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A Quantitative Approach to Measure Tax Competitiveness Between EU Countries

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Abstract

The basic purpose of the study is to find a metric-variable of competitiveness for each country's tax regime and to assess the impact of tax regime differentiation across the common market. A country adopting competitive taxation policies manages to attract productive factors, funds and investments from other intra- and inter-countries. The value added tax (VAT), property tax as well as corporate and personal taxes are examined for the twenty seven (27) European Union (EU) countries. The methods applied consist of Least Square Dummy variable models and the results from the estimations for each one of the aforementioned taxes are integrated into a new total competitiveness taxation index (TCTI), following weighted hierarchical quantitative approaches. Our findings suggest that significant differences still exist between the countries examined and the application of diverse tax regime systems results in various tax performances. Using the above procedure, we also find that subgroups exist within the (27) EU countries and that EU lacks taxation policies with common rules or restrictions. Following the TCTI methodology proposed by this research, a tool for monitoring EU tax regimes is introduced in order to assist in the EU integration to a common tax regime.

Keywords: Taxation, Public Economics, Tax Regime Structure, Quantitative Methods

JEL Classification: H20, C00, R00

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1. Introduction

Following the work of Stuckler et al. (2010), Wilkes (2009a; 2009b), Peeters (2009; 2010; 2012), Schwarz (2007), Smith and Webb (2001), Munin (2011), and Navez (2012), the tax system applied in a country has a serious impact on cross-country competitiveness, something that, in turn, impinges strongly on the actual economy of common markets such as the EU and the differences among tax regimes diversifies homogeneously. The differences and imbalances between EU countries reflect the different tax regime structures applied and this problem seems to have also a spatial character imposing a significant regional problem for the EU, and especially EMU countries, that already have a common currency and monetary policy. On the other hand, the mobility of productive factors is directly related to the country tax-regime differences, government budget funding from tax revenues and rates, which are the main fiscal policy tools. 'Taxing the rich' is a policy based on taxes increase against the recent financial crisis and carries a considerable populist appeal (as many hold those involved with the banking system responsible for the crisis and believe they should pay its price, though this happened only in the case of Ireland and not in other PIIGS countries). A key problem with the current debt crisis is that public spending is increased with slower pace than decreased tax revenue. However, some commentators argue that taxing bonuses and high incomes may stifle incentives for entrepreneurship and innovation.

In this research, the tax regimes of EU countries are analyzed in the following parts in order to present the current situation and to find the level of tax effectiveness per country's tax regime. The general rule (strongly positive correlation between tax rate and tax revenue) is not followed by the countries with significant differences in tax legislations and problems in collecting taxes. Musgrave and Musgrave (1973) argued that, obviously, the tax rate directly affects the amount of tax revenue and deviations from the rule of proportional change, between tax rate and volume of tax revenues, indicate: instability in tax performance among countries; the existence of problematic tax legislation in the countries (tax-free, tax deductible, tax exempt amounts and differences in tax rates per incremental level of tax base); tax evasion or failure of tax authorities in collecting taxes or replacement taxable amounts with tax exempt income or with income classified to other tax base with lower tax rate. The article analyzes and introduces a metric for all the above mismatches in direct and indirect taxation of EU countries. On the other hand, the tax regimes of EU countries are analyzed in the following sections in order to present the current situation and to find the structure, the trends and the similarities among applied tax regimes. The work presented herewith, also examines the implementation of fair and unfair taxes and the adequacy of each country's tax system and legislation.

2. Data, methodology and estimations

Firstly, the tax regimes of the EU countries are analyzed for the period from 1995 to 2011. The general categories of taxes are then separated into indirect and direct taxes.

Finally, at the lower level, only the three main taxes (VAT and taxes on personal and corporate incomes) are presented.

The analysis data are mainly collected from the OECD (2011) and EUROSTAT databases. The observations are yearly, starting from 1995 until 2011. There are cases where some observations are missing, but since simple descriptive statistics and panel unbalanced methodology are used, no bias is expected.

In order to present similarities between EU countries, a collection of samples from tax variables is gathered, in order to group these samples into homogeneous tax regime groups of EU countries. The most suitable diagram to analyze similarities, using deceptive statistics, is *radar*. When the line of diagram is cyclic, common structure of tax volumes between countries is expected, otherwise, serious imbalances exist.

The more suitable method to find similarities between tax regimes among countries and to classify them into separate groups of countries with similar tax regimes is the Multi sample case of Cluster analysis (Mardia et al., 1979). In this work, the Multi sample problem of Cluster analysis for tax variables is analyzed as follows:

Let $x_{ij}, i = 1, \ldots, n_j$ be the observation in the j^{th} samples for the tax variables *j=1, 2,…,m.* The aim of cluster analysis is to group the *m* samples into *g* homogeneous classes where *g* is unknown, with $g \leq m$. The clustering methods are optimization partitioning techniques since the clusters are formed by optimizing a clustering criterion. According to these hierarchical methods, once an object is allocated to a group, it cannot be reallocated as g decreases, unlike the optimization techniques. The end product of these techniques is a tree diagram (Dendrogram). In this study, the maximum similarities within groups and minimum similarities between groups as hierarchical methods are used. These techniques operate on a matrix of squares of distances $D = \left(d_{ij}\right)$ between the points $x_1, \ldots, x_n$ rather than the points themselves. The distant matrix is the Euclidian distance:

$$d_{ij}^2 = \sum_{k=1}^{p} (x_{ik} - x_{jk})^2 = \left| x_i - x_j \right|^2 \quad (1)$$

where: *x* an *(n x p)* data matrix

In the Data Matrix, the EU countries are included (therefore, cases are *j=27*). The variables used for the production of similarities between countries are separated in the tax variables according to the three taxes which are examined as percentages of Gross Domestic Product (GDP), as percentage of Public Revenues from Total Taxation, as high rate or implicit rate of each tax category for the year 2011 (so, variables are *p=3*). Also, using all kind of taxes together and for the years 1995, 2000, 2005, 2009 and 2011 (variables are *p=69*) in order to find the global classification into groups of similar tax regimes. For estimation purposes, only rates, percentages and movements are used to avoid the analysis being influenced by the original sizes of variables.

To measure the imbalances, the methodology employed includes panel regression analysis (analyzing determining factors). The panel regression analysis is carried out with a Pooled regression analysis (Ordinary least squares in panel data) and *Least Square Dummy* *variable* (LSDV) or fixed effect Pooled regression analysis (Wooldridge, 2002; Baltagi, 2005). LSDV models differentiate from a simple Ordinary Least Square model in the intercept term, because a different intercept is calculated for each individual by introducing Dummy variables for each one of the group. The advantage of Dummy variables' use is to test for different constant slopes for independent variables and to highlight any constant variance across groups. More simply, Dummy variables enable the estimation of an unknown time constant effect in the model operation, which is unmeasured by the data. If the condition of an unmeasured effect exists and it is significant, this might be the corner stone to introduce a new variable in the model. The move from Pooled regression analysis to LSDV happens only in failure of the first methodology to provide strong and unquestionable results.

Assuming the general principal that tax revenues must be strictly correlated with tax ratio. According to the tax theory and practice, tax revenue is a function of tax rate multiplied by the tax base of each tax. The tax base is a part of GDP or Gross Domestic Income or National Worth. But the volume of each tax base has been established by each country's tax authorities, tax legislation and the structure of the economy. For that reason, if one wants to find the differences between countries' tax legislations, a base measurement like GDP is used, to represent the tax revenues for all taxes. Thus:

$$TR_{ij} = a + br_{ij} + u \tag{2}$$

where:

TR tax revenues per kind of tax as percentage of GDP and

α a constant component representing the uncorrelated and stable part of tax revenues. This constant variable is introduced to the model in order to find an average amount for tax revenue of each country as a percentage of GDP for all EU countries. In real terms, *the above variable reflects the total ability of Europe to Collect Taxes.* This assumption of the study is critical in order to subsequently find the level of each country's diversification against European common practice. This assumption is expected to differentiate the estimated tax revenue elasticity against its tax ratio. Also, it is a necessary assumption for the model because, as Laffer (2004) explains, the Laffer Curve illustrates the basic idea that changes in tax rates have two effects on tax revenues: the arithmetic effect and the economic effect. The arithmetic effect is simply that if tax rates are lowered, tax revenues (per euro of tax base) will be lowered by the amount of the decrease in the rate. The reverse is true for an increase in tax rates. The economic effect, however, recognizes the positive impact that lower tax rates have on work, output, and employment – and thereby the tax base – by providing incentives to increase these activities. Raising tax rates has the opposite economic effect by penalizing participation in the taxed activities. The arithmetic effect always works in the opposite direction from the economic effect. Therefore, when the economic and the arithmetic effects of tax-rate changes are combined, the consequences of the change in tax rates on total tax revenues are no longer quite so obvious. Similarly, the curve is often presented as a parabolic shape. By using the constant variable in the model, the economic effect can be eliminated by dodging the prohibit part of the Laffer's curve and cut the effective part into two components, the constant part and the arithmetic part, using the *b* (BETA) effect on tax rates

b the arithmetic effect (BETA) according to the Laffer's Curve (outside prohibit area)

r tax ratio per kind of tax

i the years of our sample (from 1995 to 2011)

j the countries of our sample (from 1 to 27)

u the stochastic term.

In this early stage, it is expected that the data sample used entails insignificant fluctuation/volatility (since tax revenues show volatility under rare circumstances only) so that our estimations are auto-correlated. For this reason, an auto-regression scheme of low order $AR(1)$ is introduced, in order to adjust the auto-correlation in residuals, without significant effect on estimated variables. Accordingly, the model is transformed to:

$$TR_{ij} = a + br_{ij} + AR(1) + u \tag{3}$$

Then, in order to isolate all other components, a search is conducted for any common coefficient not measured by the data which is common between countries and affects the revenues from income tax. This search will further enlighten the basic question of the study, that is: *'can we find a metric-variable of effectiveness for each country's tax regime?'*. The methodology applied in order to search for an unknown unmeasured effect in the model is pool data regression with fixed effects, which is actually a dummy variable for each country [Cross Section Fixed Effect (CSFE) per Country]. This dummy variable substantially differentiates the constant variable against average constant variable of Europe and thus the ability of each country to collect taxes. As a result, the model is changed to:

$$TR_{ij} = a + br_{ij} + CSFE_j + AR(1) + u \tag{4}$$

Thus, the model is historically simulated outside the prohibited part of Laffer's Curve and auto-correlation problem and provides for the CSFE variable the quantitative diversification as percentage of GDP. The data and estimations used (Tables 1 and 2) together with all corresponding (radar and dendrogram) graphs are given below using the above methodology.

Table 1: Data used per EU country and average (VAT, Personal Income and Corporate Income)

	VAT H. RAT.		VAT % GDP		PI H. RAT.		PI % GDP		CI H. RAT.		CI % GDP	
Country / Year	**2011**	**Δ(00-11) %**	**2011**	**Δ(00-11) %**	**2011**	**Δ(00-11) %**	**2011**	**Δ(00-11) %**	**2011**	**Δ(00-11) %**	**2011**	**Δ(00-11) %**
Austria	20.0	0%	7.8	-4%	50.0	0%	9.7	-3%	25.0	-26%	2.3	6%
Belgium	21.0	0%	7.0	-2%	53.7	-11%	12.4	-6%	34.0	-15%	3.0	-7%
Bulgaria	20.0	0%	8.7	5%	10.0	-75%	2.9	-29%	10.0	-69%	1.9	-30%
Cyprus	15.0	50%	8.4	46%	30.0	-25%	4.2	16%	10.0	-66%	6.8	11%
Czech	20.0	-9%	7.0	9%	15.0	-53%	3.7	-18%	19.0	-39%	3.4	-4%
Denmark	25.0	0%	9.9	4%	51.5	-14%	24.3	-5%	25.0	-22%	2.8	-15%
Estonia	20.0	11%	8.5	1%	21.0	-19%	5.3	-23%	21.0	-19%	1.3	42%
Finland	23.0	5%	8.9	9%	49.2	-9%	12.8	-12%	26.0	-10%	2.7	-54%
French	19.6	0%	7.0	-4%	46.7	-21%	7.9	-6%	34.4	-9%	2.3	-18%
Germany	19.0	19%	7.3	8%	47.5	-12%	8.4	-18%	29.8	-42%	2.6	53%
Greece	23.0	28%	7.2	0%	45.0	0%	4.7	-5%	23.0	-43%	2.1	-49%
Hungary	25.0	0%	8.5	-2%	20.3	-54%	4.9	-32%	20.6	5%	1.2	-47%
Ireland	21.0	0%	6.2	-16%	41.0	-7%	9.2	0%	12.5	-48%	2.4	-37%
Italy	20.0	0%	6.2	-4%	45.6	-1%	11.5	0%	31.4	-24%	2.3	-7%
Latvia	22.0	22%	6.8	-4%	25.0	0%	5.6	1%	15.0	-40%	1.4	-10%
Lithuania	21.0	17%	7.9	5%	15.0	-55%	3.5	-54%	15.0	-38%	0.8	21%
Luxembourg	15.0	0%	6.3	13%	42.1	-11%	8.3	15%	28.8	-23%	5.0	-28%
Malta	18.0	20%	7.9	32%	35.0	0%	6.4	15%	35.0	0%	5.9	105%
Nederland	19.0	9%	6.9	0%	52.0	-13%	8.0	34%	25.0	-29%	2.2	-49%
Poland	23.0	5%	8.1	16%	32.0	-20%	4.5	1%	19.0	-37%	2.1	-14%
Portugal	23.0	35%	8.3	9%	46.5	16%	6.1	15%	29.0	-18%	3.2	-14%
Romania	24.0	26%	8.7	34%	16.0	-60%	3.3	-4%	16.0	-36%	2.2	-27%
Slovakia	20.0	-13%	6.8	-2%	19.0	-55%	2.5	-26%	19.0	-34%	2.4	-8%
Slovenia	20.0	5%	8.4	-3%	41.0	-18%	5.6	-1%	20.0	-20%	1.7	45%
Spain	18.0	13%	5.4	-11%	45.0	-6%	7.4	12%	30.0	-14%	1.9	-40%
Sweden	25.0	0%	9.4	10%	56.4	10%	15.0	-17%	26.3	-6%	3.4	-8%
United Kingdom	20.0	14%	7.3	12%	50.0	25%	10.1	-7%	27.0	-10%	3.1	-13%
Average	**20.7**	**9%**	**7.7**	**6%**	**37.1**	**-18%**	**7.7**	**-6%**	**23.2**	**-27%**	**2.7**	**-7%**

Table 2: Pooled Least Squares Method with constant term and *AR*(1) and CSFE per EU country

Method: Pooled Least Squares				Sample (adjusted): 2001 - 2011			
Included observations: (11) after adjustments				Total pool (balanced) observations: (297)			
Convergence achieved after (8) iterations				Cross-sections included: (27)			
Variable	**Coefficient**			***CSFE Coefficient***			
Dependent Variable:	**VAT**	**Personal**	**Corporate**	**Country**	***VAT***	***Personal***	***Corporate***
C	5,789491	6,319855	2,018287	Austria	0,254795	1,857277	-0,622995
Std, Error	*0,51176*	*0,313633*	*0,267802*	Belgium	-0,77722	4,126533	-0,143969
t-Statistic	*11,31291*	*20,15046*	*7,53649*	Bulgaria	1,798561	-4,032996	0,059118
Probability	*0,0000*	*0,0000*	*0,0000*	Cyprus	2,294573	-3,532344	3,429618
HVR (Tax Ratio)	0,092775	0,041038	0,036488	Czech	-0,74816	-3,186632	0,900406
Std, Error	*0,025604*	*0,007564*	*0,009653*	Denmark	-0,63506	0,795203	-1,875295
t-Statistic	*3,623392*	*5,425467*	*3,780082*	Estonia	1,879492	16,26535	0,094609
Probability	*0,0003*	*0,0000*	*0,0002*	Finland	0,950718	-1,326469	-1,514836
AR(1)	0,596571	0,736062	0,705964	French	-0,53685	-3,287055	-0,364623
Std, Error	*0,045253*	*0,031509*	*0,033835*	Germany	-1,70789	-1,202289	-0,227684
t-Statistic	*13,18297*	*23,36057*	*20,86492*	Greece	0,733155	5,00259	0,63502
Probability	*0,0000*	*0,0000*	*0,0000*	Hungary	-0,56351	-0,338196	-0,850917
				Ireland	0,186896	-1,222622	-0,761342
R-squared	0,883651	0,992249	0,876038	Italy	-0,83618	0,559346	0,714512
Adjusted R-squared	0,871495	0,99171	0,867425	Latvia	-1,61154	3,142353	-0,680793
S,E, of regression	0,419012	0,437806	0,475957	Lithuania	-0,05916	-1,417826	-1,352212
Sum squared residuals	47,05298	77,2446	91,29378	Luxembourg	-1,11478	-0,585783	2,949983
Log likelihood	-147,82	-241,1486	-277,2434	Malta	-0,51981	-1,569029	-0,789604
F-statistic	72,69336	1842,426	101,7141	Nederland	0,290559	-1,665803	1,551234
Prob (F-statistic)	0,0000	0,0000	0,0000	Poland	-0,3463	-1,544861	0,291774
				Portugal	-0,06905	-3,383942	-0,598441
Mean dependent var	7,583096	8,089249	3,00758	Romania	0,410911	-2,566703	0,147154
S,D, dependent var	1,16887	4,808468	1,307186	Slovakia	0,068022	-4,431389	-0,036489
Akaike info criterion	1,190705	1,250688	1,417793	Slovenia	1,11042	8,341413	0,127922
Schwarz criterion	1,551373	1,5238	1,690905	Spain	0,811715	-2,554772	-0,894738
Hannan-Quinn criterion	1,335093	1,358511	1,525617	Sweden	-0,50738	-4,406483	-0,497401
Durbin-Watson stat	1,942382	1,729775	1,780412	United Kingdom	-0,75694	2,165126	0,30999

Figure 1: Tax similarities between EU countries for the year 2011 (Radars)

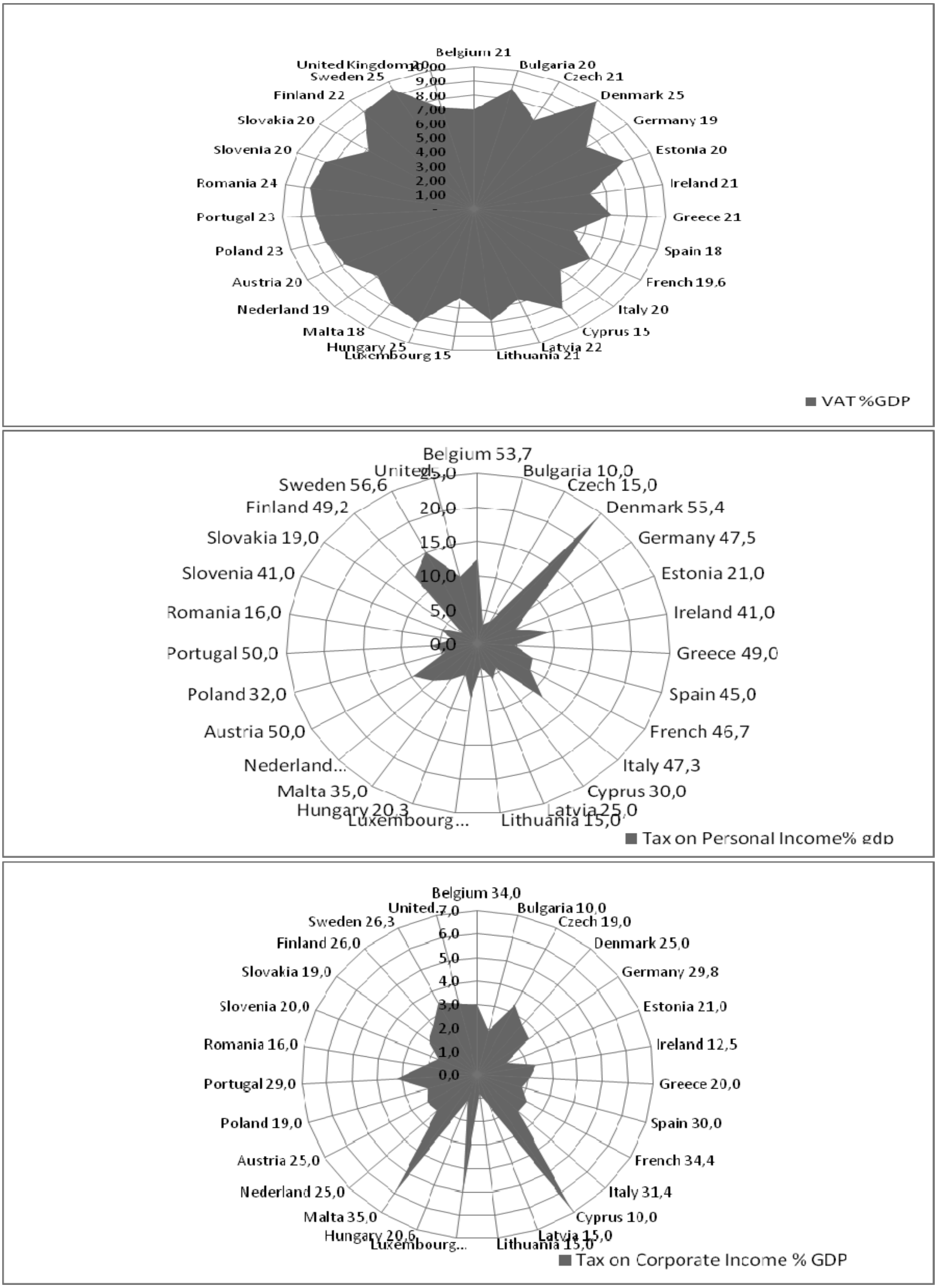
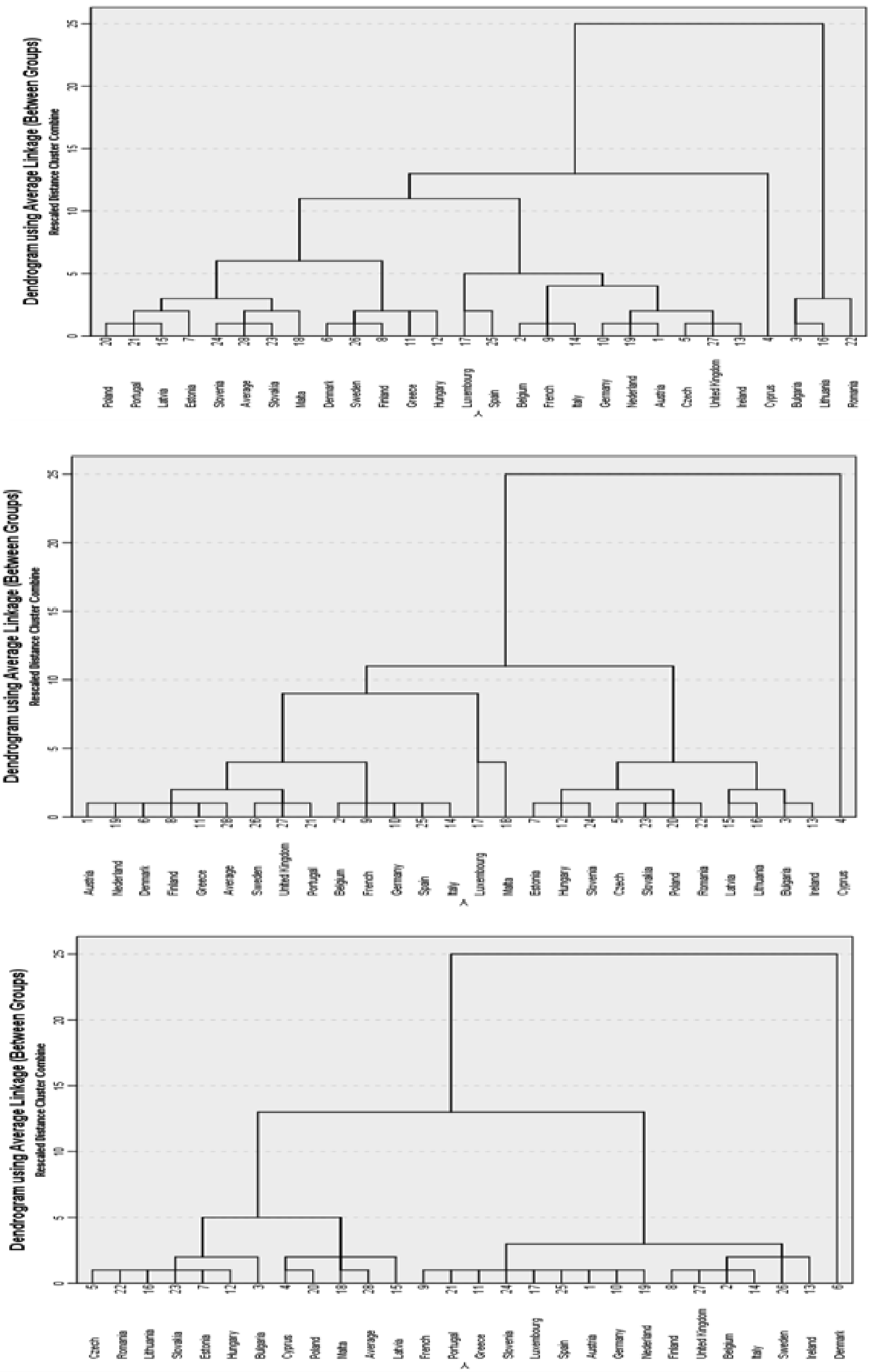


Figure 2: Tax similarities (VAT, Personal & Corporate respectively) between EU countries' groups (Dendrograms)



3. Analysis of the findings for vat and direct taxes on personal and corporate incomes

VAT is the main indirect tax on consumption and an attempt to EU VAT grouping can be found in Vyncke (2009). Table 1 presents the high ratios, the revenues of tax as percentage of GDP and the revenues of tax as percentage of total tax revenues for the years 2000 and 2011 together with the *differences* between these years (also as either a *positive or negative percentage*). Using the above data for the year 2011 a radar diagram with VAT similarities between EU countries is produced as shown in Figure 1. The axe of the radar presents the tax revenue as a percentage of GDP and the periphery consists of the countries and tax ratio. By observing the above diagram, no major differences exist in VAT among EU countries with an interval between 7% to 9% tax revenues from each country's GDP. In order to classify EU countries into similar groups, a Dendrogram of similarities is produced following multivariate cluster analysis by using percentages of GDP, percentage of Public Revenues from Total Taxation and high rate or implicit rate of tax for the year 2011. Figure 2 presents the similarities between groups among EU countries. At the lowest level of similarity, (8) different groups are produced from countries with similar characteristics of VAT regime structure and at the upper level Cyprus and the block of countries Bulgaria, Lithuania and Romania have quite different VAT tax regimes. Then, the relationship of indirect taxes (VAT) as percentage of GDP (ITV) with high tax rate of VAT (HVR) is examined. Panel least square methodology is applied first to indirect taxes and more specifically to VAT. Indeed, as per the assumption made, results suggest that the residuals suffer from auto-correlation. R-square value further strengths the outcome that this model is not adequate in this form. Therefore, we continue by inserting an $AR(1)$ to absorb the auto-correlation in residuals. The problem of auto-correlation in residuals is adequately solved. All coefficients are significant. The high VAT ratio coefficient is very low. A rise of 1% in high VAT ratio will have an impact of 0,098% on indirect taxes as percentage of GDP, considering all the other parameters stable. If taxation on high rate policy is avoided and the high VAT tax ratio is set to zero, then indirect taxes as percentage of GDP will still provide earnings (constant term). The R-squared is strong, approaching the 85,15%. The next step is to introduce the fixed effect term in pooled data. Results of final estimations are shown in Table 2. The outcomes of pool regression do not deviate from the panel analysis. Again the coefficient of income tax rates is very low, $AR(1)$ is significant and the fit of the model in data is 88,37%. If there is a rise in VAT tax ratio by 1%, this will cause a slight positive change in indirect taxes as percentage of GDP by 0,092%, considering all the other parameters unchanged. The Cross-section fixed (dummy variables) Fixed Effects (Cross) is the quantitative index which distinguishes the countries measuring imbalances. The values of VAT imbalances are also shown in Table 2. Fixed effect figure above, further highlights the notion that there is a major tax evasion in the core of EU. Spain, Germany, France, Italy, Belgium have negative fixed effect term, which is a strong indicator that the earnings from high ratio tax policy are reduced for an unrecognized factor. On the other hand the weak core of EU maintains better results from the high ratio tax policy. The interesting part is that the Cypriot economy manages to maintain strong earnings from this unmeasured factor, which has an additive role to high tax ratios policy. Moreover, if there is any intention EU countries to move close to a tax union, this kind of indirect tax will have ambiguous results.

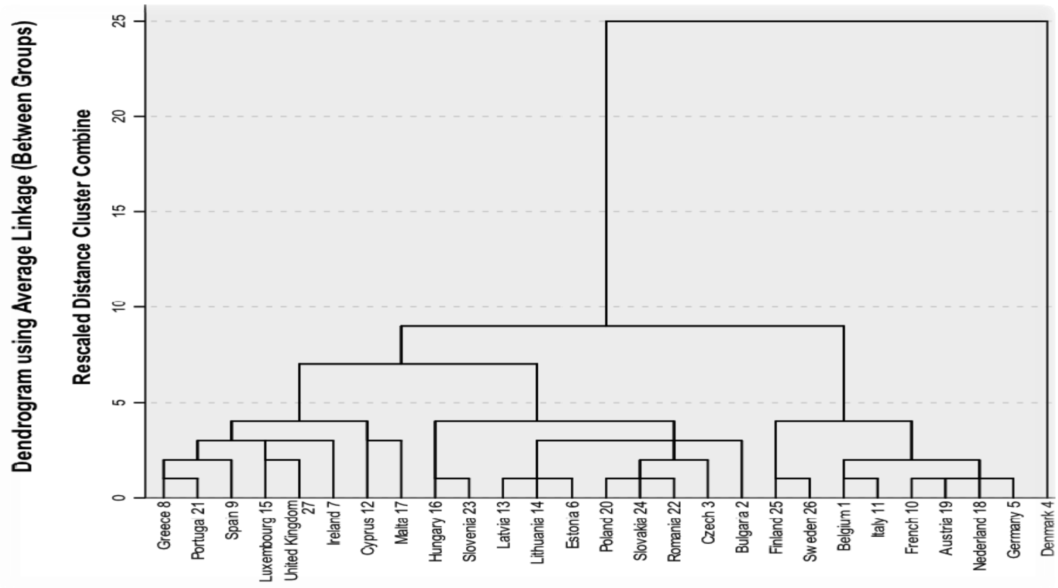
Table 1 also presents the high ratios, the revenue of each tax as percentage of GDP and the revenues of each tax as percentage of total tax revenues for the years 2000, 2011 and the differences as percentage between these years. Significant differences exist in the tax structure on income (Personal, Corporate and Other) between EU countries. The corporate and other income taxes remain at a lower level against Personal income taxes in many countries and as an average in the EU market, which denotes that personal income remains as the main income base for the direct taxation. Using the above data for the year 2011 the radar diagram of Figure 1 is produced. The axe of radar presents the tax revenue as percentage of GDP and the periphery consists of the countries and tax ratio. According to the diagram, low homogeneity exists for the volumes of personal income between EU countries. In order to classify into similar groups the EU countries a Dendrogram of similarities is produced following multivariate cluster analysis by using percentages of GDP, percentage of Public Revenues from Total Taxation, and high rate or implicit rate of tax for the year 2011. Figure 2 indicates which groups among EU countries are similar. At the lowest level of similarity, (5) different groups are produced with countries with similar characteristics of Personal tax regime structures and at the upper level Denmark has quite different VAT tax regime. It should be mentioned that ex-eastern EU countries belong to a separate group. The relationship between Personal Taxes as percentage of GDP and top personal income tax rates, including a constant term. Once again, results suggest that the model suffers from auto-correlation. Therefore, an *AR*(1) factor is used to absorb the auto-correlation in residuals. The problem of auto-correlation is solved, but the constant term is not significant and should be omitted from the model. There is a positive relation between tax ratio and personal income taxes. However, it is noticed that a rise of 1% in tax ratio will only increase the tax revenues from personal income by 0,03%. As far as it concerns the statistics of the model, the fit of data is very good approaching 99% and *AR*(1) term is significant. The final step is to insert the dummy variables, with the results also shown in Table 2. The outcomes of the pool regression do not deviate from the panel analysis. Again, the coefficient of income tax rates is very low, *AR*(1) is significant and the fit of the model in data is 99,2%. The Cross-section fixed (dummy variables) Fixed Effects (Cross) is the quantitative index that distinguishes countries measuring imbalances. The values of imbalances are provided in the Table 2. The constant term is significant suggesting that there is an unmeasured common effect, which is positive in the common sample. The cross section fixed effect has different signs. It is noticed that the strong European Economies have a positive fixed effect that increases the revenues, when a higher tax rate is imposed (Austria, Belgium, Germany, Denmark, Finland, Sweden and United Kingdom). Surprisingly, France and Nederland have negative fixed effect, which is lowering incomes from personal tax revenues. On the other hand, Italy and Ireland have identical characteristics with the core countries. All strong economies have high personal income tax rates, with sufficient results in tax revenues. On the other hand high Personal Tax policies in weak economies do not produce substantial revenues. The last (3) countries in terms of Fixed Effects Value (Romania, Slovakia and Bulgaria) lowered the personal income taxes during the last years. From the results, one can extract the outcome that high tax on personal income does not provide sufficient results on weak economies. One reason for this inability to increase the revenue with high taxes might be a high level of tax evasion these countries may suffer. Figure 1 shows the high tax ratio and the volume of tax as percentage of GDP between EU countries for the year 2011. According to the diagram low homogeneity exists for the volumes of corporate income between EU countries. Cyprus, Malta and Luxembourg as international corporate centers have high level of volumes and, on the other hand, Germany has the lowest volume as percentage of GDP from all other countries. In order to classify into similar groups the EU countries a Dendrogram of similarities is produced following multivariate cluster analysis by using percentages of GDP, percentage of Public Revenues from Total Taxation, and high rate or implicit rate of tax for the year 2011. Figure 2 presents which are the similar groups among EU countries.

The last direct tax is analysed in this part. In the beginning, direct taxes on Corporate Income as percentage of GDP and Corporate income tax rates relation are estimated with Panel Least Squares. Similarly, residuals suffer from auto-correlation. R-square is approaching to zero. Therefore, an $AR(1)$ is inserted to absorb the auto-correlation in residuals. Corporate tax rate has a positive and significant relation with revenues from corporate tax. The coefficient value of the corporate tax is rather low. As an example, if corporate tax rate is increased by 1%, revenues will increase only by 0,04%. The statistics of the model are very good with the fitness of model on data approaching around 85%. The Cross-section fixed (dummy variables) Fixed Effects (Cross) is the quantitative index which distinguishes countries measuring imbalances (Table 2). Pool data analysis outcomes provide the same result as panel analysis. A rise in corporate tax will not provide more revenues, since the coefficient of tax rate is very low. As an example, if corporate tax rate is raised by 1%, then revenues from corporate tax will raise by 0,036%, considering all other parameters stable. There exists an unmeasured factor that is not explained by the data and has positive overall effect on tax revenues. However, the cross sectional fixed effect provides ambiguous results; no certain trend can be traced in the results of fixed effects. On statistical view, the model fits very well on data by approaching 87%. $AR(1)$ term is significant and does not change the outcomes of the model. Cross sectional fixed effect graph provides an interesting point. Concerning the fixed effect adding character on corporate revenues, that is not measurable by the data, the countries with the higher fixed effect are Cyprus, Luxemburg and Malta, which are considered as Tax Heavens and with their policies drag Foreign Direct Investments. Cyprus has a very low corporate tax regime. Malta's corporate tax is very high in relation to EU standards, but with the ongoing policy a large amount of tax is refunded back to the companies. Luxemburg may not provide direct tax conveniences in companies, but a lenient tax regime on financial institutions attracts a large portion of EU funds and investors.

4. EU tax regimes structures similarities

In conclusion, corporate tax regime does not provide substantial outcomes. Policies that provide convenience for direct investments will substantially increase the tax revenues. Using Euclidian Distance and average linkage between groups, for all kinds of taxes the cluster of similarities between EU countries is produced. These similarities are presented below in Figure 3.

Figure 3: Similarities between EU countries' tax regimes



According to this global estimation, EU countries are grouped in (3) main separate groups, with obvious evidence that in the classification there is a spatial character. The first large group consists of (3) subgroups; in the first subgroup including Greece, Portugal and Spain, old members of EU at the Southern Europe facing Debt Crisis nowadays and characterized by problems in tax performance; the second subgroup is consisted by Luxembourg, United Kingdom and Ireland, old members with developed financial sector facing Financial Crisis and characterized by similar tax regimes; the third subgroup is consisted by Cyprus and Malta the newest from old members of EU with International corporate sector and characterized by similar tax regimes.

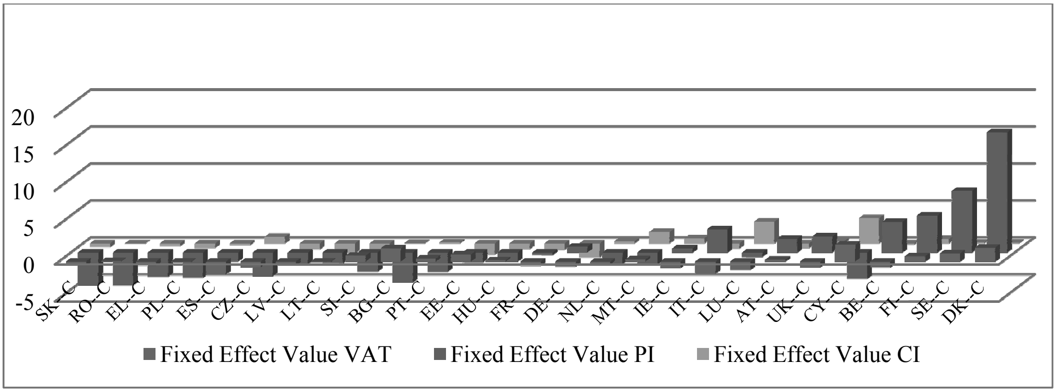
The second large group consists of Eastern European countries, new members of EU, characterized by problems or instability in tax performance and consists of (2) subgroups; in the first subgroup including Latvia, Lithuania and Estonia; the second subgroup consists of Poland, Slovakia, Romania and, slightly, Bulgaria.

The third large group consists of Central European countries, old members of EU, characterized by stable, balanced or high tax performance and consists of (3) subgroups; the first subgroup includes Finland and Sweden, the North European countries; the second subgroup is consisted by Belgium and Italy; the third subgroup is consisted by France, Austria, Nederland, Germany, the Central and more developed EU countries; at the end, with a different tax regime from all other EU countries, Denmark stands alone.

The differences and imbalances between EU countries reflect different tax regime structures and this problem seems to have also a spatial character and will pose a serious regional problem for the EU, and especially EMU countries, which already have a common currency and monetary policy.

This research managed to identify a measurement for imbalances. The introduction of the constant variable, common in all EU countries, measured as percentage of GDP embodying a common Tax Collection base, which is the desired outcome in a union of countries. However, this constant term is increased or reduced depending on which country is focused. This is achieved, with the introduction of the dummy variable, which alters the outcome and give us a clear and unambiguous measurement of tax regime diversification per country. A comparative analysis by providing all these measurements for VAT, Personal Tax and Corporate Tax is summarized in Figure 4.

