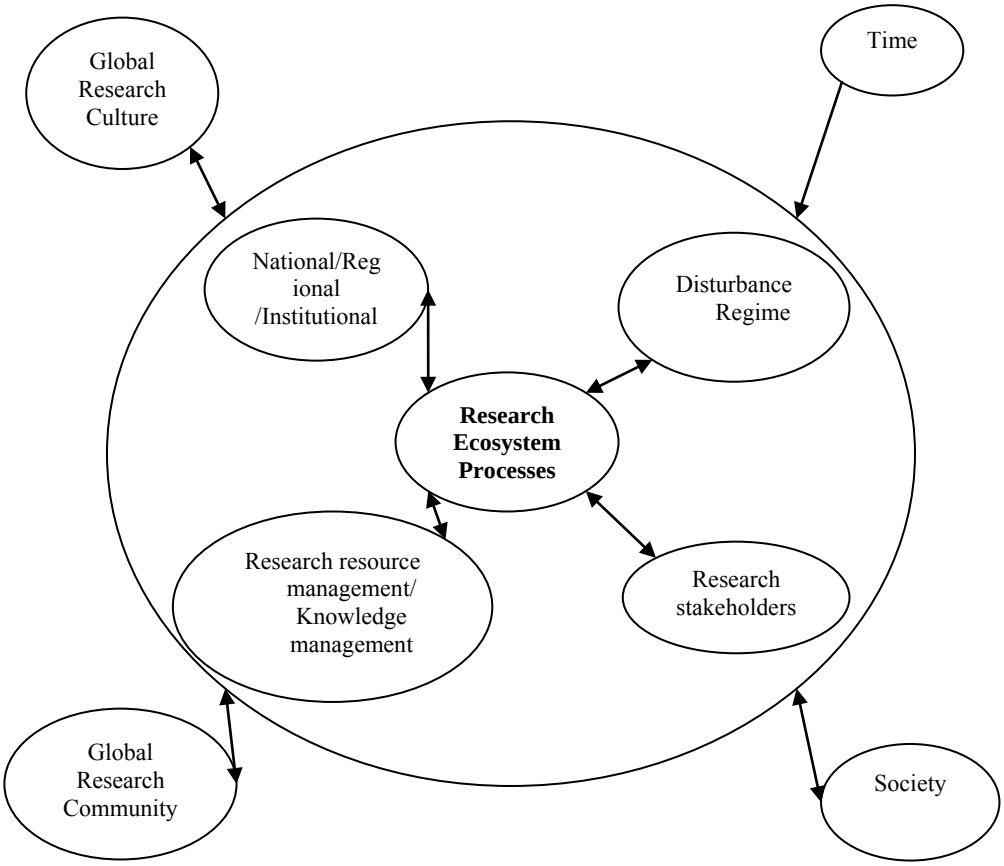

Figure 3: Conceptual Model for creation of a sustainable research ecosystem

5.1.1 Research Culture (National/ Regional/ Institutional)

Research culture is the interactive control that most strongly governs the structure and research productivity of a research ecosystem. The key ingredients of the research cultures are: trust, collaboration, cooperation, and motivation.

Trust is necessary for the stakeholders to interact and share their research ideas without fearing of theft of the same with a hope that they will get honest feedbacks from others. Trust will make the foundation for the research stakeholders to collaborate and cooperate for the greater interest of research community and society at large. Collaboration and cooperation amongst similar as well as cross disciplinary stakeholders will increase the research productivity of ecosystem and effectiveness of the research ecosystem processes. Motivation such as rewards, acknowledgements, promotions, incentives will lead to the greater interests of the

researchers and other stakeholders to concentrate towards the quality research that in turns results into the synchronization among the research stake holders and creation of sustainable research ecosystem. Sharing of knowledge plays a vital role in attaining the sustainability for a research ecosystem. However current studies show that for sharing the knowledge trust, cooperation, collaboration and motivation is required.

5.1.2 Disturbance Regime

Change in the intensity or frequency of disturbance can create long-term research ecosystem change. For example, in an economic slowdown the research grant given to the respective stakeholders may be reduced and the nature and scope of research, composition and structure of the research stakeholder may also change as a result of that. These changes may have long lasting effect on the sustainability of research ecosystem. Same may be the case with the research orientation of institute heads and government research policies.

