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CENTRAL EUROPEAN REVIEW
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Slawomir I. Bukowski[1], **Alina B. Hyz**[2]

INTEGRATION OF GREEK AND POLISH EQUITY MARKETS WITH THE EURO AREA EQUITY MARKET. COMPARATIVE ANALYSIS

Abstract

The aim of this article is to present the comparative analysis of integration of Greek and Polish equity markets with the Euro area equity market. The authors explain and analyze theoretical aspects and measures of international equity market integration and main tendencies in the development of Greek and Polish equity markets.

Econometric analysis of Greek and Polish equity markets integration with the equity market in euro area is based on the „news–based" measures and econometric model GARCH (1.1). We use monthly statistical data for the period from 1999 till 2014 in the analysis.

The results show tendencies of integration degree in euro area equity market for the analyzed period of time. In the paper authors formulate conclusions concerning present and future of Greek equity market integration with euro area equity market and future prospects for Polish membership in European Monetary Union.

JEL Classification Code: **O52**.

Keywords: monetary union, euro area, financial markets, financial markets integration, measures of financial markets integration, equity market, news-based measures.

Introduction

International integration of equity markets is synonymous with their globalization. The larger the role of global shocks (common for many markets not just the local ones) in affecting yields on equity market indices is, the more integrated the equity markets are.

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A special case is the monetary union where there are no barriers, not even in capital flows related to the existence of multiple currencies.

In the euro area a fairly advanced degree of the financial market (including equity market) integration has been achieved. Analogically, here as everywhere else a higher degree of integration indicates the increased proportion of shocks common for the euro area countries rather than that of the local shocks in affecting the yield.

The aim of paper is answer the following questions:

1. What is the degree of financial market integration with euro area equity market in the case of Greece and Poland on the background of euro area's equity market integration?
2. What experience concern Greek equity market integration with equity market in the euro area are important for Poland from the point of view of future membership in euro area?
3. What is the impact of global recession and financial crisis on the process of Greek equity market integration with euro area equity market?

The main scope of this paper is to analyse the integration of Greek and Polish equity markets with the Euro area equity market. The choice of these two countries was dictated by the following factors. Firstly, one of them belongs to the euro zone while the other is outside the zone. Secondly, these countries are characterized by different economic situation. One is in a period of recession, the second in a period of economic growth. The selection of countries with different structures and characteristics allows parallel analysis of the phenomena.

The paper is structured as follows: in Section 1 we present the theory of integration of equity markets in the international scale and its measure, Section 2 presents the tendencies in Greek and Polish equity market's development, Section 3 presents the methodology and exhibits the results obtained from the study, and Section 4 summarises the main conclusions drawn from this research, limitations and research implications.

1. Integration of equity markets in the international scale and its measures

1.1. International integration of equity markets

International integration of financial markets plays an important role in the development of financial markets and their impact on economic growth. Equity market integration on international scale can be defined more precisely according to the law of one price. Application of the law of one price means that the assets generating identical monetary flows have the same price (rate of return, yield). In the case of shares, in two countries (regions) the price of capital raised in the financial market by issuing shares should be the same (cf. Adam et. al., p. 4). In accordance

with a broader definition of the financial market integration put forward by Baele et al. (2004: 6-7), equity markets are considered fully integrated if all the possible economic agents involved in transactions at the same price:
– are governed by the same rules when they decide to participate in share trading,
– have equal access to shares,
– are treated equally when they operate in the market.

Such a broad approach to the financial market integration implies also functioning of the law of one price. The law of one price causes that assets are characterized by identical risks and yields. The quoted definition comprises the law of one price. If the law of one price is not met, then there is a possibility of arbitration which restores validity of the law (on condition there are no barriers to the financial market integration) (Baele et al., 2004: 7; Kowalak, 2006: 34-38).

Figure 1 shows a theoretical correlation between the integration of financial markets (including equity market), financial development and economic growth.

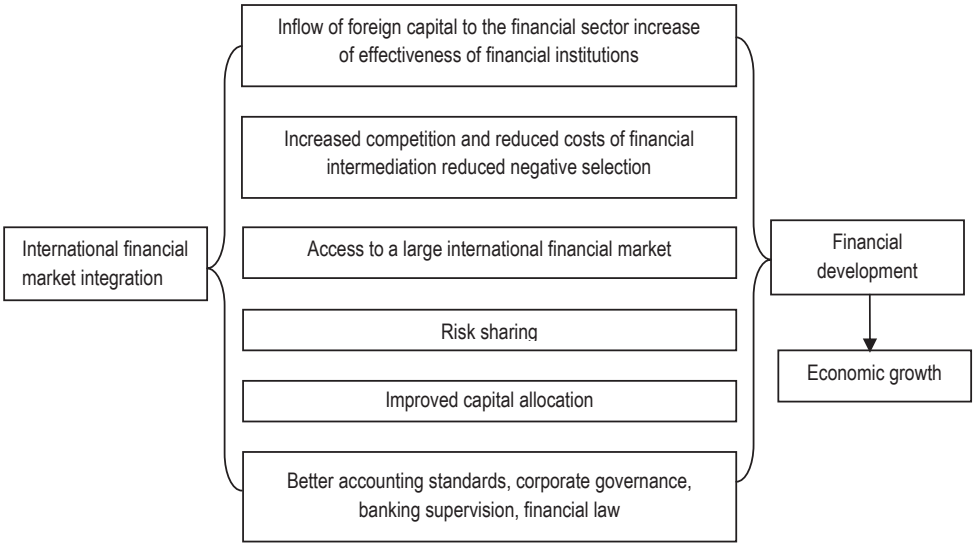

Figure 1. Theoretical correlation between international financial market integration and financial development and economic growth

Source: Bukowski, 2011: 35.

An increased degree of financial market integration means also an increased interdependence and sensitivity of markets to any kind of financial turbulences which may unexpectedly occur in different regions of global economy or in some countries of an integrated group. Integrated financial markets are becoming a major channel

for financial turbulence transmission on an international scale. The turbulences in question are transmitted via the mechanisms of:
– changes in interest rates,
– changes in exchange rates,
– changes in financial asset prices (Bukowski, 2011: 52-53).

One must also point out a significant role of the financial market (including equity markets) integration in a monetary union with a single currency and single monetary policy, hence also for the economy of a country which is a member of such a union.
– levelling out of asset-generated revenues and consumption through diversification of portfolio and mechanism of risk sharing,
– better synchronization of business cycles and economic shocks,
– reducing investment risk,
– neutralization of the shock impact on the size of incomes and consumption,
– increased synchronization degree of business cycles and reduced asymmetry of economic shocks,
– better effectiveness of uniform monetary policy of the supranational central bank[3].

On the other hand it is worthwhile to draw attention to the fact that financial market integration can also be a factor strengthening economic destabilization of the monetary union economies in the environment of growing budget deficits and public debt which result mainly from a bad expansionary fiscal policy in the past and the structure of fiscal expenses as well as in the case when the share of foreign debt dominates (Bukowski 2011: 73).

1.2. Measures of international integration of equity markets

One of the measures of the international financial market integration, including equity market integration is the one based on news.

The news-based measures grasp the impact effect of the news concerning predicted shocks in financial markets and investment risk related to them. In fully integrated markets, investment portfolios should be well diversified. Information coming from local markets should not have a major effect on the prices of assets, unlike global information regarding the entire integrated market which affects price changes quite significantly. The systematic risk degree is the same in various countries whose markets have been integrated. Measurements from this group show to what extent information specific for a local financial market is significant for the remaining markets in comparison to the effect of information of global character (see: Baele et al., 2008: 20; Kowalak, 2006: 38 and onwards). In the case of equity market, a model of the „*increased impact of the common news component on equity market yields*" is such a measure. The „common news component" is the news concerning changes in

[3] See more on this topic: Bukowski, 2011: 67-74.

the US equity market index yields (global news). In the euro area the common news component is the news concerning changes in yields on the broad DJ EUROSTOXX index corrected by the influence of the global „news" impact, i.e. from the US equity market. The higher the degree of particular countries' equity market integration with the global market is, the lower the impact of local (domestic) turbulences on shaping the yields on assets in particular countries but the higher the impact of global factors (information, signals) coming from the United States.

In the case of the euro area countries, the larger the impact of common factors (the common „news" component) for the euro area than the local (specific for the particular countries of the euro area) ones on shaping the yields in domestic equity markets is, the higher the integration degree for these countries is. Similarly, if the examined countries are from outside the euro area, then the larger the impact of the common component for the euro area on shaping the equity market yields in these countries is, the higher the integration degree between their markets and the euro area market is. On the other hand, the impact of the „news" from the US market will define the integration degree between a given market and the global market (see: Bukowski, 2011: 46-47).

2. Tendencies in Greek and Polish equity market's development

In this section we present the historical outline of equity markets in Greece and Poland and next, we try to compare the Greek and Polish equity markets using as a background their economies.

Let's start with Greece. The Greek stock market is represented by the Athens Exchange (or ATHEX for short; formerly ASE – Athens Stock Exchange) which was established in September 1876 as a self-regulated public institution. Until the beginning of 1987, interest in the ATHEX was limited to Greek nationals. Then the government freed capital controls for securities investments which helped the market to take off due to the interest shown by the third country investors. The course of the stock market is clearly reflected by the trend of the ATHEX Index. The Athens Stock Exchange General Index is a major stock market index which tracks the performance of Greek stocks listed on the Athens Exchange. It is a capitalization-weighted index. The ASE General Index has a base value of 100 as of December 31, 1980. Unprecedented rise in the Greek equity market was marked by the beginning of 1999. In September 1999 the index achieved the historical record (6484 units). Since then the fall of the stock market began which had finished at the beginning of 2003 (1462 units). At that time, many of the shares that were introduced proved to be bubble. As a result the institution of the stock market lost its credibility and investors withdrew. Since early 2003, the stock market began to recover and gradually regaining investor confidence. New environment due to the Greece admission to the European Monetary Union caused that equity market started to recover lost ground

and during the period of 2007 and 2008 the ATHEX was around 5000 units. Then, a new downturn in the equity market has started. The downward trend continues today, with plenty of stock prices range down from their nominal value. Businesses use tactics of reverse split to save the price of their shares from the „disappearance". The general index closed at the end of 2014 on 810 units, with market capitalization calculated at about 51,5 billion. euro.

Our attention shall now be drawn towards our second market: Poland. The Polish equity market is represented by the Warsaw Stock Exchange (or WSE for short) which began activity in its present form on 16 April 1991. Since then the WSE has been developing and growing rapidly and is now perceived as well established on the European market. The WSE is a joint stock company founded by the State Treasury. The Treasury holds 35% share in capital. Movements in the overall market are recorded by the Warsaw Stock Exchange Index (WIG), a value-weighted geometric mean of price relatives, based on 1,000 as at April 1991. During the first session in 1991, only five companies were listed (by the end of 1991 -12 companies were listed, joined by 6 more in 1992, and nine in 1993, further 33 companies in 1994). Despite an intervening collapse in the market in 1994-1995 and following the long-delayed mass privatisation programme, 104 companies were quoted by the end of May 1997. Subsequent years showed steady growth in the number of companies listed and there were 374 in 2008 and 470 at the end of 2014. The price variations that occurred on the WSE over 1993-1994 have to be deemed a notion of early stock market inefficiency. But it is easy to understand the development of Polish capital market comparing the following data: WIG index: 900 points in 1991 and over 50.000 points in 2014; number of companies in public trading: 12 (1991) and 470 (2014), market capitalization of WSE: 104 mln PLN (1991) and 1.251 bln PLN in 2014; turnover on WSE: 30 mln PLN (1991) and 232 bln PLN (2014).

In table 1 below we can see the main measures of the development of equity markets in Greece and Poland and main macroeconomic ratios. We measure the development of equity market using four variables: stock market capitalization to GDP, stock market total value traded to GDP and stock market turnover ratio and number of listed companies per 10k population. The stock market capitalization to GDP is a measure of the size of the stock market and is widely used in the literature as a measure of the stock market development. Because of several drawbacks of this measure we decided therefore to use also as an alternative indicator of market size the number of listed companies per 10k population. Stock market could be sizable because of the large number of listings, but it may be illiquid or shallow because of the lack of active trading. Hence, we present for stock illiquidity using the variables on stock market traded to GDP and stock market turnover ratio. Figure 2 shows the evolution of first two measures for Greek and Polish equity markets during the analyzed period. Capital markets, their situation and development are strictly correlated, inter alia, with country's economic situation. As the main macroeconomic

ratios we present GDP annual growth, government deficit, government debt and current accounts as a percentages of GDP (see table 2). The deep economic crisis that plagues Greece for last years is reflected in the macroeconomic ratios. Between 2008 and 2013 the Greek Gross Domestic Product decreased more than 25%, while unemployment increased to 27% in 2013 (Hyz, 2001; Gikas, 2004; Gikas, Tangas, 2012; Gikas et al., 2012; Gikas, 2013). Poland's overall economic performance has been very good over the last decade allowing to convert the economy towards the EU average. Economic growth slowed considerably in 2012-2013. In figure 3 we can see the trends of the GDP per Capita, in Poland and Greece, when adjusted by Purchasing Power Parity for the analysed period.