Figure 4: Measurements of EU Tax Imbalances



Gathering all the Fixed Effect values estimated for the (3) different taxes, it is noticed that the results do not deviate from the outcomes of the work using multivariate cluster analysis but now a measure for this exists. Countries that face crisis seem to face the largest portion of imbalances. In addition to that, the spatial problem between North and South Europe is obvious, which is mainly caused by the different tax regime of these (2) tiers.

5. Conclusions

Generally, the differences and imbalances between EU countries reflect different national economic legislation and fiscal policies like: imbalances in mobility of productive factors; differentiations in the current account of balance of payments; different levels of expansion in loans and advances or in use of financial or credit products; different deficit and government debt; different unemployment and gross wage revenues per country.

The problem seems to have also a spatial character and will pose a serious regional problem for the EU. The south of Europe is faced with crisis. Policies to reduce the government debt will lead to social discontent, and ultimately the collapse of the European Union.

The only policy that seems to be efficient is full integration of the countries with a common fiscal and federal face and legislated solidarity thus, the public choice has to be a common tax regime for all EU countries which eliminates imbalances and allows mobility of capital and labour.

Nowadays, there are significant differences among the applied tax regimes in EU countries and no policy has been implemented to ensure tax homogeneity across the EU, nor is there any likelihood of such. Even if, EU moves to a common taxation policy, there are obvious indications that it will fail to balance revenues from taxations at the same levels.

On the other hand, the ‘strong’ EU countries, which in reality enforce their own economic policies (mainly designed from their own economic systems), might need to redefine their attitude towards the non-homogeneity of the tax regime in the EU. Countries that are thought to be economic paradises, are actually achieving better results in tax revenue collection. A more loose taxation system might have better results in tax revenue collection.

A major question emerges regarding the performance of any taxation as a percentage of each country’s GDP. Following the outcomes of this study, the taxation imbalances between EU countries can be measured through the use of quantitative tools to analyze collected data from the National Organizations and with the introduction of the constant term (common historical performance per tax avoiding Laffer’s problem), the elasticity against tax ratio (net historical BETA of tax ratio without common historical performance of tax – an introduced by this work net arithmetic effect following Laffer’s research) and dummy variable (the quantitative diversification per country as percentage of GDP, also introduced by this paper). Using these three parameters the alteration of the outcome can be achieved, thus giving a clearer and unambiguous measurement of tax regime diversification per EU country as a percentage of each country’s GDP. Deviations from the rule of proportional change, between tax rate and volume of tax revenues that take into account the common historical performance per tax, indicates: instability in tax performance among countries; the existence of problematic tax legislation in the countries (tax-free amounts, tax deductible amounts, tax exempt amounts, and differences in tax rates per incremental level of tax base); the tax evasion or failure of tax authorities in collecting taxes or replacement taxable amounts with tax exempt income or with income classified to other tax base with lower tax rate. Under this view, the proposed measurement has obvious practical benefits to any fiscal policy maker.

The study shows the significant difference in performance between EU countries when collecting VAT as well as the significant difference in the tax structure on income (Personal and Corporate) between EU countries. The Corporate tax remains at a lower level against Personal income taxes in many countries and on average in the EU market which denotes that personal income remains as the main income base for the direct taxation. Significant decreases also exist in the tax rates of direct taxes for all EU countries. The decreases of tax rates on corporate income remain at a higher level against tax rates on personal income. Low homogeneity exists in the volumes of personal income tax revenues as well as in the volumes of corporate income tax revenues. Cyprus, Malta and Luxembourg as international corporate centers have high level of volumes and, on the other hand, Germany has the lowest volume as % of GDP from all other countries.

The general rule (strongly positive correlation between tax rate and tax revenue outside the prohibit part of Laffer's Curve) is not followed by the countries, indicating significant differences in tax legislations and problems in collecting direct or indirect taxes. These differences could be measured as a percentage of GDP using the proposed dummy variable coefficients per country contributing with practical and secure way, far from indistinct calculations.

Further implementation of more variables like taxation regimes, structure and economy, might highlight in more depth, the main forces that shape this diversification per country, but always aware of the over parameterization risk and biased results.

This study focused on imbalances of fiscal policies for countries – members of a Common Economic Union contributes such to the debate as to the implementation of a common tax regime by analyzing and measuring the present situation with future perspectives.

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Fear of Floating and Inflation Targeting in Turkey

Vasif Abiyev[1] and Munise Ilıkkan Özgür[2]

Abstract

The objective of this paper is to test empirical validity of Fear of Floating hypothesis for Turkey after the adoption of Inflation Targeting. We start applying methodologies developed by Calvo and Reinhart (2002) and Ball and Reyes (2004, 2008) to check the probabilities of changes in exchange rate and monetary policy instruments before and after inflation targeting regime. We then use a VAR model to estimate exchange rate pass-through and response of monetary policy instruments to exchange rate shocks before and after inflation targeting regime. VAR model helps to understand the impacts of switch in monetary policy regime on exchange rate pass-through and foreign exchange market interventions. The paper concludes that after the adoption of inflation targeting regime, the exchange rate pass-through still matters for the attainment of inflation targets and the monetary policy do not exhibit a fear of floating practices.

Keywords: Fear of floating, fear of inflation, exchange rate pass-through, free floating exchange rate

JEL Classification: F31, E31, E58

1. Introduction

After the severe financial crisis of the late 1990s and early 2000, a growing number of emerging economies moved away from exchange rate rigidity and adopted a combination of flexible exchange rates and Inflation Targeting (IT). However reluctance of countries to allow free fluctuations in their exchange rates has led to the case of "fear of floating" in economic literature, following Calvo and Reinhart (2002). According to Calvo and Reinhart (2002), many countries claim to float but actually use their policy instruments to prevent large fluctuations in their currency's value and term such behavior "fear of floating" (FF). Since the FF tends to arise in times of financial crises, it is considered as intervention response to exchange rate depreciations (Levi-Yeyati and Sturzenegger, 2007).

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Many authors, such as Goldfajn and Werlang (2000), Schmidt-Hebbel and Tapia (2002) and Fraga, Golfajn and Minella (2003) have shown that the exchange rate pass-through (ERPT) degree of emerging countries is greater than that of developed economies. High ERPT effect for emerging economies implies a greater difficulty for their attainment of the inflation targets. Calvo and Reinhart (2002) argue that lack of credibility of monetary authorities combined with high ERPT to domestic prices leads to FF phenomenon in emerging economies. Moreover, according to Eichengreen (2002), Calvo and Mishkin (2003) and Mishkin (2004), the reasons of the reluctance of emerging economies against free fluctuations in their nominal exchange rates are weak fiscal institutions, low credibility of monetary institutions, liability dollarization, high ERPT into domestic prices, vulnerability to sudden stops and etc. Because of such problems, monetary authorities of developing countries are likely to display a reluctance to allow free fluctuations in their nominal exchange rates, i.e. a FF.

Various studies have shown that a shift towards more credible monetary policy regimes plays an important role in reducing ERPT into domestic prices. Taylor (2000) was the first to support this view and put forth the hypothesis that low and stable inflation environment leads to a low ERPT to domestic prices. Choudhri and Hakura (2001), Campa and Goldberg (2002), Devereux and Yetman (2002), Devereux, Engel and Storgaard (2003), Baqueiro, de Leon and Torres (2003), Cagnon and Ihrig (2004), and Bailiu and Fujii (2004) provided evidence on Taylor (2000)'s hypothesis. Their studies show that lower ERPT is caused by lower persistence of price and cost changes which tend to be reduced in an environment where inflation is low and monetary policy is more credible. That is the countries with relatively stable and hence credible monetary policies will have relatively low exchange rate pass through into domestic prices, while countries with relatively high volatility of money growth will have relatively high pass through-rates. Credibility of monetary policy as well as competitive markets plays an important role in reducing ERPT. Hence, ERPT is endogenous to the monetary policy regime.

Turkish economy is still in the transition to a low and stable inflation environment, consolidating its macroeconomic stability. Over the 1990s the Turkish economy has experienced large exchange rate depreciations and high inflation. High exchange rate depreciations are likely to cause inflationary pressures in this period. The Central Bank of The Republic of Turkey (CBRT) used crawling peg regime as a nominal anchor to hold the inflation under control, but this system failed to bring down the inflation and caused high ERPT. However, the adoptions of IT regime and free floating exchange rate system in the early 2001 have decreased the inflation rate and exchange rate pass through, providing macroeconomic stability. After the adoption of IT regime and free floating exchange rate system, Turkish economy experienced rapid disinflation process that lasted until the beginning of 2004 and eventually achieved to low and stable inflation environment and still is trying to maintain announced yearly inflation target.

Our study tests empirical validity of FF hypothesis in Turkey during the targeting period by using Calvo and Reinhart (2002) and Ball and Reyes (2004, 2008) methodologies and by comparing monetary policy reactions against exchange rate developments between pre-targeting and targeting periods. In particular, we follow Nogueira Jr and Léon-Ledesma (2009) who formalized Calvo and Reinhart (2002) and Ball and Reyes (2004, 2008) methodologies and applied it to the Brazilian data. To the best of our knowledge, this is the first study to examine FF issue for Turkish economy by using Calvo and Reinhart (2002) and Ball and Reyes (2004, 2008) methodologies that is explained in detail in the third section. We then use VAR model to test whether the ERPT effect has indeed decreased after the adoption of IT regime. Thus, our paper helps to understand the impact of switch in monetary policy regime on ERPT. Using VAR model, we check for the reaction of international reserves and interest rates to changes in the exchange rate to evaluate foreign exchange market interventions in the IT regime, and check for the reaction of interest rates and international reserves to inflation shocks before and after the adoption of IT regime to see the importance of inflation stability in the IT regime. We also compare VAR results with the results obtained from the methodology of Calvo and Reinhart (2002) and its modified version proposed by Ball and Reyes (2004) in order to confirm accuracy of our empirical result.

The paper is organized as follows. Section 2 discusses theoretical framework to explain the IT country's response to exchange rate shocks in emerging countries. Section 3 applies Calvo and Reinhart (2002) and Ball and Reyes (2004) methodologies to test for the exchange rate flexibility and the FF hypothesis. Section 4 uses data and VAR method to examine FF hypothesis. Section 5 concludes.

2. ERPT, FF and IT in Emerging Countries

Eichengreen (2002), Edwards (2002), Ball and Reyes (2004), Mishkin (2004) and Nogueira Jr and Léon-Ledesma (2009) argue that when an inflation targeting monetary authority increases interest rates to prevent exchange rate movements, it should not be concluded that it cares about exchange rate but it should be considered that it may care about inflation and everything that affects it. In this sense, Baqueiro, de Leon and Torres (2003) argue that if exchange rate shocks have an impact on inflation, foreign exchange market interventions can be interpreted as "fear of inflation" rather than "fear of floating".

Following Ball and Reyes (2004), this part of the paper introduces a simple theoretical framework to explain the IT country's response to exchange rate shocks. According to Ball and Reyes (2004), the country's price level consists of both traded and non-traded goods prices. This means the nominal exchange rate enters directly in an IT regime. The price level for this economy is a combination of non-traded and traded good prices, P_H and P_T respectively.

$$P = P_H^{\alpha} P_T^{1-\alpha} \tag{1}$$

From equation (1) we can derive an inflation equation for the economy, where π is the general inflation:

$$\pi = \alpha\pi_H + (1-\alpha)\pi_T \tag{2}$$

Assuming relative purchasing power parity and constant world prices equation (2) can be written as:

$$\pi = \alpha\pi_H + (1-\alpha)\Delta e \tag{3}$$

Here Δe denotes percentage change in nominal exchange rate and captures the effect of exchange rate depreciation on general inflation. Thus, in an IT country when setting inflation target the central bank must also consider nominal exchange rate depreciation. In order to show the Central Bank's reaction to exchange rate movements in terms of Taylor reaction function in IT country, we use the following Taylor rule:

$$i_t = i^* + \lambda(\pi_t - \pi^*) + \beta(y_t - y^*) \tag{4}$$

Where i_t is the nominal interest rate, y_t is the output level, y^* is the equilibrium output level, π^* is the inflation target. Constant i^* can be defined as the equilibrium interest rate. Substituting (3) in (4) yields:

$$i_t = i^* + \lambda\left[(\alpha\pi_{Ht} + (1-\alpha)\Delta e_t) - \pi^*\right] + \beta(y_t - y^*) \tag{5}$$

It is clear from equation (5) that, although the central bank doesn't care about the exchange rate, it must respond to nominal exchange rate movements as it influences the general inflation rate. The term $(1-\alpha)$ in equations (3) and (5) shows ERPT effect. The greater this effect, the greater the response of monetary policy to the exchange rate movements[1]. As mentioned in Ball and Reyes (2004), $(1-\alpha)\Delta e_t$ term in (5) is the source of confusion that allows one mistakenly classify IT regimes as FF ones.

3. FF and Free Floating Exchange Rates

Calvo and Reinhart (2002) (henceforth C&R) analyze FF by comparing the variability of interest rates, exchange rate and international reserves for countries that claim to follow a free-floating regime. They compare their results in terms of the probability of observing monthly percent changes within a certain range for exchange rate, international reserves and interest rates. The ranges suggested are +/- 2.5 percent changes in exchange rates and international reserves, and +/- 400 basis points change in interest rates. However, Ball and Reyes (2004, 2008) use +/- 50 basis points change for interest rates in their analysis. Nogueira Jr and Léon-Ledesma (2009) formalized C&R's proposition as follows:

$$P\left[|\Delta E| < x / peg\right] > P\left[|\Delta E| < x / float\right] \tag{6}$$

$$P\left[|\Delta R| < x / peg\right] < P\left[|\Delta R| < x / float\right] \tag{7}$$

[1] Us (2007) analyzes alternative monetary policy rules in Turkey under IT regime and finds that an extended open-economy Taylor rule which takes into account exchange rates stabilizes economy much more quickly, and thus is preferable.

$$P\left[\left|\Delta i\right| < y / peg\right] < P\left[\left|\Delta i\right| < y / float\right] \quad (8)$$

Where x is equal to 2.5 percent, y is equal to 50 basis points, ΔE and ΔR are the percent changes in nominal exchange rate and international reserves respectively, and Δi is the change in nominal interest rates. According to C&R's analysis, in the case of FF, the variability of exchange rates should be low, while the variability of interest rates and international reserves should be high, as interest rate and international reserves are used to preserve the exchange rate stability. However, for a free-floating regime the opposite results should be hold.

Ball and Reyes (2004, 2008) (henceforth B&R) argue that the case of FF proposed by Calvo and Reinhart (2002) is not good enough because their proposition does not take into account the fact that many countries now target inflation and under this regime some response to exchange rate movements is required. Thus, Ball and Reyes (2004, 2008) suggest some modifications on C&R's FF approach. First, instead of using nominal interest rates they use real interest rates in their analysis. The second modification is the inclusion of the variability of inflation, so as to check if the central bank cares more about stability in inflation or in exchange. The third modification is that arbitrary ranges of each variable are changed by their standard deviations. Nogueira Jr and Léon-Ledesma (2009) formalized B&R's proposition as follows:

$$P\left[\left|\Delta E\right| > sd / FF\right] < P\left[\left|\Delta E\right| > sd / IT\right] \quad (9)$$

$$P\left[\left|\Delta R\right| > sd / FF\right] > P\left[\left|\Delta R\right| > sd / IT\right] \quad (10)$$

$$P\left[\left|\pi\right| > sd / FF\right] > P\left[\left|\pi\right| > sd / IT\right] \quad (11)$$

$$P\left[\left|\Delta r\right| > sd / FF\right] \leq P\left[\left|\Delta r\right| > sd / IT\right] \quad (12)$$

Where π is the inflation rate, Δr is the change in real interest rate and sd stands for standard deviation. According to B&R approach, under an IT regime the probability of exchange rate changes should be high, the probability of inflation and the probability of international reserve changes should be low than under a FF regime. Regarding real interest rates, the expected results from B&R's analyses show that there is no clear association between real interest rate changes and FF practices. The general belief is that the probability of large changes in real interest rates under IT should be greater or equal to a FF regime (Nogueira and Ledesma, 2009). Moreover, the "timing" of interest rate-inflation and interest rate-exchange rate changes is also important to classify the country as the IT regime or the FF regime. This is done by checking if the probability of large changes (defined as changes greater than their own standard deviation) in real interest rates and international reserves is more associated with changes in inflation or nominal exchange rates.

$$P\left[\left|\Delta r\right| > sd \,/\, \left|\pi\right| > sd \,/\, IT\right] > P\left[\left|\Delta r\right| > sd \,/\, \left|\Delta E\right| > sd \,/\, IT\right] \quad (13)$$

$$P\left[\left|\Delta R\right| > sd \,/\, \left|\pi\right| > sd \,/\, IT\right] > P\left[\left|\Delta R\right| > sd \,/\, \left|\Delta E\right| > sd \,/\, IT\right] \quad (14)$$

Equations (13) and (14) state that we expect large changes in domestic real interest rates and international reserves to be more associated with large changes in inflation rate than with the nominal exchange rate (Ball and Reyes 2004).

3.1 Data and Results of the Calvo-Reinhart and Ball-Reyes Methodology

The data are monthly and covers full sample period of 1992:01-2012:12. For the purpose of our analysis, the data are divided into two sub-periods: 1992:01-2001:12 period refers to before IT and 2002:01-2002:12 period refers to after IT. The data includes monthly percent changes of consumer price index, exchange rate, nominal interest rate and international reserves and obtained from the electronic data delivery system (EDDS) of the CBRT. Exchange rate is defined as numbers of Turkish Lira per unit of US Dollar and overnight interest rate is used as a policy interest rate[2]. Thus, we can see how the switch in monetary policy regime affected variability of interest rates, exchange rate, international reserves and inflation suggested in the FF literature.

Table 1: C&R's FF analysis (%)

	ΔE	ΔR	Δi
Before IT (1992:01-2001:12)	20.17	30.25	11.76
After IT (2002:01-2012:12)	55.73	56.49	68.70

Note: The numbers show the probabilities falling inside the ranges expressed in (6)-(8). Ranges for exchange rate and international reserves are +/- 2.5 percent, and for nominal interest rate is +/- 0.50 percent.

The results of Calvo and Reinhart's (2002) FF analysis are reported in Table 1. According to the results, the probability of exchange rate changes falling inside the range of +/- 2.5% increased from 20.17% to 55.73% after the adoption of IT. That is the flexibility of exchange rate decreased after IT. This result contradicts with C&R's proposition (6). However, after the adoption of IT, probability of changes of international reserves and interest rate falling inside the ranges increased from 36.25% and 11.76% to 56.49% and 68.70% respectively. These are the expected results of C&R propositions (7) and (8).

[2] Overnight interest rate was used as a short-term policy interest rate of The CBRT before May 2010. After May 2010, one week interest rate was used as a policy rate of the CBRT.

Table 2: B&R's FF analysis (%)

	ΔE	ΔR	Δr	π
Before IT (1992:01-2001:12)	29.41	24.37	6.78	82.35
After IT (2002:01-2012:12)	21.38	26.71	18.46	42.75

Note: The numbers show the probabilities falling outside the ranges expressed in (9)-(12).

Table 2 shows the results of B&R's FF analysis. As in C&R's analysis the flexibility of exchange rate changes decreased in the IT regime. Further, the probability of international reserve changes increased in the IT regime as compared to that of the pre-IT period. These results contradict with B&R's propositions (9) and (10). However, variability of real interest rate increased and variability of inflation decreased in the IT period which means that the probability of changes in real interest rate and inflation are in line with B&R's propositions (11) and (12).

Table 3: B&R's analysis of policy instruments' response to inflation and exchange rate changes in IT (%)

	Δr	ΔR
π	8.46	12.21
ΔE	5.38	3.82

Table 3 shows the analysis of the "timing" of the monetary policy instruments. The test results in the Table 3 show that the probability of large changes of real interest rates and international reserves in moments when inflation is increasing is higher than the probability of large changes of these instruments when the exchange rate level is changing. These results are in line with B&R's propositions (13) and (14).

The test results from Table 1 and Table 2 suggest that, after the adoption of IT the exchange rate variability decreased in the IT period. Moreover, B&R's metric shows that the variability of policy instruments increased after the regime change, while C&R's metric shows that the variability of policy instruments decreased to a great extent after the regime change. Thus, the results are mixed. On the other hand, Table 3 reveals that the variability of real interest rates and international reserves are more related to inflation changes rather than to exchange rate changes in the IT period.

We can get two conclusions from these test results: one, the exchange rate has not been freer to float in the IT regime and two, although some interventions in foreign exchange market still to occur, policy interventions are more related to inflation rather than to foreign exchange market. In the next section we will setup a VAR model for analyzing the response of monetary policy instruments to inflation and exchange rates changes in order to better investigate the case of FF in Turkey.

4. VAR Model Estimation Results

Following the above discussion on FF literature, we use VAR model to check the responsiveness of inflation, interest rates and international reserves to different shocks before and after IT, and analyze error variance decompositions of those variables. The advantage of using a VAR model over the results presented in the previous section is that it looks at relations between instruments and targets of monetary policy. Data sources and definitions are the same as in the previous section. Only we add the seasonally adjusted industrial production index as a proxy for output to the analysis. We use data on output (IPI), consumer prices (CPI), exchange rates (EX), international reserves (IRSV) and overnight interest rates (IR) to setup the general structure of the economy and check the responsiveness of inflation, exchange rate and international reserves to exchange rate changes. All variables except interest rates are in logs.

Before estimating the VAR model, ADF, DF-GLS and KPSS unit-root tests were performed to test the stationarity of these variables. With the exception of nominal interest rate in the first period, all level variables are I(1), and we used first differences of these variables to get stationary variables.

The innovations of the VAR model were orthogonalized using a Choleski decomposition of the covariance matrix. Ordering of the variables is as follows: output growth, exchange rate depreciation, inflation, international reserves changes and interest rate[3]. With this ordering output shocks contemporaneously affect other variables, and other variables affect output with a lag. The exchange rate depreciation has a contemporaneous impact on inflation, international reserves and interest rate, but it has a lagged effect on output. The international reserves and interest rate are ordered last, allowing for the central bank to react to all other variables in the model which is in line with the policy rule equation (5)[4].

The optimal lag lengths of the model are determined by the AIC criteria. Then a series of diagnostic tests (autocorrelation and heteroscedasticity) are conducted in order to assure the whiteness of residuals. Thus, we estimated the model with minimum optimal lag length of 8 lags for the period before IT, and 7 lag for the period after IT. Before analyzing the dynamic structure of the system, we checked the residual correlation matrixes of the standard form VAR. The residual correlation matrixes show that residual correlations are quiet low and therefore VAR results are robust to the ordering of the variables.

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[3] We have also estimated the VAR model using output gap (obtained using the difference between output level and HP-filtered output level) instead of output growth. The results are very similar and we have decided to report here those obtained from using output growth. The reason for this is to avoid eliminating valuable information from the data.

[4] In our model we implicitly assume that the Central Bank uses its international reserves instrument to directly intervene in foreign exchange.

Table 4: Unit root test statistics

Variables	ADF (c,t,lag)	DF-GLS (c,t,lag)	KPSS (c,t)	Result
1992:01-2001:12				
IPI	-1.884 (c,t,1)	-2.57 (c,t,1)	0.178* (c,t)	I(1)
ΔIPI	-6.83*** (c,3)[5]	-3.57*** (c,2)	0.34*** (c)	I(0)
EX	-2.32 (c,t,2)	-2.21 (c,t,2)	0.20* (c,t)	I(1)
ΔEX	-6.97*** (c,1)	-6.84*** (c,1)	0.09*** (c)	I(0)
CPI	-0.52 (c,t,2)	-1.36 (c,t,6)	0.27 (c,t)	I(1)
ΔCPI	-3.51*** (c,5)	-3.53*** (c,5)	0.34*** (c)	I(0)
RSV	-0.78 (c,t,13)	-1.25 (c,t,13)	0.22 (c,t)	I(1)
ΔRSV	-3.55*** (c,12)	-2.77*** (c,2)	0.13*** (c)	I(0)
IR	-5.30*** (c,3)	-4.94*** (c,3)	0.07*** (c)	I(0)
2002:01-2012:12				
IPI	-2.28 (c,t,1)	-1.68 (c,t,1)	0.173 (c,t)	I(1)
ΔIPI	-13.79*** (c,0)	-4.81*** (c,2)	0.116*** (c)	I(0)
EX	-2.05 (c,t,4)	-2.12 (c,t,4)	0.244 (c,t)	I(1)
ΔEX	-6.24*** (c,0)	-6.05*** (c,3)	0.07*** (c)	I(0)
CPI	-2.54 (c,t,14)	-1.13 (c,14)	0.226 (c,t)	I(1)
ΔCPI[6]	-4.61*** (c,t,11)	-3.78*** (c,t,2)	0.145*** (c,t)	I(0)
RSV	-1.91 (c,t,3)	-1.26 (c,t,3)	0.296 (c,t)	I(1)
ΔRSV	-3.93*** (c,7)	-2.10* (c,2)	0.063*** (c,t)	I(0)
IR	-3.37* (c,t,1)	-0.81 (c,t,1)	0.217 (c,t)	I(1)
ΔIR	-5.62*** (c,0)	-5.61*** (c,0)	0.153** (c,t)	I(0)

We use 95% error bands to measure the statistical significance of the impulse responses. These error bands are computed by a Monte Carlo integration following Sims and Zha (1999). They argue that the conventional error bands with one or two standard

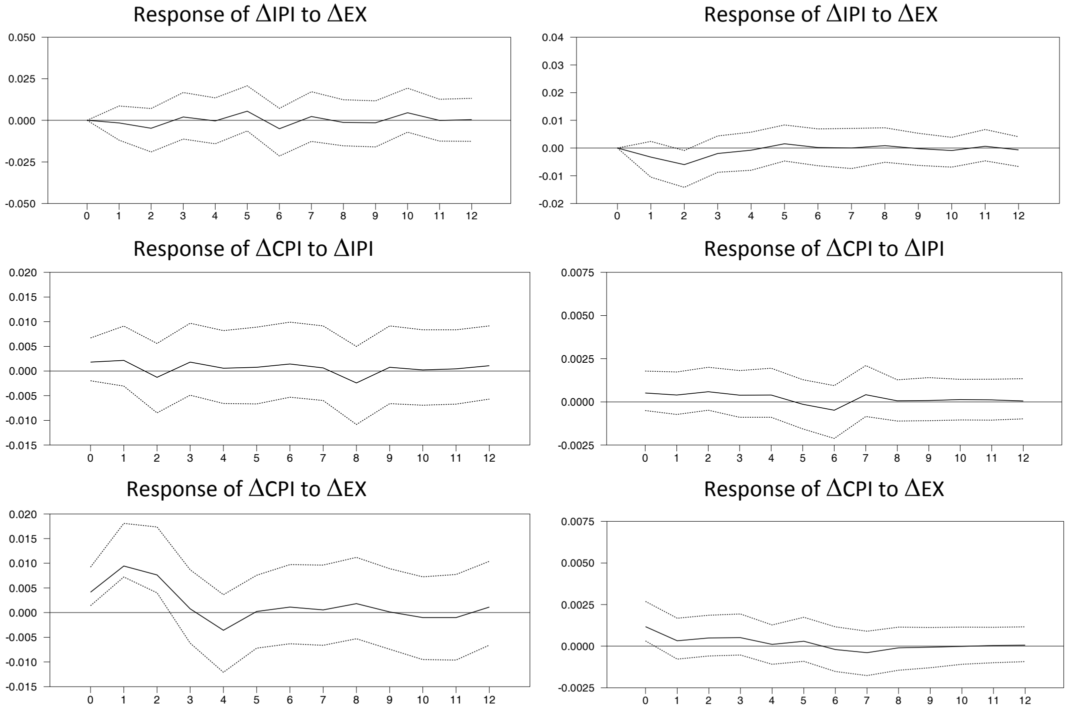
[5] All level variables are in logs except interest rates. The asterisks indicate a rejection of the null hypothesis at the 1 percent (***), the 5 percent (**) or the 10 percent (*) levels for ADF and DF-GLS tests. The asterisks for KPSS test indicate the opposite of these percent levels.

[6] We used seasonally adjusted inflation rate for the period 2002:01-2012:12

errors can be misleading as impulse responses have highly asymmetrical distributions. Following their suggestion, we generate 1000 Monte Carlo draws from the posterior distribution of the coefficients of the model and use 0.025 and 0.975 fractiles instead of a two standard deviation band to compute the true uncertainty of forecast error.

Figure 1: Impulse responses of inflation to exchange rate and output growth shocks

(1992:01-2001:12) **(2002:01-2012:12)**



Impulse response functions in Figure 1 show that although inflation reacts positively to output shocks for one month in the pre-IT period and for four months in the targeting period, these results are statistically insignificant within 95% band. On the other hand, exchange rate shock leads to a large increase in inflation in the pre-IT period. This is the evidence of high ERPT to domestic prices in the pre-IT period. However, this effect decreased largely in the targeting period and it shows that although inflation increases immediately in response to an exchange rate shock, this response is marginally significant only for the first month. The reaction of output growth to exchange rate shock remains insignificant in the first period and marginally significant only in the second month for the targeting period.

Figure 2: Impulse responses of interest rate and international reserves policy instruments

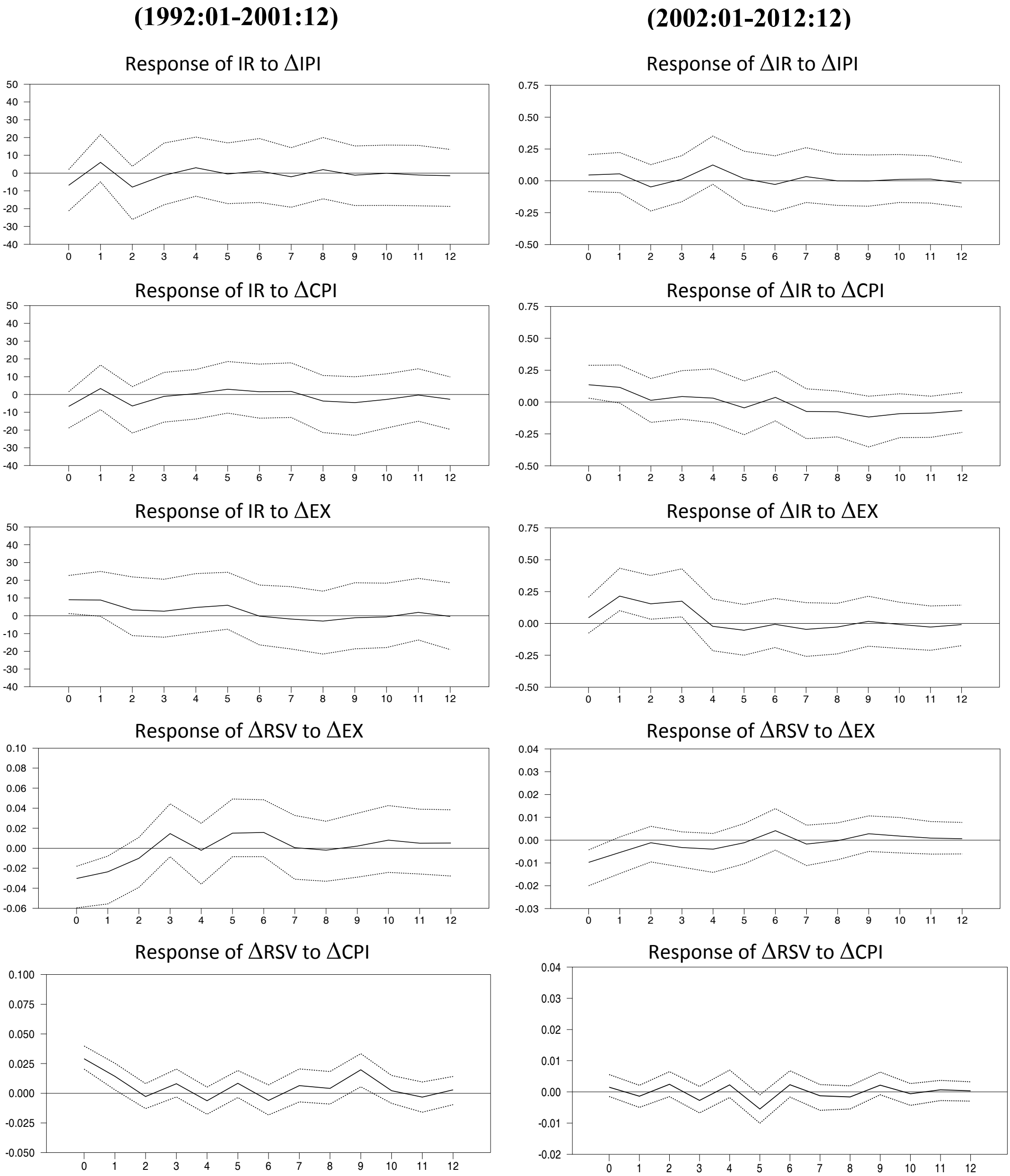


Figure 2 shows the impulse response functions for interest rates. The reaction of interest rates to output shock is insignificant in both periods. Further, the response of interest rate to a positive inflation shock is insignificant in the pre-IT period. On the other hand, in the targeting period interest rate marginally reacts to inflation just for one month and then becomes insignificant. As described in Civcir and Akçağlayan (2010), the response of interest rate to inflation is consistent with forward looking inflation targeting which focuses on future inflation rate in the targeting period. So we can say that the CBRT marginally reacts to lagged and current inflation and focuses mostly on future inflation in the targeting period. Similarly, Yazgan and Yilmazkuday (2007) estimates forward-looking monetary policy for Turkey over the period 2001:08-2004:04 and concludes that forward looking monetary policy provides reasonable description of the CBRT behavior. Moreover, as shown in Figure 2, international reserves decreases in response to a positive exchange rate shock in the pre-IT period, while the size of this negative response decreased in the targeting period. This means that the CBRT doesn't use its international reserves as an active policy instrument to intervene in foreign exchange market in the targeting period as compared to the pre-IT period. Also, the response of international reserves to inflation becomes insignificant in the targeting period.

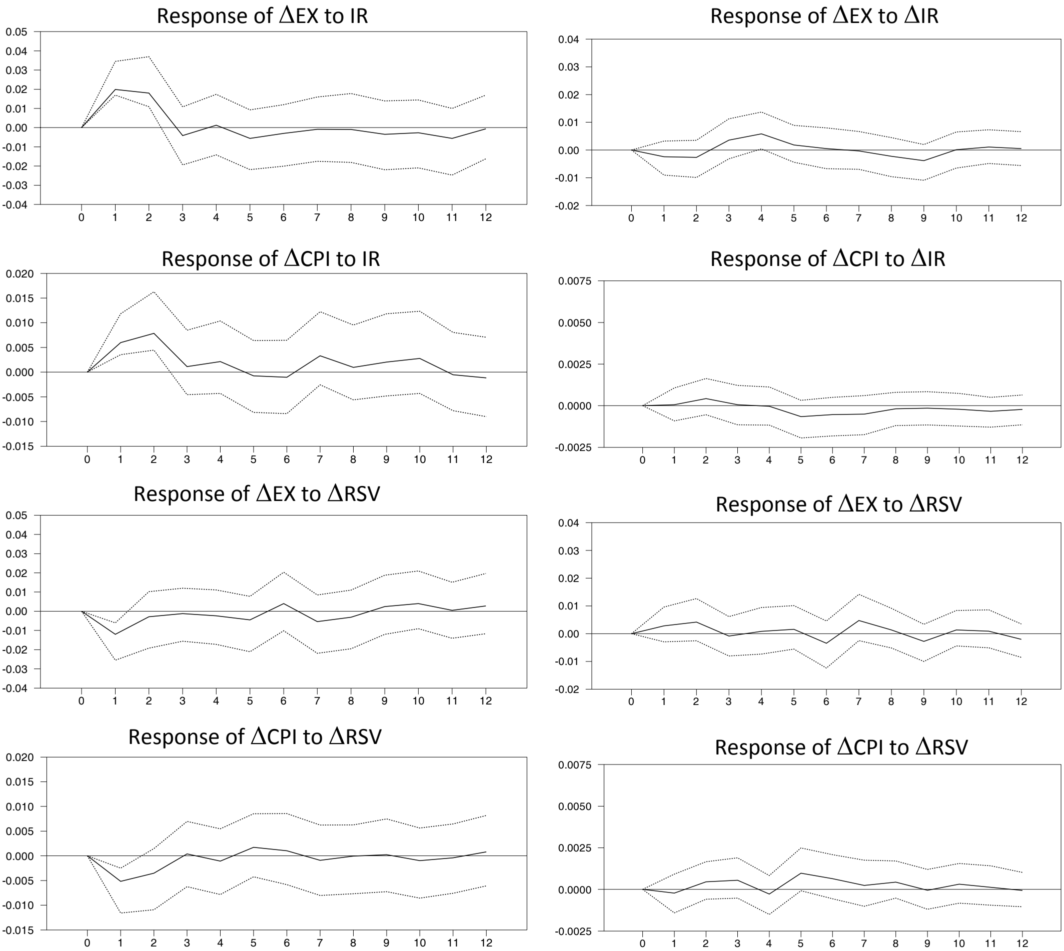
According to Figure 2, in the pre-IT period, the response of interest rate to positive exchange rate shock is marginally significant just for one month and then becomes insignificant. However, in the targeting period, the response of interest rate to exchange rate shocks increased to a great extent. Hence, monetary policy is highly driven by the developments in the exchange rate. These results indicate that moving to floating exchange rates in IT regime have increased vulnerability of domestic prices to exchange rate depreciations and therefore the CBRT prevents foreign exchange fluctuations by using its interest rate instrument in order to control inflation rather than to preserve exchange rate target. In other words, the main channel in feeding the inflation in Turkey is still the depreciation of the domestic currency. As mentioned by Reyes (2007), the pass-through effect is still relevant and therefore the Central Bank keeps on intervening in the foreign exchange rate market in order to comply with the inflation target.

Figure 3 shows that a positive interest rate shock leads to an increase in exchange rate in the pre-targeting period. Also, inflation increases in response to a positive interest rate shock. Considering the significant positive effect of exchange rate depreciation on inflation in Figure 1, this suggests that transmission of interest rate shock on inflation has occurred via the exchange rate shock. Figure 3 also indicates that both exchange rate and inflation decrease in response to a positive international reserve shock in the-pre-targeting period. The negative effect of international reserves on inflation rate occurs via the exchange rate decrease in response to a positive international reserve shock in the pre-targeting period.

However, in the targeting period, monetary policy shocks don't have any significant effect on inflation and exchange rate. This shows that the lower inflation environment and the enhanced credibility of the Central Bank has shifted inflation expectation and declined the exchange rate indexation behavior of agents in their price-setting so that the monetary policy shocks don't have any influence on exchange rate and inflation in the targeting period.

Figure 3: Impulse responses of exchange rate and inflation to monetary policy shocks

(1992:01-2001:12) **(2002:01-2012:12)**



We computed ERPT effect as accumulated response of inflation following a one percent shock to the exchange rate and the results are shown in the Table 5[7]. Following a one percent depreciation shock in the pre-IT period, 66.8% of this shock is passed-through into consumer prices within twelve months, whereas for the IT period it is 7.8% in twelve

7 Kara and Öğünç (2008) and Yüncüler (2011) also explored ERPT into consumer prices both for IT and pre-IT periods in Turkey and conclude that the switch to the IT regime significantly declined ERPT. They argue that lower inflationary environment, enhanced credibility of the Central Bank and the resulting decline in the degree of exchange rate indexation behavior of agents in their price-setting in IT period are the main reason of lower ERPT.

months after a one percent shock. The computed pass-through coefficients in this study are also lower than that of found in Kara and Öğünç (2008) and Yüncüler (2011). As mentioned by Yüncüler (2009), the degree of pass-through falls steadily as years pass under the IT regime.