5.1.3 Research Resource Management/ Knowledge Management

Research resource management or knowledge management should be catering to the need of fulfilling a research ecosystem in a way by creating a virtuous cycle of knowledge creation, sharing, storage, application and protection. If KM efforts are systematically and deliberately carried out with a research focus it will enable strategic planning to carry out newer projects; improve effectiveness and innovative thinking; allow better decision making; create better value for the research institution and subsequently enhance research performance. In the nutshell, knowledge management can be viewed as the systematic management of knowledge resources and processes in order to create value for the institution (Wong &Aspinwall, 2004). However, this management of knowledge is not easy. Knowledge sharing is the most important critical success factor of all knowledge management strategies. Effective knowledge sharing practices allow individuals to reuse and regenerate knowledge at the individual and organizational level (Chaudhry, 2005).However, at the heart of knowledge sharing, two types of bottlenecks exist; individual and organizational barriers. Individual barriers include internal resistance, trust (Barson, Foster, Struck, Ratchev, &Pawar, 2000), motivation (Disterer,2001) and a gap in awareness and knowledge (Bureš, 2003). Organizational barriers consist of language, conflict avoidance, bureaucracy (Disterer, 2001) and distance (Nonaka, 1991). Effective knowledge sharing occurs when appropriate solutions are built into an organization. Institutes of higher learning need to look into the systems

and processes within to clear this bottleneck to succeed in creation of sustainable research ecosystem.

5.1.4 Research Stakeholders

Research stakeholders as mentioned earlier form a critical part of research ecosystem. These stakeholders such as doctoral students, research associates and faculty members need open environment to be nurtured in a manner to achieve the desirable result. Interactions within and outside while collaborating with others in the similar and other disciplines encourage collaborative learning which can lead to innovative and distinguished work. Institutional collaboration and support from the government and other statutory body can help the building and smooth functioning of a research ecosystem. Grants from the government bodies and corporate for doing research of managerial and policy implication can take a nation to new heights.

6 CONTEXTUALIZING THE MODEL

As an initial attempt to propose a new perspective this paper made an effort to develop a model for creation of research ecosystem which can be sustainable. The model presented in this paper can be considered as a "small program" model where in an academic institute the faculty members of various academic disciplines are available for interaction and collaboration. This model has been developed in the context of developing countries where institutes of higher education face resource constraints. For example this model would be applicable in a small institution which has relatively small number of faculty who are working in areas which are somewhat overlapping (such as management education). The researchers are closely knitted, working together either physically as well as virtually through various modes of advanced communication (e.g. Skype, WebEx, blogs, online research communities, etc.). However, this model might fall short in major research institutions which have many faculties some of whom are working in areas which are significantly different from their colleagues and where the researchers are scattered across institutions and even internationally. Research community however will benefit if the departments (which can be treated as standalone ecosystem) interact and collaborate with one another to form a bigger ecosystem encompassing all these smaller ecosystems i.e. ecosystem of ecosystems.

7 DISCUSSION AND CONCLUSIONS

This paper started with an aim to develop a new understanding of producing high quality research through the development of a unique perspective of creation of sustainable research ecosystem. We expect that research based on this perspective would immensely benefit the research both as a practice and process in institutes of higher learning in emerging markets like India and other South East Asian countries. Firstly, it is expected that such research would provide valuable input towards the creation of such sustaining ecosystems of research, on the basis of features operationalized and described in this conceptual paper. The insights generated here would therefore contribute to the existing models and frameworks that very few institutes follow. New as well as existing institutes can take these inputs to co-create an ecosystem of learning.

7.1 Future Directions

This paper has conceived and conceptualized a new direction of thinking, i.e. creation of a sustainable research ecosystem. More research is clearly warranted on the subject to explain how some universities in the western world have managed to significantly improve their research performance. The future research initiatives need to carefully analyze the dual perspective of research as well as the teaching in the universities same can be studied from the knowledge sharing point of view.

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BOOK REVIEW

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WARNER, MALCOLM (ED.) (2013), THE SOCIOLOGY OF THE WORKPLACE. ABINGDON: ROUTLEDGE.

Reviewed by Andrzej KLIMCZUK*

This volume is a re-issue of the book published nearly 40 years ago. Although it is an edition without revised and new chapters, it has been re-released as a part of the "Routledge Library Editions: Organizations" series which aims to present major works of leading experts in their field. However, the book does not include any information why it was re-released.