Table 1. Main measures of the development of equity markets in Greece and Poland (1999-2012)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
STOCK MARKET CAPITALIZATION / GDP														
Greece	103,29	115,33	74,38	54,65	48,97	53,12	56,25	67,43	80,15	55,42	21,79	24,20	11,70	17,90
Poland	14,07	17,20	15,70	13,90	15,51	21,86	28,71	36,21	43,98	31,49	23,89	39,90	26,40	35,80
STOCK MARKET TOTAL VALUE TRADED / GDP														
Greece	85,97	103,71	49,93	21,99	17,70	18,81	22,58	32,93	43,73	31,18	15,05	15,47	8,53	5,90
Poland	5,63	7,29	6,11	3,37	3,37	5,06	8,02	12,65	17,17	15,76	12,69	14,40	18,64	13,6
STOCK MARKET TURNOVER RATIO														
Greece	112,53	56,09	33,86	28,25	38,35	34,68	48,33	62,77	65,84	28,17	82,57	81,25	46,5	37,9
Poland	37,45	43,36	22,88	19,90	23,90	29,37	34,35	44,99	46,80	44,04	60,77	54,03	58,4	42,6
NO. OF LISTED COMPANIES PER 10K POPULATION														
Greece	0,26	0,30	0,31	0,31	0,31	0,31	0,28	0,29	0,26	0,27	0,26	0,25	na	na
Poland	0,06	0,06	0,06	0,06	0,05	0,06	0,06	0,07	0,09	0,09	0,09	0,15	na	na

Source: data.worldbank.org; siteresources.worldbank.org

Table 2. Main macroeconomic ratio for Greece and Poland, 1999-2013

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
GDP GROWTH (annual %)															
Greece	3,10	4,00	3,70	3,20	6,60	5,00	0,90	5,80	3,50	-0,40	-4,40	-5,40	-8,90	-6,60	-3,30
Poland	4,50	4,30	1,20	1,40	3,60	5,10	3,50	6,20	7,20	3,90	2,60	3,70	4,80	1,80	1,70
GOVERNMENT DEFICIT/SURPLUS AS A PERCENTAGE OF GDP															
Greece	-3,00	-3,60	-4,40	-4,70	-5,60	-7,00	-5,40	-6,00	-6,80	-9,90	-15,60	-11,00	-9,60	-8,90	-12,70
Poland	na	na	-2,80	-4,50	-5,40	-5,50	-4,00	-3,60	-1,90	-3,70	-7,50	-7,80	-5,10	-3,90	-4,30
GOVERNMENT DEBT TO GDP															
Greece	96,60	94,00	103,40	103,70	101,70	97,40	98,60	100,00	106,10	105,40	112,90	129,70	146,00	171,30	156,90
Poland	38,90	39,40	36,80	37,60	42,20	47,10	45,70	47,10	47,70	45,00	47,10	50,90	54,90	56,20	55,60
CURRENT ACCOUNT TO GDP															
Greece	-2,80	-3,60	-7,70	-7,20	-6,50	-6,50	-5,80	-7,60	-11,40	-14,60	-14,90	-11,20	-10,10	-9,90	-2,40
Poland	-4,00	-9,10	-6,00	-3,10	-2,80	-2,50	-5,30	-2,40	-3,80	-6,20	-6,60	-3,90	-5,10	-5,00	-3,70

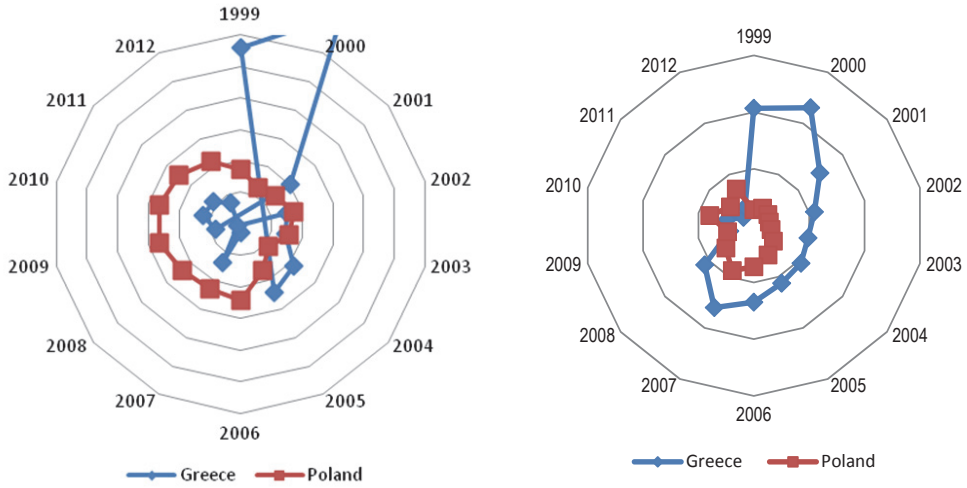

Figure 2. Evolution of Stock Market Total Value Traded as a percent of GDP (on the left) and Stock Market Capitalization as a percent of GDP (on the right) in Poland and Greece, 1999-2013.

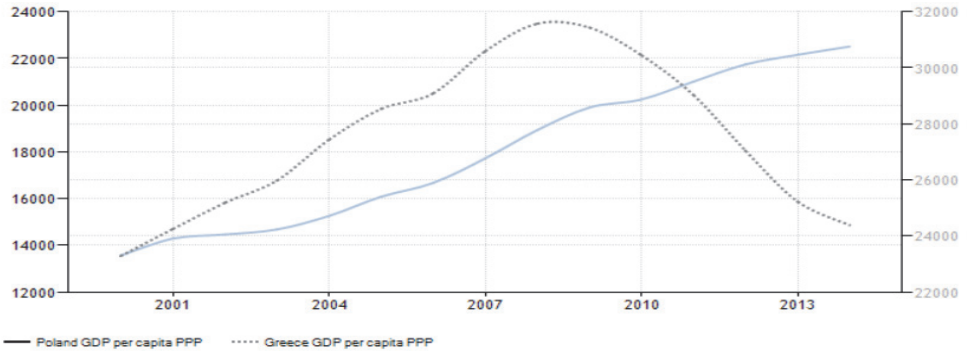

Figure 3. GDP per Capita in Poland and Greece adjusted by Purchasing Power Parity, 1999-2014

Source: www. tradingeconomics.com

3. The degree of Greek and Polish equity markets integration with the euro area's equity market

3.1. Data and a model

Our examinations covered the monthly data from the period 1999:01-2014:12 concerning indexes yields on ^ATH (*Athex Composite Share Price Index*),WIG (Warsaw Stock Exchange Index), DJ EUROSTOXX BROAD INDEX and DOW JONES COMPOSITE AVERAGE INDEX. Changes in yields on the DOW JONES COMPOSITE INDEX were treated as the global news (signal, shock), like in the case of investigations and statistics of the European Central Bank concerning equity market integration (see: Financial Integration in Europe, April, Statistical Annex. ECB 2014). The data sources were the ECB database (Statistical Data Warehouse) and data from Warsaw Stock Exchange and Athens Stock Exchange (stooq.pl.).

To measure the stock exchange integration degree we applied the measures based on the model of the „*increased impact of the common news component on equity market yields*" i.e. the above mentioned measures of the global shock spillover and yield variance proportion. The model was estimated in three stages by means of the GARCH (1,1) process[4]. Firstly, the equation for the US market yields was estimated[5]:

$$R_{us,t} = \mu_{us,t} + \varepsilon_{us,t}$$

where:

$R_{us,t}$ – equity market yield (on the stock exchange index) in country i over time t,

the expected yield component $\mu_{i,t} = \alpha_{i,t} + \gamma_i R_{us,t-1}$,

$\varepsilon_{i,t}$ – the unexpected yield component.

Secondly the conditional variance for the US market was estimated:

$$E(\varepsilon_{us,t}^2) \equiv \sigma_{us,t}^2$$

where is the expected value operator.

The subsequent stage consisted in an estimation of the euro area market yield equation:

$$R_{eur,t} = \mu_{eur,t} + \varepsilon_{eur,t}$$

where:

$$\mu_{eur,t} = \alpha_{eur,t} + \gamma_{eur} R_{eur,t-1}$$

---

[4] On the subject of the GARCH (1,1) model application for examining the relationships between the yields on equity market indices see more in: (Brzeszczyński, Kelm, 2002: 95-119; Jajuga, 2008; Mills, Markellos, 2008: 182, 323 and onwards).

[5] On the model of the „*increased impact of the common news component on the equity market yields*" see more: (Baele et al., 2004: 20-21; Baltzer et al., 2008: 8-10, Bukowski, 2011: 46-47).

and $\varepsilon_{eur,t} = \beta_{eur}^{us}\varepsilon_{us,t} + e_{eur,t}$, $e_{eur,t}$ – pure local shock.

The conditional variance takes the form of:

$$E(e_{eur,t}^2) \equiv \sigma_{eur,t}^2$$

In the last stage the yields for the Greek (gr) and properly Polish (pl) equity market were estimated (i = properly gr, pl):

$$R_{i,t} = \mu_{i,t} + \varepsilon_{i,t}$$

where:

$$\varepsilon_{i,t} = \beta_i^{us}\varepsilon_{us,t} + \beta_i^{eur}e_{eur,t} + e_{i,t}$$

$$\mu_{i,t} = \alpha_{i,t} + \gamma_{i,t}R_{i,t-1}$$

$e_{i,t}$ – pure local shock and the conditional variance $E(e_{i,t}^2) \equiv \sigma_{i,t}^2$
$\beta_{i,t}^{eur}$ and $\beta_{i,t}^{us}$ indicate a dependent on the Polish or Greek market over time t sensitivity to information concerning yields in the eurozone and the United States, respectively. The magnitude of both coefficients is a measure of intensity with which the shock originating in the euro area and the United States (global shocks), respectively, spill over the Polish or Greek equity market.

Then the variance ratio was computed:

$$VR_{i,t}^{eur} = \frac{(\beta_{i,t}^{eur})^2\sigma_{eur,t}^2}{\sigma_{i,t}^2} = \rho_{i,eur,t}^2$$

$$VR_{i,t}^{us} = \frac{(\beta_{i,t}^{us})^2\sigma_{us,t}^2}{\sigma_{i,t}^2} = \rho_{i,us,t}^2$$

Conditional variances for the euro area, the United States and the local equity market are obtained from the standard GARCH (1,1) model.

The higher the value of the yield variance ratio (the higher the ratio of the euro area or US shock to the local shock impact) is, the higher the Polish and Greek equity market integration degree with the one or the other equity market is.

3.2. Results

3.2.1. Cointegration of time series

The Engle – Granger cointegration test indicates that time series of the yields of Dow Jones Composite Index (R_{us}), DJ Eurostoxx Broad Index(R_{eur}), WIG – Warsaw Stock Exchange Index (R_{pl}), over the period 1999:1-2014:12 are cointegrated. Time series of yields of Dow Jones Composite Index (R_{us}), DJ Eurostoxx Broad Index(R_{eur}) and ^ATH – Athex Composite Share Price Index (R_{gr}) are also cointegrated (see tab. 3 below).

Table 3. Results of Engle – Granger cointegration tests for periods: 1999:1-2014:12, 1999:1- 2007:12, 2008:1-2014:12

Period	1999:1-2007:12	2008:1-2014:12	1999:1-2014:12
Greece			
Model:	(1-L)y = (a-1)·y(-1) + ... + e Test with constant and linear trend	(1-L)y = (a-1)·y(-1) + ... + e Test with constant and linear trend	(1-L)y = (a-1)·y(-1) + ... + e Test with constant and linear trend
Autocorrelation of first rank =	0,005	-0,006	0,001
Estimated value (a-1) =	-1,03162	-1,02112	-1,00527
Test statistics tau =	-7,43938	-6,23499	-9,68684
Asymptotic value p =	1,992e-006	1,624e-005	0,9125
Critical value tau = (Dickey-Fuller tables)	-3,45 with significance level = 0,05	-3,45 with significance level = 0,05	-3,43 with significance level = 0,05
Poland			
Model:	(1-L)y = (a-1)·y(-1) + ... + e Test with constant and linear trend (first differences)	(1-L)y = (a-1)·y(-1) + ... + e Test with constant and linear trend	(1-L)y = (a-1)·y(-1) + ... + e
Autocorrelation of first rank =	-0,121	0,012	-0,295
Estimated value (a-1) =	-2,02374	-1,21974	-0,245502
Test statistics tau =	-12,202	-7,53217	-5,10132
Asymptotic value p =	1	2,405e-006	0,002091
Critical value tau = (Dickey-Fuller tables)	-3,45 with significance level = 0,05	-3,45 with significance level = 0,05	-3,43 with significance level = 0,05

Source: own calculation.