Table 5: Exchange rate pass-through (%)

	1 Month	6 Months	12 Months
Before IT	17.47	39.89	66.75
After IT	4.36	10.25	7.82

The results from error variance decompositions support the results of impulse response functions. Table 6 shows that, after the adoption of IT, the variance of interest rate explained by the variance of exchange rate after 12 months increased nearly twofold (from 8.8% to 17%) in the IT period in comparison to that of the pre-IT period. The results also show that the variance of interest rate explained by the variance of inflation rate twofold increased (from 5.4% to 12%) after IT in comparison to that of before IT. Moreover, Table 6 shows that the variance of interest rate explained by exchange rate is higher than that explained by interest rate. This result contradicts with the result of Table 3. Table 6 also indicates that the variances of international reserves explained by exchange rate and inflation variances decreased substantially in the IT period in comparison to the pre-IT period. This means that, while international reserves were actively used by the CBRT to intervene in foreign exchange market in the pre-IT period, these interventions decreased in the IT period.

Table 6: Error variance decompositions

Before IT					
Interest Rates			Reserves		
Period	Exchange Rate	Inflation	Period	Exchange Rate	Inflation
1	6.586	3.609	1	17.536	10.099
6	8.877	4.065	6	26.306	9.744
12	8.788	5.414	12	25.646	11.132
After IT					
Interest Rates			Reserves		
Period	Exchange Rate	Inflation	Period	Exchange Rate	Inflation
1	0.711	6.462	1	11.479	0.309
6	18.663	6.489	6	13.556	3.084
12	16.882	12.101	12	15.006	4.134

The traditional view is that, after the adoption of IT, the response of interest rate to inflation must be higher than the response of interest rate to exchange rate in order to ensure the non-existence of FF practice. However, in our analysis, the interest rate response seems to be more linked to the exchange rate than to the inflation rate. This is because Turkey is small and highly open economy where local currency pricing is not common and the effects of the nominal exchange rate on inflation are immediate and high under IT. But the pass-through data don't show it since the effects are being reduced by the central bank actions. As mentioned by Kara and Öğünç (2010), depreciation of Turkish Lira changes the domestic prices in a short period of time. During the IT period, the CBRT frequently announced that the monetary policy was conducted with forecasted future inflation target. Hence, the CBRT intervenes in response to temporary exchange rate shocks in order to comply with the future inflation target. As described by Civcir and Akçağlayan (2010), these actions are consistent with forward looking inflation targeting which focuses only on future inflation and the lagged and current inflation shocks have not been taking into consideration. As a result, CBRT reacts to immediate exchange rate shocks in order to maintain the future inflation target.

5. Conclusion

The results from our analysis suggest that the Central Bank actively keeps on reacting exchange rate shocks and mostly focuses on future inflation target. This means that the Central Bank cares about future inflation and everything that affects it. In that sense, although the exchange rate pass-through decreased, it still matters for the attainment of the inflation targets. In other words, as mentioned by Reyes (2007), the pass-through effect is still high under IT regime, but the data don't show it since the effects are being reduced by the Central Bank's actions. Hence we can say that there is a link between the exchange rate depreciation and future inflation target, so the CBRT keeps on reacting to exchange rate depreciations in the targeting period.

Another result from Figure 2 and Table 6 is that the interest rates are mostly used to react to exchange rate shocks in IT period, while in pre-IT period international reserves are mostly used to react to exchange rate shocks. This result indicates that direct intervention in foreign exchange market has decreased in IT period.

Based on our results shown above, there is not any evidence of FF in Turkey in the IT regime. Given that Turkey is a small-open economy and trying to maintain low and stable inflation environment, exchange rate movements still matters for the attainment of the inflation target and foreign exchange market intervention can be interpreted as "fear of inflation" rather than "fear of floating".

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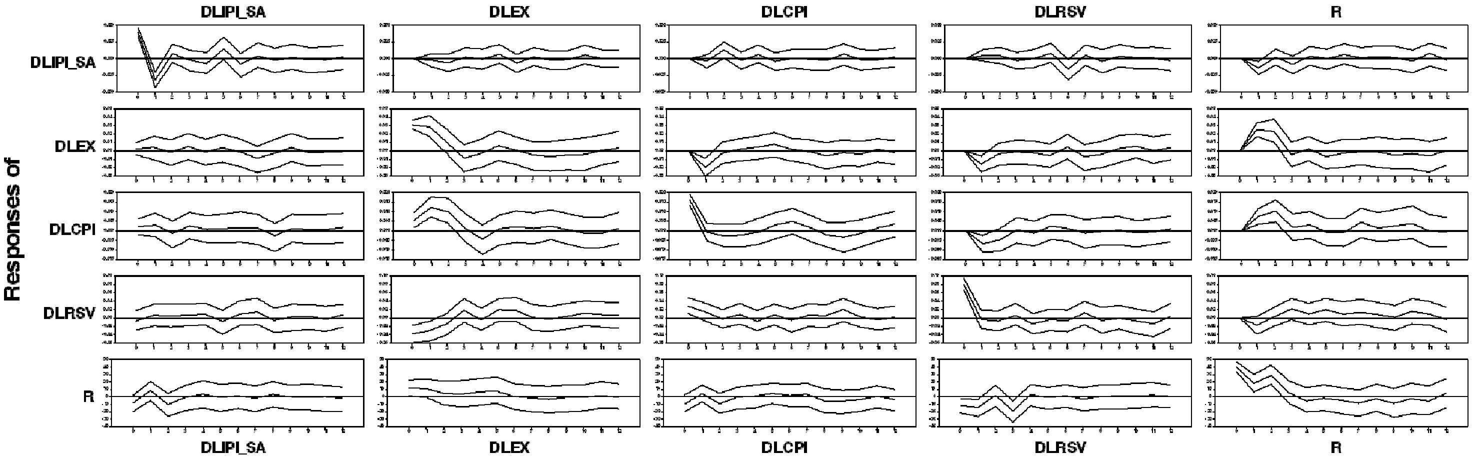
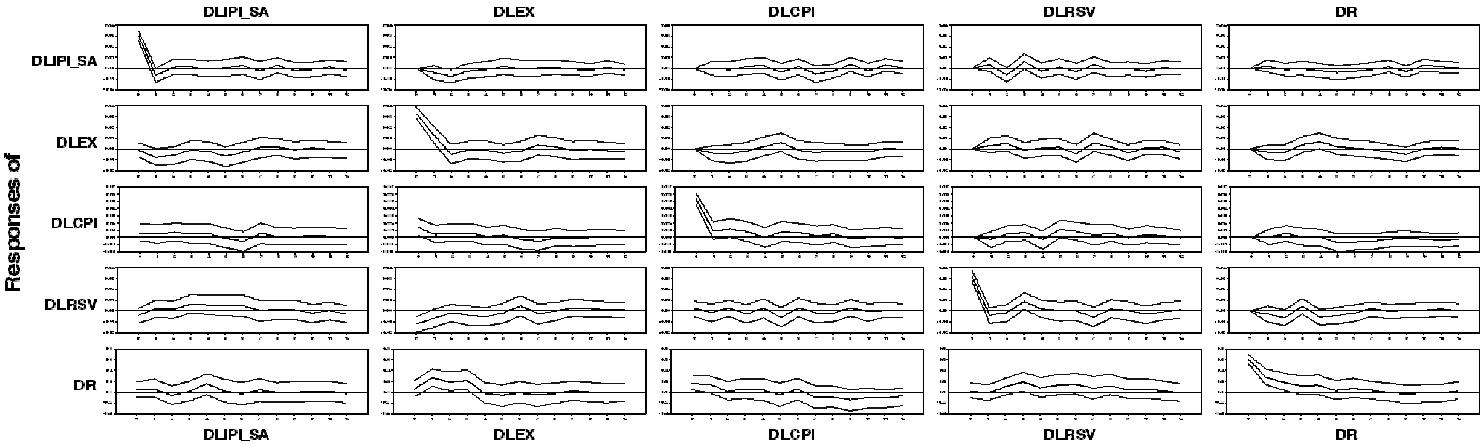
Appendix: Impulse Response Functions with 95% error bands

A) 1992:01-2001:12 period



B) 2002:01-2012:12 period



The Turn-of-the-Month-Effect: Evidence from Periodic Generalized Autoregressive Conditional Heteroskedasticity (PGARCH) Model

Eleftherios Giovanis[1,2]

Abstract

The current study examines the turn of the month effect on stock returns in 20 countries. This will allow us to explore whether the seasonal patterns usually found in global data; America, Australia, Europe and Asia. Ordinary Least Squares (OLS) is problematic as it leads to unreliable estimations; because of the autocorrelation and Autoregressive Conditional Heteroskedasticity (ARCH) effects existence. For this reason Generalized GARCH models are estimated. Two approaches are followed. The first is the symmetric Generalized ARCH (1,1) model. However, previous studies found that volatility tends to increase more when the stock market index decreases than when the stock market index increases by the same amount. In addition there is higher seasonality in volatility rather on average returns. For this reason the Periodic-GARCH (1,1) is estimated. The findings support the persistence of the specific calendar effect in 19 out of 20 countries examined.

Keywords: Calendar Effects, GARCH, Periodic-GARCH, Stock Returns, Turn of the Month Effect

JEL Classification: C22, G14

1. Introduction

Seasonal variations in production and sales of goods are a well known fact in business and economics. Seasonality refers to regular and repetitive fluctuation in a time series which occurs periodically over a span of less than a year. Similarly, stock returns exhibits systematic patterns at certain times of the day, week or month. The existence of seasonality in stock returns however violates an important hypothesis in finance that is efficient market hypothesis.

Capital market efficiency has been a very popular topic for empirical research since Fama (1970) introduced the theoretical analysis of market efficiency and proclaimed the Efficient Market Hypotheses (EMH). Subsequently, a great deal of research was devoted to

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investigating the randomness of stock price movements for the purpose of demonstrating the efficiency of capital markets. Since then, all kinds of calendar anomalies in stock market return have been documented extensively in the finance literature. The most common calendar effects are the day of the week and the month of the year effect. However a curious anomaly, the turn of the month effect, has been found, which has been firstly documented by Ariel (1987). He examined the US stock returns and found that the mean return for stock is positive only for days immediately before and during the first half of calendar months, and indistinguishable from zero for days during the second half of the month.

The purpose of this paper is to investigate the turn of the month effect in stock market indices around the globe and to test its pattern, which can be used for the optimum asset allocation with result the maximization of profits. Because each stock market behaves differently and presents different turn of the month effect patterns, the trading strategy should be formed in this way where the buy and sell signals and actions will be varied in each stock market index. Haugen and Jorion (1996) suggested that calendar effects should not be long lasting, as market participants can learn from past experience. Hence, if the turn of the month effect exists, trading based on exploiting this calendar anomaly pattern of returns should yield extraordinary profits – at least for a short time. Yet such trading strategies affect the market in that further profits should not be possible: the calendar effect should break down.

The majority of the studies examining the turn of the month effect use as main tools statistical, from parametric and non parametric, test hypotheses to conventional econometric approaches and regression models, as ordinary least squares and symmetric GARCH estimations. To my knowledge this is the first study where the Periodic Generalized Autoregressive Conditional Heteroskedasticity (PGARCH) model for the turn of the month effect is employed.

The remainder of the paper has as follows: Section 2 discusses the literature review; in section 3 the methodology is described and section 4 presents the data sample and reports the summary statistics. Section 5 reports the results, while section six discusses the concluding remarks.

2. Literature Review

Many researchers studied the turn of the month effect. One of the first studies is by Ariel (1987), who obtained daily data for Center for Research in Security Prices (CRSP) value-weighted and equally-weighted stock index returns from 1963 through 1981. Ariel (1987), using descriptive statistics, finds that there are positive returns for the period starting on the last trading day of the previous month through the first half of the next month, followed by negative returns after the mid-point of the month. Also Ariel (1987) considers the January effect and he finds that for both indexes the means of both the first and the last nine trading days are lower when January is excluded from the analysis. Cadsby and Ratner (1992) examined stock market indices in ten countries-CRSP value-weighted and equally-weighted stock index returns for USA, Toronto stock exchange equally-weighted for Canada, Nikkei index for Japan, Hang Seng for Hong Kong, Financial times 500 share or UK, All ordinaries index for Australia, Banca Commerciale index for Italy, Swiss Bank Corporation Industrial index for Switzerland, the Commerzbank index for west Germany and the Compagnie des Agents de Change General Index for France. The dates vary in each index covering the period 1962-1989. Cadsby and Ratner (1992) define the turn-of-the-month effect as the last and the first three trading days of each month. Daily returns are regressed on a constant and on a dummy variable, which equals at one for the turn-of-the month days and zero for the other days, using ordinary least squares approach. The coefficient of the dummy variable is statistically higher than zero at 1% level for both value-weighted and equally-weighted stock indices of U.S.A. Also they reject the null hypothesis for Canada, Switzerland and West Germany at the same significance level. The same coefficient is statistically higher than zero at 5% level for United Kingdom and Australia. However Cadsby and Ratner (1992) accept the null hypothesis for Japan, Hong Kong, Italy and France.

Jaffe and Westerfield (1989) obtain daily returns of stock market indices for four countries. The specific indices and the periods they examine are Financial Times Ordinary Share Index from January 2, 1950 to November 30, 1983 for UK; Nikkei Dow from January 5, 1970 to April 30, 1983 for Japan; Toronto Stock Exchange Index from January 2, 1977 to November 30, 1953 for Canada; and Statex-Actuaries Index from January 1, 1973 to April 30, 1985 for Australia. They apply *t-statistics* to test whether there is significant difference between the intervals [-9, -2] and [-1, +9], where +1 denotes the first trading day of each month and -1 denotes the last trading day of each month. The results are mixed as authors find that there are higher returns of the first half of the month than returns of the last half of the month for Canada, Australia and United Kingdom. Jaffe and Westerfield (1989) change the intervals to [-10, -2] and [-1, +8] and they found positive significant returns only for Australia, while positive returns are observed for Canada and United Kingdom; however are statistically insignificant. The mean returns in the second half of the month are higher than the first half for Japan and are significant at 1% level, suggesting a reverse monthly effect. Finally, Jaffe and Westerfield (1989) estimated a model using as dependent variable the daily returns of stock indices and independent variable a dummy, which takes value one during the first trading days and the last trading day of each month and zero otherwise. The coefficient of dummy variable is significant and positive for Canada, Australia and United Kingdom, while is significant and negative for Japan. Ziemba (1991) examines daily returns for NSA Japan during 1949-1988 for the intervals [-5, +2] and [-5, +7] and applying descriptive and *t-statistics* finds that in these intervals returns are higher than any other period. Finally, when the January effect is considered for the turn-of-the year effects, this effect starts on day -7 and it has positive returns on every trading day until day +14.

McConnell and Xu (2008) examine the turn-of-the month effect for (CRSP) value-weighted and equally-weighted stock index returns in USA obtaining daily data during period 1926-2005. In addition, they examine the same effect using two sub-periods, 1926-1986 and 1987-2005. Also they test the turn-of-the month effect for other 34 countries McConnell and Xu (2008) define the turn-of-the month interval as [-1, +3] and they found that the specific calendar effect exists for USA and for other 30 out of 34 countries except Argentina, Colombia, Italy, and Malaysia. The methodology they follow is descriptive and they use *t-statistics* to test whether the mean accumulative returns in the turn-of-the month interval are significant positive and different from zero and higher than the mean cumulative returns in the rest days of each trading month.

Martikainen et al. (1995) used daily returns of Finnish Options Index from May 2**,** 1988 to October 14, 1993. They examined the interval [-1, +4] as the turn-of-the month and they apply *t-statistics* to test if the mean returns of this interval are positive and significant different from zero. Martikainen et al. (1995) found that these positive and significant returns are observed in the interval [-5, +5]. Kunkel et al. (2003) used daily closing prices for 19 countries from August 1, 1988 to July 31, 2000 to examine the turn-of-the month effect , which is defined as the interval [-1,+3]. Kunkel et al. (2003) regress daily returns on 18 dummy variables, which for example dummy D_{-9} takes value one if returns correspond to trading day -9 , continuing through D_9 which corresponds to trading day 9. The method which is applied is ordinary least squares. Over the 4-day turn-of-the month interval, all countries have at least one positive and statistically different from zero return, while most of them have two to four positive and statistically different from zero returns. Six countries have negative returns during this 4-day turn-of-the month period; however none of these returns are statistically insignificant. Finally Kunkel et al. (2003) regressed daily returns on a constant and on a dummy, where the latter takes value one of returns are corresponding in the turn-of-the month effect [-1, +3] interval and zero otherwise. The coefficients of this regression shows that there are positive mean returns in every country during the [-1, +3] interval.

Nikkinen et al. (2007) used daily data of SP100 stock market and VIX volatility indices data from January 1995 to December 2003. In the study by Nikkinen et al. (2007) daily returns of SP100 are regressed on two dummies. The first dummy takes value one if returns refer on the interval [-9, +9] and zero otherwise, while the second variable takes value one if returns refer on the remained days of the month and zero otherwise. Nikkinen et al. (2007) find that the turn-of-the month effect is strongest in the [+1 +3] interval. Aggarwal and Tandon (1994) obtained daily data for 18 countries. The turn-of-the month is defined as the interval [-4, +4]. Aggarwal and Tandon (1994) used *t-statistics* and they found that there are significantly higher returns in the [-1, +3] interval in ten countries.

Lakonishok and Smidt (1988) used ninety year daily data of Dow Jones Industrial Average from January 4, 1897 through June 11, 1986. Lakonishok and Smidt (1988) use *t-statistics* to test the difference in the average returns between turn-of-the-month interval and non turn-of-the-month and they find that the turn-of-the month effect strongly exists in the [-1, +3] interval. Marquering, et al. (2006) used daily and monthly data of Dow Jones Industrial Average (DJIA) during period 1960-2003, with two sub-periods of estimation; 1960-1981 and 1982-2003. Marquering, et al. (2006) found that the turn-of-the-month effect still exists, while the other calendar effects, including the day of the week and the month of the year effect, disappear. Tonchev and Kim (2004) used daily values PX-50 and PX-D Indices of Czech Republic, the SAX Index for Slovakia and the SBI-20 and SBI-

20NT indices for Slovenia. The periods are 1 January 1999- 18 June 2003 for the Czech Republic and 4 July 2000- 18 June 2003 for Slovakia. Tonchev and Kim (2004) studied the day-of-the week, January, turn-of-the month, the half month and holiday effects. Tonchev and Kim (2004) regressed the daily returns on six dummies where dummy D_{-3} is equal with one if returns correspond to the trading day –3, continuing through up to D_3, which is equal with one if returns correspond to the trading day 3. All models are estimated with OLS and GARCH(1,1). Tonchev and Kim (2004) found that the turn-of-the-month effect does not exist. Giovanis (2009) examined the turn of the month effect in 55 stock market indices using bootstrapping *t-statistics*, concluding that the turn of the month effects is present in 36 indices. Georgantopoulos and Tsamis (2014) examined various calendar anomalies, including the turn-of-the-month effect, in stock returns on Istanbul Stock Exchange (ISE) over an eight years period (4/1/2000 – 4/1/2008) by Ordinary Least Squares (OLS) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH 1,1) models. Testing the presence of the turn of the month effect the authors found that this market anomaly is strongly present in the ISE.

Hansen and Lunde (2003) derived a test for calendar anomalies, which controls for the full space of possible calendar effects. The countries examined are: Denmark, France, Germany, Hong Kong, Italy, Japan, Norway, Sweden, Japan, UK, and USA. The authors investigated various calendar effects including the turn-of-the-month effect and they found significant calendar effects in most series examined. However, in recent years it seems that the calendar effects have diminished, while most robust significance is found for small-cap stock indices, where calendar effects are generally found to be significant, across countries and subsamples. Zwergel (2014) examined the turn of the month effect using the indices; Germany (DAX), Japan (Nikkei 225), UK (FTSE 100) and US (S&P 500) during the period January 1991 and November 2005. Zwergel (2014) argues that the turn of the month effect seems to be exploitable by using a futures trading strategy, even after transaction costs and slippage deductions due to the fact that turn of the month effect is quite volatile and that the liquidity at the close trades are assumed to be executed, is too low for institutional investors. Thus, the investors they would probably be paying higher prices than the closing prices when opening a long position and receiving lower prices when closing the position. Sharma and Narayan (2014) examined whether the turn-of-the-month affects firm returns and firm return volatility differently depending on their sector and size. Using 560 firms listed on the NYSE Sharma and Narayan (2014) found evidence that the turn-of-the-month affects returns and return volatility of firms. However, these effects depend on firm location and size.

On the other hand, other studies examine additional factors having impact on stock returns. A study by Vazakidis and Athianos (2010) examines the reaction of the Athens Stock Exchange (ASE) to dividend announcements by a sample of firms listed at the FTSE/ATHEX 20 and FTSE/ATHEX Mid 40 for a fixed period 2004-2008, before and after the day of the announcement (event day). The authors test the hypotheses that there is no significant abnormal activity by the stock prices during the examined period and thus, the irrelevance theory introduced by Miller and Modigliani (1961) stands true. Using various event windows, no longer than 20 days, Vazakidis and Athianos (2010) reject the irrelevance theory and the hypothesis of no abnormal stock returns. Çağlı et al. (2011) examined the volatility shifts and persistence in variance using data for the sector indices of Istanbul Stock Exchange market. The authors extended the exponential generalized autoregressive conditional heteroskedasticity (EGARCH) model, proposed by Nelson (1991), by taking account of the volatility shifts which are determined by using iterated cumulative sums of squares (ICSS) and modified ICSS algorithms such as Kappa-1 (κ-1) and Kappa-2 (κ-2). Their findings support that the inclusion of volatility shifts in the model substantially reduces volatility persistence and suggest that the sudden shifts in volatility should not be ignored in modelling volatility for Turkish sector indices.

Sariannidis (2010) using Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models examined the effects of capital and energy markets returns and exchange rate of the U.S. Dollar/ Yen on sugar features. More specifically, Sariannidis (2010) examines crude oil, Ethanol, SP500 and exchange rate of the U.S. Dollar/ Yen and he found that the higher energy prices, Crude oil and Ethanol, positively influence the sugar market, while the effects of U.S. Dollar/ Yen are negative on sugar market. Therefore, this study is suggested for future research as the calendar effects can be influenced by additional macroeconomic factors.

In recent years, there has been considerable interest in the autoregressive conditional heteroskedasticity (ARCH) disturbance model introduced by Engle (1982). Since their introduction, the ARCH model and its various generalizations, especially the generalized ARCH (GARCH) model introduced by Bollerslev (1986), have been particularly popular and useful in modelling the disturbance behaviour of the regression models of monetary and financial variables. Srinivasan and Ibrahim (2012) used a bivariate Error Correction Model Exponential GARCH (ECM-EGARCH) to examine the news effects from the spot exchange rates market to the volatility behaviour of futures market. Sariannidis et al. (2009) used the GARCH model to examine the relationship between Dow Jones Sustainability Index World (DJSI.-World) returns to 10 year bond returns and Yen/U.S. dollar exchange rate. An extensive survey of the theory and applications of these models is given by Bollerslev et al. (1992).

Previous studies found that seasonality in financial-market volatility is pervasive. Gallant et al. (1992) reported that the historical variance of the Standard and Poor's composite stock-price index in October is almost ten times the variance for March. Similarly, Bollerslev and Hodrick (1999) found evidence for significant seasonal patterns in the conditional heteroskedasticity of monthly stock-market dividend yields. Regarding daily frequency studies demonstrated that daily stock-return and foreign-exchange-rate volatility tend to be higher following non-trading days, although proportionally less than during the time period of the market closure (French and Roll, 1986; Baillie and Bollerslev, 1989). At the intraday level, Wood et al. (1985) found that the variances of stock returns over the course of the trading day present a U-shaped pattern. Similar patterns in the volatility of intraday foreign-exchange rates are reported in other studies (Baillie and Bollerslev, 1991; Harvey and Huang, 1991; Dacorogna et al., 1993).

3. Data and Methodology

3.1 Data and Summary Statistics

The data are daily closed prices of stock market indices. The analysis is conducted in terms of daily returns which is defined as $r = \log(P_t/P_{t-1})$. More specifically, in Table 1 we present the countries and the indices symbols. The final period is 31 December 2013 for all series except from the starting period, where it is shown in Table 1.

In Table 2 the descriptive statistics for stock market indices returns in 10 countries are reported. In all cases mean returns are very low and in some countries are negative as in Italy and Taiwan. As it was expected leptokurtosis is observed in all stock returns, as the value of kurtosis is very high reaching even 99 in the case of Australia.

Heavy tails are commonly found in daily return distributions. Negative skewness is presented in all series expect from Brazil, Greece, Malaysia, and Mexico. In addition based on Jarque-Bera statistic and the probability it is concluded that the normality assumption in the time series examined is rejected, supporting the non-normal distribution of the stock index returns examined in this study. One can use median return instead of mean to represent returns. Based on median returns, Argentina and Brazil report the highest return followed by India and Indonesia. On the other hand, the lowest median returns are presented in Greece, followed by China and Taiwan.

Table 1: Stock Market Indices and estimating periods

Countries	Period	Countries	Period
Argentina (MERVAL INDEX)	9 October 1996	Indonesia (JKSE Composite Index)	2 July 1997
Australia (All ordinaries Index)	9 January 2001	Italy (MIBTEL INDEX)	2 January 1998
Austria (ATX INDEX)	12 November 1992	Japan (Nikkei 225)	5 January 1984
Brazil (IBOVESPA INDEX)	28 April 1993	Malaysia (KLSE INDEX)	6 December 1993
China (Shanghai composite Index)	4 July 1997	Mexico (IPC INDEX)	11 November 1991
France (CAC 40 INDEX)	2 March 1990	Netherlands (AEX INDEX)	13 October 1990
Germany (DAX INDEX)	27 November 1990	Singapore (STI INDEX)	
Greece (GENERAL INDEX) www.enet.gr	5 January 1998	Taiwan (TSEC weighted index)	3 July 1997
Hong Kong (HANG SENG INDEX)	2 January 1987	UK (FTSE-100)	3 April 1984
India (BSE SENSEX)	2 January 1997	USA (S&P 500)	4 January 1950

Table 2: Descriptive statistics for stock returns in 10 countries

	ARGENTINA	AUSTRALIA	AUSTRIA	BRAZIL	CHINA	FRANCE	GERMANY	GREECE	HONG KONG	INDIA
Mean	0.000521	0.000271	0.000232	0.001495	0.000114	0.000141	0.000323	0.000247	0.000328	0.000390
Median	0.001011	0.000514	0.000641	0.001433	0.000110	0.000333	0.000786	0.000013	0.000529	0.000977
Maximum	0.161165	0.060666	0.120210	0.288325	0.094008	0.105946	0.107975	0.240000	0.172470	0.159900
Minimum	-0.147649	-0.287134	-0.102526	-0.172082	-0.092562	-0.094715	-0.098709	-0.24000	-0.405420	-0.118092
St. deviation	0.021687	0.010024	0.013730	0.023977	0.015081	0.014176	0.014444	0.018745	0.017398	0.016486
Skewness	-0.284545	-3.788888	-0.387938	0.490767	-0.117682	-0.028677	-0.106106	0.108420	-2.386760	-0.090520
Kurtosis	8.356421	99.66951	10.57300	12.85889	7.937991	7.492765	7.745093	35.55614	59.90492	8.552297
Jarque-Bera	5,130.839	291,553.8	12,638.12	20,949.22	4,357.296	5,078.181	5,498.291	118096.0	912,660.0	5,248.904
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

	INDONESIA	ITALY	JAPAN	MALAYSIA	MEXICO	NETHER-LANDS	SINGAPORE	TAIWAN	UK-FTSE 100	US – S&P 500
Mean	0.000440	-6.16E-05	6.71E-05	0.000121	0.000614	0.000213	0.000209	-1.16E-05	0.000242	0.000292
Median	0.000926	0.000456	0.000391	0.000277	0.000739	0.000690	0.000229	0.000152	0.000212	0.000468
Maximum	0.131278	0.108742	0.132346	0.208174	0.121536	0.100283	0.128738	0.085198	0.093891	0.109572
Minimum	-0.127318	-0.085991	-0.161375	-0.241534	-0.143145	-0.095903	-0.105446	-0.099360	-0.130221	-0.228997
St. deviation	0.017278	0.015678	0.014615	0.014583	0.015652	0.013993	0.012615	0.015307	0.011015	0.009758
Skewness	-0.188689	-0.070874	-0.297679	0.408046	0.020908	-0.147454	-0.086594	-0.150647	-0.49502	-1.030113
Kurtosis	9.854901	7.084830	11.14954	52.07823	8.765888	9.340613	11.45198	5.666394	12.88787	30.69292
Jarque-Bera	7,876.956	2,846.968	20,528.80	497,729.2	7,682.877	9,078.759	19,441.74	1,220.773	32,192.60	517,372.2
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

3.2 Stationarity and Unit Root Tests

In this section ADF test statistic (Dickey and Fuller, 1979) is applied in order to examine whether the stock returns examined in this study stock returns are stationary as it was expected. The ADF test can be defined by testing the following equation:

$$R_t = \alpha + \delta t + \varphi R_{t-1} + \text{lags of } \Delta R_t + \varepsilon_t \qquad (1)$$

and the hypotheses we test are:

$$H_0: \varphi=1, \delta=0 \Rightarrow R_t \sim I(0) \text{ with drift}$$

against the alternative

$$H_1: |\varphi|<1 \quad \Rightarrow R_t \sim I(1) \text{ with deterministic time trend}$$

In Table 3 the results of ADF test are reported. Based on the *t-statistics*, the stock returns are stationary. The stationarity is supported also based on additional tests, such as the Dickey-Fuller (DF), the Phillips-Perron (PP) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test.

Table 3: ADF test for stock returns in 20 countries

Countries	Test ADF t-statistic	Countries	Test ADF t-statistic
ARGENTINA	-51.362	INDONESIA	-44.902
AUSTRALIA	-36.224	ITALY	-48.408
AUSTRIA	-59.857	JAPAN	-58.606
BRAZIL	-58.165	MALAYSIA	-26.618
CHINA	-50.483	MEXICO	-45.397
FRANCE	-68.537	NETHERLANDS	-39.251
GERMANY	-67.875	SINGAPORE	-44.335
GREECE	-27.667	TAIWAN	-50.785
HONG KONG	-39.636	UK-FTSE 100	-39.451
INDIA	-49.398	US – S&P 500	-86.604

* MacKinnon critical values for rejection of hypothesis of a unit root at 1%, 5% and 10% are -3.4786, -2.8824 and -2.5778 respectively.

3.3 Symmetric GARCH Model

The consequences of heteroskedasticity are problematic in general, and it is well known that the consequences of heteroskedasticity for OLS estimation are very serious. Although parameter estimates remain unbiased, they are no longer efficient, meaning they are no longer best linear unbiased estimators (BLUE) among the class of all the linear unbiased estimators. For this reason GARCH and PGARCH models are employed in this study to account for autocorrelation, heteroskedasticity and volatility clustering.

The turn-of-the month (TOM) effect is defined as the interval [-1, +3], where -1 is the last trading day of each month and continuing until +3, which is the third trading day of each month. The general form of a GARCH (p,q) model, which was proposed by Bollerslev (1986) is:

$$E[\varepsilon_t \mid \Omega_{t-1}] = \sigma_t^2 = \omega + \sum_{i=1}^{p} a_i \varepsilon_{t-1}^2 + \sum_{j=1}^{q} \alpha_j \sigma_{t-j}^2 \tag{2}$$

The GARCH (1,1) model will be:

$$R_t = \beta_0 D_{\text{TOM}} + \beta_1 D_{N\text{TOM}} + \varepsilon_t, \quad \varepsilon_t \sim (0, \sigma^2) \tag{3}$$

$$\sigma_t^2 = \omega + a_1 u_{t-1}^2 + a_2 \sigma_{t-1}^2 \tag{4}$$

where (3) and (4) indicate the mean and the variance equations respectively. R_t denotes the daily stock returns, D_{TOM} is a dummy variable obtaining value 1 for mean returns belonging in the *TOM* interval [-1, +3] and 0 otherwise, D_{NTOM} is a dummy variable obtaining value 1 for mean returns not belonging in the NTOM interval and 0 otherwise and ε_t is the disturbance term. Based on the turn of the month effect, it is expected that the coefficient β_0 will be significant positive and higher than coefficient β_1. Alternatively, it is expected that coefficient β_1 will be insignificant or negative.

Regarding the diagnostic tests, firstly ARCH effects are tested using the Breusch-Pagan Lagrange Multiplier (LM) test. To test for ARCH of order p the following auxiliary regression model is considered:

$$\varepsilon_t^2 = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 \varepsilon_{t-2}^2 + \ldots\ldots + \gamma_p \varepsilon_{t-p}^2 + \eta_t \tag{5}$$

Under the null hypothesis of no ARCH,

$$H_0 = \gamma_1 = \gamma_2 = \ldots.. = \gamma_p = 0 \tag{6}$$

The hypothesis can be tested using the familiar statistic:

$$T \cdot R^{2} \rightarrow x^2(p) \tag{7}$$

The second diagnostic test is the autocorrelation test on residuals. The Ljung-Box-Pierce Q-statistic (Box and Pierce, 1970; Ljung and Box, 1978) is applied.

Let $\hat{e}(1)$,........., $\hat{e}(n)$ be the standardized residuals from fitting a time series regression model, and let (34) be their autocorrelations.

$$\hat{r}(k) = \frac{\sum_{t=k+1}^{n} \hat{e}(t)\hat{e}(t-k)}{\sum_{t=k+1}^{n} \hat{e}^2(t)}, \quad for \;\; k = 1,2,....n \tag{8}$$

If the model is correct, the Ljung-Box-Pierce Q-statistic is:

$$Q(\hat{r}) = n(n+2)\sum_{k=1}^{m}(n-k)^{-1}\hat{r}^2(k) \tag{9}$$

where (9) is asymptotically distributed as x^2 with $m - p$ degrees of freedom where p denotes the number of parameters in the model. The null hypothesis is that there is no autocorrelation in the residuals. Various lags have been used; however for the ARCH LM test 5 lags have been used and for the autocorrelation test 12 lags.

3.4 Periodic GARCH Model

In this section the methodology of Periodic GARCH (1,1) is provided, which have been proposed by Bollerslev and Chysels (1996). The class of P-GARCH processes may be defined as:

$$E[\tilde{\varepsilon}_t \mid \Omega_{t-1}^{s}] = 0 \tag{10}$$

where *s(t)* refers to the stage of the periodic cycle at time *t*. The general form of Periodic-GARCH model is:

$$E[\tilde{\varepsilon}_t \mid \Omega_{t-1}^{s}] = \tilde{\sigma}_t^{2} = \omega_{s(t)} + \sum_{i=1}^{q} a_{is(t)}\, \tilde{\varepsilon}_{t-1}^{2} + \sum_{j=1}^{p} \alpha_{js(t)}\, \tilde{\sigma}_{t-j}^{2} \tag{11}$$

In this study the Periodic GARCH (1,1) used for the turn-of-the month effect and regression (2) is the following:

$$\sigma_t^{2} = \omega + a_1 u^2_{t-1} + a_2\sigma^2_{t-1} + d_{st}\omega_s + d_{st}a_{1s}u^2_{t-1} + d_{st}a_{2s}\sigma^2_{t-1} \tag{12}$$

In the variance equation (12) the coefficients definition remain the same as in (4), with the difference that d_{st} equals with one if s is the stage of the periodic cycle at time t and $d_{st}=0$ otherwise. More precisely stage of the periodic cycle s is equal at 1 for days belonging in the *TOM* interval and 0 otherwise.

4. Empirical Results

In Tables 4 and 5 the GARCH(1,1) and PGARCH(1,1) estimates respectively are reported. Based on these results the coefficient β_0 is always positive, significant and higher than coefficient β_1 with the exception of Australia. Therefore the main conclusion is that the turn of the month effect is presented in 19 out of 20 stock market indices examined. The findings are consistent with other studies (Ariel, 1987; Cadsby and Ratner, 1992; Giovanis, 2009). The coefficient β_0 is always significant at 1% level, while in some cases coefficient β_1 is statistically insignificant. It should be noticed that different samples have been employed. More specifically, three samples have been used. Firstly, from the starting period of each stock market index up to 2007 before the financial crisis. The second sample is the period 2008-2009 and the third sample is from the starting period for each stock market index up to 2013. However, the results remain the same, only changing the magnitude of the coefficients around 1-2 %, and they are not presented due to space limitations. Nevertheless, the conclusion change only for Australia, where the turn of the month effect exists, using the first two samples, but not when the whole period is included in the analysis, obtaining also the post-financial crisis period 2010-2013.

Regarding the diagnostic tests PGARCH outperforms the GARCH model based on Log-Likelihood, on Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). In addition, in most cases the GARCH model solves for autocorrelation and ARCH effects. On the other hand, PGARCH solves for these problems in Mexico, as well as, in Netherlands for autocorrelation at 10%. However, in some countries the problems still remain. More specifically, in Hong Kong both models do not solve for the autocorrelation and ARCH effects, in Netherlands for autocorrelation at 10% and for ARCH effects at 5% and 10% and in UK for ARCH effects at 10% level.

Moreover, the condition that $a_1+a_2<1$, holds. More precisely, this condition secures covariance stationarity of the conditional variance. A straightforward interpretation of the estimated coefficients in GARCH and PGARCH models is that the constant term ω is the long-term average volatility, i.e. conditional variance, whereas α_1 and a_2 represent how volatility is affected by current and past information, respectively. Similarly, α_{1s} and a_{2s} represent how volatility is affected in the periodic cycle examined, which is the turn of the month interval.

Generally, it should be noticed that various methodologies have been applied among the studies and researchers, who examined calendar anomalies in stock returns. Most of them apply descriptive statistics, OLS and GARCH models, while none of them examined the turn of the month effect using the PGARCH model. The results of this study confirm the findings by Marquering et al. (2006), who found that the turn-of-the-month is still persistent. Marquering et al. (2006) claim that the persistence of turn-of-the-month effect might be explained by the transaction costs, which are too high for the investors to profit from this calendar anomaly, as they cannot exploit the pattern.