The book contains 11 chapters, both empirical and theoretical. The editor Malcolm Warner assumes that the analysis of industrial relations needs an interdisciplinary approach to describe the complex characteristics of workplace activities and to illustrate the potentiality of this approach in conflict resolution in the workplace. Papers included in the volume were written by scholars whose research was focused on industrial sociology (such as "Technology and Other Variables: Some Current Approaches in Organization Theory" by Celia Davies, Sandra Dawson and Arthur Francis), psychology ("A Behavioural Analysis of Bargaining" by Andrew W. Gottschalk), and anthropology ("Chance, Punters and the Fiddle: Institutionalized Pilferage in a Hotel Dining Room" by Gerald Mars).

Warner also indicated that the primary objective of the volume was to show the current state of research on bargaining, practical application of social science in industry, as well as the diversity of research and methods of social study. However, nearly half of chapters are focused on industrial relations ("Research into Workplace Industrial Relations: Progress and Prospects" by Stanley Parker; "Sociological Imagination and Industrial Life" by John E. T. Eldridge; "Industrial Conflict Revisited" by Warner; and "Cheap at Twice the Price? Shop Stewards and Workshop Relations in Engineering" by Edward Owen Evans) and organization studies ("Perceptions, the 'Principle of Cumulation' and the Supply of Labour" by

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Dan Gowler and Karen Legge; "The Task Analysis Framework in Organizational Analysis" by Peter Abell and David Mathew; and "Computers and Supervisors" by Keith E. Thurley). These chapters are entirely based on the British experience. In other words, this volume may still present even more interdisciplinary, international and intercultural approaches.

The chapters of this book may be divided into three categories. For reasons of space, we will mention here just a few contributions. The first group of chapters is related to socioeconomic changes of the 70s. Parker in his chapter presents conclusions of an official government survey (such as the significant role of shop stewards in negotiations with local management, the growth of informal practices in management) that inspires the study of industrial relations at the workplace. He also proposed macro and micro models of industrial relations (including such variables as organization characteristics, quality of industrial relations, outside influences, attitudes of the parties) that still can be adapted to analyzing more flexible work arrangements. Warner focuses more on the societal context of industrial relations by showing how endemic conflict and reliance on economic variables were underestimated and can be valid only under such conditions as a free-market economy and a democratic political system.

A few chapters focus on human behavior in organizations. For example, Gowler and Legge described a "regressive spiral" in the labour market. They show the factors that push employees into and out of the organization, as well as that attitudes to a wage payment system differ in case of manual workers, leisure industry, and public service. Authors' propose models of occupational role of differentiation and integration (which suggest that lack of change and routinization of job requirements leads to integrate an occupational role), as well as of labour mobility (showing that role integration leads to an unwillingness to change labour). Another study by Earl Hopper and Adam Pearce ("Relative Deprivation, Occupational Status, and Occupational 'Situs': The Theoretical and Empirical Application of a Neglected Concept") continued a survey of 183 men from England and Wales to describe how personal and interpersonal factors influence job participation. It is important to underline that they used an almost contempletely forgotten concept of "occupational situs" that refers to the differentiation of occupation categories by any number of criteria other than or besides economic and status values in criteria, such as "indoor" versus "outdoor" work, contact with people, etc.

A third group of chapters show skepticism related to rise of post-industrial economy. Davies, Dawson, and Francis propose a thesis that still can be used by critics of technology: technological determinism does not allow predicting

behavior of employees. Instead, organizational theory needs complex models, in which technology were a significant part of a variety of other variables, remaining relevant. Abell and Mathew continue the discussion by arguing that "task decomposition structures" related to using new technologies are not sufficient for explaining the organizational structure. They propose the redefining of these concepts, such as task and output uncertainty, using computers in supervisory functions, and control surveillance.

The studies included in this book can still be important, especially in the growing in importance after 2007-2008 financial crisis context of reindustrialisation discourse that focuses on re-establishing of industries that may improve the balance of trade and generate more socially and economically desirable jobs than the service, creative, and finance sectors. The book shows how important were institutionalized relations and conflicts between management and employees that are nowadays avoided with the rise of human resource management practices and the individualization of contracts. This volume should be particularly interesting for researchers interested in historical changes for the study of the workplace, organizational studies, for the importance of technology in industry, and for the study of labour unions.