3.2.2. The yields in the first glance

The analysis of fig. 4 substance indicates interesting information about tendencies in yields of indexes. First of all, we can observe that yields in of Rgr and Reur are highly correlated, yield Rgr is less correlated with Rus. In the case of Rwig we can observe no correlation with other yields of indexes.

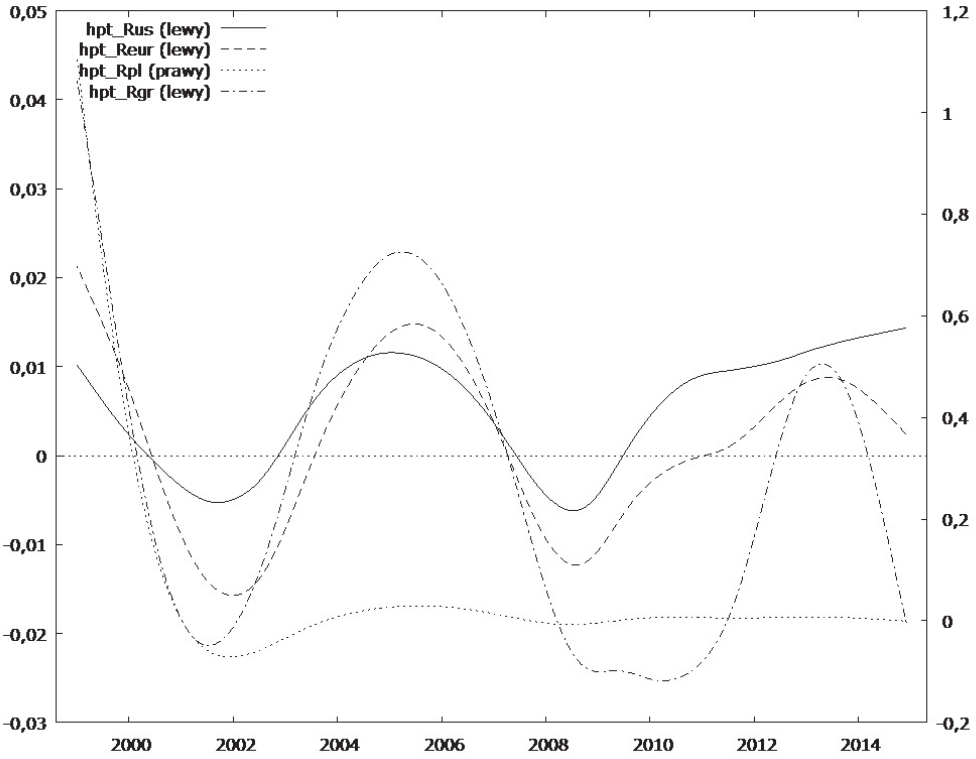

Figure 4. Yields of Dow Jones Composite Index (R_{us}), DJ Eurostoxx Broad Index(R_{eur}), WIG -Warsaw Stock Exchange Index (R_{pl}), ^ATH – Athex Composite Share Price Index (R_{gr}), over the period 1999:1-2014:12, smoothed by means of the Hodrick- Prescott (λ = 14 400) filter

Source: author's own compilation with the use of the GRETL program.

3.2.3. Results of investigation over the Greek and Polish equity market integration with equity market in euro area

Three cases have been investigated: degree of integration in the whole period of 1999-2014, degree of integration in the period before financial and fiscal crisis in the euro area and USA: 1999-2007, period after crisis: 2008-2014. Of course, analysis which is carry on the form of econometric model do not allow to include many factor which influenced equity market. But maybe it will be task for future research. Implemented model is based on the model which is applying by ECB in the reports *Financial Integration of Europe*, prepare and publish every year.

First, we will analyze the degree of Greek and Polish equity market integration with euro area equity market in the period of 1999-2014.

In the investigated period the ^ATH yield and WIG yield was affected by shocks from the US equity market and euro area shocks, however, the American shocks influence indexes yields in both compared countries with higher intensity then shocks from he euro area. The American shocks intensity of spillover measured by β coefficient was in both countries higher then euro area intensity of spillover. Of course, euro area shocks intensity spillover was higher in Greece then in Poland, because there are important barrier in transfer of shocks in Poland – this country is not member of euro area (see figure 5 and 6).

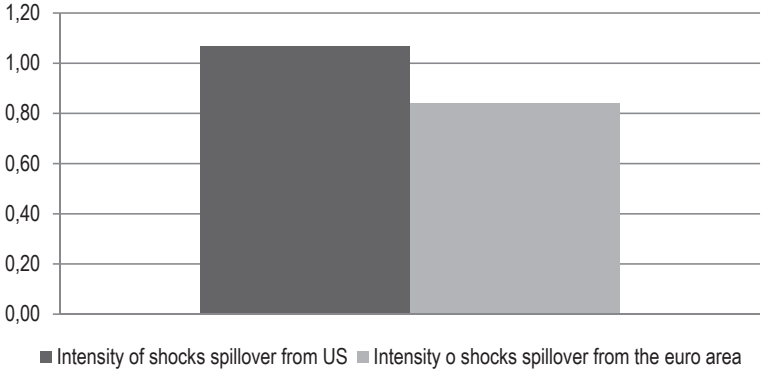

Figure 5. Intensity of global shock spillover (from the United States) and the euro area shock spillover in the Greek equity market, measured by $\beta_{gr,t}^{us}$, $\beta_{gr,t}^{eur}$ coefficients in the period of 1999-2014

Source: author's own compilation on the basis of the estimation of the model of the „i*ncreased impact of the common news component on the equity market yield*" with the use of the GRETL program.

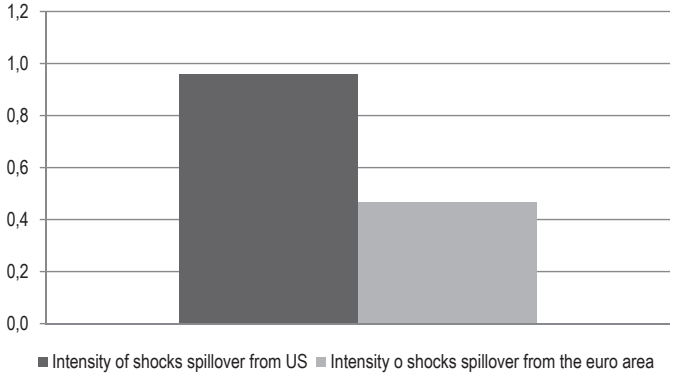

Figure 6. Intensity of global shock spillover (from the United States) and the euro area shock spillover in the Polish equity market, measured by β_{pl}^{us}, β_{pl}^{eur} coefficients in the period of 1999-2014

Source: author's own compilation on the basis of the estimation of the model of the „*increased impact of the common news component on the equity market yield*" with the use of the GRETL program.

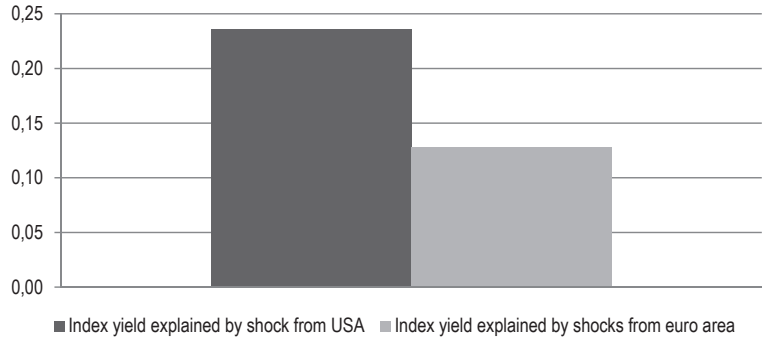

Figure 7. Greek equity market – variance ratio for the ^ATH index yield explained by shocks from the euro area ($VR_{gr,t}^{eur}$) and the United States ($VR_{gr,t}^{us}$) in the periods 1999-2014

Source: author's own compilation on the basis of the estimation of the model of the „*increased impact of the common news component on the equity market yield*" with the use of the GRETL program.

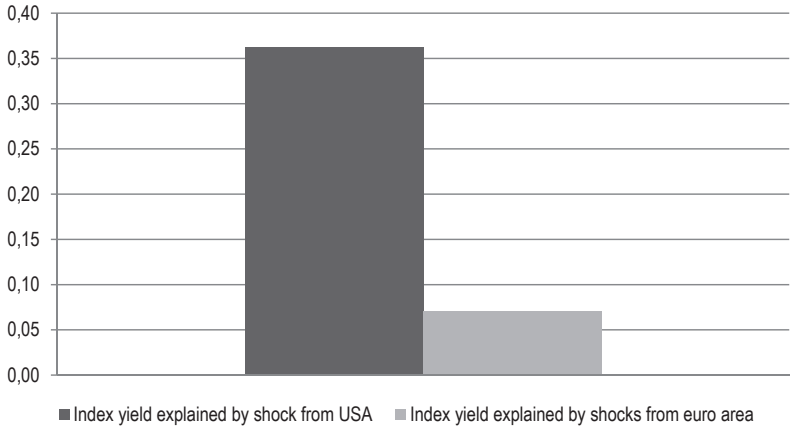

Figure 8. Polish equity market – variance ratio for the WIG index yield explained by shocks from the euro area (VR_{pl}^{eur}) and the United States (VR_{pl}^{us}) in the periods 1999-2014

Source: author's own compilation on the basis of the estimation of the model of the „*increased impact of the common news component on the equity market yield*" with the use of the GRETL program.

A similar situation existed in the case of what shocks explained the changes in the ^ATH yields and WIG yields. In both investigated countries the shocks from American market shocks explained in radically higher degree changes in the yields then shocks from euro area (see fig 6 and 7). But again, Poland is not member of euro area. Equity market in Poland is more connected with American market then with the euro area equity market. For that reason euro area shocks impact on Polish equity market is much less than in the case of Greece. If we take in to account the ratio of variance, Polish market is higher integrated with American market the Greek market.

The second case was the analysis of the degree of Greek and Polish equity market integration with euro area equity market in the period of 1999-2007 (before crisis) and 2008-2004 (period before the crisis and years after crisis). Analysis of fig. 8,9,10,11 gives us interesting information. First of all, analysis indicates that American and euro area shocks intensity spillover increased in the period of 2008-2014 in comparison to the period of 1999-2007 in the case of both countries. However that growth was higher in Greece in the case of euro area intensity spillover then in Poland. In Greece level of variance ratio VR explained share of American market shocks increased much less in the comparison with Polish equity market in the same period (see fig. 10 and 11).

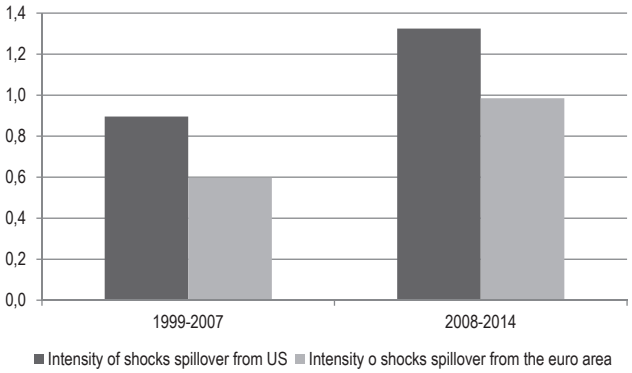

Figure 9. Intensity of global shock spillover (from the United States) and the euro area shock spillover in the Greek equity market, measured by $\beta_{gr,t}^{us}$, $\beta_{gr,t}^{eur}$ coefficients in the period of 1999-2007 and 2008-2014

Source: author's own compilation on the basis of the estimation of the model of the „*increased impact of the common news component on the equity market yield*" with the use of the GRETL program.