Table 4: GARCH (1,1) estimation of mean equation (3) and variance equation (4)

Countries	β_0	β_1	ω	α_1	α_2	AIC	SBC	LL	$LBQ^2(12)$	ARCH-LM (5)
ARGENTINA	0.0024	0.0007	1.46e-05	0.114	0.855	-5.080	-5.070	10,807.157	8.974	1.006
	(3.824)*	(2.701)*	(9.892)*	(16.394)*	(95.238)*				[0.705]	[0.4122]
AUSTRALIA	0.00032	0.001474	5.57e-05	0.215	0.734	-6.801	-6.795	20,796.31	7.011	1.083
	(6.420)*	(2.621)*	(10.929)*	(75.850)*	(74.604)*				[0.857]	[0.3669]
AUSTRIA	0.0019	0.0005	2.80e-06	0.0987	0.885	-6.151	-6.145	16,100.75	11.161	0.845
	(5.840)*	(3.297)*	(7.429)*	(18.707)*	(136.14)*				[0.523]	[0.5168]
BRAZIL	0.0054	0.00081	7.30e-06	0.117	0.863	-4.853	-4.845	12,881.77	13.863	1.690
	(6.723)*	(1.991)**	(7.138)*	(15.768)*	(92.089)*				[0.310]	[0.1333]
CHINA	0.0014	-0.0001	6.31e-06	0.0961	0.845	-5.635	-5.624	12,310.71	8.554	0.113
	(2.670)*	(-0.556)	(11.400)*	(18.760)*	(77.084)*				[0.710]	[0.9894]
FRANCE	0.00198	0.0002	3.02e-06	0.0855	0.898	-6.022	-6.015	17,934.18	10.176	1.440
	(4.890)*	(0.984)	(7.994)*	(12.603)*	(113.54)*				[0.601]	[0.2061]
GERMANY	0.0015	0.0005	3.36-06	0.0833	0.897	-6.019	-6.012	17,462.67	2.187	0.303
	(4.094)*	(3.328)**	(8.531)*	(12.133)*	(104.09)*				[0.999]	[0.9107]
GREECE	0.0025	0.0001	5.57e-06	0.0154	0.837	-5.602	-5.591	15,496.013	12.103	1.573
	(4.537)*	(0.379)	(5.570)*	(15.637)*	(82.562)*				[0.511]	[0.249]
HONG KONG	0.0021	0.0007	6.73e-06	0.1382	0.845	-6.694	-6.688	19,172.44	165.70	35.316
	(5.586)*	(3.711)*	(16.738)*	(42.535)*	(199.68)*				[0.000]	[0.000]
INDIA	0.0028	0.0006	4.30e -06	0.1067	0.881	-5.546	-5.536	11,522.97	11.043	0.345
	(6.434)*	(3.054)**	(7.112)*	(13.645)*	(78.324)*				[0.525]	[0.8856]

Table 4: (cont.) GARCH (1,1) estimation of mean equation (3) and variance equation (4)

Countries	β_0	β_1	ω	α_1	α_2	AIC	SBC	LL	$LBQ^2(12)$	ARCH-LM (5)
INDONESIA	0.0019	0.00088	6.01e-06	0.1336	0.854	-5.457	-5.446	11,227.33	8.9700	0.327
	(3.909)*	(4.015)*	(9.970)*	(15.485)*	(91.517)*				[0.705]	[0.8966]
ITALY	0.0015	0.0002	1.47e-06	0.1028	0.888	-6.437	-6.425	11,968.15	19.849	2.316
	(3.478)*	(1.053)	(5.048)*	(11.839)*	(90.571)*				[0.070]	[0.0413]
JAPAN	0.0014	0.0006	2.52e-06	0.1228	0.874	-5.977	-5.971	21,821.54	6.6564	0.666
	(4.439)*	(4.734)*	(10.191)*	(35.319)*	(215.64)*				[0.879]	[0.6489]
MALAYSIA	0.00099	-9.62e-05	3.75e-06	0.1813	0.823	-6.226	-6.217	15,654.33	8.2017	0.457
	(3.256)*	(-1.040)	(14.708)*	(19.549)*	(124.74)*				[0.769]	[0.8083]
MEXICO	0.0024	0.0005	6.81e-06	0.1020	0.890	-5.627	-5.620	15,996.79	24.964	3.083
	(6.055)*	(3.033)*	(7.976)*	(19.629)*	(113.116)*				[0.015]	[0.0088]
NETHERLANDS	0.0017	0.0003	1.32e-06	0.0985	0.8963	-6.254	-6.246	16,738.62	21.142	2.922
	(5.501)*	(2.341)**	(5.374)*	(14.556)*	(135.34)*				[0.048]	[0.0122]
SINGAPORE	0.0014	0.0002	3.95e-06	0.1348	0.844	-5.736	-5.725	20,428.87	2.923	0.267
	(5.368)*	(1.675)***	(16.287)*	(15.177)*	(54.065)*				[0.988]	[0.9307]
TAIWAN	0.0026	0.0001	1.68e-06	0.0854	0.9092	-5.575	-5.565	11,733.02	20.484	3.366
	(5.386)*	(0.498)	(4.175)*	(11.554)*	(119.45)*				[0.058]	[0.0049]
UK-FTSE 100	0.0016	0.0003	1.67.e-06	0.0881	0.889	-6.566	-6.560	25,481.57	12.153	2.158
	(6.539)*	(3.169)*	(6.502)*	(17.923)*	(133.65)*				[0.433]	[0.065]
US – S&P 500	0.00127	0.00021	7.15e-06	0.0815	0.9120	-6.862	-6.859	54,787.79	13.239	1.333
	(8.744)*	(2.961)*	(11.161)*	(50.132)*	(416.11)*				[0.352]	[0.2462]

z-statistic between brackets, p-values between square brackets, *denotes significance in 0.01 level , **denotes significance in 0.05 level and *** denotes significance in 0.10 level AIC and SBC refer to Akaike and Schwarz information criteria, LL is the Log Likelihood, LBQ^2 is the Ljung-Box test on squared standardized residuals

Table 5: Periodic-GARCH (1,1) estimation of mean equation (3) and variance equation (12)

Countries	β_0	β_1	ω	α_1	α_2	ω_s	α_{1s}	α_{2s}	AIC	SBC	LL	LBQ^2 (12)	ARCH-LM (5)
ARGENTINA	0.0025	0.0007	1.53e-05	0.1282	0.8423	0.4739	-0.0892	0.0962	-5.095	-5.083	10,815.46	10.900	1.300
	(3.641)*	(2.679)*	(8.832)*	(17.695)*	(73.767)*	(1.701)***	(-4.872)*	(1.816)***				[0.537]	[0.2607]
AUSTRALIA	0.0006	0.0007	5.37E-06	0.1844	0.7813	-0.6021	-0.0275	0.0579	-6.803	-6.794	20,803.39	6.945	1.080
	(3.525)*	(7.179)*	(7.307)*	(74.052)*	(90.116)*	(-1.262)	(-1.414)	(1.191)				[0.861]	[0.3687]
AUSTRIA	0.0019	0.0005	1.39e-05	0.1095	0.8849	0.0830	-0.0463	0.0273	-6.153	-6.147	16,104.35	11.230	0.646
	(5.792)*	(3.517)*	(4.528)*	(17.339)*	(96.550)*	(2.492)**	(-2.819)*	(0.674)				[0.509]	[0.6644]
BRAZIL	0.0039	0.0005	3.99E-05	0.1073	0.8817	0.1586	-0.0268	0.0103	-4.861	-4.852	12,882.72	18.735	2.117
	(5.449)*	(2.063)**	(3.396)*	(17.725)*	(97.434)*	(0.861)	(-1.496)**	(0.282)				[0.115]	[0.0941]
CHINA	0.0016	-0.0002	1.07E-05	0.1115	0.8467	0.0579	0.0433	0.0333	-5.640	-5.626	12,349.66	8.970	0.327
	(3.697)*	(-0.205)	(3.093)*	(17.364)*	(123.63)*	(6.223)*	(2.647)*	(1.414)				[0.705]	[0.8966]
FRANCE	0.0017	0.0002	3.31E-06	0.0940	0.8825	-0.0144	-0.0422	0.0962	-6.024	-6.013	17,933.21	7.344	1.168
	(4.803)*	(1.669)***	(1.523)	(14.625)*	(101.81)*	(-1.420)	(-2.501)**	(2.193)**				[0.834]	[0.3218]
GERMANY	0.0016	0.0005	3.52E-06	0.0778	0.9031	0.0928	-0.0281	0.0826	-6.026	-6.015	17,464.62	3.031	0.493
	(4.671)*	(3.340)*	(5.859)*	(4.944)*	(33.636)*	(4.298)*	(-1.524)	(2.087)**				[0.995]	[0.7813]
GREECE	0.0025	-0.00010	9.61E-05	0.2479	0.4579	-0.0497	0.0458	0.0261	-5.612	-5.597	15,502.29	11.865	1.493
	(2.954)*	(-0.220)	(16.729)*	(13.920)*	(74.518)*	(-0.031)	(1.645)***	(26.731)*				[0.592]	[0.316]
HONG KONG	0.0022	0.0007	1.63E-05	0.1027	0.8522	0.0644	-0.0381	0.1413	-5.703	-5.692	19,172.83	148.79	31.401
	(5.169)*	(3.334)*	(10.803)*	(12.237)*	(71.340)*	(3.896)*	(-2.500)**	(5.447)*				[0.000]	[0.000]
INDIA	0.0029	0.0006	2.99e -06	0.0989	0.9053	0.3137	-0.0135	0.0924	-5.546	-5.529	11,522.27	8.544	0.548
	(6.539)*	(3.055)*	(9.571)	(16.093)*	(120.35)*	(0.223)	(-0.806)	(-2.700)*				[0.741]	[0.7339]

Table 5: (cont.) Periodic-GARCH (1,1) estimation of mean equation (3) and variance equation (12)

Countries	β_0	β_1	ω	α_1	α_2	ω_s	α_{1s}	α_{2s}	AIC	SBC	LL	$LBQ^2(12)$	ARCH-LM (5)
INDONESIA	0.0021	0.0008	1.83E-06	0.1263	0.8826	0.8060	-0.0064	0.1388	-5.461	-5.443	11,230.06	9.925	0.881
	(3.923)*	(3.934)*	(1.730)***	(18.010)*	(128.64)*	(5.832)*	(-0.349)	(4.714)*				[0.623]	[0.4927]
ITALY	0.0015	0.0002	2.52E-06	0.1010	0.8900	0.2931	-0.0445	0.0882	-6.440	-6.419	11,971.45	15.578	1.897
	(3.848)*	(1.221)	(4.535)*	(14.324)*	(101.61)*	(2.991)*	(-2.842)	(2.225)**				[0.141]	[0.1090]
JAPAN	0.0014	0.0005	3.08E-06	0.1249	0.8663	0.8821	0.0002	0.0343	-5.981	-5.972	21,823.87	4.553	0.463
	(4.463)*	(4.304)*	(9.205)*	(28.808)*	(162.46)*	(3.098)*	(0.130)	(1.074)				[0.971]	[0.8036]
MALAYSIA	0.0011	-2.28E-05	5.42E-06	0.1864	0.7978	0.0983	-0.0821	0.2029	-6.225	-6.211	15,658.16	8.393	0.542
	(4.271)*	(-0.286)	(3.037)*	(20.103)*	(80.344)*	(6.772)*	(-3.462)*	(5.094)*				[0.754]	[0.7439]
MEXICO	0.0023	0.0003	2.69E-05	0.0692	0.9182	0.2071	-0.0282	0.0903	-5.629	-5.617	16,008.43	15.945	1.429
	(5.303)*	(1.447)	(5.182)*	(3.476)*	(84.831)*	(3.717)*	(-2.093)**	(2.974)*				[0.194]	[0.2102]
NETHERLANDS	0.0017	0.0002	2.01E-06	0.1060	0.8884	-0.4478	-0.0869	0.0836	-6.253	-6.241	16,738.36	18.693	3.299
	(5.630)*	(2.519)**	(1.057)	(15.096)*	(106.37)*	(-0.267)	(-4.386)*	(1.944)***				[0.082]	[0.0056]
SINGAPORE	0.0015	0.0003	6.11E-07	0.1324	0.8485	0.0047	0.0253	0.0316	-5.735	-5.717	20,431.55	2.881	0.280
	(5.717)*	(1.654)***	(0.451)	(20.212)*	(105.58)*	(0.007)	(1.289)	(0.934)				[0.992]	[0.9240]
TAIWAN	0.0027	2.16E-05	1.91E-06	0.0640	0.9294	-0.5494	0.0527	0.0426	-5.578	-5.561	11,737.30	17.986	2.630
	(5.521)*	(0.106)	(3.221)*	(12.227)*	(129.19)*	(-0.733)	(3.580)*	(1.229)				[0.116]	[0.0222]
UK-FTSE 100	0.0016	9.97E-06	1.04E-06	0.0958	0.9011	0.0332	-0.0670	0.0091	-6.566	-6.557	25,492.71	15.081	1.935
	(6.760)*	(3.304)*	(2.488)**	(17.633)*	(123.08)*	(1.720)*	(6.410)*	(0.266)				[0.237]	[0.0849]
US – S&P	0.0009	0.0003	6.26E-07	0.0834	0.9141	0.7155	-0.0193	0.0381	-6.865	-6.862	54,789.86	15.636	1.961
	(6.758)*	(6.907)*	(4.780)*	(12.891)*	(148.89)*	(1.442)	(-3.057)*	(4.658)*				[0.206]	[0.1809]

z-statistic between brackets, p-values between square brackets, *denotes significance in 0.01 level , **denotes significance in 0.05 level and *** denotes significance in 0.10 level
AIC and SBC refer to Akaike and Schwarz information criteria, LL is the Log Likelihood, LBQ^2 is the Ljung-Box test on squared standardized residuals

5. Conclusions

This study examined the turn of the month effect in 20 stock markets around the globe using GARCH and PGARCH models. The results show that the turn of the month effect is persistent in 19 out of 20 stock market indices during the whole period examined. Moreover, sub-sample periods have been explored too supporting the same concluding remarks. In addition, when the post financial crisis period sample 2010-2013 is excluded from the analysis, the turn of the month effect is present in all stock market indices.

The results of this study are consistent with earlier literature showing positive returns at the beginning of the month and zero returns in the latter part of the month (see e.g. Lakonishok and Smidt, 1988; Marquering et al., 2006). The paper provides several important implications for investors and academic researchers. For investors this paper gives useful information of the stock market behaviour during a calendar month and may provide some ideas for profitable trading strategies. More specifically, the results established that the stock market indices, examined in this study and regarding the turn of the month effect, are not efficient, with the exception of Australia. Thus, investors can improve their returns by timing their investment. However, given that the risks are also higher, extra returns may not be obtainable.

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Structural Breaks and Finance-Driven Growth Hypothesis in ECOWAS: Further Empirical Evidence

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Abstract

This study makes a cross sectional case in investigating the validity, or otherwise, of the finance-driven growth hypothesis in the ECOWAS countries using annual data from 1970 to 2008 for seven countries namely: Burkina Faso, Cote d'Ivoire, The Gambia, Ghana, Nigeria, Senegal and Togo. In contrast to earlier studies on developing countries, this study specifically tests for the possibility of structural breaks/regime shifts in the finance-growth long run relationship by employing the Gregory and Hansen (1996) residual based test which accounts for endogenous structural break. While the Gregory-Hansen structural break cointegration result confirms the existence of cointegration relationships among the selected countries despite the breakpoints, the Granger-causality test result indicates a general pattern of causality running from financial development to economic growth in most of the countries. Also, the striking feature of the result of our estimated growth model generally lends credent to the importance of financial development in explaining growth dynamics among the selected countries, thus reinforcing the finance-driven growth hypothesis.

Keywords: Financial development, Economic growth, Structural break, Cointegration

JEL Classification: B23, C31, C51, F36, G15

1. Introduction

For several years, the relationship between economic growth and financial development has been of paramount research interest to various researchers and policy makers as well. This is not unconnected with the understanding of the crucial role being played by the financial markets and institutions in the mobilization and allocation of financial resources to the productive sector of the economy. To this end, various theoretical and policy-oriented empirical studies have increasingly examined the dynamic causal and long run relationship between financial development and economic. Of course, the theoretical

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paradigm underlying this relationship can be traced back to the work of Schumpeter (1911). Schumpeter opined that financial institutions play a very significant role in the process of economic growth and development. In the same vine, Patrick (1966) argued that financial expansion through the creation of financial institutions and the supply of financial assets do have a positive impacts on the economic growth especially in early stage of development. Thus, financial development is postulated to be playing a supply-leading role in economic development.

Even in more advanced stages of economic development, the importance of efficient financial institutions could also be revealed through increased demand for a greater variety of financial assets. Basically, at the heart of this hypothesis is this submission that a well-developed financial system plays an essential role in fostering a country's economic growth and development through channeling the limited resources from surplus to deficit side of the economy. This implies, therefore, that for efficient allocation of resources, the role of well-developed financial institutions cannot be undermined.

Following the seminal work of McKinnon (1973) and Shaw (1973), the literature on finance and economic development has been flooded with divergent theoretical opinions and empirical evidences as regards the role of financial development in economic growth. Despite the overwhelming theoretical proposition on the importance of finance to growth, starting with the work of Bagehot (1873), Schumpeter (1911), Gurley and Shaw (1955), Goldsmith (1969), McKinnon (1973), findings from many empirical studies still differ with respect to the role of financial institutions in economic growth and development.[1]

The results from these findings could easily be classified into four main groups. The first group of the empirical results pertains to those who reinforce the finance driven growth hypothesis by finding evidence for the unilateral causality running from financial development to economic growth, thus identifying the supply leading relationship between financial development and economic growth (see Levine, 2004; Demetriades, et al., 1996; Luintel et al, 2008 and Ang, 2008). Next, and in sharp contrast too, are those whose findings support the growth-driven finance hypothesis, thus, indicating causality running from

[1] It is worthy of note, however, that various factors could be responsible for the different empirical evidences so far established in the literature as regards the relationship between financial development and economic growth. Factors such as differences in the data definitions and measurement techniques, time frame and methodological approaches employed in various empirical studies could be responsible for the conflicting findings. There are a number of methodological issues arising from the investigation of financial development and economic growth. For instance, econometric methodologies such as single equation Ordinary Least Energy Square (OLS), Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1990) cointegration procedures have been widely used in the literature. Of course, the application of these methodologies is not without various limitations. For instance, the use of traditional Granger causality test becomes insufficient in a situation where the time series are I (1) and cointegrated (Toda and Yamamoto, 1995; Zapata and Rambaldi, 1997). Also, the application of Johansen (1988) cointegration technique presupposes that the underlining regressors are all integrated of order one, otherwise, the standard statistical inference based on the conventional likelihood ratio tests becomes invalid and could also lead to erroneous inferences (Pesaran et al., 2001).

economic growth to financial development (see, for instance, Dritsakis and Adamopoulos, 2004, Adamopoulos, A. 2010). Again, while some empirical studies have rightly established the fact that the relationship between financial development and economic growth seems to be bidirectional, very few studies in the empirical literature, on the other hand, lay credence to the notion of no relationship between the variables. Evidently, findings from these empirical studies have different policy implications especially in the face of recent global financial/economic meltdown.

The focus of this study is on the relationship between financial development and economic growth in the ECOWAS countries. With a drive for trade competitiveness, strong financial institutional development, sustained economic growth and, of course, in the face of recent global financial meltdown, most of the ECOWAS countries have continued to witness various types of financial reforms and economic restructuring. These developments are, however, often plagued with unstable domestic financial policies, high and frequent rates of political instability and, of course, incessant policy regime shifts and/or policy reversal. These factors do have analytical and policy implications on the long run relationship between financial development and economic growth. To better enhance the formulation of optimal financial and economic policy, there is need to understand the role of domestic economic and financial environment of most of the developing countries in the analysis of finance-growth nexus. To this end, many empirical studies conducted on these countries often fail to give an account of the possibility of structural breaks caused by regime shifts in these countries in their analysis. In lieu of this, this study contributes to the literature by making an ingenious attempt in addressing the issue of structural breaks in the analysis of finance-driven growth hypothesis in the selected ECOWAS countries.

Contribution of the present study comes from the use of Hansen (1992) and Gregory-Hanson (1996) co-integration approach with structural break as it helps in determining the presence of cointegration among the variables while adjusting for possible structural break endogenously where most of the study fails to accommodate this approach. This study contributes to the literature by making an ingenious attempt to address the issue of structural breaks in the analysis of finance driven growth hypothesis in some selected ECOWAS countries. Specifically, the contributions of this present study to the literature on the relationship between financial development and economic growth are clear. The study attempts to make a case for cross countries investigation of the finance driven hypothesis in some selected ECOWAS countries. Also, in allowing for the effects of regime shifts in testing for cointegration relationship and following Omisakin et al (2012), the study employs the Gregory and Hansen (1996) residual based test which accounts for endogenous structural break. Gregory-Hansen approach to cointegration helps in determining possibility of structural break endogenously.

The remainder of this study is organized thus: Section 2 presents the basic theory of cointegration with structural breaks/regime shifts as applied in this study. Section 3 involves methodology which entails data employed, measurement, study scope and model specification. While section 4 concerns the empirical analysis and results discussion, conclusion is made in section 5.

2. Basic Theory of Cointegration with Structural Breaks/Regime Shifts

In investigating the relationship among economic variables in face of structural breaks, therefore, the concept and dynamics of cointegration in time series econometrics has been further examined. Different types of cointegration with structural breaks haven been identified namely: cointegration with parameter changes, partly cointegration and cointegration with mechanism changes. Simply speaking, cointegration with parameter changes means the parameters of the cointegration equation happen to change at some time, but the cointegration relationship still exists. Partly cointegration means the cointegration relationship exists before or after some time but disappears in other periods. Cointegration with mechanism changes means the former cointegration relationship is destroyed because new variables enter the system and they form a new type of cointegration relationship (see Baochen and Shiying, 2002). For instance, given the following cointegration equation:

$$Y_t = a + bX_t + \varepsilon_t$$

where X_t, Y_t are integration time series with order of d and $\{\varepsilon_t\}$ is residual series, the conventional residual-based cointegration test presume that there is no cointegration between variables (Y and X) if the test fails to reject the null hypothesis for a sample period. However, the presence of structural break(s) in this equation simply nullifies, breaks down and disintegrates this assertion or presumption.

Based on the works of Perron (1989), Banerjee, Lumsdaine, and Stick (1992), Perron and Vogelsang (1992), and Zivot and Andrews (1992) where the null of a unit root in univariate time series is tested against the alternative of stationarity while allowing for a structural break in the deterministic component of the series, Gregory and Hansen (1996) developed a residual-based cointegration approach that allows for regime shifts. Gregory and Hansen (1996) residual-based tests for cointegration centers on deriving an alternative hypothesis of one break in the cointegrating vector.[2] According to Gregory and Hansen (1996), the power of the Engle-Granger (1987) test of the null of no cointegration is substantially reduced in the presence of a break in the cointegrating relationship. To overcome this problem, Gregory and Hansen (1996) extended the Engle-Granger test to allow for breaks in either the intercept or the intercept and trend of the cointegrating relationship at an unknown time. Therefore, Given the rejection of cointegration with unknown break in the parameter, Gregory and Hanson (1996) technique allows testing the null of no cointegration of variables with I(1) order in the presence of structural break in the cointegrating relationship.

The GH test allows to test the presence of cointegration among the variables of

[2] In the presence of structural break(s)/regime shift, the common test for cointegration between variables becomes bias since the distributional theory of evaluating the residual-based tests is not the same. In Gregory et al. (1996), the impact of break in the test for cointegration is further explained as the rejection frequency of the ADF test is said to fall dramatically in the presence of a break in the cointegration vector.

interest given the variables are integrated of order I(1) i.e. difference stationary, with regime shift in the long run relationship at an unknown point. As earlier stated, this cointegration technique is an extension of ADF, Zα, and Zt tests for cointegration and can be seen as a multivariate extension of the endogenous break test for univariate series. Basically, in the G-H tests, there are four different models for the analysis of structural change in the cointegrating relationship. These models are: (i) level shift, C; (ii) level shift with trend, C/T; (iii) regime shift where both intercept and slope coefficient change, C/S; and (iv) regime shift where intercept, slope coefficient and trend change, C/S/T. Hence, the following equations represent the specifications of the models, respectively:

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha y_{2t} + e_t \tag{1}$$

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta t + \alpha y_{2t} + e_t \tag{2}$$

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta t + \alpha_1 y_{2t} + \alpha_2 y_{2t} \varphi_{t\tau} + e_t \tag{3}$$

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta_1 t + \beta_2 t \varphi_{t\tau} + \alpha_1^T y_{2t} + \alpha_2^T y_{2t} \varphi_{t\tau} + e_t \tag{4}$$

Equations (1) to (4) represent the generalized standard model of cointegration. The idea here is to allow for both a regime trend shift under the alternative hypothesis (Gregory and Hansen, 1996). The observed data are $y_t = (y_{1t}, y_{2t})$ where y_{1t} is a scalar variable, y_{2t} is a vector of explanatory variables and μ is the disturbance term. While φ represents the dummy variable both y_{1t} and y_{2t} are expected to be I(1) variables. The dummy variable is then defined as:

$$\varphi_{t\tau} = \begin{cases} 0, \; if \; t \le [n\tau] \\ 1, \; if \; t > [n\tau] \end{cases} \tag{5}$$

The unknown parameter, $\tau \in (0,1)$ is the relative timing of the change point and [ ] denotes integer part. Parameters μ, α and β measure, respectively, the intercept, slope coefficients and trend coefficient before the break and μ_1, α_1 and β_1 are the corresponding changes after the break. Following the computed cointegration test statistic for each possible regime shift by Gregory and Hansen (1996), equations (1) to (4) are estimated for all possible break date in the sample. The smallest value of ADF(τ), $Z_\alpha(\tau)$ and $Z_t(\tau)$ across all possible break points are selected to reject the null hypothesis of no cointegration.[3]

3. Methodology

3.1 Data Sources and Measurement

With the overall aim of examining the relationship between financial development and growth in the selected ECOWAS countries, this section delves into issues concerning

[3] The critical values for the break test are reported in Gregory and Hansen (1996).

data employed and study scope among other things. The variables used in this study include the following: real gross domestic product per head; ratio of gross domestic investment to gross domestic product; trade (the sum of exports and imports of goods and services) measured as a share of gross domestic product; the ratio of government consumption to gross domestic product; the consumer price index; money supply (M2, % of GDP) and the domestic credit provided by banking sector (% of GDP)[4]. All variables are sourced from World Development Indicator (2009) and the International Financial Statistics. The study scope ranges from 1970 to 2008. The availability of data informed our choice of countries and scope. The countries included in our analysis are: Burkina Faso, Cote d'Ivoire, The Gambia, Ghana, Nigeria, Senegal and Togo.

3.2 Model Specification

Over time, financial development and economic growth relationship have been subjected to rigorous empirical investigation especially in the developing countries. Following recent developments in time series econometrics, a number of authors have been able to model various determinants of core growth models augmented with indicators of financial development. Until now, these varied specifications reflect mainly differences in data employed and theoretical underpinning. Following the work of Levine et al., (2000) which searched for a set of robust variables to model growth, this study shall employ the Aggregate Production Function (APF) framework. This production function which has been widely applied in the analysis of financial development and economic growth assumes unconventional inputs such as trade openness, financial development and government consumption along the conventional input of capital in the model. The aggregate growth model is thus specified as:

$$Y_t = A_t K_t^{\beta_1} \tag{6}$$

From [1], Y_t represents the aggregate production of the economy (proxied by GDP) at time t; A_t, K_t and L_t also denote the total factor productivity (TFP), capital stock and labour stock at time t respectively. Consequently, TFP is therefore specified thus:

$$A_t = C_t OPENESS_t^{\beta_2} GOVC_t^{\beta_3} INF_t^{\beta_4} FD_t^{\beta_5} \tag{7}$$

Hence, the model used in this study not only reflects theoretically enriched but also parsimonious specification models of core growth. Therefore, to estimate [1], we take the natural logs of both sides which result in the following equation:

$$y_t = \beta_0 + \beta_1 \left(\frac{INV}{GDP} \right)_t + \beta_2 OPENESS_t + \beta_3 GOVC_t + \beta_4 INF_t + \beta_5 FD_t + \varepsilon_t \tag{8}$$

[4] Both the money supply (M2, % of GDP) and domestic credit provided by banking sector (% of GDP) are the two financial development indicators we use in this study.

where y_t = real GDP per head; $\left(\frac{INV}{GDP}\right)$ = the ratio of gross domestic investment to GDP; $OPENESS_{i,t}$ = trade openness measure; GOVC = the ratio of government consumption to GDP; INF = represents the change in the consumer price index and FD is the financial development indicator. The term ε_t is the error term bounded with the classical statistical properties. The selected countries are: Burkina Faso, Cote d'Ivoire, The Gambia, Ghana, Nigeria, Senegal, and Togo.

3.3 Econometric Analytical Procedures

The standard econometric analytical procedures of time series model estimation are strictly adhered to in this study. We commence our empirical exercise by performing unit roots test with the aim of confirming the integration properties of the variables employed. Basically, the idea is to test whether the variables are integrated. We, consequently, employ the Augmented Dickey-Fuller (ADF) and Phillips-Peron (PP) tests (Dickey and Fuller, 1979; Phillips and Peron, 1988). Also, since we are more interested in investigating the long run relationship of the variables under consideration allowing for the incidence of structural breaks, this study employs batteries of cointegration techniques including the more recent and robust Gregory and Hansen (1996) approach which allows for endogenous identification of break in the variables. This is also needful in order to further present a more rigorous cointegration analysis especially when external shocks or policy shift/reversal are assumed in the model[5]. Finally, following the results of the cointegration tests (where cointegration relationship is established), we proceed to estimating the growth model with special emphasis on the influence of financial development on growth.

4. Empirical Analysis and Discussion

4.1 Unit root test

The study performs the unit root tests on all variables under consideration for all the selected countries. As earlier highlighted, two unit root tests- ADF and PP- are used. While the null hypothesis for both tests is that there is a unit root, the optimal lag lengths selection is done by the Schwarz Bayesian criteria. All unit root test regressions are run with a constant and trend term. The results as detailed in Table 1 indicate the existence of unit root for all the variables at their levels. In other words, the tests were unable to reject the null hypothesis for all the variables. However, the variables appear to be stationary at first difference, i.e. integrated at order 1. This result, therefore, implies that examination of possible cointegration relationship among the variables is worthwhile.

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5 This is quite prevalent in the ECOWAS region.

Table 1: Unit Root Test Result for the Selected Countries

Country	Variables Level	ADF		PP	
		First Diff.	Level	First Diff.	
Burkina Faso	y	-2.154558 (0.4984)	-4.503866 (0.0056)	-1.154481 (0.9044)	-3.764751 (0.0316)
	OPENNESS	-2.167772 (0.4919)	-3.926651 (0.0213)	-1.932991 (0.6168)	-3.92665 (0.0213)
	GOVC	-2.008722 (0.5770)	-5.231487 (0.0008)	-2.260405 (0.4437)	-5.24553 (0.0008)
	INF	-2.002350 (0.5804)	-6.051710 (0.0001)	-2.008085 (0.5773)	-6.05888 (0.0001)
	FD1	-1.670274 (0.7282)	-5.461752 (0.0011)	-3.606375 (0.0481)	-3.652 (0.04289)
	FD2	0.609014 (0.9992)	-4.885953 (0.0020)	0.609014 (0.9992)	-4.87313 (0.0020)
	$\left(\frac{INV}{GDP}\right)$	-2.210005 (0.4696)	-7.770975 (0.0000)	-2.108985 (0.5231)	-7.78574 (0.0000)
Cote D'Ivoire	y	0.719465 (0.9995)	-5.489108 (0.0004)	3.133991 (1.0000)	-5.760836 (0.0002)
	OPENNESS	-1.391850 (0.8459)	-5.026372 (0.0014)	-1.477203 (0.8184)	-5.79570 (0.0002)
	GOVC	-2.571428 (0.2947)	-5.448403 (0.0004)	-2.701719 (0.2419)	-6.25346 (0.0000)
	INF	-2.665746 (0.2562)	-4.366883 (0.0094)	-1.708635 (0.7267)	-6.19813 (0.0001)
	FD1	-3.477104 (0.0586)	-5.445134 (0.0005)	-2.426467 (0.3605)	-5.46967 (0.0004)
	FD2	-1.451463 (0.8276)	-4.563796 (0.0045)	-1.616250 (0.7666)	-4.56481 (0.0045)
	$\left(\frac{INV}{GDP}\right)$	-2.330120 (0.4080)	-6.680391 (0.0000)	-2.526250 (0.3145)	-6.65066 (0.0000)
Gambia	y	-2.583884 (0.1077)	-3.582059 (0.0114)	-1.752727 (0.3971)	-3.529860 (0.0129)
	OPENNESS	-0.661248 (0.8438)	-4.551513 (0.0009)	-0.680591 (0.8391)	-4.465550 (0.0011)
	GOVC	-1.025727 (0.7336)	-6.664185 (0.0000)	-0.942314 (0.7629)	-6.676969 (0.0000)
	INF	-0.399615 (0.8987)	-5.374684 (0.0001)	-0.399615 (0.8987)	-5.376164 (0.0001)

	FD1	-2.156021 (0.2252)	-7.244365 (0.0000)	-2.045541 (0.2670)	-7.473725 (0.0000)
	FD2	-0.423201 (0.8945)	-4.119779 (0.0028)	-0.807467 (0.8049)	-4.119779 (0.0028)
	$\left(\frac{INV}{GDP}\right)$	-3.211259 (0.0275)		-3.211259 (0.0275)	
Ghana	y	0.265806 (0.9731)	-4.192181 (0.0023)	0.126640 (0.9635)	-4.192181 (0.0023)
	OPENNESS	-2.710614 (0.0821)	-6.741368 (0.0000)	-2.700393 (0.0838)	-6.695253 (0.0000)
	GOVC	-2.336276 (0.1668)	-5.537422 (0.0001)	-2.459508 (0.1338)	-6.278817 (0.0000)
	INF	-1.880975 (0.3370)	-8.015277 (0.0000)	-1.880975 (0.3370)	-13.38855 (0.0000)
	FD1	-1.372044 (0.5850)	-6.425870 (0.0000)	-1.372044 (0.5850)	-6.420263 (0.0000)
	FD2	-1.696212 (0.4246)	-5.845192 (0.0000)	-1.713347 (0.4162)	-5.845781 (0.0000)
	$\left(\frac{INV}{GDP}\right)$	-2.157926 (0.2245)	-6.440776 (0.0000)	-2.154418 (0.2258)	-6.876651 (0.0000)
Nigeria	y	-2.141800 (0.2303)	-4.496896 (0.0010)	-2.206883 (0.2074)	-4.511692 (0.0010)
	OPENNESS	-0.584120 (0.8513)	-2.979471 (0.0572)	-0.664184 (0.8318)	-2.819172 (0.0764)
	GOVC	-1.601997 (0.4713)	-5.285453 (0.0001)	-1.567885 (0.4883)	-6.949871 (0.0000)
	INF	-1.020156 (0.7356)	-5.734233 (0.0000)	-0.947091 (0.7613)	-5.761893 (0.0000)
	FD1	1.495147 (0.9990)	-6.371900 (0.0000)	2.120023 (0.9999)	-6.385855 (0.0000)
	FD2	-1.745325 (0.4007)	-5.449437 (0.0001)	-1.758578 (0.3943)	-4.964741 (0.0003)
	$\left(\frac{INV}{GDP}\right)$	-2.455755 (0.1345)	-9.299939 (0.0000)	-2.455755 (0.1345)	-17.08447 (0.0001)
Senegal	y	-0.864277 (0.7880)	-4.502209 (0.0010)	-1.138264 (0.6898)	-4.470693 (0.0011)
	OPENNESS	1.049889 (0.9963)	-4.113939 (0.0029)	1.049889 (0.9963)	-4.139798 (0.0027)

	GOVC	-0.610127 (0.8560)	-5.208150 (0.0001)	-0.775055 (0.8141)	-5.218083 (0.0001)
	INF	-1.020787 (0.7354)	-4.508328 (0.0010)	-1.206214 (0.6611)	-4.504288 (0.0010)
	FD1	-0.367587 (0.9042)	-4.080140 (0.0031)	-0.671850 (0.8412)	-4.100981 (0.0030)
	FD2	-1.879706 (0.3377)	-5.533872 (0.0001)	-1.988669 (0.2903)	-5.524102 (0.0001)
	$\left(\frac{INV}{GDP}\right)$	-1.321937 (0.6087)	-6.235579 (0.0000)	-1.320960 (0.6092)	-6.248737 (0.0000)
Togo	y	-1.953964 (0.3050)	-5.880862 (0.0000)	-2.128377 (0.2352	-6.086160 (0.0000)
	OPENNESS	11.25046 (1.0000)	-11.45468 (0.0000)	11.25046 (1.0000)	-4.664317 (0.0028)
	GOVC	-2.034751 (0.2713)	-4.444507 (0.0012)	-2.269634 (0.1869)	-4.223417 (0.0021)
	INF	-0.307591 (0.9140)	-6.645066 (0.0000)	-0.307591 (0.9140)	-6.765124 (0.0000)
	FD1	-0.753544 (0.8200)	-4.443611 (0.0012)	-1.045758 (0.7261)	-4.468782 (0.0011)
	FD2	-0.298924 (0.9153)	-5.812651 (0.0000)	-0.602683 (0.8577)	-5.885219 (0.0000)
	$\left(\frac{INV}{GDP}\right)$	-0.005177 (0.9519)	-5.231253 (0.0001)	0.050018 (0.9571)	-5.279029** (0.0001)

Notes:
a. The ADF lag length of the dependent variable used to obtain white noise residuals is 2.
b. The lag lengths for ADF equation were selected using Schwarz Information Criterion (SIC).
c. Mackinnon (1991) critical value for rejection of hypothesis of unit root applied.
d. The bandwidth selected based on Newey West (1994) method using Bartlett Kernel is 2.

4.2 Cointegration Test

In this study, we embark on investigating the long run relationships among the variables using both conventional and relatively recent cointegration methodologies[6]. Among the cointegration techniques employed are the VAR-based multivariate Johansen

[6] We earlier tested for the causality principally between financial development and economic growth among the selected countries. There are evidences for the unilateral causality running from financial development to economic growth among these countries by identifying the supply leading relationship between financial development and economic growth. The result is presented in Table 2.

cointegration and Gregory-Hansen cointegration technique which allows for endogenous identification of structural breaks.

Without structural breaks

The result of the VAR-based Johansen maximum likelihood tests is presented in Table 3. From the table, the result establishes long run relationship among the variables under consideration in the selected countries using Trace and Max-angel statistics.. It must, however, be noticed that the conventional cointegration test results in the presence of structural break(s)/regime shift become biased following the fact that the distributional theory of evaluating the residual-based tests is not the same (see Gregory and Hansen, 1996 and Gregory et al., 1996). This explains while most findings from earlier studies which predominantly rely on these conventional tests in establishing the long run relationships could be biased. For instance, it would be erroneous, and of course misleading, to conclude and thus deduct policy inference based on the results of cointegration tests as seen in Table 3. More specifically, since the power of this conventional cointegration test often fall dramatically in the presence of a break in the cointegration vector, there is need for an alternative cointegration test which fundamentally allows for the possibility of structural breaks/regime shifts in our models.

Table 2: Granger Causality Test Result for the Selected Countries

Country	Direction of Causality	Lag	F-statistics	P value	Status
Burkina	ΔFD *causes* ΔY	1	4.138	0.010***	Accept
	ΔY *causes* ΔFD	1	1.285	0.325	Reject
Cote D'Ivoire	ΔFD *cause* ΔY	2	4.204	0.048**	Accept
	ΔY *causes* ΔFD	2	1.610	0.347	Reject
Gambia	ΔFD *causes* ΔY	2	2.676	0.049**	Accept
	ΔY *causes* ΔFD	2	1.699	0.187	Reject
Ghana	ΔFD *causes* ΔY	2	6.609	0.004***	Accept
	ΔY *causes* ΔFD	2	1.302	0.362	Reject
Nigeria	ΔFD *causes* ΔY	2	3.084	0.061*	Accept
	ΔY *causes* ΔFD	2	1.141	0.333	Reject
Senegal	ΔFD *causes* ΔY	1	1.893	0.196	Reject
	ΔY *causes* ΔFD	1	4.301	0.046**	Accept
Togo	ΔFD *causes* ΔY	1	3.060	0.032**	Accept
	ΔY *causes* ΔFD	1	2.264	0.100	Reject

Note: Δ symbol represents first difference.

Table 3: Multivariate Johansen Cointegration Test

Countries	Model	Test	Statistics	Critical Value	P. value	r	Status
Burkina Faso	1	Trace	135.9706	117.7082	0.0021	1	Cointegration
		Max-engel	44.07981	44.49720	0.0555	1	Cointegration
	2	Trace	133.7417	117.7082	0.0033	1	Cointegration
		Max-engel	47.13154	44.49720	0.0252	2	Cointegration
Cote D'Ivoire	1	Trace	115.2003	117.7082	0.0712	1	Cointegration
		Max-engel	42.93271	44.49720	0.0732	2	Cointegration
	2	Trace	142.2389	117.7082	0.0006	3	Cointegration
		Max-engel	41.36219	44.49720	0.1055	0	No cointegration
Gambia	1	Trace	146.4427	117.7082	0.0002	2	Cointegration
		Max-engel	47.12999	44.49720	0.0252	2	Cointegration
	2	Trace	141.4590	117.7082	0.0007	1	Cointegration
		Max-engel	53.94627	44.49720	0.0036	2	Cointegration
Ghana	1	Trace	135.3632	117.7082	0.0024	1	Cointegration
		Max-engel	38.95523	44.49720	0.1770	0	No cointegration
	2	Trace	129.2757	117.7082	0.0076	3	Cointegration
		Max-engel	40.76855	44.49720	0.1204	2	Cointegration
Nigeria	1	Trace	167.5797	117.7082	0.0000	2	Cointegration
		Max-engel	47.04876	44.49720	0.0258	2	Cointegration
	2	Trace	191.6419	117.7082	0.0000	1	Cointegration
		Max-engel	57.23427	44.49720	0.0013	1	Cointegration
Senegal	1	Trace	127.9505	117.7082	0.0096	1	Cointegration
		Max-engel	44.76743	44.49720	0.0467	1	Cointegration
	2	Trace	124.9090	117.7082	0.0161	3	Cointegration
		Max-engel	36.43167	44.49720	0.2864	0	No cointegration
Togo	1	Trace	140.7962	117.7082	0.0008	3	Cointegration
		Max-engel	49.54272	44.49720	0.0130	2	Cointegration
	2	Trace	142.9945	117.7082	0.0005	1	Cointegration
		Max-engel	63.81835	44.49720	0.0002	1	Cointegration

Note:

a. Critical values derive from Mackinnon-Hang-Michelis (1999).

b. r denotes the number of cointegrated vectors.

c. The order of VAR model is 2 using the Akaike and Schwarz criterion are used for

With structural breaks

Since the Gregory-Hansen structural break test is based on the notion of regime change, it thus allows for an endogenous structural break in the cointegration vector by considering three alternative models: a level shift (model C), a level shift with a trend (model C/T), and a regime shift which allows the slope vector to shift as well (model C/S). Given the short-coming of the earlier conventional test in identifying any meaningful long run relationship in the presence of structural breaks, this study finds it needful to further subject the long run relationship among the variables in the selected countries to a more rigorous and robust test which consents to possibility of structural breaks in the relationship.[7] This, therefore, informs our choice for the Gregory-Hansen test in this study. The result of this test is depicted in Table 4 for the two measures of financial development (hence two models). From the table, evidence of cointegration relationships is clearly established when assuming a shift which allows the slope vector to shift (model C/S), otherwise known as structural break in all the selected countries. Having identified plausible breaks in the systems, the test does suggest that a structural break in the cointegration vector is important and needs to be taken care of in the specification of growth-finance relationship in these countries. Also, the structural breakpoints as identified in the results of seem to match clearly with the corresponding critical economic incidents in the selected countries.

Table 4: Gregory-Hansen Structural Break Cointegration Result

Country	Model	ADF*	Estimated breakpoint	Z_t*	Estimated breakppoint	Z_α*	Estimated breakpoint
Burkina	1	-3.377(1)	1993	-3.167	1994	-16.48	1994
	2	-6.132(1)*	1995	-5.619*	1994	-22.48	1996
Cote d'Ivoire	1	-4.076(1)	1994	-5.275	1992	-33.82	1993
	2	-5.70 (1)*	1993	-5.742*	1997	-72.71*	1992
Gambia	1	-4.504(2)	1985	-4.109	1988	-23.897	1990
	2	-5.500 (2)*	1987	-5.60*	1986	-29.00	1991
Ghana	1	-5.715(1)*	1982	-3.822	1984	-20.844	1979
	2	-12.56 (1)*	1980	-10.60*	1980	-59.69*	1981
Nigeria	1	-6.008(1)*	1986	-6.125*	1988	-53.139	1986
	2	-10.23 (1)*	1989	-11.38*	1987	67.88*	1987
Senegal	1	-4.346(2)	1984	-4.406	1984	-26.094	1983
	2	-3.90 (2)	1984	-3.80	1987	-32.71	1985
Togo	1	-4.288(1)	1993	-4.806	1978	-29.204	1981
	2	5.504(1)*	1991	-7.444*	1979	-24.722	1981

Note: * indicates 5% level of significance. The 5% critical values are -5.50 and -58.33 for the ADF/ Zt*and Zα* tests, respectively (see Table 1 of Gregory and Hansen, 1996). Model is C/S.

7 See, for instance, Dritsakis (2012), on the application of Gregory-Hansen structural breaks test on demand for money in Greece.

4.4 Long Run Estimates

Table 5 depicts the output of estimated growth models with emphasis on the role of financial development in influencing growth dynamics in the selected countries. To start with, following the Granger-causality test which supports the finance-driven growth hypothesis for all the countries under consideration[8], the result of the estimated growth model generally lends credent to the importance of financial development in explaining growth dynamics among the selected countries, thus reinforcing the finance-driven growth hypothesis. Also, while the roles of trade openness, capital investment and government consumption in enhancing growth are clearly revealed in most of the countries as they seem to follow the *a priori* expectation in terms of their relationships with respect to signs and magnitudes, the result with respect to the role of inflation are, however, mixed across countries.

Table 5: Estimated Growth Model (using M2 as a % of GDP)

Country	C	$\left(\frac{INV}{GDP}\right)$	*OPENESS*	*GOVC*	*INF*	*FD*	R^2	$AdjR^2$	F-stat
Burkina Faso	0.793 (4.857)	1.017 (2.600)**	0.261 (2.876)**	1.066 (0.625)	0.268 (2.687)**	0.637 (0.649)	0.41	0.35	25.32
Cote d'Ivoire	4.703 (3.925)	0.521 (8.597)*	1.838 (1.968)**	0.326 (1.825)	-0.445 (-4.829)*	1.002 (3.787)*	0.65	0.60	18.12
The Gambia	1.682 (5.510)	0.311 (0.664)	0.331 (2.256)**	0.024 (0.087)	-0.292 (-2.391)**	0.092 (1.749)	0.63	0.59	21.47
Ghana	-1.486 (-3.816)	1.488 (1.081)	0.156 (0.479)	0.154 (2.244)**	-0.084 (-0.844)	0.367 (2.775)**	0.57	0.54	12.76
Nigeria	-1.613 (-7.548)	0.845 (4.681)*	0.639 (2.208)**	0.537 (0.335)	-0.091 (-0.685)	0.631 (2.769)**	0.52	0.48	10.71
Senegal	-1.907 (-2.972)	0.798 (2.98)**	0.651 (1.719)	-0.925 (-3.082)*	-1.131 (-5.602)*	1.320 (2.205)**	0.40	0.36	14.6
Togo	-2.002 (-11.71)	0.001 (0.002)	1.093 (4.239)*	1.167 (0.884)	-0.393 (-2.437)**	1.165 (3.020)*	0.61	0.59	26.30

Note: *, ** indicate 1%, 5% levels of significance.

[8] with the exception of Senegal where the causality runs from growth to financial development

Table 6: Estimated Growth Model (using domestic credit provided by banking sector as a % of GDP)

Country	C	$\left(\frac{INV}{GDP}\right)$	*OPENESS*	*GOVC*	*INF*	*FD*	R^2	$AdjR^2$	F-stat
Burkina Faso	2.410 (12.70)	0.867 (3.777)*	0.721 (1.614)	0.503 (1.056)	0.137 (4.303)*	0.805 (2.783)**	0.50	0.46	43.52
Cote d'Ivoire	0.913 (3.586)	0.325 (6.768)*	0.045 (3.262)*	0.271 (2.982)**	-0.597 (-0.924)	0.127 (1.974)**	0.71	0.68	13.45
The Gambia	1.585 (2.374)	0.462 (0.816)	0.816 (5.487)*	0.203 (1.076)	0.442 (2.026)**	0.865 (2.633)**	0.64	0.57	66.13
Ghana	1.582 (5.881)	1.710 (2.782)**	0.185 (2.185)*	0.932 (5.423)*	0.162 (1.405)	0.609 (2.635)**	0.61	0.58	34.56
Nigeria	1.276 (12.600)	0.105 (3.070)*	0.363 (2.473)*	1.105 (0.872)	-0.120 (-0.937)	0.061 (4.682)*	0.61	0.56	0.66
Senegal	4.715 (5.162)	0.139 (2.733)**	1.283 (1.464)	0.977 (2.926)**	0.994 (1.165)	0.037 (2.919)**	0.50	0.47	23.12
Togo	1.661 (7.773)	0.617 (0.819)	1.646 (4.780)*	0.395 (9.395)*	0.755 (4.417)*	0.093 (2.487)**	0.72	0.68	47.89

Note: *, ** indicate 1%, 5% levels of significance.

5. Summary and Conclusion

For several years, the relationship between economic growth and financial development has been of paramount research interest to various researchers and policy makers as well. This is not unconnected with the understanding of the crucial role being played by the financial markets and institutions in the mobilization and allocation of financial resources to the productive sector of the economy. The theoretical paradigm underlying this relationship can be traced back to the work of Schumpeter (1911). Schumpeter opined that financial institutions play a very significant role in the process of economic growth and development. In the same vine, Patrick (1966) argued that financial expansion through the creation of financial institutions and the supply of financial assets do have a positive impacts on the economic growth especially in early stage of development. Thus, financial development is postulated to be playing a supply-leading role in economic development.

With a drive for trade competitiveness, strong financial institutional development, sustained economic growth and, of course, in the face of recent global financial meltdown, most of the ECOWAS countries have continued to witness various types of financial reforms and economic restructuring. These developments are, however, often plagued with unstable domestic financial policies, high and frequent rates of political instability and, of course, incessant policy regime shifts. To better enhance the formulation of optimal financial and economic policy, there is need to understand the role of domestic economic and financial environment of most of the developing countries, especially the sub-Saharan Africa in the analysis of finance-growth nexus.

The striking feature of our results as evident in this study, though preliminary, generally lends credent to the importance of financial development in the explanation of growth dynamics among the selected countries, thus reinforcing the finance-driven growth hypothesis. There are evidences for the unilateral causality running from financial development to economic growth among these countries by identifying the supply leading relationship between financial development and economic growth. Again, and more importantly, having identified plausible breaks in the systems, the test does suggest that a structural break in the cointegration vector is important and needs to be taken care of in the specification of finance-growth models in the selected countries. Also, the structural breakpoints as identified among these countries seem to match clearly with the corresponding critical economic, financial and social incidents in the countries.

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The Role of Agriculture in Economic Growth: A Comparison of Mediterranean and Northern Views in Europe

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Abstract

The main objective of this paper is to identify the causal relationship that exists between agricultural value added per worker and Gross Domestic Product per capita in Europe. More specifically, the role of agriculture in economic growth is examined with special emphasis to the differences and similarities among Mediterranean and Northern countries. In order to examine short-run and long-run relationships, recent methods of linear co-integration are employed while the role of agricultural value added in economic growth is also examined by Granger causality tests. Results show a bi-directional relationship between agricultural value added and economic growth in the northern EU countries and only in one Mediterranean country. From a policy point of view, this relationship is of crucial importance since it can facilitate successful economic decisions. Taking into consideration that the role of agriculture in economic growth is an issue that always attracts the interest of scholars, this research could be prove extremely interesting and useful. Especially for this period of economic crisis, when the whole growth approach is reexamined and reevaluated, the research findings provide evidence that agriculture can lead as an engine of growth in several EU countries and can play stabilizer's role in the whole EU economy.

Keywords: Agricultural value-added, GDP, Causality, Co-integration

JEL Classification: F15, F43, O13

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1. Introduction

The role of agriculture in economic growth was first analyzed, by the middle of twentieth century, mainly by historians and institutionalists. In particular, Clark (1940) and Kuznets (1966) provided the first basic facts regarding the agriculture's role during the growth process. Since then, the role of agriculture was always an issue that attracted the global interest of economists that focused on how agriculture could best contribute to the overall economic growth and modernization. All the while, the vast majority of studies are referred in theoretical models attempting to measure the impact of agriculture in economic growth or identify the relationship between agriculture and the rest of the economy. However, dual-economy or two-sector model was firstly used by Lewis (1954) bases on the idea of surplus labor in the agricultural sector and consequently the linkage from agriculture to economic growth. Few years later the two-sector model has been extended by Ranis and Fei (1961) and then has been adopted by many researchers (Matsuyama 1992; Steger 2000; Vollrath 2009). According to Johnston and Mellor (1961), most of the classical analyses consider agriculture as a vigorous and dynamic economic sector that plays an active role in economic growth through important production and consumption linkages. The significance of such linkages was further stressed by Singer (1979) and explicitly embodied in general equilibrium idea of Agricultural Demand Led-Industrialization (ADLI). Adelman (1984) suggests that ADLI is suitable for low-income countries which are not yet export-driven. However, Gollin (2010) considers that the large share of agriculture in several developing countries does not directly imply that overall growth has to be based on an ADLI-type strategy.

Traditional agriculture, that particularly was characteristic of developing economies, was slow and weak in its response to market signals, owing to such constraints as imperfect factor mobility (Prebisch, 1950; Singer, 1950). This assumption caused structuralists to disregard these linkages in their strategy (Myrdal, 1957). In fact, little empirical evidence was produced regarding the strength or extent of the interrelationship between agriculture and the larger economy and thus agricultural sector was perceived as having few or weak linkages with the rest of economy and thus, unable to serve as an engine of growth (Valdes, 1991).

More recently, in Gardner's (2005) study it is claimed that agriculture does not seem to be a primary force behind Gross Domestic Product (GDP) per capita growth. However, World Development Report's 2008 (World Bank, 2007) suggests that in agriculture-based economies, agriculture could be the main engine of growth, while in transforming countries agriculture is already less important as an economic activity but is still a major instrument to reduce rural poverty. An empirical approach to evaluate the impact of agriculture on economic growth is to augment theories of endogenous growth by including the potential contribution of agriculture (Barro and Sala-i-Martin, 1994; Botrić, 2013; Gouveia, 2014). This approach is tested empirically by Hwa (1988) and proves that agriculture might benefit from non-farm growth since agriculture's growth depends mostly on the provision of "modern" inputs and technology from the industrial sector. In addition, computing linkages between agriculture and overall economy at the aggregate level has relied on Mundlak-type, multi-sectoral simulation models which trace the dynamic interaction of exogenous changes in agricultural productivity with the rest of the economy (Mundlak and Cavallo, 1982; Mundlak et al., 1989; Block and Timmer, 1994; Loizou et al., 1997; Naanwaab and Yeboah, 2014). In several studies the relationships between agricultural and non-agricultural growth are estimated and modeled at regional or local level. The regional process uses household data on consumption and incomes joined to a regional Social Accounting Matrix (SAM) to investigate the impact of exogenous changes in agricultural productivity on incomes in non-agricultural households (Bell et al., 1982; Haggblade et al., 1989; Ranis et al., 1990). Some studies use a SAM-based Computable General Equilibrium (CGE) modeling (Winters et al., 1997) which has been mainly used for assessing the effects of supply and demand shocks on the agricultural sector, on other sectors or on the overall economy (Dervis et al., 1982; Higgs, 1986; Greenaway and Milner, 1993).

Other empirical investigations that examine the causal relationship between agriculture and economic growth provide conflicting results. Thus, some of them consider that the export of surplus resources from agriculture leads to an agricultural driving economic growth while others, argue that increases in the non-agricultural productivity thereby implying that causality runs from general economic growth to agriculture. For example, Estudillo and Otsuka (1999) prove that growth in the non-agriculture economy is the key driver of growth in agricultural wage rates. In addition, the relationship between the average rate of economic growth and the rate of agricultural growth for developing countries is examined by Stern (1996) whose findings prove that there is significant and positive relationship during the years before 1980. Furthermore, Echevarria (1997) investigated 62 countries, for the period 1970-1987, and show that a positive linkage exists between the average rate of growth and agriculture's share of GDP while Timmer (2002) also prove that a positive correlation exists between growth in agricultural GDP and non-agricultural GDP growth using a panel of 65 developing countries, for the period 1960-1985. Self and Grabowski (2007) investigated the period 1960-1995 for a cross-section of countries and show that the relationship between average growth of real GDP per capita and different measures of agricultural productivity is positive.

Many empirical studies establish a correlation between agriculture and GDP growth and they do not imply causality in either direction. But when both sectors have been growing independently or as a result of a common third factor, the correlation observed could be spurious. For this reason, several authors consider that there is a causal effect of agricultural sector to economic growth and finally, address the problem of endogeneity in empirical work. Bravo-Ortega and Lederman (2005) re-estimate the effect of agricultural growth on the total economic growth using panel data tools such as Granger causality tests for the period 1960-2000. They prove that in developing countries an increase in agricultural GDP raises non-agricultural GDP, but there is not a reverse relationship in developed countries. Similar findings revealed from the study of Tiffin and Irz (2006) that investigate the direction of causality between agricultural value added per worker and GDP per capita for 85 countries and address the problem of endogeneity using Granger causality tests in the panel data. Their results provide evidence that agricultural value added causes GDP in developing countries, while the causality in developed countries is not clear except from countries with highly competitive agriculture.

A drawback of cross-country studies is that differences in country conditions do not permit to a general relationship between agricultural and aggregate economic growth. Matsuyama (1992) argues that the relation between agricultural and total economic growth depends on the "openess" of a country to international trade. Several authors have tried to enlighten on the significance of linkages between the agricultural sector and the rest of economy in different developing countries because these linkages differ across countries. The study of De Janvry and Sadoulet (2009) find that 1% of agricultural growth have an effect of 0.45% on aggregate growth in China for the period 1980-2001, while the indirect effect through the non-agricultural sector is almost half that amount.

According to Chenery and Syrquin (1975), a probable solution for the problem of cross-country studies is the combinatorial analysis of cross-section and time-series data. Moreover, cointegration analysis, VAR (vector auto-regression) and VEC (vector error correcting) models provide useful insights regarding the relationship between agriculture and the rest of the economy (Robertson and Orden, 1990). Several studies usually examine causal relationships using the Johansen framework for co-integration whereas the Vector Error Correction (VECM) framework is further used to provide estimates for both short-run and long-run dynamics in the series (Haldar and Mallik, 2010; Mishra, 2011; Matchaya et al., 2013). In some studies, an unconditional VEC model that only has endogenous variables has been extended to a conditional VEC model by adding exogenous policy variables providing stronger and more robust results (Robertson and Orden, 1990; Ardeni and Rausser, 1995).

Similarly, Gemmel et al., (2000) examine the significance of inter-sectoral linkages for agricultural growth in Malaysia and deal with the problem of endogeneity of the variables using a VAR approach to the estimation of the model, which permits to examine for Granger causality. Results show that expansion of manufacturing output causes negative agricultural growth in the short-run, as sectors compete for fixed endowment of resources, while positive agricultural growth in the long-run, considering that manufacturing growth spills-over to the farm sector. On the contrary, expansion of the agricultural sector does not affect the other sectors of the economy. Consequently, manufacturing growth stimulates demand for agricultural commodities and provides the agricultural sector with new technology and inputs. Samini and Khyareh (2012) examine the relationship between agriculture and economic growth of Iran using annual time-series data for the period 1970-2009. By multivariate Granger causality tests based on the ARDL-ECM estimates prove that there is short-run and long-run relationship from agriculture value added to real GDP per capita. Moreover, they show that real GDP per capita causes agricultural value added only in the short-run.

The main objective of this paper is to identify the relationship that exists between agricultural value added per worker and GDP per capita in Europe. An exploratory study among Mediterranean and Northern countries is applied in order to examine possible differences and similarities concerning agriculture's role in economic growth. The analysis employs an Autoregressive Distributed Lag (ARDL) approach for cointegration and the Granger causality test in an attempt to examine the role of agriculture in economic growth by short-run and long-run relationships, as well as the direction of causality. The bi-directional relationship between agricultural value added and economic growth is of crucial importance since it can facilitate successful economic policies in EU countries.

The rest of the paper develops as follows: The next section describes the data and the methodological framework employed in the study, while the third section presents the empirical results and finally concluding remarks are offered in the last section.

2. Employed Methodology

2.1 Data

The data used in this paper to study the relationship between agriculture and economic growth are the real Agricultural value added per worker (AVAw) and real Gross Domestic Product per capita (GDPc) in constant prices (2000 US$). AVAw is a measure of agricultural productivity and is also considered as a good indicator because the sector generates for each productively engaged person over and above the cost of inputs outside agriculture. GDPc represents the economy's growth.

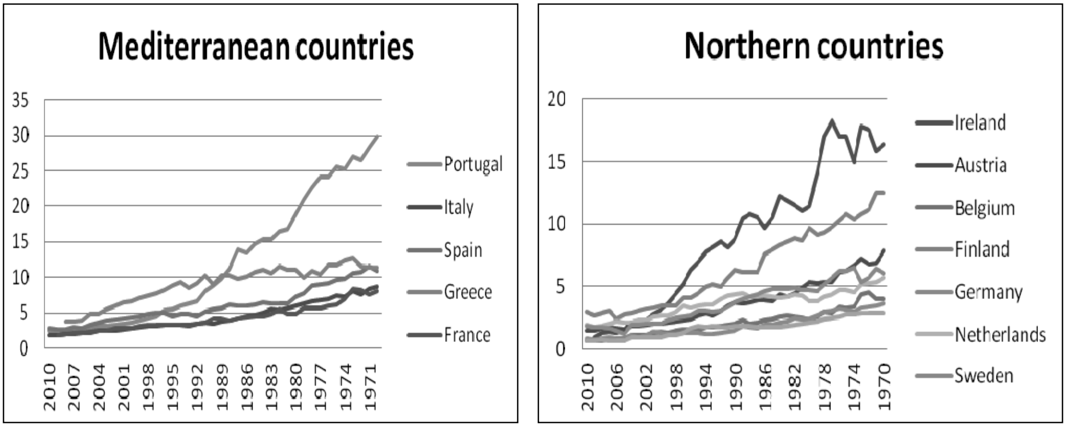
Annual time series data are used in the analysis for the 14 oldest member states of the European Union (EU-15 except Luxembourg which is a country with non-significant agricultural sector). The sample is divided in the five Mediterranean countries and the nine Northern EU countries (table 1). The specific sample was selected in order to examine the existence of similarities and differences regarding the role of agriculture in economic growth between the Mediterranean and northern countries of EU.

Table 1: Period of examined Mediterranean and Northern EU countries

Mediterranean countries		***Northern countries***			
Country	*Period*	*Country*	*Period*	*Country*	*Period*
France	1970-2011	Austria	1970-2011	Ireland	1970-2011
Greece	1981-2011	Belgium	1970-2011	Netherlands	1970-2011
Italy	1977-2011	Denmark	1980-2010	Sweden	1970-2011
Portugal	1980-2010	Finland	1980-2010	Un. Kingdom	1970-2011
Spain	1970-2011	Germany	1980-2011		

The economic contribution of agriculture varies significantly among the most developed Northern EU countries and the less developed Mediterranean countries. This situation continues to exist despite the many important changes observed the last years, mainly through the various reforms of the Common Agricultural Policy (CAP). As it can be seen in Figure 1, a significant reduction in agricultural value added as share of GDP is observed during the period 1970-2010. Mainly, in the Mediterranean countries such as Portugal (from 29,8% to 2,4%), Spain (from 10,9% to 2,7%), Italy (from 8,8% to 1,9%), France (from 8,1% to 1,8%) and Greece (from 11,4% to 3,4%). A different view is observed from the northern EU countries. Thus, an exploratory study among Mediterranean and northern EU countries may provide useful information for the role of agriculture.

Figure 1: AVA (% of GDP) in Mediterranean and Northern EU countries



Source: World Bank

The main source of data was the World Bank database; nominal agricultural gross value added and GDP per capita were taken from United Nations Statistics Division (UNSD), employment in agriculture from International Labor Organization (ILO) and consumer price index (CPI) from the International Monetary Fund (IMF). It is important to mention that all data are converted to natural logarithms. In time series analysis this transformation is often considered to stabilize the variance of a series (Brooks, 2008). Moreover, taking the differences of the examined variables, the growth rates are obtained.

2.2 ARDL approach to cointegration

Cointegration analysis naturally arises in economics and is widely used in empirical macroeconomics. It is most often associated with economic theories that imply equilibrium relationships between time series variables which are referred to as long-run equilibrium relationships (Greene 2000; Gujarati 2004), because the economic forces that act in response to deviations from equilibrium may take a long time to restore equilibrium. As a result, cointegration is modeled using long spans of low frequency time series data.

Cointegration analysis is used to examine the study's objectives and specifically the Autoregressive Distributed Lag (ARDL) approach that was originally introduced by Pesaran and Shin (1999) and later extended by Pesaran et al. (2001). The ARDL approach presents numerous advantages in contrast to other cointegration methods (Katrakilidis et al. 2013). It is an efficient technique for determining cointegrating relationships even if the sample size is small. Additionally, the ARDL approach can be applied irrespectively of the regressors' order of integration. Thus, allowing for statistical inferences on long-run estimates that are not possible under alternative cointegration techniques. Moreover, the ARDL technique generally provides unbiased estimates of the long-run model and valid t-statistics even when some of the regressors are endogenous (Harris - Sollis 2003).

First, in order to find out the appropriate ARDL (p, q_i) model, an estimation with the OLS method was made for all possible values of p=0, 1, 2,…, m, q_i= 0, 1, 2,…, m, i=1, 2, ..., k; namely a total of $(m+1)^{k+1}$ different ARDL models. The maximum lag (m), is determined by the frequency of the data set and all the models are estimated on the same sample period, namely t=m+1, m+2,..., n. One of the $(m+1)^{k+1}$ estimated models using the Akaike information criterion (AIC) is selected. The ARDL model used in this study is represented in Table 2.

Table 2: Presentation of ARDL approach to Cointegration

Equations	No	Variables
ARDL model $\Delta Y_t = \lambda' w_t + a_1 Y_{t-1} + a_2 A_{t-1} + \sum_{i=1}^{k} \gamma_{1i} \Delta Y_{t-i} + \sum_{i=0}^{k} \gamma_{2i} \Delta A_{t-i} + \varepsilon_{1t}$	(1)	w_t: a s x 1 vector of deterministic variables Δ: the first difference operator ε_{1t} : is error term (white noise) Y_t: dependent variable (GDPc or AVAw) A_t: independent variable (AVAw or GDPc) ψ: the coefficient of the ECM
Long-run equation $Y_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} Y_{t-i} + \sum_{i=0}^{k} \beta_{2i} A_{t-i} + \varepsilon_{2t}$	(2)	
Short-run equation $\Delta Y_t = \delta_0 + \sum_{i=1}^{k} \delta_{1i} Y_{t-i} + \sum_{i=0}^{k} \delta_{2i} A_{t-i} + \psi ECM_{t-i} + \varepsilon_{3t}$	(3)	
Error correction term's equation $ECM_t = Y_t - \beta_0 - \sum_{i=1}^{k} \beta_{1i} Y_{t-i} - \sum_{i=0}^{k} \beta_{2i} A_{t-i}$	(4)	

The bounds testing procedure is based on the joint F-statistic or Wald statistic that is testing the null hypothesis of non-cointegration, H_0: $\alpha_1=\alpha_2=0$ against the alternative hypothesis, H_1: $\alpha_1 \neq 0$ and $\alpha_2 \neq 0$. In Pesaran et al. (2001) there are critical value bounds for all classifications of the regressors into purely I(0), purely I(1) or mutually cointegrated. If the calculated F-statistics is below the upper critical value, then we cannot reject the null of non-cointegration. If it lies between the bounds, the results would be inconclusive. The null hypothesis is rejected and there is cointegration whether the calculated F-statistics are above the upper level of the band.

The existence of long-run relationship between the two variables was examined. If there is evidence of long-run relationship, cointegration between the variables, then there is a short-run equation. The error correction model is applied to investigate the short-run relationship between the variables. The value of the coefficient ψ in equation 3 must be negative and statistical significant that indicates how far we are from the long-run equilibrium which will show the short-run equilibrium between the variables.

2.3 Granger causality test

The next step in the analysis employs the Granger causality test to investigate the causal relationship between the variables under examination. The conventional Granger causality test involves the testing of the null hypothesis that a variable Y_t does not cause variable A_t and vice versa (Granger 1969). Unfortunately, this test does not examine the basic time series properties of the variables. If the variables are cointegrated, then this test incorporating different variables will be mis-specified unless the lagged error-correction term is included (Granger 1988). In addition, this test turns the series stationary mechanically by differencing the variables and consequently eliminates the long-run information embodied in the original form of the variables. As opposed to the conventional Granger causality method, the error-correction-based causality test allows for the inclusion of the lagged error-correction term derived from the cointegration equation. By including the lagged error-correction term, the long-run information lost through differencing is reintroduced in a statistically acceptable way.

However, the existence of a long-run relationship between Y_t and A_t suggests that there should be Granger causality in at least one direction. The direction of the causality in this case is only determined by the F-statistic or Wald statistic and the lagged error-correction term. As the t-statistic on the coefficient of the lagged error-correction term represents the long-run causal relationship, the F-statistic or Wald statistic on the explanatory variables represents the short-run causal effect. It should be noted that only equations where the null hypothesis of non-cointegration is rejected will be estimated with this process. Table 3 presents the Granger causality model.

An alternative method to test Granger causality when variables are non-cointegrated is Toda and Yamamoto (1995) approach. This approach ignore any possible non-stationarity or cointegration between series when testing for causality and fitting a standard VAR in the *levels* of the variables rather than first differences [as is the case with the Granger (1969) and Sims (1972) causality tests]; thereby, minimizing the risks associated with possibly wrongly identifying the orders of integration of the series or the presence of cointegration and minimizes the distortion of the tests' sizes as a result of pre-testing (Giles 1997; Mavrotas - Kelly 2001).

The Granger causality test based on Toda-Yamamoto procedure is a modified Wald test for restriction on the parameters of the VAR (k) with k being the lag length of the VAR system. The correct order of the system (k) is augmented by the maximal order of integration (d_{max}) then the VAR ($k+d_{max}$) is estimated with the coefficients of the last lagged d_{max} vector being ignored. Toda and Yamamoto (1995) confirm that the Wald statistic converges in distribution to a χ^2 random variable with degrees of freedom equal to the number of the excluded lagged variables regardless of whether the process is stationary, possibly around a linear trend or whether it is cointegrated. As regards the asymptotic distribution, Kurozumi and Yamamoto (2000) find that in a small sample the asymptotic distribution might be a poor approximation to the distribution of the test statistic however the distortion remains lower than other and it may still be preferable for small sample size.

Following the approach of Toda and Yamamoto (1995) based Granger causality, the bivariate VAR model (Table 3) shows the relationship between AVA per worker and GDP per capita for each country. In equation 7, the null hypothesis can be drawn as "Y_t does not Granger cause A_{it}" if $\gamma_{1i}=0$ against the alternative hypothesis "Y_t does Granger cause A_{it}" if $\gamma_{1i}\neq 0$ for each i. Similarly, in equation 8 the null can be drawn as "A_{it} does not Granger cause Y_t" if $\delta_{1i}=0$ against the alternative "A_{it} does Granger cause Y_t" if $\delta_{1i}\neq 0$ for each i.

Table 3: Presentation of Granger causality tests

Equations	No	Variables
Granger causality model $\Delta Y_t = \delta_0 + \sum_{i=1}^{k}\delta_{1i}Y_{t-i} + \sum_{i=0}^{k}\delta_{2i}A_{t-i} + \psi ECM_{t-1} + \mu_t$	(5)	ECM_{t-1}: the lagged error-correction term (from the long-run equilibrium relationship)
$\Delta A_t = \delta_0^{'} + \sum_{i=1}^{k}\delta_{1i}^{'}A_{t-i} + \sum_{i=0}^{k}\delta_{2i}^{'}Y_{t-i} + \psi^{'} ECM_{t-1} + \mu_t$	(6)	
Toda & Yamamoto procedure $A_{it} = a_o + \sum_{i=1}^{k}a_{1i}A_{it-i} + \sum_{j=k+1}^{d_{max}}a_{2j}E_{it-j} + \sum_{i=1}^{k}\gamma_{1i}Y_{t-i} + \sum_{j=k+1}^{d_{max}}\gamma_{2j}Y_{t-j} + \varepsilon_{1t}$	(7)	A_{it}: AVAw Y_t: GDPc ε_{1t}, ε_{2t}: error terms (white noise)
$Y_t = b_o + \sum_{i=1}^{k}b_{1i}Y_{t-i} + \sum_{j=k+1}^{d_{max}}b_{2j}Y_{t-j} + \sum_{i=1}^{k}\delta_{1i}A_{it-i} + \sum_{j=k+1}^{d_{max}}\delta_{2j}A_{it-j} + \varepsilon_{2t}$	(8)	

3. Results

The order of integration is identified in an attempt to investigate the existence of the Granger causality between AVAw and GDPc. Stationarity tests for each variable are conducted, prior to the testing of cointegration, using the Augmented Dickey-Fuller (ADF), Dickey-Fuller GLS, Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests (see Table 4). The results of the unit root tests indicate that the variables used are a mix of I(0) and I(1) series. So, in this paper an ARDL approach for cointegration is applied, which is the most appropriate analysis because of the fact that the examined variables with different order of integration, are I(0) and I(1). Even if the ARDL framework does not require pre-testing variables to be used, the unit root tests provide evidence whether the ARDL approach should be applied or not. For example, the ARDL procedure is not suitable when any of the series are I(2).

Table 4: Results of the Unit Root Tests

Variable	Unit Root test		Countries
AVAw	ADF	I(0)	BEL, GR, IRL
		I(1)	AUT, DEU, DNK, ESP, FIN, FRA, GBR, ITA, NLD, PRT, SWE
AVAw	DF	I(0)	BEL, ESP, FRA, GBR, IRL, SWE
		I(1)	AUT, DEU, DNK, FIN, GR, ITA, NLD, PRT
AVAw	PP	I(0)	BEL, GR, IRL
		I(1)	AUT, DEU, DNK, ESP, FIN, FRA, GBR, ITA, NLD, PRT, SWE
AVAw	KPSS	I(0)	BEL, DNK, ESP, FIN, FRA, IRL, ITA, SWE
		I(1)	AUT, DEU, GBR, GR, NLD, PRT
GDPc	ADF	I(0)	AUT, BEL, NLD
		I(1)	DEU, DNK, ESP, FIN, FRA, GBR, GR, IRL, ITA, PRT, SWE
GDPc	DF	I(0)	ESP, GBR, ITA, SWE
		I(1)	AUT, BEL, DEU, DNK, FIN, FRA, GR, IRL, NLD, PRT
GDPc	PP	I(0)	GR, PRT
		I(1)	AUT, BEL, DEU, DNK, ESP, FIN, FRA, GBR, IRL, ITA, NLD, SWE
GDPc	KPSS	I(0)	BEL, DEU, ESP, FIN, FRA, ITA, NLD, SWE
		I(1)	AUT, DNK, GBR, GR, IRL, PRT

The conventional stationarity tests which lead to the non-rejection of a unit root may be suspect when the sample under consideration incorporates economic events capable of causing shifts in regime. Breakpoint unit root tests are also conducted such as Zivot and Andrews (1992) and Perron (1997) that allows an endogenous structural break. The null hypothesis of these tests is that series has a unit root against the alternative of a trend stationarity process (TSP) with a structural break. The results of the breakpoint unit root tests for the examined variables in each country (Table 5) show that there are statistically significant breaks for the AVAw in Greece, Italy, Portugal, Spain, Sweden and United Kingdom while concerning to the GDPc, significance is found in Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain and United Kingdom. The findings are inconclusive because there are differences between the Zivot-Andrews and Perron test as regards the existence of a structural break and the dates (the breakpoints which found in the Perron test are usually lagging 1 year of those that obtained by the Z-A test). However, in our analysis we took into account that variables have structural breaks and have to be adjusted prior to entering the ARDL model. For this reason dummies were used when it was required.

Table 5: Results of Breakpoint Unit Root Tests

Variable	Unit Root test		Countries
AVAw	Zivot-Andrews	I(0)	ESP (‘81^{C}, ‘84^{T}), GBR (‘81^{C}, ‘84^{T}, ‘87^{B}), GR (‘03^{C}), ITA (‘99^{C}, ‘02^{T}, ‘00^{B}), PRT (‘87^{T}), SWE (‘05^{T})
	Perron	I(1)	AUT, BEL, DEU, DNK, FIN, FRA, IRL, NLD
GDPc	Zivot-Andrews	I(0)	ESP (1980)^{C,B}, ITA (2002)^{C,B}
	Perron	I(1)	AUT, BEL, DEU, DNK, FIN, FRA, GBR, GR, IRL, NLD, PRT, SWE

Note: C, T and B denote model with intercept (a change in the level), trend (a change in the slope of the trend function) and both (intercept and trend), respectively.

Therefore, the ARDL cointegration procedure is preferable to other conventional approaches such as Johansen multivariate test which require all the variables be of equal degree of integration. The results of the ARDL bounds test for cointegration are reported in Table 6 and prove that when the real AVAw is used as the dependent variable, the calculated F-statistic is higher than the critical value in Austria, France, Greece, Ireland, Portugal and Sweden. Moreover, when the real GDPc is used as the dependent variable, the calculated F-statistic is higher than the upper-bound critical values in all examined EU countries except for Greece and Spain. A number of diagnostic tests were applied so as to examine the reliability of the ARDL models. Results of diagnostic tests in all ARDL models (for each country and dependent variable) indicate that there is no evidence of residual serial autocorrelation (LM test) and the residuals are linearly independent. The Ramsey RESET tests show that all ARDL models are correctly specified.