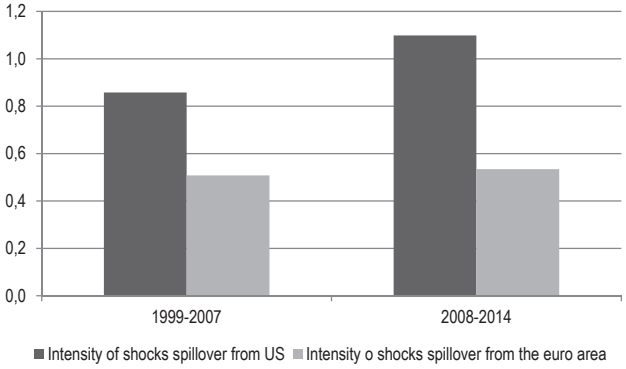

Figure 10. Intensity of global shock spillover (from the United States) and the euro area shock spillover in the Polish equity market, measured by β_{pl}^{us}, β_{pl}^{eur} coefficients in the period of 1999-2007 and 2008-2014

Source: author's own compilation on the basis of the estimation of the model of the „*increased impact of the common news component on the equity market yield*" with the use of the GRETL program.

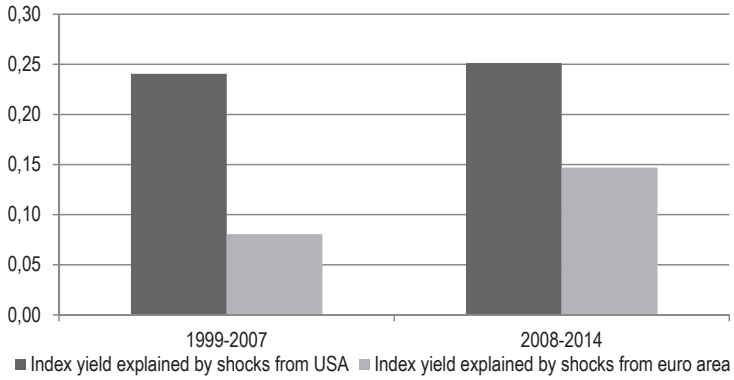

Figure 11. Greek equity market – variance ratio for the ^ATH index yield explained by shocks from the euro area ($VR_{gr,t}^{eur}$) and the United States ($VR_{gr,t}^{us}$) in the periods 1999-2007 and 2008-2014

Source: author's own compilation on the basis of the estimation of the model of the „*increased impact of the common news component on the equity market yield*" with the use of the GRETL program.

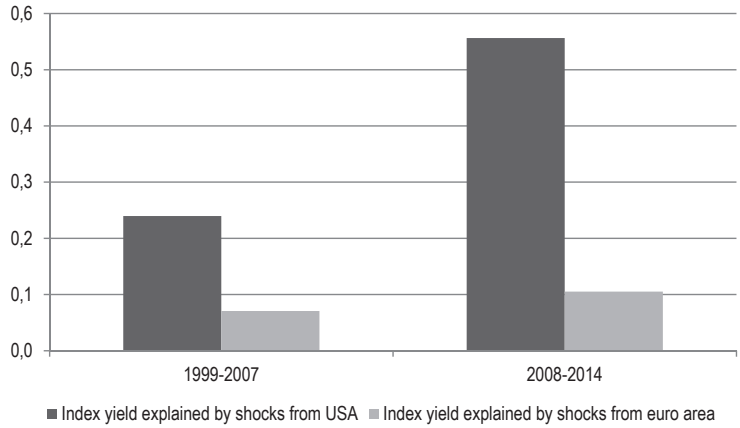

Figure 12. Polish equity market – variance ratio for the WIG index yield explained by shocks from the euro area (VR_{pl}^{eur}) and the United States (VR_{pl}^{us}) in the periods 1999-2007 and 2008-2014

Source: author's own compilation on the basis of the estimation of the model of the „*increased impact of the common news component on the equity market yield*" with the use of the GRETL program.

Conclusions

The world's economic and financial systems are becoming increasingly integrated due to the rapid expansion of international trade in commodities and financial assets. The financial assets linkage arises because households, corporations and financial

institutions can increasingly decide whether to hold domestic assets as bonds, equity and other in foreign countries.

The aim of this paper was to explore the financial integration hypothesis for equity markets (Polish and Greek) into the euro area market. There are two categories of basic approaches to defining the extent to which international financial markets are integrated: direct and indirect measures. The first one is couched in terms of the extent to which the rates of return on financial assets with similar risk characteristics are equalized, which invokes the law of one price. This is an approach which we used in this paper.

Greek and Polish equity markets can be described as emerging markets. This term was born in 1980s for countries which are considered to be in a transitional phase between developing and developed status. Our results show that both of analyzed equity markets are more integrated with the American (global) equity market then with euro area equity market. On the background of the results of analysis presented above some important questions can be formulated. First – what are the reasons that Greek equity market, market of the member country of euro area, is more integrated with American equity market then with the euro area market?

Second- what are the reasons that Polish equity market (Poland is member of EU and member high integrated in the trade business cycle dimensions), is more integrated with American equity market then with the euro area market?

It is very difficult to find answer in the framework of classical theory of finance, maybe in the behavioral finance and psychology of financial market.

Investors can be relatively firmly convinced of the determined big financial markets' news significance and its impact on the financial instruments yields, especially equities. The signals from American market are treated as signals from the global market. American economy is very attractive economy with specific features: high level of competition and economic freedom, property law protection, high level of technology, labor mobility, market flexibility and relatively high dynamics of economic growth. Those features explained the dollar's role as the world's primary reserve currency. It is very important that American sovereign debt is denominated in American dollars. 80% of official central bank reserves in the world are denominated in American dollars. As a result investors treat information and signals from American market as a most important for their investment decisions. On the other side, investments in the euro market in the case of Greek investors are easier than in the Wall Street, because common currency let them to avoid currency risk. But Greek investors can be convinced that all changes in the financial markets in the world are cause by changes in the global, American market. The same can be said in the case of Polish investors.

It is interesting that the same situation exists in Czech Republic, Slovenia, Hungary. The degree of equity market integration in those countries with American equity market is higher than with euro area equity market. Important is the case of Slovenia as a member of euro area (see: Bukowski, 2013).

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EVALUATION OF LEASING AS A METHOD OF FUNDING INVESTMENTS IN GREEK AGRIBUSINESS SECTOR

Abstract

Funding for acquiring assets in Greek agribusiness sector is very common and supports Greek agribusiness SME's production. Purpose of this study is evaluation of leasing as a method of financing in order to acquire assets used directly in the production process of a business of secondary Greek agribusiness sector or even vertically integrated business. Thus, research was held in December of 2012, collecting proper data from Greek banking sector and considering Tax Legislation. Selection decision of practices financing in the event of such an investment should be made after taking into consideration several factors. Proper financial evaluation of future investment is necessary, while it's too necessary to be compared the financing choices that are given in Greece. Considering Tax Legislation, Banking Practices, and Law on Leasing, financing methods were compared in reference period. Avoiding generalizations, typical examples are given, showing that leasing preceded against borrowing, considering conditions prevailing in Greece at the time. But decision making for selection of financing method is affected by factors, which may lead to either correct or incorrect conclusions for firm's interests, if evaluation is not correct or there are personal interests of decision-makers in the administration. Consequently, incentives to use leasing for financing a business can be a lot, but quite important are ownership structure, nature of investment opportunities, business risk and tax status.

JEL Classification Code: **G11, Q14**.

Keywords: financial leasing, SME's finance, investments, agribusiness sector, Greece.

Introduction

Greek agricultural sector is facing multiple problems that are mainly structural and exacerbated in recent decades. Intense structural problems existing in Greek

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agricultural sector can be summarized in topics such as producers' large number associated with a large number of small farms, significant geographic dispersion of production units, small production factors mobility, main characteristics of human resources – low educational level and high average aged – cooperatives' functional problems, and imbalance between crop and livestock production.

Towards improving competitiveness of Greek agricultural production and therefore necessity of agricultural structures' improvement, some investments are essential to be made. However, investment financing is a major problem, particularly in a crisis period, for Greek agribusinesses of secondary sector. Common agricultural structural policy has contributed so far in this direction. Of course, compulsory participation of owner's equity for funding such investments drives owners to external financing, of which bank lending is the most common.

In this study, we examined a different way for financing new investments in Greek agribusiness sector. Thus, we compared leasing to bank loans. A comparative analysis and determination of best financing method was held.

Literature Review

Leasing is a method, but above all, a financing technique that allows business either to obtain use of capital goods without cash flow disbursement, or to utilize any unused funds already invested in capital goods. There are two main categories of leasing that distinguished based on their characteristics: operating leasing and financial leasing. Literature has identified firms' characteristics influencing choice of financing method for acquisition of fixed assets. These are ownership structure, nature of investment opportunities, business risk, and tax status.

Ownership structure consists of elements such as percentage of shares held by top management, and existence of blockholders or not. These elements may affect incentives of top management, and effectiveness of shareholders' control in top management, as described in agency theory and mentioned by Jensen and Meckling (1976). Smith and Wakeman (1985) argued that if management holds a high degree of shares then looks for external financing at a higher degree, either financial leasing or lending. Flath (1980) supported that use of financial leasing is more likely in closely controlled firms.

Firm's investment opportunities, expressed by nature of current and future assets, affect investors' willingness to borrow. Moreover, importance of growth opportunities associated with assets, and firm's specialization affect use of financial leasing and lending. Barclay and Smith (1995) argued that firms with higher growth opportunities rely more on leasing than other lower forms of debt, for a given indebtedness amount. Williamson (1988) supported that easily reusable assets, such as equipment, are more preferable by a lessor or lender as collateral in case of external financing.

The bigger business risk is, the greater chances for conflicts of interest between shareholders and creditors are, and the higher financial distress costs are, too. Financial theory predicts that bigger business risk will tend to reduce use of fixed assets (Gikas and Hyz, 2000). Financial theory argues that firms with small or no tax liabilities are more likely to lease goods than use borrowing, while opposite is valid for fully taxed firms.

Theory of leasing had focused on differences between taxation of the lessee and the lessor as dominant concept for leasing (Bower 1973; Brealey and Young 1980; Brick Fung and Subrahmanyam 1987; Lewellen, Long and McConnell 1976; Miller and Upton 1976; Myers, Dill and Bautista 1976). Finucane (1988) showed that firms in certain industry sectors, including aviation and retail, rely on leasing more than others in various other sectors, while leasing varies relatively more across sectors of industry and relatively less within firms (Graham and Leary, 2011). Vora and Ezzell (1991) identified significant tax difference between lessee and lessor, even though tax rate of each one didn't differ necessarily.

Financial theory suggests that leases and corporate debt are substitutes. Despite this, confusion prevails in empirical level. Leasing and borrowing are two kinds of specific contractual indebtedness that both reduce a firm's potential to further borrowing (debt capacity). Thus, greater use of lease financing relates to reducing use of debt financing.

In every business, financial leasing and borrowing are substitutes, but firms used leasing use indeed higher debt levels compared with those do not use it (Marston and Harris, 1988). Deloof and Verschueren (1999) found a significant negative relationship between long-term debt and proportion Financial Leases/Total Assets known as Lease Ratio, but financial leasing isn't perfect substitute for long-term debt.

As business profitability increases, lease ratio will decrease, since they have a negative correlation. Gavazza (2010) supported that expected costs of external financing decrease with asset liquidity.

Business size has correlated significantly positive with leasing in literature, although Rampini and Viswanathan (2010) supported that business size influences debt structure but not total amount of leverage, since they found that mean debt plus lease ratios are relatively constant across firm size, but debt ratios without leases are positively correlated to business size.

Firm growth seems to have no effect on leasing, while current and fixed assets were significantly negative influenced. Variability and lease ratio had a positive correlation, since the bigger business risk is, the more businesses choose leasing. In case of default, it is rather easier for lessor to regain assets' possession than a lender to acquire collateral. Studies showed that in case of distress, collateral tied to a lease contract is easier to seize than is collateral tied to secured debt, and thus, leasing increases debt capacity (Eisfeldt and Rampini, 2009; Rampini and Viswanathan, 2010). Research conducted with use of dynamic models pointed that mentioned above benefit of leas-

ing is offset by cost of separating asset ownership and control in leasing, and thus, more constrained and less profitable businesses are more likely to lease (Eisfeldt and Rampini, 2009; Rampini and Viswanathan, 2010). Also, businesses with low leverage level are mainly those with few tangible assets, and these firms are significant users of leasing (Rampini and Viswanathan, 2010). Mehran et al. (1999) examined the effect of shareholding by top management on leasing, since theory suggests that ownership structure is an important determinant of lending and financial leasing. Theory suggests that ownership structure affects decision to lease assets. Top management that owns a large number of shares prefers to use leasing as a financing method.

Methodology

Research was held in December of 2012, collecting proper data from Greek banking sector and considering Tax Legislation. Selection decision for financing an assets investment by a Greek agribusiness must be done taking into consideration several factors.

Proper financial evaluation of future investment is necessary, and also comparing financial choices given in Greece is mandatory. Considering Tax Legislation (tax and depreciation rates), Banking Practices (interest rate, discount rate, lease rate), and Law on Leasing, financing methods were compared in reference period.

For study conducted, we obtained data from banking institutions and their affiliates, which are active in leasing, tax office, National Printing Office, European Central Bank, and finally by internet. Particularly, we compare two most common methods of obtaining assets used by Greek agribusiness sector that is financial leasing and borrowing. The choice of a financing method with minimum cash outflows about same financial investment was sought. Using comparison of methods based on net present value (NPV) of cash outflows, conclusions are drawn regarding the most advantageous of financing methods.

A spreadsheet was developed and thus, present value of cash outflows was calculated for both financing methods (financial leasing and borrowing). These cash outflows were calculated using the method of present value so that is comparable, taking into consideration tax rates, depreciation rates, tax saving, interest and lease rates, while discounting was performed using interest rate after taxes.

Thus, we present some patterns, which are as far as possible nearest to Greek agribusiness reality, and we use the most common data for borrowers and lessees received from lessors and tax office. Avoiding generalizations, typical examples are given, considering conditions prevailing in Greece at the time.

Evaluation of Financing Methods

Depreciation rates vary by case, and are 12% - 8% min. and 12% max. - for canning machinery, 15% - 11% min. and 15% max. - for other machinery and equip-

ment of an agribusiness, provided that specific assets used directly in the production process, and finally 20% - 15% min. and 20% max. - for office equipment.

Tax rate for fiscal year 2013 - refers to period from 01/01/2012 to 31/12/2012 - was 20% for all domestic public limited companies, limited liability companies, general and limited partnerships, cooperatives and associations, public and municipal enterprises, and foreign companies and organizations.

Lease rate, for lease payments per quarter, formed of the sum of euro interbank offered rate 3 month and spread amounting to 8.92%. Thus, EURIBOR 3M was at the level of 0.19%, while lease rate at 9.11% in December of 2012.Basic interest rate for asset investment ranged from 8.90 to 9.25%. In pattern, interest rate suitable for amount of funds loaned is considered the percentage of 11.20% (9.10% +1.5% spread +0.60% of Law 128/75).

In first pattern, we assume an asset investment in peaches processing firm, which seeks to obtain equipment like a new cutting machine and canning to produce stewed fruit, or a poultry processing plant that goes into obtaining equipment for cutting and packaging of fresh and frozen chicken. The value of investment is suitable for this kind of investments and amounts to € 80,000. For each funding method, we make final calculation of outflows' present value, taking into account above elements. In this calculation, tax saving known as tax shield is included, while discount rate is the after-tax cost of debt capital. The results showed that funding with leasing method was more advantageous (see Appendix Pattern 1).

In second pattern, we refer to equipment for other agribusiness firms and thus depreciation rate is at 15%. It seems that leasing is the most advantageous method in this case, too (see Appendix Pattern 2).

In third pattern, an agribusiness firm invests in office equipment with depreciation rate 20%. We are talking now about generality of specific pattern, due to non-specific use of this equipment, which it makes it more precious for leasing. Financial leasing is a rational choice in particular case (see Appendix Pattern 3).

In all mentioned above patterns, we used as discount rate - in order to find outflows' present value - the borrowing cost corresponding to particular investment, taking into consideration taxation. Therefore, we used the after tax interest rate as discount rate. Also, we ended up to the same conclusions when payments of financial leasing were done either in arrear or in advance. In appendices, we collocated patterns, but due to shortage of space, we showed only table for payments in arrears for financial leasing.

It should be noted that a difference between leasing and borrowing is mainly the time period of assets depreciation, according to Greek Law. In Greece, tax return is sent at the second quarter of each year and thus, tax saving is calculated at the same time.

Conclusions and Discussion

Decision for funding future investments is an important point for further operation and viability of a Greek agribusiness. Thus, it should not be a rushed action without prior proper financial assessment. Avoiding generalizations, typical patterns are given showing that leasing preceded against borrowing, considering conditions prevailing in Greece at the time. Of course, financial assessment is needed for each investment.

Certainly, financial assessment is not the only factor leading to selection decision of a financing method. It is noted the existence of certain variables that are determinants of use of leasing or borrowing. Consequently, incentives to use leasing for financing a business can be a lot, but quite important are ownership structure, nature of investment opportunities, business risk and tax status.

Top management that owns a large number of shares prefers to use leasing as a financing method, while use of financial leasing is more likely in closely controlled firms.

Firm's investment opportunities, expressed by nature of current and future assets, affect investors' willingness to borrow. Moreover, importance of growth opportunities associated with assets, and firm's specialization affect use of financial leasing and lending.

The bigger business risk is, the greater chances for conflicts of interest between shareholders and creditors are, and the higher financial distress costs are, too. Financial theory predicts that bigger business risk will tend to reduce use of fixed assets.

Financial theory argues that firms with small liabilities are more likely to lease goods than use borrowing, while opposite is valid for fully taxed firms. Also, other reasons play a prominent role for specific choice decision. These reasons don't relate to a proper financial evaluation or rationality in choosing financing method, but either to the particular circumstances prevailing at the time, or to decision concerning specific business goals or management's special purposes. Such reasons may be beautifying balance sheets, listing at stock exchange, national and Community legislation.

Anyway, results of this study showed that financial leasing prevailed against borrowing for financing an investment in Greek agribusiness sector at reference time, if only we insist on proper financial evaluation.

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PPENDICES

PATTERN 1

INVESTMENT VALUE € 80,000 (borrowing)								
Investment (€)			**80.000,00**		Peaches processing firm - canning machinery			
Duration (years)			**5**					
No. periods per year			**4**					
No. Payments			**20**					
Depreciation rate			**12%**					
Interest rate			**11,20%**					
Tax rate			**20%**					
Discount rate			**11,20%**					
Period	**Discount factors**	**Payments**	**Depreciation**	**Interest**	**Depreciation +Interest**	**Tax saving**	**Net Outflows**	**P.V. of n. o.**
1	*0,978091*	5.278,319	0	2.240,000	2240,000		5.278,319	**5.162,675**
2	*0,956662*	5.278,319	0	2.154,927	2154,927		5.278,319	**5.049,564**
3	*0,935702*	5.278,319	0	2.067,472	2067,472		5.278,319	**4.938,932**
4	*0,915201*	5.278,319	9.600	1.977,568	11577,568		5.278,319	**4.830,724**
5	*0,895150*	5.278,319	0	1.885,147	1885,147		5.278,319	**4.724,887**
6	*0,875538*	5.278,319	0	1.790,139	1790,139	3.607,994	1.670,325	**1.462,433**
7	*0,856356*	5.278,319	0	1.692,470	1692,470		5.278,319	**4.520,117**
8	*0,837593*	5.278,319	9.600	1.592,066	11192,066		5.278,319	**4.421,085**
9	*0,819242*	5.278,319	0	1.488,851	1488,851		5.278,319	**4.324,222**
10	*0,801293*	5.278,319	0	1.382,746	1382,746	3.311,964	1.966,354	**1.575,627**
11	*0,783738*	5.278,319	0	1.273,670	1273,670		5.278,319	**4.136,817**
12	*0,766567*	5.278,319	9.600	1.161,539	10761,539		5.278,319	**4.046,183**
13	*0,749772*	5.278,319	0	1.046,270	1046,270		5.278,319	**3.957,534**
14	*0,733345*	5.278,319	0	927,772	927,772	2.981,361	2.296,957	**1.684,462**
15	*0,717278*	5.278,319	0	805,957	805,957		5.278,319	**3.786,021**
16	*0,701563*	5.278,319	9.600	680,731	10280,731		5.278,319	**3.703,072**
17	*0,686192*	5.278,319	0	551,998	551,998		5.278,319	**3.621,940**
18	*0,671158*	5.278,319	0	419,661	419,661	2.612,146	2.666,173	**1.789,423**
19	*0,656454*	5.278,319	0	283,619	283,619		5.278,319	**3.464,971**
20	*0,642071*	5.278,319	9.600	143,767	9743,767		5.278,319	**3.389,056**
21	*0,628004*	0	0	0	0,000		0,000	**0,000**
22	*0,614245*	0	0	0	0,000	2.199,809	-2.199,809	**-1.351,221**
23	*0,600787*	0	0	0	0,000		0,000	**0,000**
24	*0,587624*	0	9.600	0	9600,000		0,000	**0,000**
25	*0,574750*	0	0	0	0,000		0,000	**0,000**
26	*0,562158*	0	0	0	0,000	1.920,000	-1.920,000	**-1.079,343**
27	*0,549841*	0	0	0	0,000		0,000	**0,000**
28	*0,537795*	0	9.600	0	9600,000		0,000	**0,000**
29	*0,526012*	0	0	0	0,000		0,000	**0,000**
30	*0,514487*	0	0	0	0,000	1.920,000	-1.920,000	**-987,816**
31	*0,503215*	0	0	0	0,000		0,000	**0,000**
32	*0,492190*	0	9.600	0	9600,000		0,000	**0,000**
33	*0,481407*	0	0	0	0,000		0,000	**0,000**
34	*0,470860*	0	0	0	0,000	1.920,000	-1.920,000	**-904,050**
35	*0,460543*	0	0	0	0,000		0,000	**0,000**
36	*0,450453*	0	3.200	0	3200,000		0,000	**0,000**
37	*0,440584*	0	0	0	0,000		0,000	**0,000**
38	*0,430931*	0	0	0	0,000	640,000	-640,000	**-275,796**
TOTAL		105.566,370	80000,000	25566,370	105566,370	21113,274	84453,096	**69.991,52**

INVESTMENT VALUE € 80,000 (financial leasing)					
ARREAR					
Investment (€)			**80.000,00**		
Duration (years)			**5**		
No. periods per year			**4**		
No. Payments			**20**		
Interest rate			**9,11%**		
Discount rate			**11,20%**		
Tax rate			**20%**		
Period	**Discount factors**	**Payments**	**Tax saving**	**Net payment**	**P.V. of n. o.**
1	*0,978091*	5.024,533		5.024,533	**4.914,450**
2	*0,956662*	5.024,533		5.024,533	**4.806,778**
3	*0,935702*	5.024,533		5.024,533	**4.701,465**
4	*0,915201*	5.024,533		5.024,533	**4.598,459**
5	*0,895150*	5.024,533		5.024,533	**4.497,711**
6	*0,875538*	5.024,533	4.019,627	1.004,907	**879,834**
7	*0,856356*	5.024,533		5.024,533	**4.302,787**
8	*0,837593*	5.024,533		5.024,533	**4.208,516**
9	*0,819242*	5.024,533		5.024,533	**4.116,311**
10	*0,801293*	5.024,533	4.019,627	1.004,907	**805,225**
11	*0,783738*	5.024,533		5.024,533	**3.937,916**
12	*0,766567*	5.024,533		5.024,533	**3.851,640**
13	*0,749772*	5.024,533		5.024,533	**3.767,253**
14	*0,733345*	5.024,533	4.019,627	1.004,907	**736,943**
15	*0,717278*	5.024,533		5.024,533	**3.603,986**
16	*0,701563*	5.024,533		5.024,533	**3.525,026**
17	*0,686192*	5.024,533		5.024,533	**3.447,795**
18	*0,671158*	5.024,533	4.019,627	1.004,907	**674,451**
19	*0,656454*	5.024,533		5.024,533	**3.298,373**
20	*0,642071*	5.024,533		5.024,533	**3.226,108**
21	*0,628004*			0,000	**0,000**
22	*0,614245*		4.019,627	-4.019,627	**-2.469,035**
TOTAL		100.490,665	20.098,133	80.392,532	**65.431,99**
P.V. borrowing					69.991,52
P.V. borrowing – P.V. leasing					**4.559,53**