Table 6: Results of bounds F-statistic for cointegration

Country	Model	Dependent variable	F-statistic	Wald-statistic
Northern countries				
AUT	ARDL(1,1)	LAVAw	9.3479**	18.6959**
	ARDL(1,1)	LGDPc	8.4785**	16.9570**
BEL	ARDL(1,1)	LAVAw	2.8546	5.7092
	ARDL(2,0)	LGDPc	10.2715*	20.5430*
DEU	ARDL(1,1)	LAVAw	2.7889	5.5778
	ARDL(1,1)	LGDPc	4.6285**	9.2570**
DNK	ARDL(1,0)	LAVAw	5.2884	10.5768
	ARDL(2,1)	LGDPc	14.8314*	29.6629*
FIN	ARDL(1,0)	LAVAw	2.3233	4.6466
	ARDL(2,4)	LGDPc	6.0262**	12.0524**

GBR	ARDL(1,1)	LAVAw	4.1344	8.2688
	ARDL(2,1)	LGDPc	9.3721**	18.7443**
IRL	ARDL(1,1)	LAVAw	5.2569***	10.5138***
	ARDL(2,0)	LGDPc	14.8450*	29.6901*
NLD	ARDL(1,3)	LAVAw	2.2508	4.5016
	ARDL(2,1)	LGDPc	8.4436**	16.8871**
SWE	ARDL(1,1)	LAVAw	9.0179**	18.0359**
	ARDL(1,1)	LGDPc	8.7496**	17.4992**
Mediterranean countries				
ESP	ARDL(1,1)	LAVAw	1.4665	2.9330
	ARDL(2,1)	LGDPc	1.7136	3.4273
FRA	ARDL(1,3)	LAVAw	4.0422***	8.0844***
	ARDL(2,1)	LGDPc	17.2484*	34.4968*
GR	ARDL(1,2)	LAVAw	7.9797**	15.9595**
	ARDL(1,1)	LGDPc	2.9415	5.8830
ITA	ARDL(3,1)	LAVAw	3.3480	6.6961
	ARDL(3,1)	LGDPc	6.5403***	13.0806***
PRT	ARDL(1,0)	LAVAw	9.5934**	19.1868**
	ARDL(2,2)	LGDPc	7.9025*	15.8050*

Note: *, ** and *** denote statistical significance at the 1%, 5% and 10% levels, respectively. Critical value bounds (see appendix, Table A1) are obtained from Pesaran et al. (2001)

It should be mentioned that in a cointegrating relationship, the residuals from the long-run equation by the ARDL procedure, must necessarily be stationary, I(0). Otherwise, the results of the F-statistic for the existence of long-run equilibrium relationship between the examined variables are unreliable.

Therefore, in order to confirm the claim that exist cointegration between the variables an ADF unit root test is applied on the residuals. The results (Table 7) show that the residuals from the long-run equation when the AVAw is the dependent variable are a stationary series and there is cointegration only for Austria, France, Greece and Sweden. Additionally, when the real GDPc is the dependent variable the residuals are stationary and exists cointegration in Belgium, France, Germany, Italy, Netherlands, Portugal and Sweden. However, the residuals from the long-run equation when the AVAw is the dependent variable are a non-stationary series for Ireland and Portugal. Moreover, the residuals are not I(0), when the dependent variable is the real GDPc for Austria, Denmark, Finland, United Kingdom and Ireland.

Table 7: Results of ADF Unit Root Test in residuals

Country	Depend. variable	ADF test statistic	Country	Depend. variable	ADF test statistic	Country	Depend. variable	ADF test statistic
Northern countries								
AUT	LAVAw	-3.971167 (0.0177)**	DNK	LGDPc	-0.199828 (0.6059)	IRL	LAVAw	0.823025 (0.8855)
	LGDPc	1.838282 (0.9825)	FIN	LGDPc	1.086117 (0.9236)		LGDPc	1.785970 (0.9805)
BEL	LGDPc	-4.178951 (0.0105)**	GBR	LGDPc	0.389331 (0.7917)	SWE	LAVAw	-2.852160 (0.0600)***
DEU	LGDPc	-3.762670 (0.0078)*	NLD	LGDPc	-5.097078 (0.0009)*		LGDPc	-3.639190 (0.0091)*
Mediterranean countries								
FRA	LAVAw	-5.039799 (0.0010)*	GR	LAVAw	-2.194389 (0.0293)**	PRT	LAVAw	2.165963 (0.9910)
	LGDPc	-3.751948 (0.0071)*	ITA	LGDPc	-3.650771 (0.0097)*		LGDPc	-4.210757 (0.0148)**

Note: *, ** and *** denote statistical significance at the 1%, 5% and 10% levels, respectively and probability reported in parenthesis. Critical values are reported in appendix, Table A2.

Tests for the causality between the variables used are applied by incorporating the lagged error correction term. The causality is examined through the statistical significance of the coefficient of the lagged error correction term and joint significance of the lagged differences of the explanatory variables using the Wald test (see Table 8). In order to test the reliability of the error correction models, a number of diagnostic tests were applied. No evidence of autocorrelation in the disturbance of the error term is found. The results indicate that there is heteroskedasticity only in France (model with dependent variable AVAw), Germany and Netherlands (models with dependent variable GDPc). However, since the time series constituting both the equations are of mixed order of integration, I(0) and I(1), it is natural to detect heteroskedasticity (Shrestha - Chowdhury 2005). Moreover, all models pass the Jarque-Bera normality test suggesting that the errors are normally distributed and the stability Ramsey RESET tests indicate that all models are correctly specified. The high values of R^2 for all models prove that the overall goodness of fit of the model is satisfactory.

The long-run causality from the real GDPc to AVAw is statistically significant in France and Greece (Mediterranean countries). Relating to the northern EU countries is significant in Austria but not in Sweden. The reverse long-run causality from AVAw to GDPc is statistically significant in France, Italy, Portugal (Mediterranean countries), Belgium, Germany, Netherlands and Sweden (northern countries).

Table 8: Results of causality test

Country	Dependent variable	Model	Long-run relationship	Short-run relationship	ECM	Causal flow
			Wald statistic (χ^2)		*t-statistic*	
Northern countries						
AUT	LAVAw	ARDL(1,1)	63.4771*	108.2242*	-0.61723 (-4.0817)*	GDPc → AVAw (long-run and short-run)
BEL	LGDPc	ARDL(2,0)	15.8404*	13.4400*	-0.50494 (-6.3243)*	AVAw → GDPc (long-run and short-run)
DEU	LGDPc	ARDL(1,1)	2089.8*	17.4650*	-0.18014 (-1.8800)***	AVAw → GDPc (long-run and short-run)
NLD	LGDPc	ARDL(2,1)	8.2070*	85.1407*	-0.31004 (-4.0266)*	AVAw → GDPc (long-run and short-run)
SWE	LAVAw	ARDL(1,1)	1.7282	80.0178*	-0.44772 (-2.5958)**	GDPc → AVAw (short-run)
	LGDPc	ARDL(1,1)	43.4875*	95.8112*	-0.34881 (-3.7122)*	AVAw → GDPc (long-run and short-run)
Mediterranean countries						
FRA	LAVAw	ARDL(1,2)	66736.0*	74.5371*	-0.33973 (-2.8419)*	GDPc → AVAw (long-run and short-run)
	LGDPc	ARDL(1,3)	2.8156***	117.3427*	-0.40747 (-4.8029)*	AVAw → GDPc (long-run and short-run)
GR	LAVAw	ARDL(1,2)	40.3565*	32.0008*	-0.72358 (-3.9750)*	GDPc → AVAw (long-run and short-run)
ITA	LGDPc	ARDL(3,1)	6.6675*	153.9298*	-0.27751 (-3.0638)*	AVAw → GDPc (long-run and short-run)
PRT	LGDPc	ARDL(2,2)	17143.9*	1.7579	-0.14155 (-3.1338)*	AVAw → GDPc (long-run)

Note: *, *** denote statistical significance at the 1%, 10% levels, respectively and t-statistics reported in parenthesis.

The coefficient of the lagged error correction term, ECM, is negative and statistically significant, as expected, in all models and EU countries making certain that the series is non-explosive and that long-run equilibrium is attainable. ECM measures the speed at which dependent variable adjust to changes in the explanatory variable before converging to its equilibrium level and depicts that adjustment in dependent variable (GDPc or AVAw) does not occur instantaneously. As regards the northern EU countries, in Belgium 51%, Germany 18%, Netherlands 31% and Sweden 35% of the disequilibria of the previous year's shock to GDPc adjust back to the long-run equilibrium in the current year, while in France 41% and Greece (Mediterranean countries) the percentage is 72% which suggests a fast adjustment process. In Austria 62% (northern country) of the disequilibria of the previous year's shock to agriculture adjust back to the long-run equilibrium in the current year. Concerning the Mediterranean countries, in France, Italy and Portugal, the percentages are 34%, 28% and 14% respectively which imply a slow adjustment procedure.

The short-run causality from the real GDPc to AVAw is statistical significant in two northern EU countries, Austria, Sweden and two Mediterranean countries, France, Greece. Moreover, AVAw cause GDPc and there is statistically significant short-run relationship in Belgium, Germany, Netherlands, Sweden (northern EU countries), France and Italy (Mediterranean countries). The short-run relationship from GDPc to agriculture is not significant in Portugal (Mediterranean country).

The empirical results show that in most of the examined and cointegrated EU countries there is a distinct unidirectional causal flow from GDPc to AVAw and vice versa. However, there is a bi-directional relationship between the variables in the both long-run and short-run for France (Mediterranean country) and only in the short-run for Sweden (northern country). The bi-directional causality indicates a feedback relationship and these findings suggesting that AVAw and GDPc mutually influence each other.

Furthermore, in relation to the EU countries which their variables are not cointegrated with the ARDL approach an alternative test was applied to investigate the causality. The results of Granger causality by Toda and Yamamoto approach (Table 9) show that there is no causal relationship in northern EU countries such as Finland and Ireland. On the other hand, there is Granger causality from real GDPc to AVAw for Denmark, United Kingdom (northern EU countries) and Spain (Mediterranean country). In addition, AVAw causes real GDPc in Denmark. Consequently, there is a bi-directional Granger causality for Denmark which indicates a feedback relationship signifying that real GDPc and AVAw jointly influence each other. Diagnostic tests were applied in each VAR model and the findings show that there are not heteroskedasticity and autocorrelation problems. As regards the dynamic stability of each model, the inverse roots associated with the characteristic equation corresponding to the model for each country, lie within the unitary circle.

The empirical findings prove that there is a unidirectional causal relationship from agricultural value added per worker to GDP per capita and vice versa in several Mediterranean and northern countries in Europe, but feedback relationship (bi-directional causal relationship) exists only in one Mediterranean country and two northern EU countries.

Table 9: Results of Granger causality by Toda & Yamamoto approach

Country	Dependent variable	Independent variable	Modified Wald statistics	Causality
Northern countries				
DNK	LAVAw	LGDPc	4.339112** (0.0372)	GDPc → AVAw
	LGDPc	LAVAw	3.282986*** (0.0700)	AVAw → GDPc
FIN	LAVAw	LGDPc	1.086111 (0.5810)	No
	LGDPc	LAVAw	4.034331 (0.1330)	No
GBR	LAVAw	LGDPc	5.832381*** (0.0541)	GDPc → AVAw
	LGDPc	LAVAw	2.917743 (0.2325)	No
IRL	LAVAw	LGDPc	3.216726 (0.2002)	No
	LGDPc	LAVAw	0.623493 (0.7322)	No
Mediterranean countries				
ESP	LAVAw	LGDPc	9.107974** (0.0105)	GDPc → AVAw
	LGDPc	LAVAw	3.610824 (0.1644)	No

Note: ** and *** denote statistical significance at the 5% and 10% levels, respectively and p-values reported in parenthesis.

4. Conclusion

In this paper, an effort was made to identify the relationship between agricultural value added per worker and GDP per capita in a sample of Mediterranean and northern countries in Europe by employing cointegration analysis and Granger causality tests. Results regarding the autoregressive distributed lag (ARDL) model show that there is a distinct unidirectional relationship from AVAw to GDPc both in the long-run and short-run for Belgium, Germany, Netherlands, (northern countries) and Italy, while only in the long-run for Portugal (Mediterranean countries). The reverse causality from GDPc to AVAw both in the long-run and short-run exist for Austria (northern country) and Greece (Mediterranean country). There are bi-directional long-run and short-run relationships between the examined variables in France (Mediterranean country) and only in the short-run for Sweden (northern country). Additionally, Granger causality test by Toda and Yamamoto approach prove that GDPc cause AVAw in United Kingdom (northern country) and Spain (Mediterranean country). There is also feedback between the investigated variables for Denmark (northern country).

Despite the fact that the contribution of agriculture in Northern EU countries is marginal, findings provide evidences that agriculture might drive economic growth, especially in Germany and Belgium. The relative economic significance of agriculture in these northern countries is not high however the sector maintains an essential role in the growth process. Northern EU country such as the Netherlands and Mediterranean countries such as France, Italy and Portugal have a clear comparative advantage in agriculture and are major exporters on world agricultural markets.

Results prove that there are many Mediterranean and northern countries in which causality exists in one direction from AVAw to GDPc, or, in other words, that agriculture can lead to growth in European Union. Those findings are consistent with studies supporting that agricultural productivity growth is essential to bear the economy into growth (get the economy moving) because of the fact that releases a surplus of raw materials, food, capital, labor and simultaneously generates demand for industrial goods and services. Moreover, there are several northern countries and only one Mediterranean country (Greece) which the causal relationship exists from GDPc to AVAw. A possible explanation of this finding is that increases in the non-agricultural wage lead to relocation and raises in agricultural productivity thereby implying that causality runs from economic growth to agriculture. Additionally, the bi-directional relationship between agriculture and economic growth occurs in two northern EU countries (Denmark and Sweden) and only in one Mediterranean country (France) which indicates that there are "strong" economies in this period of economic crisis.

On the other hand, some crucial differences among the Mediterranean and northern countries in Europe were observed. Thus, the speed at which GDPc adjusts to changes in agricultural value added per worker before converging to its equilibrium level is lower in Spain and Portugal than in the northern EU countries. In particular, Greece has faster adjustment process than the northern EU countries when the causality runs from GDPc to AVAw. However, the empirical results failed to provide obvious differences and strong evidence as regards the agriculture's role in economic growth among northern and Mediterranean countries in Europe. So, it would be useful to re-examine the role of agriculture in economic growth adding Central and Eastern European countries in the sample.

In conclusion, it is noteworthy that although in the European Union is observed a significant reduction in AVA as a percentage of GDP agriculture may lead to economic growth in several EU countries. Hence, policy makers have to take into account the fact that agriculture can become the engine of growth in Europe and play the stabilizer's role in the whole EU economy especially for this period of economic crisis.

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Appendix

Table A1: Critical value bounds of the F-statistic and Wald-statistic

Critical value bounds of the F-statistic						*Critical value bounds of the Wald-statistic*					
1%		5%		10%		1%		5%		10%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Case I: No intercept and no trend						***Case I: No intercept and no trend***					
5.020	6.006	3.145	4.153	2.458	3.342	10.040	12.011	6.291	8.307	4.916	6.684
Case II: Intercept and no trend						***Case II: Intercept and no trend***					
7.057	7.815	4.934	5.764	4.042	4.788	14.114	15.630	9.867	11.528	8.085	9.576
Case III: Intercept and trend						***Case III: Intercept and trend***					
9.063	9.786	6.606	7.423	5.649	6.335	18.126	19.571	13.212	14.847	11.299	12.670

Source: Pesaran et al. (2001)

Table A2: Critical values of ADF Unit Root Test in residuals

Dependent variable	**Country**	**Critical values**		**Country**	**Critical values**		**Country**	**Critical values**	
LAVAw	AUT	1%	-4.198503	FRA	1%	-4.198503	SWE	1%	-3.600987
		5%	-3.523623		5%	-3.523623		5%	-2.935001
		10%	-3.192902		10%	-3.192902		10%	-2.605836
LGDPc		1%	-2.622585		1%	-3.621023		1%	-3.600987
		5%	-1.949097		5%	-2.943427		5%	-2.935001
		10%	-1.611824		10%	-2.610263		10%	-2.605836
LAVAw	GR	1%	-2.644302	IRL	1%	-2.624057	PRT	1%	-2.647120
		5%	-1.952473		5%	-1.949319		5%	-1.952910
		10%	-1.610211		10%	-1.611711		10%	-1.610011
LGDPc	GBR	1%	-2.622585		1%	-2.622585		1%	-4.394309
		5%	-1.949097		5%	-1.949097		5%	-3.612199
		10%	-1.611824		10%	-1.611824		10%	-3.243079
LGDPc	DNK	1%	-2.644302	ITA	1%	-3.639407	BEL	1%	-4.198503
		5%	-1.952473		5%	-2.951125		5%	-3.523623
		10%	-1.610211		10%	-2.614300		10%	-3.192902
LGDPc	FIN	1%	-2.647120	NLD	1%	-4.198503	DEU	1%	-3.762670
		5%	-1.952910		5%	-3.523623		5%	-2.960411
		10%	-1.610011		10%	-3.192902		10%	-2.619160

Innovation, R&D and Productivity: Evidence from Thai Manufacturing

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Abstract

This paper empirically examines the relationship between innovation, R&D (Research and Development), and productivity in Thai manufacturing using cross-sectional data from the 2007 Industrial Census of Thailand. We utilize a simplified structural model (CDM model) that describes the link between innovation output, R&D and productivity for the Thai case. Various estimation techniques are used to compare and provide evidence for empirical results. Our findings generally suggest that government aid and plant characteristics play an important role for a plant to engage in R&D and to be innovative, both in terms of process innovation and product innovation. Exporting plants, plants in the central region, and plants that are categorized as Head Branch type are more likely to engage in R&D and be innovative. The type of industry and specific technological characteristics of plants are shown to influence innovation effort and decisions to undertake R&D. On average, plant size, foreign ownership, exporting and product innovation are important drivers of productivity enhancement in Thai manufacturing.

Keywords: Productivity, Innovation, R&D, CDM model, Thailand

JEL Classification: F14, L60, O31

1. Introduction

Research and Development (R&D) has generally been acknowledged as an important factor in fostering development and cultivating new driving forces for economic growth. Today's world economy has been described as a "Knowledge-Based Economy" (OECD, 1996) with knowledge being the most crucial resource and learning being the most important process (Lundvall, 2003). Furthermore, it is widely recognized that R&D and innovation may result in significant improvements in firm performance. Accordingly, innovation and R&D in manufacturing firms can be considered as one of the major reasons for industrial competitiveness in many countries (Porter, 1985). Innovation has been receiving a special attention in many development debates in recent years. Far from being

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a concern of advanced economies alone, the capability to introduce new technologies is now strongly considered in many developing economies as a crucial element in the process of industrialization. It is, therefore, necessary not only for developed economies but also developing economies to encourage innovation and R&D, especially at the plant and firm level, in order for firms to be able to compete successfully in the international market. As a result, innovation has been a key concept in moving many countries into the knowledge-based economy similar to the United States and European countries. Innovation and R&D at the firm level can consequently be considered as a vital step in improving productivity, sustaining the transformation of industrial structure and supporting manufacturing firms' competitiveness in the global market. In most cases, developed economies and high income countries have dominated R&D activities in the past two decades. From Table 1, we can see that the EU-15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom) generally outperforms emerging countries in terms of innovative output, but the degree of variability among the latter is also large (Bogliacino et al., 2009). Explicitly, the position of Thailand reflects its weakness in terms of product and/or process innovation, especially in the case of extremely low share of innovative firms in Thai manufacturing, compared to those of neighboring countries such as Malaysia and Singapore.

Table 1: Innovative Output in the Manufacturing Sector from Various Countries

	Share of Innovative Firms	Product and Process Innovation (as share of innovative firms)	Product Innovation (as share of innovative firms)	Process Innovation (as share of innovative firms)	Innovative Turnover
EU-15	48.9	45.2	21.3	27.7	10.4
China	30	21.3	3.8	4.8	14.4
Korea	42	18	18	5	54
Malaysia	53.8	N/A	10.6	6.2	42
Singapore	31.7	N/A	24.1	22.4	29
Thailand	**6.4**	**N/A**	**4.1**	**4.3**	**N/A**

Source: Retrieved from Bogliacino et al. (2009)
Notes: The time period is between 2002 and 2006, by utilizing the proper wave of innovation surveys in each country. See Bogliacino et al. (2009) for full details and explanation.

Since the 1980s, the economic performance of Thailand has relied heavily on foreign investment and exports and Thailand's economy has become one of the fast-growing economies in Southeast Asia in the last two decades. However, Thailand has surprisingly one of the lowest levels of R&D spending, R&D workers, and innovation in Southeast Asia and continues to fall behind other countries in the region on most competitiveness indicators, including productivity and innovation (World Bank, 2010). Specifically, Thailand's total domestic expenditure on research is only about 0.25 percent of GDP, significantly less than other countries in Southeast Asia. Additionally, the country has a much lower share of R&D financed by the private sector than other middle-income countries in the region, with just over 40 percent contributed by industry, mostly by large multinationals, compared to over 50 percent in Malaysia and the Philippines (Intarakumnerd, 2010). As can be seen in Table 2, not only is Thailand's overall R&D expenditure low, (amounting to only around 0.25% of GDP), but R&D by the Thai private sector is also especially low (World Bank, 2007). Specifically in the Thai case, R&D expenditure and its growth rate were relatively small compared to other Asian countries. In 2001-2006, R&D expenditure accounted only for 0.25 percent of GDP and gradually decreased to 0.21-0.23 percent in recent years.

Table 2: Low R&D Investment in Thailand

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Public R&D (million baht)	8,202	8,138	9,571	10,548	9,988	11,550	10,015	11,887	12,737
Private R&D (million baht)	5,284	5,164	5,928	6,023	6,679	7,998	8,210	7,278	8,174
Total R&D (million baht)	13,486	13,302	15,499	16,571	16,667	19,548	18,225	19,165	20,911
R&D/GDP (%)	**0.25**	**0.24**	**0.26**	**0.25**	**0.24**	**0.25**	**0.21**	**0.21**	**0.23**

Source: Ministry of Science and Technology, Thailand
Notes: Public R&D investments from 2001 to 2007 are collected from the national surveys on R&D expenditure and personnel by the Office of the National Research Council of Thailand. Public R&D investments from 2008 to 2009 are collected from GFMIS, the Comptroller General's Department, Ministry of Finance. Private R&D Investments from 2001 to 2009 are collected from the national surveys on Private R&D Investment by the National Science Technology and Innovation Policy Office (STI Office).

Moreover, according to the Innovation Survey of Thailand in Table 3[1], it is found that only 6 percent of indigenous firms invest in innovation and R&D, primarily to improve production processes rather than to engage in product innovation. The survey also indicates that firms in Thailand are lagging behind in terms of enhancing their technological and innovative capabilities, upgrading learning process, and forging linkages with other actors of its national innovation system (Intarakumnerd and Fujita, 2008). Thai firms in the automotive, electronics, and food processing industries focus mainly on labor-intensive and lower-technology areas and rely more on labor cost advantages and lower overheads to compete in the Southeast Asian region. Very few firms are attempting to move up the

[1] The Innovation Survey of Thailand is commissioned by the National Science and Technology Development Agency (NSTDA) of Thailand, and conducted by the Brooker Group plc. The survey concentrates only on manufacturing companies.

value chain by investing in R&D to stimulate innovation and enhance their technological capability and increase productivity (OECD, 2010). Furthermore, several other survey studies of Thai firms conducted since the 1980s assert that most firms have grown without deepening their technological capabilities in the long run (Intarakumnerd, 2007)[2]. In addition, although there has been a recent increasing trend of innovation patents granted in Thai firms, the level is still low when compared to those of other lower-middle income countries (Jongwanich and Kohpaiboon, 2011). R&D Surveys and Community Innovation Surveys have been carried out periodically in Thailand since 1999 by the Thai National Science and Technology Development Agency (NSTDA). R&D surveys are carried out every year but the innovation surveys were done only in the years 1999, 2001 and 2003.

Table 3: Thailand's Innovation Surveys - Characteristics and Overall Results

	1999	2001	2003
Size of population			
Manufacturing sector	13,450	14,870	16,432
Service sector	Not included	26,162	5,221
Total	**13,450**	**41,032**	**21,653**
Response rate (%)			
Manufacturing sector	47.00%	36.70%	42.30%
Service sector	Not included	37.30%	45.00%
Total	**47.00%**	**36.90%**	**42.80%**
R&D performing firms (%)			
Manufacturing sector	12.70%	4.40%	7.20%
Service sector	Not included	0.20%	2.40%
Total	**12.70%**	**1.70%**	**6.00%**
Innovating firms (%)			
Manufacturing sector	12.90%	4.70%	6.40%
Service sector	Not included	1.40%	4.00%
Total	**12.90%**	**2.60%**	**5.80%**

Source: Retrieved from Intarakumnerd (2007) and data compiled from Reports on R&D/Innovation Surveys Year 1999, 2001, 2003 by National Science and Technology Development Agency (NSTDA).

The survey in 1999 was the first of its kind in Thailand and it covered both R&D and other technological innovation activities only in the manufacturing sector. The second innovation survey in 2001 and the third one in 2003 (with the fourth one currently being

[2] See Intarakumnerd (2007) and Doner et al. (2010) for the main features of the Thai national innovation system and the knowledge of the innovativeness of Thai enterprises.

undertaken) included the service sector in order to gain a better understanding of the nature and differences of R&D and innovation activities in both manufacturing and services sectors. As a result, the scope of the survey has been expanded to be more informative by also including firms in the service and other industries from the year 2001 onwards.

As a result, the main objective of this paper is to empirically examine the relationship between innovation, R&D, and productivity within a single framework using plant-level data from the Thai manufacturing sector. To the best of our knowledge, our paper is one of the first studies for the Thai case to focus on the analysis of the relationship between innovation, R&D, and productivity in detail and provide empirical evidence and policy implications regarding this issue. The main point of why our study is different from those conducted previously is that we are among the first to utilize the plant-level data from the 2007 Industrial Census of Thailand, while previous studies for the Thai case often use the Innovation Survey, which has much less sample coverage. This paper should also help contribute to the body of knowledge on the subject when applying more advanced methods with a newer dataset and a focus on various aspects. Specifically, apart from R&D expenditures (traditional measures of the R&D input) which have been commonly used in many previous studies, we also utilize the number of laboratory units reported in the data as an alternative proxy for the R&D input variable. This is one of the novel contributions of this paper that makes our study different from previous research. In addition, most of the empirical studies on the influences of innovation and R&D on productivity have generally been carried out only in developed countries. However, the R&D and innovation process in developing countries depends on various cultural and economic dimensions such as market structure and business environment. Thus, evidence from Thai manufacturing may provide a good model for other developing countries concerning this topic where there is currently a scarcity of evidence. Since the R&D situation in Thailand has not drastically changed since 2007, although the data employed in this study might be relatively old by the time of this research, results and suggestions are still relevant and important. Moreover, it is very crucial to provide fundamental estimates in developing countries which have less statistical data and fewer empirical studies at the micro level.

This paper is organized as follows. Section 2 describes the related literature. Section 3 presents the econometric model for the analysis and the data used. Next, results from the analysis are discussed in section 4. Finally, section 5 concludes with a summary of our findings and some policy implications and suggestions for future research.

2. Related Literature

One of the earliest studies which examine the relationship between innovation, R&D and productivity using firm-level data is the empirical study developed by Crépon et al. (1998), also known as the *CDM (Crépon, Duguet, and Mairesse) model*[3]. In their paper,

[3] See Crepon et al. (1998) for the full explanation of the CDM Model, and Johansson and Lööf (2009) for alternative specifications of CDM models.

the authors use a structural model to analyze the link between R&D, innovation output and productivity. They explain productivity by innovation output and innovation output by R&D expenditure using a cross-section of French firm data from the European Community Innovation Survey (CIS). The results reveal that the propensity of a firm to conduct R&D increases with firm size, market share and diversification as well as with demand pull and technology push indicators. Research effort (R&D capital intensity) depends on the same set of variables, excluding firm size. Innovation output (either measured as number of patents or innovative sales) increases with R&D input and with demand and technology variables. In addition, innovation output correlates positively with productivity.

Subsequently, Griffith et al. (2006) extend the work of Crépon et al. (1998) and estimate a variation of the CDM model for France, Germany, Spain, and the United Kingdom. They find that the innovation output is significantly determined by the innovation effort, while a significant productivity effect of product innovations can only be confirmed for France, Spain and the UK, but not for Germany. The results also depict some interesting heterogeneity across the four countries. Masso and Vahter (2008) apply a structural model that involves a system of equations on innovation expenditure, innovation outcome and productivity. Their results from the data from innovation surveys show that both product innovation and process innovation can increase productivity in post-transition Estonia. Furthermore, Crespi and Zuniga (2012) examine the determinants of innovation and its impact on firm labor productivity across Latin American countries and find the importance of innovation in enabling firms to improve economic performance.

In addition, Lee (2008) estimates a CDM model based on firm-level data from the Malaysian manufacturing sector. The results suggest that the decision to conduct R&D activities is significantly determined by firm size, exports and the technology intensity of a firm's sector. Furthermore, the level of R&D expenditure is significantly correlated with firm size. Output (product and process innovations) is positively and significantly determined by R&D expenditure, firm size, exports and local ownership. The author concludes that investment intensity and labor quality appear to be important determinants of productivity, but not innovation or firm size for the Malaysian case.

For the Thai case, recent studies regarding R&D and innovation can be found in Intarakumnerd (2005; 2010) and Intarakumnerd and Chairatana (2008). However, these papers mainly deal with elements of the national innovation system, capabilities and firm competitiveness in terms of qualitative aspects. The authors mostly examine the situation and evaluate Innovation Surveys of Thailand and investigate the state of innovation of firms in developing countries using Thailand, a less successful country in catching up economies, as a case study. Moreover, Berger (2010) applies a CDM model to firm-level data from innovation surveys in order to establish the relationship between innovation activities and labor productivity in 18 OECD countries. Berger (2010) extends the analysis to Thailand by estimating an identical econometric model for data from the R&D and Innovation Surveys of Thailand, and compares the results with those of the OECD project. The results confirm that large and international firms that belong to an enterprise group have a higher probability of being innovative, and tend to invest more resources in innovation activities.

Firms receiving public financial support and participating in innovation cooperation show higher innovation expenditure. Innovation input positively correlates with innovation output, which in turn increases labor productivity.

More recently for the Thai manufacturing sector, Jongwanich and Kohpaiboon (2011) investigates the role of multinational enterprises (MNEs) and exporting on R&D activity using the 2007 Industrial Census with an emphasis on providing suggestions for the promotion of R&D activities in Thailand. The key finding is that the determinants of each type of R&D are not straightforward, suggesting that it is necessary to distinguish between the types of R&D when examining their determinants. The statistical significance of firm-specific factors found in their study suggests that the decision to carry out R&D largely depends on the firm's profitability. Firms exposed to global competition through either exporting or involving in global production networks are more likely to make R&D investments. Nevertheless, our study differs from the mentioned and existing literature and that of Jongwanich and Kohpaiboon (2011) in two ways. First, we try to utilize the number of laboratory units as an alternative for the R&D input variable, and also provide various estimation techniques in order to confirm results with previous studies. Second, this is one of the few studies for the Thai case to consider possible heterogeneity in firms' decision regarding R&D and innovation at the micro level analysis.

Despite the importance of this topic, concerning the direct relationship between innovation, R&D and productivity in the full view, there has been little empirical evidence so far regarding this relationship for the Thai case. For this reason, there is a need to create a concrete research design for this matter in order to empirically examine the relationship between innovation, R&D and productivity within a single and understandable framework. The findings from this study should add to the literature and provide some insight for policy makers in Thailand by shedding light on the puzzle between these variables and their impact on the productivity of domestic firms and the overall economy.

3. Econometric Model and Data

3.1 Model Specification

For the empirical analysis of innovation, R&D and productivity for the Thai case, we use the structural model developed by Crepon et al. (1998) and Griffith et al. (2006). Our analysis here follows the research style from Lee (2008) for the Malaysian case, but adapts the context to the Thai case. Essentially, there are two components in the model. First, research activity influences innovation output. Second, innovation output influences productivity. The standard framework for the structural model comprises four equations that can be estimated in three stages. The details are as follows.

Research Activity Function

The first two sets of equations are related to research activities of a plant and can be estimated using the ordinal probit model and Heckman selection model. In the model, the regression equation for research activity - R&D (r_i) can be modeled as follows:

$$r_i^* = x_i\beta + e_{1i} \tag{1}$$

where x_i is the set of explanatory variables (a vector of determinants of innovation effort), r_i^* is an unobserved latent variable. Since this is the plant-level analysis, for r_i^*, we use R&D expenditure and the number of laboratory units reported in a plant for our analysis. It is important to note that we do not have the exact amount of R&D expenditure from the Industrial Census data and R&D laboratory expenditure is reported instead as a categorical unit ranging from 1 to 5[4]. Specifically, there are two main sources of R&D expenditure from the 2007 Industrial Census of Thailand that can be used. First, R&D expenditure in a plant (research cost) is reported as a proportion of expenses (in percentage unit). Second, R&D expenditure is also reported as laboratory expense (in categorical unit and total number of laboratory units). Since we are trying to analyze innovation effort, the number of laboratory units in a given plant and the R&D expenditure from a plant's laboratory (categorical unit) is the appropriate choice in our study given that the Census data do not provide the exact monetary amount of R&D expenditure (the census only provides research cost and budget in percentage unit). Also, other suitable measures of innovation expenditure are not available to fully utilize. Therefore, we mainly use the number of laboratory units (in nominal unit) as a core R&D proxy in our analysis and only use R&D expenditure (categorical unit) in the ordinal probit (and ordinal logit) model.

Next, β is the coefficient vector and e_{1i} is an error term. As mentioned earlier, we mainly measure (or proxy) plants' innovative effort r_i^* by their number of laboratory units, denoted by r_i only if plants have (and/or report) their laboratory unit, thus we could only directly estimate equation (1) at the risk of selection bias. However, not all plants are observed to have or report the number of their laboratory units. Utilizing the Heckman selection model, the selection equation provides the condition under which a plant *i* is observed to undertake R&D proxied by the number of laboratory units reported in the plant, namely when:

$$z_i\gamma + e_{2i} > 0 \tag{2}$$

where z_i is the set of explanatory variables, γ is is the coefficient vector and e_{2i} is an error term. For equation (1), assuming that the error terms e_{1i} and e_{2i} are bivariate normal with zero mean, we estimate the system of equations (1) and (2) as a generalized Tobit model by maximum likelihood (Heckman selection model by Heckman, 1979) when the dependent variable is the number of laboratory units reported in a plant. This will be our benchmark specification for the first step in the estimation procedure. Moreover, we also estimate

[4] The R&D laboratory expenditure in the 2007 Industrial Census is categorized as follows. 1 = less than 500,000 baht, 2 = 500,001 – 1,000,000 baht, 3 = 1,000,001 – 5,000,000 baht, 4 = 5,000,001 – 10,000,000 baht, and 5 = more than 10,000,000 baht.

equation (1) separately by first using the ordinal (categorical) probit (and logit) model for the case of the dependent variable being a categorical R&D expenditure (ranging from 1 to 5) to provide more evidence and compare our estimated results.

Importantly, there are some variations in the literature in terms of the set of explanatory variables included in the regression equation (1) and selection equation (2). In Crépon et al. (1998), it is assumed that $x_i = z_i$. This implies that the set of explanatory variables with the propensity to undertake R&D (having reported the use of laboratory units) is the same as those regarding R&D intensity (the number of laboratory units). The explanatory variables used in their study include market share, equivalent number of activities (degree of diversification), number of employees (size), and dummy variables for demand pull factors, supply push factors and industry factors. Griffith et al. (2006) adopts a different approach where there are some differences in the explanatory variables used to explain R&D intensity (regression equation) and R&D propensity (selection equation). In their study, the explanatory variables included in both the regression and selection equations include international competition, dummies for formal and strategic protection, dummies for funding, and dummies for industries. Dummies for plant size are included in the selection equation. In our study, the set of explanatory variables x_i for the regression equation includes the dummy variable for foreign ownership, the dummy variable for plant export status, plant technological characteristics (namely, the use of energy saving systems and waste management systems), the central region dummy variable, the BOI (Thai Board of Investment) dummy – investment promotion status of a plant, the dummy variable for government aid status, the dummy variable for the form of organization of the plant, and the dummy variable for selected industries. Lastly, dummies for plant size are included in the selection equation in our study to cope with the issue of exclusion restriction.

Innovation Function

Next, we model the innovation production function, following Lee (2008), as:

$$g_i^* = r_i^* \beta_2 + x_{2i}\beta_3 + e_{2i} \tag{3}$$

where g_i^* is the latent binary innovation indicator proxied by both product innovation and process innovation (taking the value of 1 if a plant reports the innovation indicator, and zero otherwise), r_i^* is the latent innovation effort and enters as an explanatory variable, x_{2i} represents other explanatory variables (a vector of other determinants of innovation function) which include the dummy variable for foreign ownership, the dummy variable for plant export status, plant technological characteristics (namely, the use of energy saving systems and waste management systems), the central region dummy, the BOI (Thai Board of Investment) dummy, the dummy variable for the form of organization of the plant, the dummy variable for selected industries, and dummies for plant size. Finally, β_2 and β_3 are coefficient vectors and e_{2i} is an error term.

We estimate the innovation equation (3) as two separate univariate probit and bivariate probit equations for the process and product innovation indicators. For the plants' innovative effort (r_i^*), we use the predicted value from the estimated generalized tobit equations (1) and (2). That is, we estimate (3) for the sample of all firms, not only for the sub-sample of those reporting R&D activities (the number of laboratory units). By using its predicted value, we calculate the innovative effort r_i^* and take caution that it is possibly endogenous to the innovation function. As mentioned in Griffith et al. (2006), it seems likely that firm characteristics unobservable to us (and thus omitted) can make firms both increase their innovative effort and also their productivity in producing innovations.

As a result, the estimation of equation (3) is realized by performing univariate probit and bivariate probit estimations using the predicted value of R&D intensity (r_i). Following Griffith et al. (2006), separate estimates are carried out for product and process innovations. In short, the bivariate probit model is a joint model for two binary outcomes (product innovation and process innovation). These binary outcomes may be correlated and if the correlation turns out insignificant, then we can estimate two separate probit models, otherwise it is more appropriate to utilize and consider the bivariate probit model.

Production Function

The final component of the model involves the use of an augmented Cobb-Douglas production function to measure plant productivity:

$$q_i = \alpha_1 k_i + \alpha_2 l_i + \alpha_3 g_i^* + \alpha_4 w_i + \alpha_5 X_i + \varepsilon_i \tag{4}$$

where q_i is labor productivity (natural log of value-added per worker). k_i is the capital intensity (proxied by fixed assets per worker). l_i is labor quality (proxied by the share of skilled workers in the total workforce of each plant). g_i^* is the predicted innovation input. w_i is the plant size and ε_i is an error term. X_i is the vector of other control variables which affect labor productivity. We take care of the endogeneity of g_i (respective binary variable) in this equation by using the predicted values from the innovation function equations (3).

In summary, our model consists of the four equations, (1), (2), (3), and (4). Since we assume a recursive model structure and do not allow for feedback effects, we follow a three-step estimation procedure as a simplified CDM model. In the first step, we estimate the generalized tobit model (equations (1) and (2)) by Heckman selection model (we also perform ordinal probit/logit regressions and univariate probit/logit regressions separately in the first step to compare the results, however, the estimated results, other than those of the Heckman selection model in the first step, are not related to the further steps of the analysis). In the second step, we separately estimate the two innovation production functions for product and process innovations as two univariate probit and bivariate probit equations using the predicted value of innovative effort from the first step to take care of both selectivity and endogeneity of r_i^* in equation (3). In the last step, we estimate the productivity equation using the predicted values from the second step to take care of the endogeneity of g_i in equation (4). Finally, it should be noted again that we perform many estimations side-by-side in the first and second step to compare and cross-check our estimated results. We will discuss the details for estimated results later in section 4.