PATTERN 2

INVESTMENT VALUE € 80,000 (borrowing)								
Investment (€)			**80.000,00**		Other equipment used in agribusiness sector			
Duration (years)			**5**					
No. periods per year			**4**					
No. Payments			**20**					
Depreciation rate			**15%**					
Interest rate			**11,20%**					
Tax rate			**20%**					
Discount rate			**11,20%**					
Period	**Discount factors**	**Payments**	**Depreciation**	**Interest**	**Depreciation +Interest**	**Tax saving**	**Net Outflows**	**P.V. of n. o.**
1	*0,978091*	5.278,319	0	2.240,000	2240,000		5.278,319	**5.162,675**
2	*0,956662*	5.278,319	0	2.154,927	2154,927		5.278,319	**5.049,564**
3	*0,935702*	5.278,319	0	2.067,472	2067,472		5.278,319	**4.938,932**
4	*0,915201*	5.278,319	12.000	1.977,568	13977,568		5.278,319	**4.830,724**
5	*0,895150*	5.278,319	0	1.885,147	1885,147		5.278,319	**4.724,887**
6	*0,875538*	5.278,319	0	1.790,139	1790,139	4.087,994	1.190,325	**1.042,175**
7	*0,856356*	5.278,319	0	1.692,470	1692,470		5.278,319	**4.520,117**
8	*0,837593*	5.278,319	12.000	1.592,066	13592,066		5.278,319	**4.421,085**
9	*0,819242*	5.278,319	0	1.488,851	1488,851		5.278,319	**4.324,222**
10	*0,801293*	5.278,319	0	1.382,746	1382,746	3.791,964	1.486,354	**1.191,006**
11	*0,783738*	5.278,319	0	1.273,670	1273,670		5.278,319	**4.136,817**
12	*0,766567*	5.278,319	12.000	1.161,539	13161,539		5.278,319	**4.046,183**
13	*0,749772*	5.278,319	0	1.046,270	1046,270		5.278,319	**3.957,534**
14	*0,733345*	5.278,319	0	927,772	927,772	3.461,361	1.816,957	**1.332,456**
15	*0,717278*	5.278,319	0	805,957	805,957		5.278,319	**3.786,021**
16	*0,701563*	5.278,319	12.000	680,731	12680,731		5.278,319	**3.703,072**
17	*0,686192*	5.278,319	0	551,998	551,998		5.278,319	**3.621,940**
18	*0,671158*	5.278,319	0	419,661	419,661	3.092,146	2.186,173	**1.467,268**
19	*0,656454*	5.278,319	0	283,619	283,619		5.278,319	**3.464,971**
20	*0,642071*	5.278,319	12.000	143,767	12143,767		5.278,319	**3.389,056**
21	*0,628004*	0	0	0	0,000		0,000	**0,000**
22	*0,614245*	0	0	0	0,000	2.679,809	-2.679,809	**-1.646,059**
23	*0,600787*	0	0	0	0,000		0,000	**0,000**
24	*0,587624*	0	12.000	0	12000,000		0,000	**0,000**
25	*0,574750*	0	0	0	0,000		0,000	**0,000**
26	*0,562158*	0	0	0	0,000	2.400,000	-2.400,000	**-1.349,178**
27	*0,549841*	0	0	0	0,000		0,000	**0,000**
28	*0,537795*	0	8.000	0	8000,000		0,000	**0,000**
29	*0,526012*	0	0	0	0,000		0,000	**0,000**
30	*0,514487*	0	0	0	0,000	1.600,000	-1.600,000	**-823,180**
TOTAL		105.566,370	80000,000	25566,370	105566,370	21113,274	84453,096	**69.292,29**

INVESTMENT VALUE € 80,000 (financial leasing)					
ARREAR					
Investment (€)			**80.000,00**		
Duration (years)			**5**		
No. periods per year			**4**		
No. Payments			**20**		
Interest rate			**9,11%**		
Discount rate			**11,20%**		
Tax rate			**20%**		
Period	**Discount factors**	**Payment**	**Tax saving**	**Net payment**	**P.V. of n. o.**
1	*0,978091*	5.024,533		5.024,533	**4.914,450**
2	*0,956662*	5.024,533		5.024,533	**4.806,778**
3	*0,935702*	5.024,533		5.024,533	**4.701,465**
4	*0,915201*	5.024,533		5.024,533	**4.598,459**
5	*0,895150*	5.024,533		5.024,533	**4.497,711**
6	*0,875538*	5.024,533	4.019,627	1.004,907	**879,834**
7	*0,856356*	5.024,533		5.024,533	**4.302,787**
8	*0,837593*	5.024,533		5.024,533	**4.208,516**
9	*0,819242*	5.024,533		5.024,533	**4.116,311**
10	*0,801293*	5.024,533	4.019,627	1.004,907	**805,225**
11	*0,783738*	5.024,533		5.024,533	**3.937,916**
12	*0,766567*	5.024,533		5.024,533	**3.851,640**
13	*0,749772*	5.024,533		5.024,533	**3.767,253**
14	*0,733345*	5.024,533	4.019,627	1.004,907	**736,943**
15	*0,717278*	5.024,533		5.024,533	**3.603,986**
16	*0,701563*	5.024,533		5.024,533	**3.525,026**
17	*0,686192*	5.024,533		5.024,533	**3.447,795**
18	*0,671158*	5.024,533	4.019,627	1.004,907	**674,451**
19	*0,656454*	5.024,533		5.024,533	**3.298,373**
20	*0,642071*	5.024,533		5.024,533	**3.226,108**
21	*0,628004*			0,000	**0,000**
22	*0,614245*		4.019,627	-4.019,627	**-2.469,035**
TOTAL		100.490,665	20.098,133	80.392,532	**65.431,99**
P.V. borrowing					69.292,29
P.V. borrowing – P.V. leasing					**3.860,30**

INVESTMENT VALUE € 80,000 (borrowing)		
Investment (€)	**80.000,00**	
Duration (years)	**5**	**Office Equipment**
No. periods per year	**4**	
No. Payments	**20**	
Depreciation rate	**20%**	
Interest rate	**11,20%**	
Tax rate	**20%**	
Discount rate	**11,20%**	

PATTERN 3

Period	Discount factors	Payments	Depreciation	Interest	Depreciation +Interest	Tax saving	Net Outflows	P.V. of n. o.
1	*0,978091*	5.278,319	0	2.240,000	2240,000		5.278,319	**5.162,675**
2	*0,956662*	5.278,319	0	2.154,927	2154,927		5.278,319	**5.049,564**
3	*0,935702*	5.278,319	0	2.067,472	2067,472		5.278,319	**4.938,932**
4	*0,915201*	5.278,319	16.000	1.977,568	17977,568		5.278,319	**4.830,724**
5	*0,895150*	5.278,319	0	1.885,147	1885,147		5.278,319	**4.724,887**
6	*0,875538*	5.278,319	0	1.790,139	1790,139	4.887,994	390,325	**341,744**
7	*0,856356*	5.278,319	0	1.692,470	1692,470		5.278,319	**4.520,117**
8	*0,837593*	5.278,319	16.000	1.592,066	17592,066		5.278,319	**4.421,085**
9	*0,819242*	5.278,319	0	1.488,851	1488,851		5.278,319	**4.324,222**
10	*0,801293*	5.278,319	0	1.382,746	1382,746	4.591,964	686,354	**549,971**
11	*0,783738*	5.278,319	0	1.273,670	1273,670		5.278,319	**4.136,817**
12	*0,766567*	5.278,319	16.000	1.161,539	17161,539		5.278,319	**4.046,183**
13	*0,749772*	5.278,319	0	1.046,270	1046,270		5.278,319	**3.957,534**
14	*0,733345*	5.278,319	0	927,772	927,772	4.261,361	1.016,957	**745,780**
15	*0,717278*	5.278,319	0	805,957	805,957		5.278,319	**3.786,021**
16	*0,701563*	5.278,319	16.000	680,731	16680,731		5.278,319	**3.703,072**
17	*0,686192*	5.278,319	0	551,998	551,998		5.278,319	**3.621,940**
18	*0,671158*	5.278,319	0	419,661	419,661	3.892,146	1.386,173	**930,341**
19	*0,656454*	5.278,319	0	283,619	283,619		5.278,319	**3.464,971**
20	*0,642071*	5.278,319	16.000	143,767	16143,767		5.278,319	**3.389,056**
21	*0,628004*	0	0	0	0,000		0,000	**0,000**
22	*0,614245*	0	0	0	0,000	3.479,809	-3.479,809	**-2.137,455**
TOTAL		105.566,370	80000,000	25566,370	105566,370	21113,274	84453,096	**68.508,18**

INVESTMENT VALUE € 80,000 (financial leasing)					
ARREAR					
Investment (€)			**80.000,00**		
Duration (years)			**5**		
No. periods per year			**4**		
No. Payments			**20**		
Interest rate			**9,11%**		
Discount rate			**11,20%**		
Tax rate			**20%**		
Period	**Discount factors**	**Payment**	**Tax saving**	**Net payment**	**P.V. of n. o.**
1	*0,978091*	5.024,533		5.024,533	**4.914,450**
2	*0,956662*	5.024,533		5.024,533	**4.806,778**
3	*0,935702*	5.024,533		5.024,533	**4.701,465**
4	*0,915201*	5.024,533		5.024,533	**4.598,459**
5	*0,895150*	5.024,533		5.024,533	**4.497,711**
6	*0,875538*	5.024,533	4.019,627	1.004,907	**879,834**
7	*0,856356*	5.024,533		5.024,533	**4.302,787**
8	*0,837593*	5.024,533		5.024,533	**4.208,516**
9	*0,819242*	5.024,533		5.024,533	**4.116,311**
10	*0,801293*	5.024,533	4.019,627	1.004,907	**805,225**
11	*0,783738*	5.024,533		5.024,533	**3.937,916**
12	*0,766567*	5.024,533		5.024,533	**3.851,640**
13	*0,749772*	5.024,533		5.024,533	**3.767,253**
14	*0,733345*	5.024,533	4.019,627	1.004,907	**736,943**
15	*0,717278*	5.024,533		5.024,533	**3.603,986**
16	*0,701563*	5.024,533		5.024,533	**3.525,026**
17	*0,686192*	5.024,533		5.024,533	**3.447,795**
18	*0,671158*	5.024,533	4.019,627	1.004,907	**674,451**
19	*0,656454*	5.024,533		5.024,533	**3.298,373**
20	*0,642071*	5.024,533		5.024,533	**3.226,108**
21	*0,628004*			0,000	**0,000**
22	*0,614245*		4.019,627	-4.019,627	**-2.469,035**
TOTAL		100.490,665	20.098,133	80.392,532	**65.431,99**
P.V. borrowing					68.508,18
P.V. borrowing – P.V. leasing					**3.076,19**

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IMPROVING THE QUALITY OF KNOWLEDGE LEVELS THROUGH MATURITY MODEL IN SME OF SERVICES

Abstract

The aim of the paper is to show possibility of using knowledge management maturity model (KMMM) for knowledge processes assessment. As a support tool for increasing quality of the knowledge processes can be used mainly PDCA cycle and Kolb's learning cycle. PDCA cycle ensures creation of new knowledge and Kolb's cycle ensures improving the quality of existing knowledge. ISO 9001 standard can provide documentation of knowledge. Important is perception management knowledge like never-ending and continuously improving process.

JEL Classification Code: **E220**.

Keywords: management maturity model, quality of the knowledge processes.

Introduction

Most of the business failures lie in the lack of knowledge. On the other hand the rapid development of knowledge and informatization may represent source barriers to business development. Comparing enterprises in terms of size, the situation is worse in SMEs. In the business environment of SMEs are different barriers such as: lack of financial resources, own professional background as well as sufficient human resources. In SMEs also far more frequently, than in large enterprises, occurs unsystematic process of handling with knowledge. There is a lack systems for storing knowledge, it is not supported knowledge sharing and there are not produced sufficient conditions for learning [Pee-Kankanhalli, 2009].

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If the enterprise is focused on the provision of services, the importance of knowledge management for him is even greater, because the provision of services depends mainly on who and how the services are provided – on human resources and their knowledge level.

Increasing and decreasing the level of knowledge in the enterprise

In enterprises it is important to support knowledge processes in which either increases the amount of knowledge or improve existing knowledge quality [Choi-Lee, 2002].

However, in the case of the human factor occurs in addition to processes of learning also of forgetting the learned. In this paper, we focus on knowledge-intensive processes, which:

1. improves the quality of knowledge in the enterprise:
   a) generate new knowledge – learning
   b) enhances the level of existing knowledge – knowledge retention and repetition
2. reduces the quality of knowledge in the enterprise:
   a) occurs knowledge losses – forgetting,
   b) and this may influence in maturity models transition from level to level.

For each enterprise, it is important to focus on improving the quality of knowledge (learning and retention) and eliminate knowledge losses (forgetting) [Chen-Fong, 2012].

The German psychologist and scientist Hermann Ebbinghaus was the first to perform elaborate and scientific experiments on how we learn and forget. His fundamental finding, one that was confirmed in hundreds of scientific studies over time, is the forgetting curve. – On – Fig. 1 is simplified forgetting curve, which shows exactly how humans, and as it turns out other living organisms, forget an initially learned fact. Ebbinghaus found that the forgetting curve is exponential.

That means that the retention rate (the percentage of what we still remember) decays in the first days and weeks extremely rapidly. In fact the decay is so strong, that we forget almost 80% of all new learned items within one to two weeks.

To reduce losses knowledge, it is necessary to ensure continuity of learning processes, as well as the retention of existing knowledge. This leads to continual repetition of already learned knowledge and also to the formation of new knowledge. As a continuous process, understood the learning process Denis Kolb (1984), when create the Kolb learning cycle. (Fig. 2). This is composed of four phases:

1. Personal experience – situation which gives rise to new experiences. This situation can be planned or accidental.
2. Observing realities and its reflection – involves active thinking about the experience acquired and its significance.

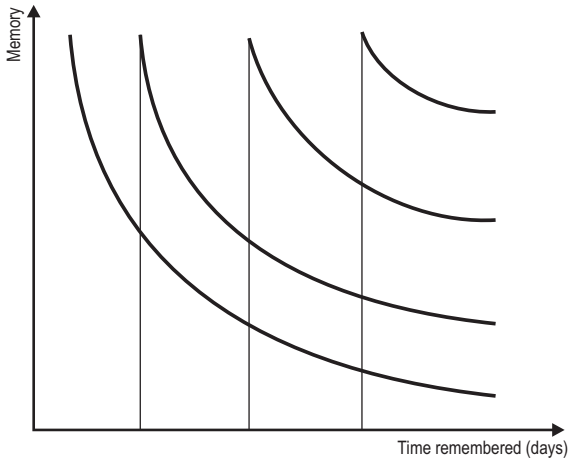

Figure 1. Forgetting curve
Source: Ebbinghaus (1964).

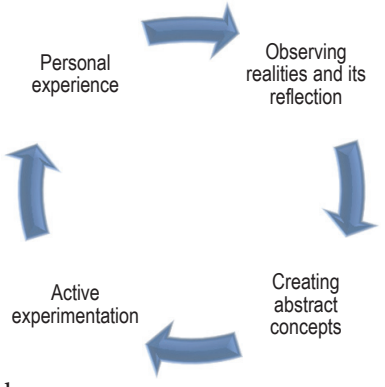

Figure 2. Kolb learning cycle
Source: Kolb (1984).

3. Creating abstract concepts and generalization – at this stage there is a generalization of the experience and its potential use in similar situations.
4. Active experimentation – the testing of new knowledge in new situations, which provides the foundation for the emergence of a new experience. Then the cycle begins anew, but with a higher amount of knowledge [Kolb, 1984].

From the perspective of knowledge management and knowledge processes in the enterprise is essential to ensure the creation of new, documentation and qualitative improvement of existing knowledge. For ensuring these processes it can be connected Kolb´s learning cycle with Deming's PDCA cycle (Fig. 3).

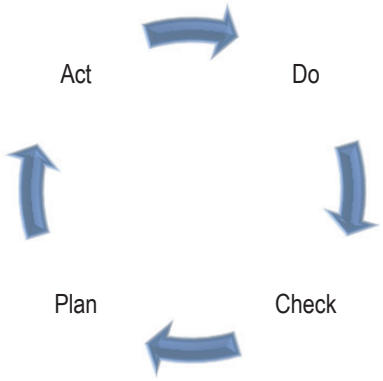

Figure 3. PDCA cycle
Source: Deming (1993).

PDCA cycle has four phases:

1. Plan – plan what you want to do.
2. Do – implement the plan, do, what you have planned.
3. Check – check if everything is done according to plan.
4. Act – act according to what you found, or execute a correction if there a plan has not been fulfilled [Deming, 1993].

By comparison of the two basic models specific to Knowledge Management (Kolb´s learning cycle) and Quality Management (PDCA cycle), it is possible to express the relationship between knowledge management techniques and quality management (Fig. 4). If we want to be more specific about the existing relationship between research sites, we could give him the adjective „support", because studied discipline can support each other through mutual use of tools.

In terms of knowledge, it is relevant that the PDCA cycle for the checking of making, occurs new knowledge, which is used to improve planned, made against a controlled activity. Cycle retains its continuous nature of continuous improvement, because after the improve phase, occurs a new plan and the cycle continues. PDCA cycle also allows storing of existing knowledge.

In Kolb's learning cycle occurs learning through experience. Entity obtains experience (knowledge), it is observed, compared with the general theory, verify it in practice and then on the basis that creates new knowledge. Resulting knowledge pass again all phases learning cycle, so their quality is constantly increasing (Fig. 5).

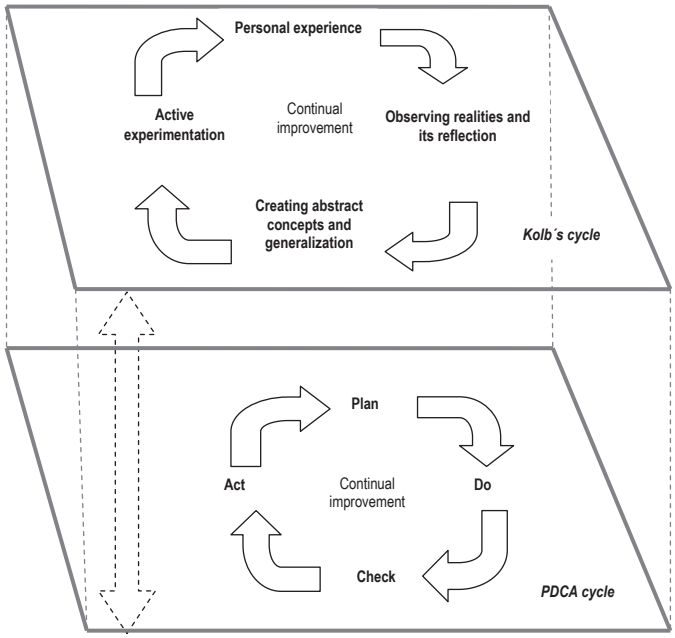

Figure 4. Comparison of Kolb´s learning cycle and PDCA cycle
Source: own processing.

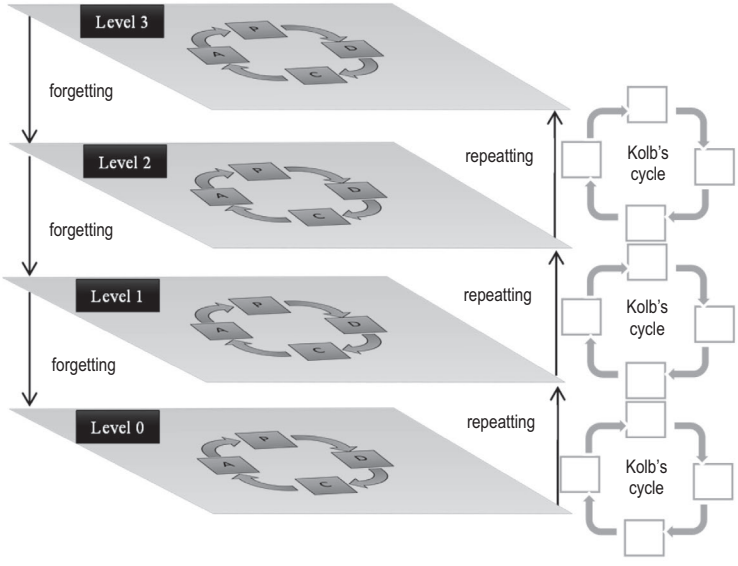

Figure 5. Possibilities of increasing and decreasing the quality of knowledge levels KMMM
Source: own processing.

PDCA cycle as well as Kolb learning cycle help improve the quality knowledge and knowledge processes, while in the PDCA cycle knowledge creation – are the result new knowledge and Kolb's learning cycle to improve knowledge – the result is improved quality level of knowledge in the enterprise. Opposite effect causes forgetting, this may reduce the quality of knowledge and also may reduce the level of knowledge management in the enterprise. To prevent loss of knowledge is very important retrieval of knowledge. Therefore, learning should take place as a continuous process. Repeated evaluation of the knowledge level in the enterprise using a model of maturity is possible to determine on which curve the enterprise is (Fig. 6).

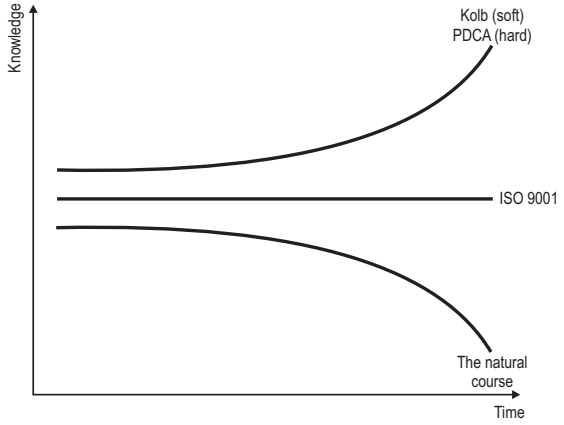

Figure 6. Graphical representation of increasing and decreasing the quality of knowledge levels KMMM

Source: own processing.

Figure 6 shows three alternatives – 3 curves, which reflect the progress of knowledge processes in the company and may be:

1. Declining – if the amount resp. reduces the level of knowledge. In this case occurs loss of existing knowledge caused by forgetting or Failure to keep knowledge.
2. Linear – ISO 9001 supports the retention of knowledge and thus prevents the Knowledge losses in the enterprise.
3. Growing – continuity of PDCA cycles and Kolb's learning cycle allows increasing the knowledge levels in the enterprise.

KMMM creation

In terms the level of implementation includes the proposed model six basic components:

1. The criteria for assessing knowledge management K1-K6:

- K1: People, education, competence
- K2: Environment
- K3: Processes
- K4: Leadership
- K5: Technology
- K6: Continuous Improvement

2. Levels of knowledge management maturity
3. Indicators of the evaluation criteria
4. Scale of points for evaluating the maturity level of criteria
5. Suggestions and recommendations for achieving a higher knowledge management maturity level
6. Glossary

For improving the knowledge management is in the KMMM important recommendations and suggestions for improvement. The fulfillment of these recommendations in the different levels is an essential attribute for the transition to the next level. Characteristics of levels and suggestions and recommendations illustrate Table 1.

Table 1. Suggestions and recommendations for achieving higher maturity levels

Maturity level	State of the KM corresponding to the maturity level	Proposals for moving to a higher maturity level	PDCA cycle and Kolb learning cycle
Level 0	The company has a system of knowledge management, there are not defined knowledge processes, knowledge in the company are chaotic – after the enterprise fragmented or isolated – hidden in the minds of so employees do not know about them and not use them adequately. In enterprise is – lacks of the real vision of KM.	At this level it is important to create a vision and set goals KM. Furthermore, it is necessary to develop a positive attitude for KM of employees, establish programs for the introduction of KM and initiate the process of acquiring, sharing and documentation such as. training courses, coaching, capturing of experience and so on., which can be transferred and used for further development and support KM.	Knowledge is created Existing knowledge is improve
Level 1	It Occurs first practical definition of KM and based on which are formed the first pilot projects KM. Staff are familiar with what is KM but not yet identified with this approach. Knowledge processes are described only partially based on literary sources of „KM pioneers".	When reaching level of initiation is recommended to create a „developed" strategic plan focused on standardized approaches of knowledge MANAGEMENT SYSTEM, which are an expression existence of a knowledge management system in the enterprise. Managers should utilize knowledge and information from all sources within the enterprise and use them in creating competitive strategies.	Knowledge is created Existing knowledge is improve

Table 1 continued.

Maturity level	State of the KM corresponding to the maturity level	Proposals for moving to a higher maturity level	PDCA cycle and Kolb learning cycle
Level 2	In enterprise is creating a strategic plan, whose main goal is to build a knowledge management system. Employees are identified with enterprise vision of KM, trying to reach their full potential of knowledge. Change in thinking.	Enterprise should focus on an integrated approach to KM – encompass all parts of the enterprise, systemic approach to KM, the ability to develop flexibility, regularly evaluate on the results achieved in order to meet the new requirements in KM, to fulfil the vision of enterprise in terms of KM.	Knowledge is created Existing knowledge is improve
Level 3	In enterprise is a system providing KM process knowledge in all directions from the acquisition to the documentation, so that the most effective use of all the possibilities. Enterprise also evaluate the results of KM and fills arrangements for continuous improvement.	Achieve the highest level KM should not mean a static condition, but a dynamic fighting in terms of continuous improvement. It is particularly important to respond flexibly to changes in the environment. This level is probably the most obvious evidence of the enormous importance of learning as a cyclical never ending process.	Knowledge is created Existing knowledge is improve

Source: own processing.

Maturity model should have an essential as the PDCA cycle, and Kolb´s learning cycle in the cyclicality of knowledge management. This will ensure the principle of continuous improvement.