3.2 Data and Variable Construction

Concerning the Thai data, there are three types of data sets which can be used in the micro-level analysis regarding the relationship between innovation, R&D and productivity for the manufacturing sector. First, comprehensive datasets and samples are available in the National Statistical Office's (NSO) Industrial Census for 1997 and 2007 (data collected in 1996 and 2006, respectively). To date, the 1997 and 2007 censuses are by far the most comprehensive data available in Thai manufacturing. However, the main disadvantage of this census data is that it is cross-sectional data, which limits its use for sophisticated research such as panel data and dynamic analysis. Second, another micro-level data set in Thai manufacturing can be found in the Manufacturing Industry Survey by the NSO. However, the Manufacturing Industry Survey does not provide enough information and variables necessary for our innovation analysis. Third, there is also the Innovation Survey conducted by the National Science and Technology Development Agency (NSTDA) of Thailand. However, these innovation surveys include relatively little information on firm characteristics, especially for non-innovative firms. This causes some problematic variable definitions and model specifications for empirical studies (Berger, 2010).

In our econometric investigation into the relationship between innovation, R&D, and productivity, we use the detailed data set at plant level from the 2007 Industrial Census of Thailand. This data set was collected by Thailand's National Statistical Office (NSO) which surveyed all establishments in 2006. The information is one of the most current plant-level data sets in Thailand. The original sample size consists of 73,931 observations, of which 71,154 observations are domestic plants (plants owned by domestic firms), and 2,777 observations are foreign plants (plants owned by foreign-owned firms)[5]. The census covers 34,625 establishments belonging to 127 four-digit industries of the International Standard Industrial Classification of All Economic Activities (ISIC Rev3.0). Due to missing information on some key variables, the census was cleaned up by deleting plants which had not responded to one or more of the key questions and those which had provided seemingly unrealistic information, such as negative value added and inputs used or total employment being less than one. As described in more detail in Kohpaiboon and Ramstetter (2008), there are some duplicated records in both the data from Manufacturing Surveys and the Industrial Census of Thailand, presumably because plants belonging to the same firm filled the questionnaire using the same records. The procedure followed to address this problem was to treat the records that report the same value of the seven key variables of interest in this study as one record[6]. Industries that are either to serve niches in the domestic market in

[5] In this study, if the foreign investment in a plant is reported, we consider the plant as foreign plant and if there is no report of foreign equity participation, we consider the plant to be domestic plant.

[6] See details in Ramstetter (2004). In addition, there are the near-duplicate records. A careful treatment to maximize the coverage of the sample is used as described in full detail in Ramstetter (2004).

the service sector or explicitly preserved for local enterprises are excluded[7]. As a result, the final dataset contains 49,432 observations as shown in Table 4. Additionally, the pairwise correlation matrix of the key variables can be found in Table 5 as shown below.

Table 4: Statistical Summary of the Key Variables

Variable	Unit	Obs	Mean	Std. Dev.	Min	Max
R&D Expense	categorical (1 to 5)	1702	1.7086	0.9942	1.0000	5.0000
Lab Number	number of laboratory units	1731	1.7163	1.5499	1.0000	20.0000
Value-added per worker	(ln) baht	49432	11.1916	1.6783	2.5621	19.2820
Capital Intensity	(ln) baht	49432	11.5081	1.8936	1.2217	20.2177
Material Intensity	(ln) baht	49432	10.7221	2.1947	-5.4972	20.1004
Labor Quality	(ln) share of skilled workers	49432	0.5970	0.1908	0.0000	0.6931
Lab (Status)	zero-one dummy	49432	0.0350	0.1838	0.0000	1.0000
Process Innovation	zero-one dummy	49432	0.0277	0.1640	0.0000	1.0000
Product Innovation	zero-one dummy	49432	0.0314	0.1743	0.0000	1.0000
Foreign	zero-one dummy	49432	0.0391	0.1937	0.0000	1.0000
Exporting	zero-one dummy	49432	0.0781	0.2684	0.0000	1.0000
Energy	zero-one dummy	49432	0.0206	0.1419	0.0000	1.0000
Waste	zero-one dummy	49432	0.0197	0.1391	0.0000	1.0000
Gov Aid	zero-one dummy	49432	0.0460	0.2095	0.0000	1.0000
BOI	zero-one dummy	49432	0.0678	0.2514	0.0000	1.0000
Central	zero-one dummy	49432	0.4388	0.4962	0.0000	1.0000
State-Owned	zero-one dummy	49432	0.1605	0.3671	0.0000	1.0000
Head Branch	zero-one dummy	49432	0.0703	0.2557	0.0000	1.0000
Size 2-50	zero-one dummy	49432	0.8716	0.3345	0.0000	1.0000
Size 51-100	zero-one dummy	49432	0.0511	0.2202	0.0000	1.0000
Size 101-200	zero-one dummy	49432	0.0348	0.1832	0.0000	1.0000
Size 201-500	zero-one dummy	49432	0.0268	0.1615	0.0000	1.0000
Size 501-1000	zero-one dummy	49432	0.0095	0.0972	0.0000	1.0000

Source: Author's calculation

[7] See details in Kohpaiboon and Ramstetter (2008).

Table 5: Pairwise Correlation Matrix of the Key Variables (Observations are 1,702)

Correlation	R&DExpense	Lab Number	LnVAL	LnKI	LnMI	LnLQ	Process	Product	Foreign	Exporting	Energy	Waste	Gov Aid	BOI
R&DExpense	1													
Lab Number	0.249*	1												
LnVAL	0.257*	0.078*	1											
LnKI	0.223*	0.063*	0.551*	1										
LnMI	0.217*	0.055*	0.740*	0.434*	1									
LnLQ	0.028	0.021	-0.069*	0.119*	-0.102*	1								
Process	0.088*	0.076*	0.191*	0.121*	0.164*	-0.041*	1							
Product	0.090*	0.049*	0.200*	0.124*	0.175*	-0.052*	0.678*	1						
Foreign	0.050*	0.045	0.257*	0.163*	0.228*	-0.040*	0.154*	0.164*	1					
Exporting	0.135*	0.054*	0.323*	0.180*	0.295*	-0.074*	0.246*	0.263*	0.447*	1				
Energy	0.068*	0.072*	0.170*	0.110*	0.145*	-0.039*	0.646*	0.661*	0.152*	0.219*	1			
Waste	0.037	0.064*	0.165*	0.108*	0.143*	-0.040*	0.648*	0.662*	0.148*	0.209*	0.798*	1		
GovAid	0.112*	0.047	0.222*	0.112*	0.207*	-0.093*	0.247*	0.287*	0.198*	0.317*	0.234*	0.233*	1	
BOI	0.151*	0.050*	0.310*	0.180*	0.284*	-0.073*	0.242*	0.251*	0.458*	0.913*	0.216*	0.202*	0.321*	1

Notes: All correlation coefficients are significant at the 5% level or better (VAL=Value-Added per worker, KI=Capital Intensity, MI=Material Intensity, LQ=Labor Quality).

Given the nature of data availability in this study, although the more preferred panel data choice is desirable, the two industrial censuses (1997 and 2007) provide inconsistent establishment identification numbers. As a result, it is difficult to utilize both data sets and leads to difficulties in creating complete panel data. This lack of complete panel data in many developing countries, including Thailand, is one of the main reasons there have been so few comprehensive studies using firm-level analysis.

Next, the explanation of key variables used in our analysis can be described in detail as follows (see Table 4 for the statistical summary of key variables used in the analysis).

Knowledge/Innovation

R&D Intensity: R&D laboratory expenditure (as a categorical unit ranging from 1 to 5) and the number of laboratory units in a plant (in nominal unit)

Process Innovation: Dummy variable, which takes the value 1 if a plant reports having introduced new or significantly improved its production technology

Product Innovation: Dummy variable, which takes the value 1 if a plant reports having introduced new or significantly developed its product

Labor Productivity: Value added per worker of a plant

Capital Intensity: The ratio of fixed assets to total number of employees in each plant (average physical capital stock per worker)

Material Intensity: Material input intensity, defined as the ratio of raw material input purchases of each plant to total number of workers in that plant

Labor Quality: The share of skilled workers in the total workforce of each plant (both male and female skilled operatives and non-production workers). The actual number of supervisors and management workers are not available in the census. Therefore, the number of non-production workers reported would also include administrative staff.

Public Support

Government Aid: Dummy variable, which takes the value 1 if a plant receives or demands financial support or aid from government agencies for innovation projects.

BOI: Dummy variable for the Thai Board of Investment - the investment promotion status of a plant (equal to 1 if a plant is investment-promoted, and zero otherwise). The plant receives tax incentives or non-tax incentives or other investment benefits from BOI under the Investment Promotion Act of Thailand. Recent policies to promote R&D activity in Thailand are principally implemented through the Broad of Investment.

Demand Pull

Energy Saving: Dummy variable, which takes the value 1 if a plant reports having implemented an energy saving system

Waste Management: Dummy variable, which takes the value 1 if a plant reports having implemented an improved waste management system

Region and Form of Organization

Central: Central area dummy (equal to 1 if plants are in the central area - Bangkok and the central region of Thailand, and zero otherwise)

Head Branch: Form of economic organization dummy (equal to 1 if these are plants belonging to multiple-unit plants, and zero if they are Single Unit type - plants belonging to single-unit or stand-alone plants)

State-Owned: Form of legal organization dummy (equal to 1 if plants are state-owned, and zero if they are private enterprises)

Other

Foreign Ownership: Dummy variable, which takes the value 1 if a plant is a foreign plant, and zero if the plant is a domestic plant

Size: Set of size dummy variables according to a plant's number of employees. Categories are 2-50, 51-100, 101–200, 201–500, and 501-1,000 employees.

Industry: Set of industry dummies according to the plant's main business activity

4. Empirical Results

Before reviewing and interpreting the estimated results, we point to an important caveat of our study in that we only have cross-sectional data for the analysis and that most of the factors we consider may be simultaneously determined. Therefore, we need to take great care in interpreting our results. Although the panel data analysis is more preferred, it is impossible to obtain the complete set of data at the time of this study. In addition, the data on innovation and innovative indicators is rather scarce for the Thai case, making it even harder to utilize the data from other sources. Additionally, since the analysis from the Innovation Survey of Thailand has already been explored in previous studies, our estimation here would better contribute to the literature on the subject when applying other methods with a newer dataset from the Industrial Census, which has a direct focus on the relationship between innovation, R&D, and productivity in Thai manufacturing. The results of our analysis can be divided into three sections as shown below.

4.1 Research Activity and R&D Intensity Function

We start this section by considering estimates of the determinants of whether or not plants undertake R&D and if so, how much R&D they conduct. As noted before, we use both R&D expenditure (in categorical unit) and the number of laboratory units (in nominal unit) as the dependent variable in equation (1) and (2). The estimated results of the research equation for the case of R&D expenditure (dependent variable) being a categorical unit are shown in Table 6 to provide initial evidence. Later, the main results in our analysis will be thoroughly explained from Table 7.

Table 6: Research Equation - R&D Expenditure (Coefficients)

R&D Expenditure	Ordinal Probit		Ordinal Logit	
(Categorical Unit: 1 to 5)	(1)	(2)	(3)	(4)
Foreign	-0.0128	0.0515	-0.0164	0.0928
	(-0.19)	(0.72)	(-0.14)	(0.75)
Exporting	-0.134	-0.197	-0.204	-0.340
	(-0.88)	(-1.24)	(-0.75)	(-1.17)
Energy	0.135	0.184*	0.247	0.328*
	(1.51)	(2.08)	(1.55)	(2.08)
R&D Expenditure	Ordinal Probit		Ordinal Logit	
(Categorical Unit: 1 to 5)	(1)	(2)	(3)	(4)
Waste	-0.0702	-0.149	-0.124	-0.249
	(-0.78)	(-1.65)	(-0.77)	(-1.53)
Gov Aid	0.237***	0.206***	0.392***	0.347***
	(4.00)	(3.44)	(3.85)	(3.34)
BOI	0.262	0.293	0.408	0.487
	(1.71)	(1.84)	(1.49)	(1.68)
Central	0.293***	0.275***	0.476***	0.478**
	(3.84)	(3.29)	(3.61)	(3.29)
State-Owned	0.418	0.461	0.733	0.793
	(1.46)	(1.55)	(1.44)	(1.49)
Head Branch	0.193**	0.154*	0.328**	0.254*
	(3.28)	(2.53)	(3.22)	(2.42)
Size 2-50	-1.100***	-1.407***	-1.801***	-2.376***
	(-7.89)	(-9.51)	(-7.31)	(-9.09)
Size 51-100	-0.936***	-1.138***	-1.538***	-1.904***
	(-7.38)	(-8.68)	(-6.79)	(-8.19)
Size 101-200	-0.751***	-0.926***	-1.228***	-1.537***
	(-6.27)	(-7.58)	(-5.76)	(-7.04)
Size 201-500	-0.513***	-0.617***	-0.837***	-1.021***
	(-4.40)	(-5.27)	(-4.03)	(-4.92)
Food		0.302***		0.584***
		(3.36)		(3.70)

Textiles		-0.101		-0.197
		(-0.66)		(-0.74)
Apparel		-0.199		-0.392
		(-0.64)		(-0.74)
Wood		0.770*		1.340
		(2.06)		(1.83)
Chemicals		0.681***		1.214***
		(7.14)		(7.21)
Rubber and Plastics		-0.107		-0.171
		(-0.92)		(-0.86)
Non-metallic		0.00475		0.0328
		(0.03)		(0.13)
Basic metals		-0.152		-0.305
		(-0.80)		(-0.91)
Observations	1702	1702	1702	1702
Pseudo R2	0.0514	0.0759	0.0472	0.0742

Source: Author's calculation
Notes: Robust t-statistics in parentheses and ***, **, * indicates a statistical significance at 1, 5, 10 percent, respectively.

First, the results of our research equation, estimated by using the ordinal probit (and ordinal logit) model provide first insight regarding the relationship between R&D expenditure and determinant variables. From Table 6, the positive coefficients of *Gov Aid* (government aid) mean that the likelihood of plants' R&D expenditure increases with public financial support from the government. Moreover, plants in the central region of the country and plants, categorized as Head Branch type, have higher propensity to engage in R&D. Plant size is positively correlated with R&D expenditure and indicates a significant positive effect on the probability to perform R&D. The majority of plants in Thailand are small in terms of employees. As a result, for the Thai manufacturing sector, smaller plants have lower propensity to engage in R&D. In addition, plants in the food production industry (Industry division 15) and the chemical production industry (Industry division 24) are also more likely to invest in R&D. Importantly, from Table 6, we can conclude that being large plants, plants in the central region, and plants demanding government funding increases the probability of engaging in R&D.

Table 7: Research Equation: Laboratory Unit (Marginal Effects)

Lab/Lab Number	Probit	Logit	Heckman	
	(1)	(2)	(3) Main	(4) Select
Foreign	0.000765	0.000412	0.134	0.00130
	(1.45)	(0.93)	(1.35)	(1.72)
Exporting	0.00201	0.00185	0.0304	0.00277
	(1.61)	(1.66)	(0.15)	(1.44)
Energy	0.0116**	0.00826***	0.0373	0.0173**
	(3.28)	(3.45)	(0.32)	(2.93)
Waste	0.0108**	0.00789***	-0.146	0.0134**
	(3.17)	(3.37)	(-1.24)	(2.66)
Gov Aid	0.0431***	0.0262***	-0.216**	0.0594***
	(9.23)	(9.08)	(-2.58)	(6.58)
BOI	0.00233	0.00198	-0.0807	0.00252
	(1.71)	(1.72)	(-0.41)	(1.34)
Central	0.00182***	0.00173***	0.0156	0.00234***
	(4.63)	(4.40)	(0.19)	(4.27)
State-Owned	-0.00325***	-0.00413***	1.679*	-0.00263***
	(-9.48)	(-10.58)	(2.17)	(-5.16)
Head Branch	0.00338***	0.00274***	0.0450	0.00458***
	(4.64)	(4.99)	(0.59)	(4.14)
Food	0.00639***	0.00640***	-0.0839	0.00809***
	(6.82)	(7.69)	(-0.84)	(4.90)
Textiles	0.000702	0.000601	0.193	0.00139
	(0.93)	(0.84)	(1.22)	(1.27)
Apparel	-0.00256***	-0.00317***	0.0217	-0.00299***
	(-8.88)	(-9.58)	(0.08)	(-5.39)
Wood	-0.00223***	-0.00300***	0.212	-0.00252***
	(-6.61)	(-7.02)	(0.98)	(-4.45)
Lab/Lab Number	Probit	Logit	Heckman	
	(1)	(2)	(3) Main	(4) Select
Chemicals	0.0330***	0.0248***	0.312*	0.0634***
	(6.59)	(6.65)	(2.21)	(5.42)
Rubber and Plastics	0.00261**	0.00273**	-0.0714	0.00317*
	(2.72)	(3.26)	(-0.60)	(2.34)

Non-metallic	0.00347**	0.00347***	0.0300	0.00488*
	(3.24)	(3.52)	(0.18)	(2.51)
Basic metals	-0.00127**	-0.00153**	-0.121	-0.00170**
	(-2.99)	(-3.15)	(-0.82)	(-3.16)
Furniture	-0.00234***	-0.00295***	0.311	-0.00257***
	(-7.76)	(-8.38)	(1.40)	(-4.63)
Size 2-50	-0.0535***	-0.0451***		-0.102***
	(-5.25)	(-5.58)		(-4.40)
Size 51-100	-0.00195***	-0.00224***		-0.00252***
	(-6.29)	(-6.11)		(-5.21)
Size 101-200	-0.00151***	-0.00170***		-0.00207***
	(-4.18)	(-4.07)		(-4.46)
Size 201-500	-0.000690	-0.000835		-0.00125*
	(-1.25)	(-1.53)		(-2.14)
Observations	49432	49432	49432	

Source: Author's calculation
Notes: Robust t-statistics in parentheses and ***, **, * indicates a statistical significance at 1, 5, 10 percent, respectively.

Second, the results from the research equation using the Heckman selection method provide further insight on both the decision to undertake R&D (by having laboratory units in a plant) and the intensity of R&D. In Table 7, we estimate the research equation by probit, logit, and Heckman selection models to compare our results. We can observe that the sign of the estimates (marginal effects) is the same with the results only differing in magnitude. However, we will only consider the results from the Heckman selection model for our research equation, with the dependent variable being the number of laboratory units, as our benchmark results. The estimated results suggest that the plant's decision to undertake R&D is positively influenced by energy saving status, waste management status, government aid, and central region status. Specifically, the marginal effect for government aid (*Gov Aid*) is relatively large. Plant size appears to positively affect the decision to undertake R&D, with bigger plants having more and smaller plants having less probability to engage in R&D activities. Larger plants, which may have more stable funding access, are likely to afford R&D investment as opposed to smaller plants (Jongwanich and Kohpaiboon, 2011). For this reason, as confirmed by our estimated results in Table 6 and Table 7, smaller plants are less likely to engage in R&D (the magnitude of coefficients is larger as the firm size is smaller). It is interesting to note that state-owned plants (in terms of legal organization) are less likely to invest in R&D while plants that are Head Branch type (in terms of economic organization) are more likely to engage in R&D. Furthermore, the BOI and export status of a plant appears to weakly affect the propensity of a plant in conducting R&D. Finally, we find that being a foreign plant is not related to greater engagement in R&D activities. Moreover, the estimated results from Table 7 reveal that plants in some industries are more likely to engage in R&D activities; namely, plants in the food production (Industry division 15), chemical production (Industry division 24), rubber and plastic production (Industry division 25), and non-metallic mineral production industries (Industry division 26). Conversely, plants in the following industries have less probability to undertake R&D: apparel (Industry division 18), wood production (Industry division 20), metal production (Industry division 28), and furniture (Industry division 36). In summary, from Table 6 and Table 7, in terms of industry, it is found that almost all industries are more likely to carry out R&D than the textiles industry; especially the chemical industry which has a relatively high marginal effect. These results are in line with the previous study by Berger (2010).

4.2 Innovation Function

We next consider the results of the innovation equation in Table 8 and Table 9. These empirical results provide us with an idea of important determinants for the propensity to innovate in both product innovation and process innovation.

Table 8: Innovation Equation (Marginal Effects)

	Univariate Probit		Bivariate Probit	
	(1) Process	(2) Product	(3) Process	(4) Product
	Innovation	Innovation	Innovation	Innovation
Lab Number	-0.0145**	-0.00164	0.007**	0.067***
	(-3.25)	(-0.40)	(3.20)	(6.69)
Foreign	0.00172	0.000274	0.001	0.001
	(1.04)	(0.20)	(-0.04)	(-0.07)
Exporting	0.0101*	0.0176***	0.004	0.014***
	(2.43)	(3.52)	(1.57)	(3.49)
Energy	0.148***	0.173***	0.054***	0.079***
	(7.69)	(7.83)	(6.03)	(6.03)
Waste	0.119***	0.159***	0.055***	0.071***
	(6.48)	(6.98)	(5.84)	(5.68)
GovAid	0.00284	0.0154***	0.001	0.001*
	(1.43)	(4.19)	(1.15)	(1.83)
BOI	-0.000211	-0.00289*	0.001	-0.003***
	(-0.10)	(-2.31)	(0.69)	(-4.21)

Central	0.00291***	0.00665***	0.001	0.004***
	(3.47)	(7.78)	(1.42)	(6.71)
State-Owned	0.0312	-0.00488	-0.004***	-0.004***
	(1.16)	(-1.19)	(-6.22)	(-5.88)
Head Branch	0.0103***	0.00463**	0.006***	0.001
	(5.09)	(3.23)	(4.48)	(0.96)
Food	-0.000657	0.00350*	-0.001	0.001
	(-0.56)	(2.38)	(-0.79)	(1.23)
	Univariate Probit		Bivariate Probit	
	(1) Process	(2) Product	(3) Process	(4) Product
	Innovation	Innovation	Innovation	Innovation
Textiles	-0.00102	0.000565	-0.003**	0.000
	(-0.67)	(0.36)	(-3.51)	(0.27)
Apparel	-0.00533***	-0.00356***	-0.004***	-0.001
	(-6.67)	(-3.63)	(-6.24)	(-0.72)
Wood	-0.000988	-0.00433***	-0.002*	-0.003***
	(-0.60)	(-3.96)	(-1.8)	(-3.22)
Chemicals	0.0230***	0.0362***	0.003	0.014***
	(4.19)	(5.50)	(1.75)	(4.41)
Rubber and Plastics	-0.00118	0.000839	-0.001	0.000
	(-0.84)	(0.50)	(-1.27)	(0.28)
Non-metallics	0.000312	0.00315*	-0.002*	0.002
	(0.24)	(1.96)	(-2.92)	(1.29)
Basic metals	-0.00435***	-0.00340**	-0.003***	-0.002**
	(-4.59)	(-3.19)	(-4.25)	(-2.67)
Size 2-50	-0.00776	-0.0123*	-0.002	-0.001
	(-1.71)	(-2.11)	(-0.96)	(-0.49)
Size 51-100	0.00203	0.000890	0.003	0.004
	(0.63)	(0.30)	(1.06)	(1.18)
Observations	49432	49432	49432	49432

Source: Author's calculation
Notes: Robust t-statistics in parentheses and ***, **, * indicates a statistical significance at 1, 5, 10 percent, respectively. Dummy variables: Size 101-200 and Size 201-500 are statistically insignificant and omitted to save space.

Table 9: Innovation Equation (Coefficients)

	Univariate Probit		Bivariate Probit	
	(1) Process	(2) Product	(3) Process	(4) Product
	Innovation	Innovation	Innovation	Innovation
Lab Number	-0.730**	-0.0882	0.530**	1.104***
	(-3.27)	(-0.40)	(3.40)	(9.43)
Other	Omitted	Omitted	Omitted	Omitted
Independent	(Same with	(Same with	(Same with	(Same with
Variables	Table 8)	Table 8)	Table 8)	Table 8)
Observations	49432	49432	rho	0.875***
Pseudo R2	0.5222	0.5567		(24.73)

Source: Author's calculation
Notes: Robust t-statistics in parentheses and ***, **, * indicates a statistical significance at 1, 5, 10 percent, respectively.

From Table 8, most of independent variables are statistically significant. We can see that exporting plants, plants with energy saving and waste management systems, plants that receive or demand public financial support, plants in the central region, and plants which are categorized in terms of economic organization as Head Branch type are more likely to be innovative. More importantly, comparing Table 8 and Table 9, the variable *Lab Number* (the number of labs reported in a plant), which is a proxy for R&D expenditure, negatively relates to process innovation in the univariate probit model. As stated in Berger (2010), international competitive advantage for Thai plants is based on (labor) cost advantages and not (as in most of OECD countries) on innovative products. For this reason, it is not surprising that we might observe a negative and/or insignificant relationship between innovation indicators (process and product innovation) and the number of laboratory units (R&D expenditure), especially for process innovation, where we find a strong and negative relationship. However, if we consider the bivariate probit model instead, we find that *Lab Number* is positively related with both process and product innovation. Because the bivariate model estimates decisions that are interrelated, and the estimated results may differ if the two decisions (process and product innovation) are indeed interrelated. Another explanation for the negative sign for *Lab Number* might be that the number of labs may be not suitable for R&D input proxy for the Thai case. However, we can see in the correlation matrix in Table 5 that *Lab Number* has a positive correlation with both product innovation and process innovation (and also categorical R&D expense). As a result, from this section on, we will compare the estimated results from both the univariate probit model and the bivariate model. Although the correlation coefficient of binary outcomes in the bivariate model (rho) in Table 9 is statistically significant and the bivariate model might be more appropriate, we will compare the estimated results side-by-side since our paper is one of the first studies trying to proxy *Lab Number* as one of the key R&D inputs.

We clearly observe that the marginal effects for product innovation are generally larger than those of process innovation. For the innovation equation, we also find that being a foreign plant or BOI-promoted plant is not related to being more innovative both in terms of process or product innovation. The negative and insignificant results for BOI are in line with Jongwanich and Kohpaiboon (2011). We also find a positive and statistically significant relationship between exports and a firm's decision to invest in product development. This reflects the idea that exporters tend to learn more about competing products and customer preferences in international markets. For selected industries, plants in the food production (Industry division 15), chemical production (Industry division 24), and non-metallic mineral production industries (Industry division 26) are more likely to innovate, especially in the aspect of product innovation. In contrast, plants in the apparel (Industry division 18), wood production (Industry division 20), and metal production industries (Industry division 28) are less likely to innovate both for process and product innovation. Our results confirm the positive role of exports in R&D decision found by Jongwanich and Kohpaiboon (2011), and uncover additional determinants of innovation such as energy saving status and waste management status. The use of *Lab Number* is also to show the qualitative differences between the natures of innovation activity undertaken in smaller firms, which may have few or have no formal R&D units, and those of larger firms, which may have formal R&D laboratories (Schumpeter, 1942).

From Table 7 and Table 8, in contrast to some previous studies, we find that government funding or aid plays an important role for a plant to engage in R&D activities and to be innovative, especially in terms of product innovation. On one hand, the demand-pull aspect of a plant such as energy saving and waste management systems is a crucial determinant of innovative effort. On the other hand, the economic organization of a plant (Head Branch type) and location (the central region) also affects the probability of a plant being more innovative. According to the literature in this field, plant size may affect innovative effort. However, from our estimated results, we find that it is not the first or an important determinant since we only observe a weak relationship between plant size and innovative indicators. In short, plants operating in exports markets, relatively larger plants, and plants belonging to the chemical sector have a higher likelihood to innovate, especially in product innovation. In contrast to Jongwanich and Kohpaiboon (2011) and Berger (2010) which find relatively unimportant role of public financial support in stimulating R&D and innovation expenditure in Thailand, we find a positive relationship between government support (*Gov Aid*) and product innovation. Nevertheless, we confirm the same results for a negative relationship between BOI and product innovation. One explanation for previous negative signs for BOI is that, with weak national innovation system and surrounded by firms and public organizations that lack innovation capabilities, innovative firms might prefer to stay away from innovation collaboration since the perceived costs (knowledge losses) may be higher than the benefits (knowledge gains). In contrast, less capable firms (need to) seek cooperation in order to pool scarce resources and knowledge to enhance their innovative capabilities (Intarakumnerd et al. 2002; Berger 2010).

4.3 Productivity Function

Finally, we consider our results for the productivity equation shown in Table 10 with various OLS estimators to compare and check the robustness of our estimated results. The results are shown for both univariate probit model and bivariate probit model. The details of the OLS estimators employed in Table 10 can be described as follows; *reg* is the OLS estimator with robust standard errors, *rreg* is robust regression and this estimator yields a highly efficient M-estimator (an alternative to least squares regression used for the purpose of detecting influential observations), *qreg* is median (quantile) regression and this estimator protects against vertical outliers but not against bad leverage points, and *mmreg* is the estimator which yields a MM-estimator that combines high breakdown points and high efficiency[8]. Industry dummies are included but not reported in the table to save space. It is clear from Table 10 that the results from various OLS estimators yield the same direction and sign of estimated coefficients and only differ in magnitude.

In terms of general sources of productivity, exporting plants, foreign plants, plants with high capital and material intensity are more likely to be productive. The negative values of the coefficients for labor quality indicate that lower labor quality is associated with higher levels of productivity. This is surprising but the reason may be that the majority of manufacturing plants in Thailand are still in labor-intensive industries and these industries do not require highly skilled workers. Moreover, the education system in Thailand is not highly ranked and there are also some deficiencies in the training of workers in both the private and manufacturing sectors (World Bank, 2007). Foreign plants usually tend to have higher productivity and use more modern equipment than domestic enterprises in Thailand. Specifically, having foreign equity participation and involving in export markets is associated with approximately 10 to 20 percent increase in labor productivity. The plant size, measured by number of employees, also plays a crucial role in determining the level of productivity with larger plants being more productive on average.

The results for product innovation are conclusive. Product innovation increases productivity by 3 to 4.7 times in productivity equation in the univariate probit model, and increases productivity by 1.4 to 2.2 times in productivity equation in the bivariate probit model. However, the results for process innovation are mixed. On one hand, if we consider findings in the univariate probit case, process innovation decreases productivity by 3 to 4.5 times. The negative results are in line with previous studies from Berger (2010) and Jongwanich and Kohpaiboon (2011). This may imply a lack of efficiency in the innovation

[8] A discussion of these methods is beyond the scope of this paper; see Verardi and Croux (2009) for an introduction with a view on applications (plus Stata code) and for references to the theoretical literature.

process of Thai plants and/or process innovation may have a time lag before they can fully enhance labor productivity and/or process innovation may not be related with the number of lab units in our study. On the other hand, findings in the bivariate probit case indicate that process innovation enhance productivity by 2.4 to 4.4 times. This may conversely imply an aim of the process innovation could be to reduce production costs and that we expect that process innovation is more relevant in the Thai context than the product innovation. Overall, if we consider the univariate probit model, we observe from the estimated results that there is a negative impact of process innovation on productivity. Instead, if we consider the case for the bivariate model, we find that there is a positive relationship between process innovation and productivity.

Particularly, if we consider only for the bivariate probit model, two puzzling findings in the univariate probit case (the negative relationship between the number of laboratory units (as the proxy measure of R&D) and innovation, and the negative relationship between process innovation and productivity), would be resolved. In fact, we can look at the estimated rho (r is the correlation coefficient between the bivariate outcomes). If rho is statistically and significantly different from zero, we should use the estimated results from the bivariate probit model as our benchmark results since the decisions (regarding process innovation and product innovation) are interrelated in modeling of process innovation and product innovation (rho is shown in Table 9 to be statistically significant). However, since this is cross-sectional analysis for one year, it is possible that we may obtain some surprising results (i.e. the above two puzzling findings). Therefore, both the estimated results from the univariate and bivariate probit models are provided side-by-side for comparison. Nevertheless, it is obvious from the estimated results that, in any case, there is a positive relationship between product innovation and productivity. This indicates that product innovation is likely to be an important and promising source of the productivity improvement of plants in the Thai manufacturing sector. In contrast, depending on research methodology and the nature of data, process innovation might exhibit unexpected signs. The wrong sign could also be caused by the usage of cross sectional data (Berger, 2010). Another explanation for negative process innovation could be that process and product innovations are closely linked and hard to separate from one another. Panel data would be more ideal for future analysis. Nevertheless, product innovation can be an important driver of productivity growth in Thai manufacturing apart from exporting and foreign direct investment. For the Thai case, Innovation might also be a condition for the transformation process from being traditional production-oriented industries to becoming more oriented towards knowledge intensive production (Dilling-Hansen and Jensen, 2011).

Table 10: Productivity Equation

LnVAL	Productivity Equation (after Univariate Probit)				Productivity Equation (after Bivariate Probit)			
	(1) OLS	(2) Robust OLS	(3) Median Reg.	(4) Robust MM Reg.	(1) OLS	(2) Robust OLS	(3) Median Reg.	(4) Robust MM Reg.
Capital Intensity	0.224***	0.160***	0.169***	0.146***	0.222***	0.222***	0.168***	0.146***
	(57.75)	(66.06)	(58.83)	(49.16)	(57.69)	(57.69)	(58.78)	(49.05)
Material Intensity	0.417***	0.560***	0.523***	0.574***	0.416***	0.416***	0.522***	0.573***
	(62.65)	(262.36)	(207.12)	(138.95)	(62.53)	(62.53)	(207.31)	(138.36)
Labor Quality	-0.331***	-0.179***	-0.204***	-0.144***	-0.329***	-0.329***	-0.196***	-0.144***
	(-13.50)	(-8.40)	(-8.10)	(-6.74)	(-13.45)	(-13.45)	(-7.84)	(-6.73)
Foreign	0.203***	0.118***	0.126***	0.0974***	0.209***	0.209***	0.142***	0.101***
	(8.29)	(5.07)	(4.59)	(4.63)	(8.45)	(8.45)	(5.21)	(4.78)
Exporting	0.289***	0.214***	0.229***	0.207***	0.238***	0.238***	0.203***	0.178***
	(15.89)	(11.35)	(10.27)	(12.35)	(12.54)	(12.54)	(8.85)	(10.25)
Process Innovation	**-4.582*****	**-3.401*****	**-3.433*****	**-2.904*****	**4.435*****	**4.435*****	**2.862*****	**2.407*****
	(-15.60)	(-10.79)	(-9.22)	(-10.82)	(8.39)	(8.39)	(4.94)	(5.05)
Product Innovation	**4.734*****	**3.518*****	**3.521*****	**2.995*****	**2.195*****	**2.195*****	**1.498*****	**1.378*****
	(17.23)	(12.00)	(10.16)	(11.90)	(13.87)	(13.87)	(7.26)	(9.60)
Size 2-50	-0.00594	0.0959	0.0857	0.0717	-0.0257	-0.0257	0.0587	0.0457
	(-0.12)	(1.81)	(1.37)	(1.73)	(-0.53)	(-0.53)	(0.95)	(1.10)
Size 51-100	0.257***	0.233***	0.257***	0.199***	0.224***	0.224***	0.222***	0.167***
	(5.31)	(4.31)	(4.03)	(4.70)	(4.54)	(4.54)	(3.51)	(3.92)
Size 101-200	0.282***	0.251***	0.247***	0.219***	0.241***	0.241***	0.228***	0.187***
	(5.79)	(4.59)	(3.83)	(5.25)	(4.85)	(4.85)	(3.56)	(4.43)
Size 201-500	0.281***	0.243***	0.273***	0.217***	0.167***	0.167***	0.182**	0.140***
	(5.80)	(4.37)	(4.15)	(5.19)	(3.35)	(3.35)	(2.79)	(3.30)
Size 501-1000	0.360***	0.291***	0.302***	0.254***	0.146**	0.146**	0.154*	0.116*
	(6.59)	(4.50)	(3.96)	(5.32)	(2.60)	(2.60)	(2.03)	(2.38)
Observations	49432	49432	49432	49432	49432	49432	49432	49432
Adjusted R2	0.642	0.751			0.643	0.643		

Source: Author's calculation **Notes:** Robust t-statistics in parentheses. Industry dummies are included and ***, **, * indicate a significance at 1, 5, 10 percent, respectively.

Table 11: Percentage Difference in Labor Productivity (VAL) among Plants

Average Labor Productivity of Plants with and without Innovation in the Sample						Percentage Difference in VAL
Type of Plant	Observation	Mean	Std. Dev.	Min	Max	Compared to non-innovative plants
Process Innovation	1367	1056925	3245375	1225	8.79E+07	127.23%
Product Innovation	1550	991695.4	3058226	2500	8.79E+07	123.36%
Process & Product	1001	1137167	3723510	2500	8.79E+07	131.49%
No Innovation	47516	235032.1	1484607	12.96296	2.37E+08	0

Source: Author's calculation

In addition, we can see in Table 11 that the percentage difference in average productivity of the innovative and non-innovative plants is approximately 120 to 130 percent in our sample. This indicates that both process and product innovation may play a crucial role in determining plant productivity. Lastly, with more available data in the future, it is noteworthy that this issue should be closely re-investigated to provide more solid evidence for the Thai case.

5. Summary and Conclusions

Innovation, R&D and productivity have long been considered as the main sources of economic growth for many countries. The recent poor productivity and firm performance of Thailand compared to other countries in Southeast Asia has been a key focus for government policy in recent years. In response to current concerns regarding lagging productivity and poor innovative performance in Thailand, this paper empirically investigates the relationship between innovation, R&D, and productivity in the Thai manufacturing sector. This study is among one of the first studies for the Thai case to estimate a structural model that describes the link between R&D input, innovation output, and productivity empirically using the enriched Industrial Census data of Thailand. Importantly, our econometric model is aware of the fact that some plants may engage in innovation efforts, but do not explicitly report them as R&D in the data since we apply the CDM model to the case of Thai manufacturing.

Specifically, the main contribution of Crépon et al. (1998) and Griffith et al. (2006) is their design of the structural model appropriate for empirical studies based on information regarding non-innovative firms and innovative firms (Johansson and Lööf, 2009). However, it should be noted that the CDM model is accounting for relatively strong assumptions and potential endogeneity problems. As we emphasize in presenting our results, a major drawback of our data is that it is cross-sectional, so we do not observe many of the same plants repeatedly over time. This means that we need to take great care in interpreting our results. On the whole, our major finding is that government aid or funding and plant characteristics play an important role regarding the decision for a plant to engage in R&D and to be innovative both in terms of process innovation and product innovation. Exporting plants, plants in the central region, and plants that are categorized as Head Branch type are more likely to engage in R&D. Specifically, our results reveal that plants in the food production industry (Industry division 15) and the chemical production industry (Industry division 24) are more likely to invest in R&D and are more innovative compared to plants in other industries.

More importantly, our results from the structural model also provide further insights into the complex relationship between innovation, R&D and productivity. The type of industry and specific technological characteristics of plants are shown to influence the decision to undertake R&D. Interestingly, while the sign of the coefficients for product innovation is consistently positive, the sign of the coefficients for process innovation can be either negative or positive depending on research design (and possibly the nature of data). Explicitly, capital and material intensity, exporting status, plant size, and product innovation appear to be important determinants of productivity in the Thai manufacturing sector. In general, firms in Thailand tend to lag behind firms in other Southeast Asian countries in innovative performance whether they are multinational enterprises, state-owned enterprises, or small-medium enterprises (World Bank, 2010). The majority of Thai firms do not invest in R&D, but rather in technological learning through acquisition of existing technology, reverse engineering, testing, and quality control. Only a small minority of large subsidiaries of transnational corporations (TNCs), large domestic firms and SMEs have capability in R&D and innovation. Most SMEs are concerned mainly with building up basic operational capabilities, and using technicians to obtain and gradually improve fairly standard technology (Intarakumnerd, 2007).

In addition, government efforts have generally done little to strengthen the innovative or absorptive capabilities of Thai suppliers as most firms do not avail themselves of government programs including R&D tax incentives, subsidies and grants, and technical and consulting services (OECD, 2010). Moreover, fragile and sporadic links between government agencies and firms have contributed to the government's poor record in helping to detect, support, and aid the growth of local technological capacities (Doner et al, 2010). It is obvious that Thailand is placed at a relatively low rank in the context of R&D and innovation at both the aggregate and firm levels. The stage of development towards knowledge economy is underway in Thailand, but still not in a favorable condition due to the lack of firm incentives and full support from government. Based on our findings, the main issue will be initiating new knowledge for firms through basic research and R&D spending and developing strong linkages in universities, research and government institutions as a foundation for knowledge creation and technology catching-up (OECD, 2008).

Last but not least, despite some initiatives and policy attempts, innovation effort in Thai manufacturing has been limited due to a failure to coordinate agencies and policies. Further improvements are needed, specifically in the institutional arrangements for the coordination of national science and technology policies (Intarakumnerd, 2010). It is hoped that there will be future research on this issue to help clarify solid conclusion for the Thai case.

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The Evaluation of Company's Intangible Assets' influence for Business Value

Živilė Savickaitė[1]

Abstract

Mismeasurement of intangible assets in a company may result in high costs and loss of it's competitiveness and position in the market. Conventional evaluation methods are not able to identify reliably intangible intensive business value because of such assets specificity. Therefore, the business assessment process adjustment, making it comprehensive and including the intangible asset valuation methods is a critical process that allows to evaluate companies better and increases business management efficiency and quality. The article states the importance of further scientific research in the areas of the intangible value resources, creation of business valuation, intangible assets valuation methods and models - the creation of intangible assets on the firm level and how they meet changing needs of the company's owners, capital markets investors, politicians and other interest-groups needs in the intangible intensive economy should be analysed as well as how economic systems based on intangible assets operates. Also special attention is be given to the strenghtening of the cooperation of scientific research and business. Its important to avoid a repeat of guidelines, methods, models and systems of intangible assets' measurement and business valuation methods and to eliminate it's disadvantages in order to create and establish universal system for effective intangible intensive business valuation.

Keywords: intangible assets, business measurement process, models

JEL Classification: D24, E22, G12

1. Introduction

It is very difficult to evaluate intangible assets as a whole. Although human capital, structural capital, and relational capital lead to superior firm operational and financial performance (Wang et al., 2014). Ross et al. (2005) provides the comprehensive classification of company's resources with the distinction of monetary, physical, relational, organizational and human resources to tangible and intangible assets as well as to traditional accounting assets and intellectual assets which illustrates the complexity of identification and understanding of intangible assets in business processes. Respectively, evaluation

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process is complicated mainly because of such assets nature, namely dependence from human factor (especially the intellectual capital). Moreover, it is not possible to evaluate some elements of intangible assets properly at all. Many scientists have analysed the intangible assets conception and offered models for its'evaluation, both financial and non-financial. Lev (2001), Hagg and Schentz (2006), Hall (1993), Villalonga (2003), Rodgers (2003), Palliam (2006), Worthington and West (2001), Daum (2001), etc. analysed the financial measurement tools and models of intangible assets while Roy (1999), Kannan, Aulbur (2004), Rodov, Leliaert (2002), Klaila, Hall, (2000), Sveiby (1997), Norton and Kaplan (1992), Letza (1996), Marr and Adams (2004), Martin (2004), etc. concentrated on non-financial measurement models creation, analysis and improvement. But there are only a few studies that compare research results on intangible assets measurement and there barely are research papers comparing financial and non-financial models which are mostly used for intangible assets' evaluation. In 2000 European Commision published a study on recognition and evaluation of intangible assets called 'The Intangible Economy'. The following findings were stated by the experts in the Study:

- There are too many different definitions and classifications for intangible assets at micro and macro level, which causes its' recognition and measurement difficulties;
- It is difficult to separate extraneous users of the intangible assets (the problem of public good arises), so company cannot adopt all benefits from investment in such assets;
- It is difficult to evaluate reliably imputs needed, future products, time, amount of the benefit for a company from these assets (the problem of uncertainty);
- The transfer or exchange of intangible assets is complicated on as it has no physical form (the problem of making agreements).

Mentioned conditions are the main causes of a misleading measurement of intangible assets. On the other hand, even if the measurement is difficult (sometimes even impossible), ignoring of intangible assets usually results in negative outcomes for a company. Outcomes can be divided into four levels:

Company level – risk of choosing a wrong strategy; *Industry level* – inadequate allocation of resources within an industry; *Capital market level* – underevaluation or overevaluation of companies, instability, inadequate allocation of capital resources; *Country (Europe) level* – inadequate choose of policy based on misleading ratios. It is obvious that mismeasurement (not measurement at all) of intangible assets is closely related within all levels – the mismeasurement of intangible assets in a separate company determines inaccuracy of measurement in the industry, which in turn causes misleading decisions in higher levels. It is very important because effective measurement of assets is crucial for company results as it directly affects decisions, choices, allows perception of real value of business and its disclosure inside (employees, internal processes and environment) and outside (customers, community, investors) the company. So the problem of the research is what models are mostly used for intangible assets measurement. The aim of the research is to analyse the mostly used intangible assets' measurement models, evaluate its' advantages and disadvantages and usage possibilities. The object of the research intangible assets' measurement. The main objectives of the research are:

- To explain the classification of intangible assets' measurement models;
- To analyse financial and non-financial intangible assets' measurement models;
- To compare advantages and disadvantages of intangible assets'measurement models.
- To provide further guidlines for intangible assets'measurement and definition of business value.

Methods of the research: comparative analysis of scientific literature and statistical data, sace study.

2. The classification of intangible asstes' measurement models

Although intangible assets are difficult to measure, its importance in economy is growing. Therefore various systems and methods are made and analysed. Since 1950 researchers presented 34 models for intangible assets valuation (European Commission, 2003). All models can be grouped in four categories: *financial, non-financial*, *holistic* and *detailed*. Depending on the measurement methods used models are classified into four groups (Rumizen, 2002):

1) *Direct Intellectual Capital methods (DIC)* – these models are able to capture the financial value of intangible assets by identifying various its components. When such components are stated, they are measured directly, individually or as cumulative ratios.
2) *Market Capitalization Methods (MCM)* – the difference between company's market capitalisation and it's share holders equity are measured. It is considered as the value of company's intangible capital.
3) *Return on Assets methods (ROA)* – material assets and financial growth ratios of a company are compared with the same ratios and values of a particular industry. Income which is above the average is used for companies' intangible assets measurement.
4) *Scorecard Methods (SC)* – various components of intangible assets or intellectual capital are indentified as ratios and indexes in the models and after they are shown in special scorecards and diagrams.

Hereinafter eight models of intangible assets' measurement are analysed. Four of them are financial and four are non-financial. Also this analysis covers both holistic and detailed models in order to reflect its' reliability, efectiveness, advantages and disadvantages fully which is crucial for the estimation of intangible assets measurement system potential.

3. Intangible assets measurement models

3.1 Financial models

Market – to – book value ratio is usually used as an intangible assets' measurement model for investment decisions. Using this ratio company's market capitalization and its book value is compared. Intangible assets can be both included and not included in to this ratio calculation, however if it is aimed to evaluate company's intangible assets effectively it has to be included into calculation. Since usually some intangibles are not registered in accountancy (e.g. intellectual capital or brand value), company's book value does not reflect the real value of it. So it is assumed that the market value, by contrast, reflects not only the material, but also its intangible value. Comparing the market and book value, it is possible to evaluate the intangible assets held by the company. It will include a market capitalization value which exceeds the book value of the company, recorded in the balance sheet.

Tobin's Q value is based on hypothesis that company's market value is close to it's replacement costs. 'Working capital' in this case is the capital company gets benefit from. Capital replacement costs are costs which appear for company's owner on purpose of buying a substitute of asstets company has (Hagg and Schentz, 2006). If Tobin's Q ratio is above 1, company's market value is higher that its book value, so market value reflects unvalued and unregistered company's assets – usually intangible assets, which are imput of knowledge, prestige, technologies etc., but not registered in the accountancy. According to Hall (1993) intangible assets are evaluated by the market, but it is not included in the evaluated company's capital. In order to maximize company's value it has to be invested considering its capital value changes in the market. Villalonga (2003) states that the real value of tangible assets is its replacement cost – price of assets with the equivalent productivity. Researcher notices that material assets is capitalised while intangible assets are written off with regular expenses. Intangible assests value can be estimated by the difference between company's market value and its replacement costs. That is why Tobin's Q ratio is extremely high in the research and development or intensive advertising areas operating companies.

Economic value added (EVA) is a measure of the business, which includes the calculation of capital costs and also is a management control system component in individual business units (Palliam, 2006). Capital cost here is Weighted Average Cost of Capital. EVA is calculated adjusting company's profit according its expenses for intangible assets. EVA changes allow identifying if intellectual capital is productive. In other words, EVA is profit of a company after capital financing cost is deducted. Bose (2004) highlights that EVA model is concentrated for maximizing the wealth of shareholders, but it is very effective for business planning and control of business processes too. However, for effective use of model company is required to make many adjustments (164 are counted). Their main objectives are (Worthington and West, 2001):

1. Get the value of the EVA, close to the cash flows, and therefore less exposed to the accounting distortions;
2. Aside the distinction between investments in tangible assets which are capitalized and in intangible assets, which are often written off as expenses when incurred;
3. Do not allow goodwill amortization and write-downs;
4. To correct deviations caused by mismeasurement in the accountancy.

Intangible assets are not automatically debited to the cost in EVA system. Since EVA is a tool to measure the business value added, it will increase if (The Antidote Issue 3, 1996):

1. The new capital is invested in the company and it earns more than it costs;
2. Capital is taken out of business if it does not cover its costs;
3. NOPAT or Net Operating Profit after Taxes increases, but there is no increase in capital employed.

EVA can be influenced by four groups of factors: innovations, customers, financial and inner factors. From the economic point of view, value is created when a company's income is in excess of the economic cost of such income. And this value is the value of intangible assets company has.

Knowledge capital value (KCV) is a model which evaluates intangible assets from macro perspective, i.e. in the beginning general company results (income) are evaluated and then it is identified which assets generate such income (Daum, 2001). Knowledge capital value ratio reflects not only historical data and results, but also a future perspective and potential of a company. In order to evaluate intangible assets comprehensively Daum (2001) in his study beyond knowledge capital value states other calculated ratios (change of knowlegde capital income, knowledge capital/book value, market value/book value etc.), which are given in a special table called konwledge capital card.

More details about financial intangible assets' measurement models are given in the Table 1.

3.2 Non – financial models

Skandia Navigator model uses 164 measuring and recording instruments in total – 91 for the intellectual capital and 73 traditional means of measuring and recording – in order to focus on five key spheres of company's activity: finance, human, customers, processes, renewal and development (Kannan, Aulbur, 2004). Financial focus includes the company's financial performance. Here long term goals are stated, namely level of profitability, growth rate, which are required by shareholders. The indicators in this area capture the company's performance in monetary terms. Customer focus allows identifying how well organization and services (or) products meet customer needs. It reflects the attitude of the company from outside to inside (key performance indicators: number of accounts, number of lost customers, and number of agents). Processes focus is based on individual customer desired product and service development processes. Focus center here is associated with the internal business processes and a structural capital of the company plays an important role. Indicators in this field record company's infrastructure in terms of how effectively it carries out its activities (key performance indicators: number of accounts per employee, the administrative costs per employee). Renewal and development focus allows organizations to verify its long-term renewal and stability. Indicators in this field shows regenerative potential of a company, namely how it is able to respond to changes, future perspective and planned development (key performance indicators, employee satisfaction index, marketing cost per customer, number of hours of training). Human are organization centre and they are necessary for the organization that develops value. Knowledge creation process takes place particularly in this section. The importance of workers satisfaction with the work situation has to be stressed, as satisfied staff means satisfied customers, increasing enterprise sales, and improving its performance. The indicators in this area, which is the most dynamic, record the diversity and innovation of a company (key performance indicators: changes in staff, number of managers, number of women in management positions, training costs per employee).

Financial ratios are the information of the past performance of a company, customers, people and processes reflect the current situation of a company, and the renewal and development shows future perspectives (Bose, 2004). Although various intellectual capital measurement indicators can be excessive and duplicate each other, it is recommended to use no less than 112 measurement instruments in Skandia Navigator. Skandia Navigator does not set a cash value for intellectual capital (corporate intangible assets), but uses the instruments that can track changes in the value-added creation processes trends in an enterprise. However, it should be noted that ratios that are used in the model are highly subjective and can not be generalized or standardized (Kannan, Aulbur, 2004).

The Intangible Assets Monitor is intended for companies with high intangible assets - knowledge-based organizations. Klaila and Hall (2000) indicate that the intangible asset monitor is aimed at highlighting the results of intangible assets usage and it is a tool for long-term knowledge management strategies for enterprise development and monitoring. The model can be integrated into management information systems. Intangible assets are classified into three categories in the model: External structure; Internal structure and Competence. Patents, ideas, models, computer and management systems belong to the internal structure. These assets are created by employees, so it is under company's ownership. 'Culture' and 'spirit' of a company also belong to the internal structure. Relations with customers and suppliers, brands, reputation and image belong to external structure. In public organizations society may be external agent. The company's internal departments also have their internal customers, which may also form the external structure. Employees' ability to act in various situations belongs to competence category.

Table 1: Financial intangible assets' measurement models

Model	Market-to-book value ratio	Tobin's Q value	Economic value added (EVA)	Knowledge capital value
Definition	Measures the relative value of a company compared to its stock price or market value	Measures the relative value of a 'working capital' compared to replacement price of the capital	Economic profit or sum by which revenues exceed or fall below the minimum rate of return required by shareholders or creditors, which they could receive by investing in other securities with similar risk levels	General company results (income) are evaluated and then it is identified which assets generate such income.
Calculation	$\frac{\text{Market capitalization}}{\text{Book value}}$	$\frac{\text{Market value of installed capital}}{\text{Replacement cost of capital}}$	$EVA = (r - c)\, x\, K$	$KCV = \frac{Normalized\ income - Income\ from\ tangible\ and\ financial\ assets}{Rate\ of\ return\ of\ knowledge\ capital}$
Meaning	Ratio above one suggests the company is undervalued, while a ratio over one suggests the company might be overvalued.	If the market value reflected solely the recorded assets of a company, Tobin's q would be 1. If Tobin's q is > 1.0, then the market value is greater than the value of the company's recorded assets. This suggests that the market value reflects some unmeasured or unrecorded assets of the company. If Tobin's q is < 1, the market value is less than the recorded value of the assets.	NOPAT - Net Operating Profit After Taxes; c - Weighted Average Cost of Capital; K - Capital employed. Shareholders will receive a positive value of the EVA, when return of capital employed in business operations is greater than the cost of such capital.	Normalized income – average of three-year historical average basic income and three-year „IBES International" analysts average income forecast; Rate of return of knowledge capital – 10, 5%.

Model	Market-to-book value ratio	Tobin's Q value	Economic value added (EVA)	Knowledge capital value
Advantages	- Most useful when valuing knowledge-intensive companies, where physical assets may not accurately or fully reflect the value of the business; - Simple and easy to use; - Can be quickly adapted by a company	- Simple and quickly adapted for usage; - Covers a whole value of intangibles and a value of its' separate parts; - Useful for investment decisions	- Model can be used for a whole company, separate department, production line etc.; - Intangible assets are not written-off to expenses, adjustments in accountancy for its evaluation are made; - Model includes capital costs, so it determines better investment decisions, identification of activity improvement, evaluation of top management decisions	- Measurement is future orientated, model has a prognistic abilities; - Adjusted to intangible assets particularities ratios are used in the calculations
Disadvantages	- Model covers a whole value of intangibles, but not of its' separate parts; - Sensitive for speculations in the market; - Risk of inaccurate company data (book value)	- Sensitive for speculations and the value changes in the market; - Not always can be used (e.g. during the periods of big inflation company's asstes book value is not able to reflect replacement cost of it	- Complexity of the model (164 adjustments needed); - Data from balance sheet is used which does not reflect the present value of assets; - It is ifficult to evaluate the amount of capital employed in the company; - Model is difficult to use for comparison of companies.	- Very subjective model, because normalized income are based on subjective forecasts; - Model covers a whole value of intangibles, but not of its' separate parts; - It is difficult to make comparisons within particular industry or economic sectors

Source: prepared by author.

People set up two types of intangible structures - internal and external. In the outer structure company is trying to show up as accurately as possible to its agents, i.e. customers, creditors, shareholders, when in an internal assessment the main aims is to gather more information in order to monitor performance and take appropriate actions. Analysis using this model is made through the 4 ways of creating value: Growth rate/volume, Renewal/ innovation, Effective usage and Risk minimization. It is important to construct indicators correlated with each way of creating value - real assets value growth, the renewal rate, how efficiently it is used and what is risk of its loss. These indicators usually are selected individually according to the company's strategy.

Balanced Scorecard model's basic idea is the critical success factors analysis on the basis of the four business perspectives. Each persspective is evaluated in accordance with the objectives formulated, the selected indicators, the challenges and initiatives. The main aim of Balanced Scorecard system is to move the company's mission to the concrete, perceived targets and indicators. This system retains traditional financial indicators, in retrospect reflecting events that have occurred, but it also adds to the mentioned indicators the outlook of the future perspective. The essence of financial perpective is the identification of shareholders needs.

According to the Balanced Scorecard Institute (2010), timely and accurate financial data always takes priority area in a company, but when the company's management concentrates measurement exclusively on this area, the imbalance in the assessment of other perspectives of company appears. Customer perspective objectives indicate how the company is focused on customers and what company has to do that customers would be satisfied with the firm's activities. These factors are key factors, because if customers are not satisfied with the activities of the company and its products, it is probable that they will find another supplier that will meet their needs. Operational inefficiency in this perspective is a factor leading to decline in the company in the future, even if the current financial results are favorable. Processes perspective aims specify what company should do to have effective business processes in order to meet customer and shareholder expectations. Perspective is focused on internal business processes. So continuous monitoring of processes quality and processes structural efficiency is impelemented. Process indicators enable managers to assess how effectively they operate their business and whether they offered products and services meet customer expectations (company's mission). Aims of the development and innovations persective specify what is needed to be done in order to have well prepared and motivated company's workforce, in which way the possibility for rapid change and improvement is ensured and what is the company's IT potential. The ability to maintain adequate staff qualification level and the proper handling of IT potential of the firm guarantees not only its survival, but also allows company remains competitive and develops its business. Training and innovation perspective includes both individual and corporate development. Employees are a key knowledge resource in a company, so in a constantly changing technological environment, it is necessary to create a continuous learning environment. In order that Balanced Scorecard would work effectively, it is necessary to formulate the company's strategy accurately and express it in specific strategic objectives, identify the links between strategic objectives and their achievement indicators and give descriptive information to all the company's divisions. It is also important to continually plan, establish the goals and strategic initiatives and develop strategic feedback and awareness at corporate level.

Value Chain Scoreboard is a 3 × 3 sized matrix, structured according to three levels of the value chain model: 1) Discovering and learning; 2) Implementation; 3) Commercialization. At each level B. Lev identifies three dimensions in which each company should set appropriate targets for computation, which can provide information to both internal and external business stakeholders interested in efficiency of business. But companies should not be required to fill each cell arrays - it can be used creating also 10-12 set of indicators. Value Chain Scoreboard is an information system, which primarily emphasizes the economic value of the company created by the intangible assets. One of the main objectives of the model is to standardize information relating to intangible assets of the company. The model consists of nine blocks of indicators that provide information about the innovation life within a company. The first phase of discovery and learning, including investments in research and development, brand awareness building, information technology, is the one in which new products and services, or processes are developed. The second is the implementation phase. Technical justification of products, services or processes is carried out and feasibility studies (e.g. clinical trials) are made. The last stage is called commercialization. It includes the products and services release to the market. At each stage the company's created value varies, so with different selected indicators it is possible to monitor the extent of these changes. Since most companies value is created (determined) by intangible assets' changes or its usage efficiency, the model allows the company to monitor and evaluate the intangible assets in these aspects.

Intellectual Capital Statement is a strategic management instrument for assessing and developing the Intellectual Capital (IC) of an organisation. It is constructed within the collective research project 'Intellectual Capital Statement – Made in Europe' (InCaS) funded by the European Commission (2007). It shows how IC is linked to corporate goals, business processes and the business success of an organisation using indicators to measure these elements. An Intellectual Capital Statement assesses the internal capabilities, i.e. a firm's intangible resources, from the point of view of external strategic objectives, e.g. growth, market position, customer satisfaction etc. The approach of conducting an Intellectual Capital Statement is divided into five steps (Management meeting, 1st workshop on IC analysis, internal work on measurement, 2nd workshop on strategy refinement and measures and internal work on final documents) with each step building on the prior one. The Intellectual Capital Statement implementation is a workshop-based procedure involving a selected number of employees from the implementing organisation.

More details about non-financial intangible assets' measurement models are given in the Table 2.

Table 2: Non - Financial intangible assets' measurement models

Model	Skandia Navigator	The Intangible Assets Monitor	Balanced Scorecard	Value Chain Scoreboard	Intellectual Capital Statement
Definition	Identifies company's particular assets that determines effectiveness and crates value added and creates preconditions for sustainable competitiveness.	Captures the efficiency of intangible assets, including tangible and intangible investments.	The strategic management system, transforming the company's strategy to daily operations and controlling the implementation of the strategy.	Continuous monitoring of the effectiveness of the business and intangible asset valuation method, in which performance is correlated with assets development or growth, as well as its recovery rate, efficiency and risk of loss	Strategic management instrument for assessing and developing the Intellectual Capital (IC) of an organisation. It shows how IC is linked to corporate goals, business processes and the business success of an organisation using indicators to measure these elements.
Structure	5 areas of focus: - Finance; - Human; - Customers; - Processes; - Renewal and development	Intangible assets are classified into three categories: - External structure; - Internal structure; - Competence Analysis through the ways of creating value: - Growth rate/volume; - Renewal/innovation; - Effective usage; - Risk minimization	Each company's activities (its vision and strategy) are assessed according to four perspectives: financial, relationships with customers, internal business processes, staff training, development and innovation.	3 x 3 size matrix, structured according to three levels of the value chain model: 1) Discovering and learning; 2) Implementation; 3) Commercialization.	The structural model describes the main elements of the ICS as well as their interrelations: - Human Capital (HC) - 'what the single employee brings into the value adding processes'; - Structural Capital (SC) -'what happens between people, how people are connected within the company, and what remains when the employee leaves the company'; - Relational Capital (RC) is defi ned as 'the relations of the company to external stakeholders'; - Business Processes (BP) which are chains of activities within an organisation and their network-like contexts; - Knowledge processes (KP).

Model	Skandia Navigator	The Intangible Assets Monitor	Balanced Scorecard	Value Chain Scoreboard	Intellectual Capital Statement
Advantages	- The model is a tool to assess the intangible assets of the firm and also a management reporting system at the same time; - It allows companies to identify activities that create high value added for gaining sustainable competitive advantage; - It gives the scheme of the perception of the value, which sets out key value-generating intangible sources	- Captures the effectiveness of the use of intangible assets, including tangible and intangible investments; - Shows non-physical flows and changes that are resources of the value development of the enterprise; - Allows the identification of results of performance based on intangible assets, and development of a long-term Knowledge Management Strategy; - Promotes communication within the company	- Allows identification of the intangible assets as factor of operating performance improvement and effectiveness and monitors its development, as well as enables the company's management based on information available make necessary decisions and actions to improve performance efficiency; - Indicates that firms intangible assets are a key factor in determining its financial performance in the future; - The same report reflects the company's competitive advantage: orientation to customers, quality improvement, new product development time etc.; - The use of indicators in the model is chosen according to individual company's strategy and objectives.	- The model is able to provide quite detailed information about intangible assets changes and the efficiency of its usage in a company through created value; - Simple and easily adapted in a company; - Includes the intangible assets that are generated within the company; - Intangible assets evaluation is included in the management, strategic and control processes, as well as investors' analysis.	- Helps to determine strengths and weaknesses of strategic IC factors (diagnosis); - Prioritises improvement opportunities with the highest impact (decision support); - Supports the implementation of actions for organizational development (optimisation and innovation) - Enhances transparency and the involvement of employees (internal communication); - Diminishes strategic risks and controls the success of actions (monitoring); - Facilitates the communication of corporate value towards stakeholders (reporting).

Model	Skandia Navigator	The Intangible Assets Monitor	Balanced Scorecard	Value Chain Scoreboard	Intellectual Capital Statement
Disadvantages	- Model does not specify any numerical evaluation of intangible assets; - Its provided performance measurement tools are very individual to each company and their number is quite large; - A practical use of model is heavily dependent on workers' willingness to cooperate and record the information and work results; - effective information technology infrastructure is needed.	- Company employees must be fully equipped with the necessary information and have the ability to communicate information related to intangible assets with each other, what is not always easy to implement; - is not completely clear how to integrate the Intangible Assets Monitor to the other broader performance measurement systems in order to create relationship between the intangible sources of efficiency and performance results; - Does not specify any monetary evaluation of intangible assets and is very specific to each company according to the choice of indicators.	- The four perspectives in the model includes only the investors' and customers' wishes and needs, but do not include an analysis of employees, suppliers, business partners, local communities and other interest groups; - Training and innovation perspective is referred to as not very clear, so companies often do not include it while implementing model in its' operations so it can be assumed that the intangible assets of the company can be measured unreliably; - Indicators used in the model are very individual for each company.	- Does not assess all individual components of intangible assets; - Unable to quantify intangible assets; - Is not very accurate as changes in value are not always determined only by intangible asset's usage efficiency.	- Time consuming and resource intence implementation process; - Support material for the use is needed; - Its provided performance measurement tools are very individual to each company as it is set during workshops by company representatives; - Does not cover all intangible assets.

Source: prepared by author.

4. The comparative analysis of intangible assets' measurement models

In summary, analysing the intangible assets' valuation methodology it can be concluded that the intangible assets' valuation theory is quite widely analyzed by the world researchers, but there are still gaps in effective valuation ways for intangibles. The main models for evaluating intangible assets mentioned and constantly discussed in scientific journals are analysed in the article, what allows distinguishing the common advantages and disadvantages of valuation process.

Financial intangible assets measurement models are usually adjusted with relative ease in a company's business, it is quite easy to use and understand. They enable company to assess the overall value of intangible assets (some of which even a vale of an individual intangible asset), but they can be easily affected by changes in market and various speculations, since in many cases, the assessment is based on the real market value of the company. Non-financial models can not provide monetary value of intangible assets, however, they reflect the value creation process and significant changes in a company allowing companies to make reasonable decisions to improve operational efficiency. However, these models are often very individual, with a lot of different characteristics inside, requiring a lot of adaptations, and very dependent on the quality of information provided and a company's employees willingness to cooperate, making it hard to implement in the company. Also, comparability problem between enterprises arises, as each company choosing individual indicators of measurement, makes particular model very specific.

Scientific analysis of the proposed financial and non-financial intangible asset models shows that they are all valuable and innovative, because they represent the transition from the Industrial age, when primary role was given to tangible assets and material resources, to the Knowledge age, which is based on immaterial economy (Chareonsuk, Chansangave, 2008). However, despite these advantages, the models can be criticized for a lack of consistency, their insufficient credibility; subjectivity, when for every company model is individualized; depth, because the models are not able to perform a comprehensive evaluation of intangible assets. Significance of models also may be debatable since such factors as high subjectivity in choosing the most appropriate indicators for a company's activity, which reflect performance in the most favourable way for a company, also the lack of extra features of indicators and its very high specificity do not allow an objective evaluation of intangible assets. These features lead to the non-comparability between companies because each company (even acting in the same field or in the market and with a similar type of activity), the same model uses very specifically, so methods of intangible asset valuation also differs as well as reflection of its value. In this case models have the advantage that they can be quite simply and effectively adapted in each firm's business, but due to their individuality they lose universality, which could be stated as one of the biggest drawbacks. While performance comparison to other market participants is especially important in gaining a competitive advantage, because according to the results strategic decisions are made.

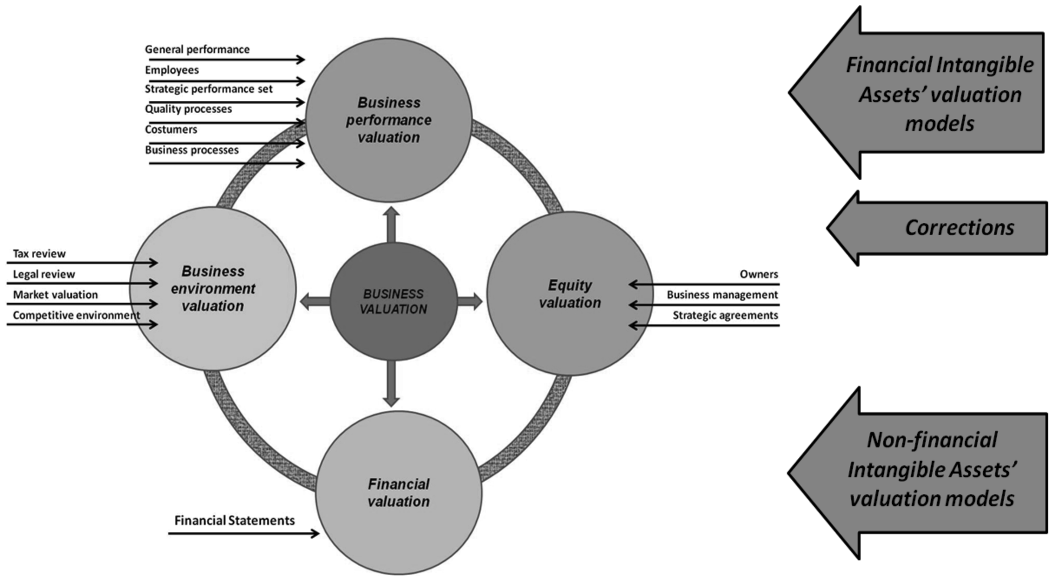
It is obvious that the economy already reached a level where it is based on intangible resources and assets and factors that influence innovation, technology and business process improvement, development and other changes. This means that the growing importance of intangible assets leads to new ways of value creation and new forms of economic organizations, which must be measured as well. According to Mehlman et al., 2010, it is a 'cooperative relationship base on the development of innovation'. Therefore, new types and quality information is necessary because the failure to appreciate the intangible assets or inappropriate, incorrect assessment of it causes high cost for business and determines the loss of market position. As shown in Figure 1, Intangible intensive business valuation process has to be improved substantially by evaluating, applying and adapting both financial and non-financial intangible assets valuation models to be complete. Appropriate corrections to meet the requirements and nature of intengibles have to be adopted in order to ensure the objecvity and comparability of the companies at the certain sufficient level. Better evaluation of intangible assets is very important both in the micro (enterprise) and macro levels, and appropriate methods used in micro-level allows to create a better performance indicators in the macro level. Considering the current methodology of valuation of intangible assets it can be noticed that convergence between the existing valuation models is necessary, but not creation of new models, because the existing measurement models cover various aspects of the intangible assets' valuation, so all attention should be paid to the improvement of models and elimination of weaknesses they have. The general measurement standard should be possible to some extent, although very difficult to implement, since intangible assets are highly specific for each company to be valued equally. It is important that the more business system is based on intangible assets, the stronger it is, because intangible assets are a one of a key growth and value creation factors, but at the same time, the more the system is based on intangible assets, the more vulnerable it becomes. This is one of the most important factors that should be considered in research and development of the intangible assets'measurement methodology.

In the mid term intangible intensive business valuation is aimed to lead to more detailed company reporting which means that value creation process within the company would be reflected and reported in detail. This would involve identifying, measuring, and reporting, as well as constructing a coherent presentation of how the enterprise uses its resources, both tangible and intangible (RICARDIS Report to the European Commission, 2006). The same experts identify two functions that are fulfilled by such reporting:

1. complement financial management information (internal management function);
2. complement the financial statement (external reporting function).

Having and operating more accurate intangible assets' measurement methods and reporting it is important, because it not only helps to develop the company's strategy, but also focuses on the development and use of intangibles and is a monitoring system at the same time, which makes company accountable for its intangible resources.

Figure 1: Intangible intensive business valuation process

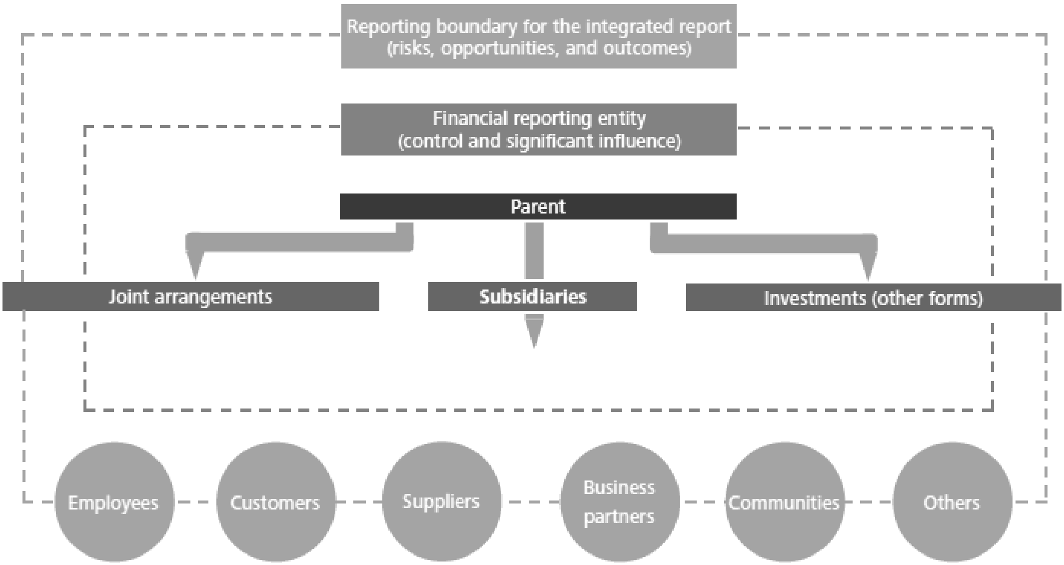


Source: prepared by author.

Some efforts to combine intangible assets valuation and reporting are made and integrated reporting (see Figure 2) framework is introduced. The framework explains that 'providers of financial capital are interested in the value an organization creates for others "when it affects the ability of the organization to create value for itself, or relates to a stated objective of the organization (e.g., an explicit social purpose) that affects their assessments' (Deloitte, 2013). Comprehensive reporting can communicate with relevant external stakeholders such as employees, partners, customers, investors, regulatory institutions, etc. in order to inform and persuade them about the firm's unique characteristics, resources, capabilities and other intangibles that have an impact on the future of the firm, thereby facilitating their decisions about interacting with it in new ways (RICARDIS Report to the European Commission, 2006). However, framework is explicit about not requiring an organization to quantify or monetize its use of, or effects on, all of the capitals (i.e. tangible and intangible); quantitative indicators are to be included in an integrated report only when it is practicable and relevant to do so.

These tendencies in scientific research show that business companies have a need to manage their intangibles in a similar way to how they manage their tangible resources, i.e. to have similar an accounting and reporting system for decision making, yet measurement methods and models are not as comprehensive as it should be for completed and fully integrated measurement and reporting system. This situation leads to individualised measurement with different indicators and incomparable reports of different companies.

Figure 2: Integrated reporting boundaries



Source: '*IIRC releases the International Integrated Reporting <IR> Framework*', Deloitte, 2013

5. Conclusions

Analysis shows that the concept of intangible assets, although has been examined by researchers, is still not clearly understood - there is no universal definition of this economic category, the researchers emphasize different characteristics of intangible assets and, although it is possible to distinguish the common points in definitions, which allows the standardization of the concept at some level, but there are still remaining lot of different criteria of the analysis of intangible assets, what makes it a very complicated concept and is a basic measurement problem. Intangible assets' valuation process is very complicated because of its unique features, so companies generally measure intangible assets only to the extent required by accounting standards what means that usually actual value is not revealed. Valuation process is ineffective itself, since it is put to the circle: intangibles are not recognized because the evaluation criteria are not reliable, so it is not measured, and due to the absence of a reliable ability to determine intangibles' value, it is not recognized. Current financial and non-financial intangible assets' measurement models are valuable and innovative, enabling structuring of measurement process, but they also have many drawbacks: a lack of consistency, their insufficient credibility; subjectivity, when for every company model is individualized; depth, because the models are not able to perform a comprehensive evaluation of intangible assets. The high subjectivity in choosing the indicators reflecting company's activities in the most proper way for a company does not allow an objective evaluation of intangible assets, which leads to the emergence of non-comparability between companies.

As intangible assets significance and importance in business processes is not always recognized appropriately, these assets' measurement is highly fragmented, in an uncoordinated manner, without much regard to the assessment of different assets' types, therefore businesses potential and intangible benefits of creating value for the company are not being used as well as a competitive advantage it provides, because these assets are highly specific and very difficult to imitate. Moreover, measurement of intangible assets can provide a systematic way to create value for a business that makes it sustainable. A knowledge-based approach of making decisions and managing business provides an opportunity to sense, anticipate and respond rapidly and effectively to any changes, both internal or external. In order to reach such results an organisation needs to systematically assess its core competencies (inlc. all intangibles) against other elements of the business model to evaluate current situation and to be able to identify and capitalise on market opportunities. Systematic and comprehensive approch of intangibles measurement would allow evaluate not only internal elements of organisation for decision making, but also could be a reliable tool for investor decision making when purchasing shares (i.e. intangible intense companies' shares value usually increases when using integrated measurement methods for evaluation).

As intangible assets are a unique source of value in a company which has to be used the following suggestions for the improvement of intangible assets' measurement should be implemented. It is important to obtain an overall concept of the intangible assets, which forms a base for a measurement. Moreover, further research on the intangible value resources and tangible and intangible assets interaction in value creation process is necessary. The creation of intangible assets on the firm level and how they meet changing needs of the company's owners, capital markets investors, politicians and other interest-groups needs in the intangible intensive economy should be analysed as well as how economic systems based on intangible assets operates. Encouragement of businesses to measure the intangible assets as well as disclose information related to it and use it for decision making is a crucial step for the intangible assets measurement system development, but at the same time a common minimum universal set of indicators for effective valuation has to be defined and established to make it possible. Also it is very important to avoid the unnecessary duplication and growth of measurement guidelines, models and systems, giving more special attention to development and promotion of relationship between research institutions and business on the intangible asset valuation models. As a result of interaction, the best practice in the measurement of intangible assets should be constantly exchanged between companies and public organizations and institutions. It is necessary to highlight that such factors as general rules for defining the value of intangible assets not traded in market and establishment and development of markets for certain intangible assets (such as patents, copyrights, etc.) also determine progress in measurement system improvement. This will allow eliminating current measurement system disadvantages in order to create and establish universal system for effective measurement of intangibles.

In conclusion, estimating the current situation of intangible assets' measurement system, two goals could be set: the short term goal - to form a comprehensive set of micro-and macro-economic indicators, methods and models, which could be able to measure all the characteristics of intangible assets; and the long term goal - to set common accounting standards and a global framework for effective measurement and reporting of intangible assets.

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