Research results

The above-referenced assessment model of knowledge management was the subject of verification in the micro-enterprise services (micro enterprise A). The following are partial results of the verification evaluation model of knowledge management in the micro-enterprise A.

The following tables show the results score of criteria K1-K6. Each table presents maximum possible score of the indicator, score and percentage of obtained scores for individual indicators reached a maturity level of the criteria, which stems from the specified point of scale for assigning maturity level as a criterion.

K1: People, education, competence

In criterion K1attention was focused on human resources. People can be considered as the most important source of productive resources in the enterprise. In the field of knowledge management is the importance of people more significant because people are just bearers of knowledge.

K1 contains indicators of education, knowledge and behaviour, which illustrates the Table 2.

Table 2. Evaluation criteria K1 in the micro enterprises A

Indicator	Maximum score	Obtained score		K1 Maturity level
		N	f (%)	
Education	9	6	67	
Knowledge	9	3	33	
Behaviour	9	4	44	
Total	27	13	48	**1**

Source: own processing.

In the indicator Education is evaluated level of training of educational achievement or training. Knowledge indicator evaluates the knowledge level of all human resources in micro-enterprise A. Behavioural indicators evaluates behaviour of all employees in micro-enterprise A. Table 2 illustrates evaluation the criteria and the maturity level K1.

Based on the results in Table 2 was the criterion K1 in the micro-enterprise A assigned by maturity level 1, which means that the company in terms of the criteria K1 – people, education, competence – is at the initiation of knowledge management. Based on the characteristics of the different maturity levels classified according to the criteria, we can conclude that people in micro-enterprise A have the basic knowledge necessary for the performance of work and these are reflected in the behaviour of employees.

In the same manner in the form of frequency tables are evaluated the other criteria of knowledge management maturity model for micro-enterprise services.

K2: Environment

In this criterion the emphasis is to determine, whether in the micro-enterprise A occurs creating business climate supporting knowledge processes, whether employees actively cooperate with each other and how important are the views of employees. Table 3 expresses the evaluation of the criteria K2 in micro-enterprise A.

Table 3. Evaluation the criteria K2 in the micro-enterprises A

Indicator	Maximum score	Obtained score		K2 Maturity level
		N	f (%)	
Business climate	9	3	33	
Interpersonal relationships in the enterprise	9	3	33	
People's views and delegation	9	6	67	
Total	27	12	44	**1**

Source: own processing.

In criterion K2 was achieved level 1 – levels initiation, which we can according to the characteristics maturity levels classified under the criteria defined as the levels the neutral atmosphere and the business relationships between human beings usually of a formal nature.

K3: Knowledge Processes

In this criterion, we searched for evidence of the existence and promotion of knowledge process in the micro enterprises A, which are the acquisition, sharing and use of of knowledge. Results are summarized in Table 4.

Table 4. Evaluation the criteria K3 in the micro-enterprise A

Indicator	Maximum score	Present state	Obtained score		K3 maturity level
			N	f %	
The acquisition of knowledge	9	depending on the actual needs	4	44	
Knowledge sharing	9	as appropriate	3	33	
Knowledge using	9	depending on the actual needs	4	44	
Total	27		11	41	**1**

Source: own processing.

K3 criterion was rated as well the above criteria and it has been assigned levels of initiation. This maturity level can be characterized as a level where knowledge processes are partially supported depending mainly on the legislative requirements.

K4: Leadership

Securing of knowledge management by top management is necessary for micro enterprise. The management should support the processes of acquisition, sharing and utilization of knowledge and continuously improve them. It should also define the objectives of knowledge management and ensure the company against losses of knowledge capital. In Table 5 shows the maturity level criterion for K4.

Table 5. Evaluation criteria K4 in the micro-enterprise A

Indicator	Maximum score	Present state	Obtained score		K4 maturity level
			N	f %	
Support of knowledge processes		Unsystematic supporting	6	67	
Objectives of knowledge management		Undefined	0	0	
Knowledge loss		Unsecured	0	0	
Total	27	-	6	22	**0**

Source: own processing.

Leadership is considered to be in the business for one of the criteria with the greatest shortcomings because insufficiently secure the area of knowledge management. This is the finding level maturity criterion for K4 shown in the table above. In micro enterprises and from the perspective of top management would be appropriate to focus on personal development in terms of management skills, identify of knowledge management goals and ensure enterprise before the Knowledge losses.

K5: Technological Infrastructure

In criterion K5 intention was to find out at what level the enterprise is in the ownership and use of technology, whether it has sufficient technological base, or whether using information technology in the knowledge management. Indicators in criterion K5 are: technological base, use of technology, interest in IT, which reflects Table 6.

Table 6. Evaluation criteria K5 in the micro-enterprise A

Indicator	Maximum score	Present state	Obtained score		K5 maturity level
			N	f %	
Technological – base	9	Basic	3	67	
Using of the IT	9	Partial	3	0	
Interest in IT	9	Does not expres	0	0	
Total	27	–	6	22	**0**

Source: own processing.

Maturity level of technological infrastructure is in the micro-enterprise critical since reaching level 0, which is a serious deficiency for the enterprise, especially because information technology represents an important support tool in the management knowledge.

K6: Continuous improvement

Criterion K6 – Continuous improvement is an important criterion with regard obtaining information on the existence of feedback in the enterprise. Table 7 shows the level maturity criteria K6 – Continuous improvement in the micro-enterprise the knowledge management A. Under this criteria, we focused on the detection monitoring requirements within the knowledge management in the enterprise, on the way evaluation results in the knowledge management and corrective actions taken.

The level of maturity for K6 is zero, which represents with regard the requirements for the cyclicality, the serious lack of management knowledge. Level 0 can be based on K6 Tables 1 characterized as a state in which the company does not pay performance monitoring management knowledge nor has developed procedures in terms of continuous improvement.

Table 7. Evaluation criteria K6 in the micro-enterprise A

Indicator	Maximum score	Obtained score		K6 Maturity level
		N	f (%)	
Analysis and monitoring of knowledge	9	0	0	0
People vigor and continuity processes	9	0	0	0
Elimination of the identified shortcomings	9	3	33	1
Total	27	3	11	**0**

Source: own processing.

Based on the score of indicators in the micro-enterprises A was evaluated levels maturity of all specified criteria K1 to K6. Then evaluated by based level of the individual criteria may be applied to the evaluation of the overall level maturity in micro-enterprise A. Table 8 shows the result of the overall evaluation of knowledge management in the micro-enterprises A, which we have obtained based on point scale.

Table 8. Cumulative assessment of the overall KM maturity level in micro-enterprise A

Criteria	The obtained point evaluation	Assigned maturity level
K1 – People, education, competence	13	1
K2 – Environment	12	1
K3 – Knowledge processes	11	1
K4 – Leadership	6	0
K5 – Technological infrastructure	6	0
K6 – Continual improvement	3	0
Total score	**51**	**1**

Source: own processing.

The achieved maturity level of knowledge management in the micro-enterprise A is 1 – levels of initiation. Based on the characteristics maturity levels can be concluded that in the micro enterprises and appear first practical definition of MZ and based on them the first pilot projects are formed the KM. Staff are familiar with what is the KM but not yet identified with this approach. Knowledge processes are described only partially based on literary sources of „the KM pioneers".

This result may be due to the clarity of the display using the spider graph. For illustration evaluation of knowledge management expresses Fig. 7th.

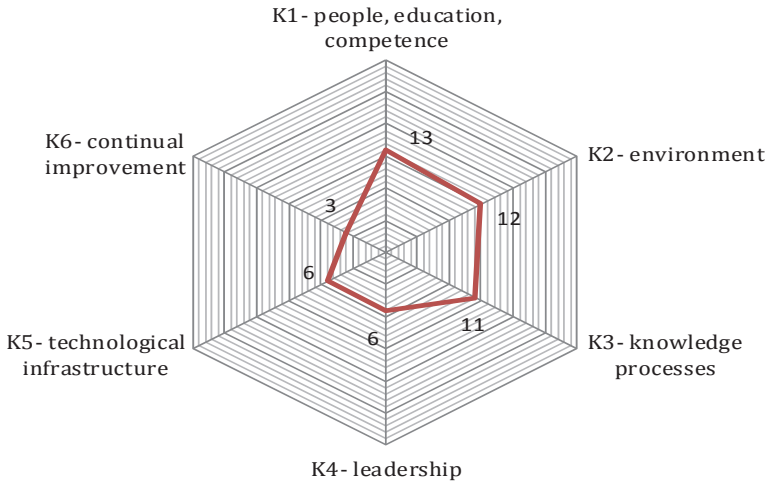

Figure 7. Spider view maturity levels of KM in the micro-enterprise
Source: own processing.

From fig. 7 is a noticeable lack elaboration of knowledge management especially in the criterion K6, although a low level of maturity achieved in the criteria K4 and K5. The results show a few facts, which may be selected for micro-enterprise as a benefit:

1. Micro-enterprise A has three fundamental under-developed areas (K4 – Leadership, K5 – K6 and Information Technology – Continuous improvement).
2. Maximum level achieved in all assessment criteria is 1.
3. Micro-enterprise A reach an overall maturity level 1 – levels initiation, but based on a set point scale it can be stated, that the obtained point evaluation is borderline with the maturity level 0.

Based on the above conclusions it is possible to choose and propose from the part of the proposals and recommendations for the micro-enterprise the following measures to improve the state of knowledge management and to increase the maturity level in the micro enterprise A:

- to develop a positive employees attitude of the knowledge management;
- to develop programs for the implementation of knowledge management;
- to initiate the process of obtaining, sharing and documentation such as: training courses, coaching, capturing of experience and so on., which can be transferred and used for the further development and promotion of knowledge management.

At the same time the enterprise can lay down a new vision and objectives of management knowledge depending on its own circumstances and needs arising from the business activities.

Conclusion

The value of the knowledge and knowledge management in the current competitive environment of the enterprises has a justification. The reason of excessively and frequently using of this concept is the value of the knowledge capital that is often hidden in the minds of employees or explicitly located in the enterprise as an internal guidelines, a knowledge base, documented procedures, etc.

Large enterprises are more engaged in knowledge and knowledge processes such as micro-enterprises. They have developed many methods to measure and evaluate knowledge while micro enterprises considered those methods as complicated in relations of data acquisition and of their evaluation too.

The paper deals with the evaluation of knowledge management in micro enterprises and proposing of steps for the improvement of knowledge management. For this purpose is used knowledge management maturity model.

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ECONOMIC EFFECTS OF USING 5 IN + 1 H TOOL IN LIMITING THE NOISE SOURCES IN THE INTERNAL TRANSPORT

Abstract

In the paper the problems identified during the review and evaluations of correctness of applying safety at work regulations, and the correctness of the production processes on the production hall in the internal transport are analyzed. During the review a very high noise level which was close to the upper limit of the norm and amounted 83 dB in the production hall was verified [9]. To identify source problems a tool „5W+1H" was used – analysis 5 x why and Ishikawa diagram. Research results were a base of drafting the project of improving wagons for transporting production parts and components what allowed to lower the noise level in the production hall. In the project financial and immaterial benefits resulting from the project implementation were calculated, as well as few lowered occupational risks which occur in the unit. The project was carried out in a production unit in the household industry considering the data sensitivity the unit name where the project was carried out wasn't revealed. An identification of economic effects as a result of eliminating the exaggerated noise sources made during the in-house components transport from magazines into the factory floors was a purpose of the project research.

JEL Classification Code: **L15, M53**.

Keywords: 5 in + 1 H tool, Ishikawa diagram.

Introduction

The internal transport in an enterprise carried out in the factory halls is without a doubt the area directly connected with the logistics. Usually it is made on low dis-

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tances, mainly at the section – spare parts warehouses – production lines – finished products warehouses or marked sections. The production halls among themselves and warehouses are connected with transport roads appointed for vehicles. These are tractors towing carts with parts and semi-finished products for the production, so-called „gitterboxes" (system of steel net containers), containers or other „packaging". In the production halls forklift trucks for transport of palettes or containers of different kind are used more rarely. Considering the work safety regulations production halls are separated from warehousing facilities with special curtains, or barriers what is advisable for the workplace which is different on the warehouses area and production halls. The internal transport as the element of logistics carries a lot of threats and occupational risks associated with them which in case of production units may reach the number of a few thousand. Reducing the noise level and the number of risks is a result of studies described in the article. Obtained results were presented not only from the technical side but also in economic aspect, that is obtained benefits as a result of work and safety actions. Benefits were calculated according to the comparative research made in various countries and production units. These are also benefits in the form of the profit.

1. Identification of causes and sources of the exaggerated noise in the internal transport

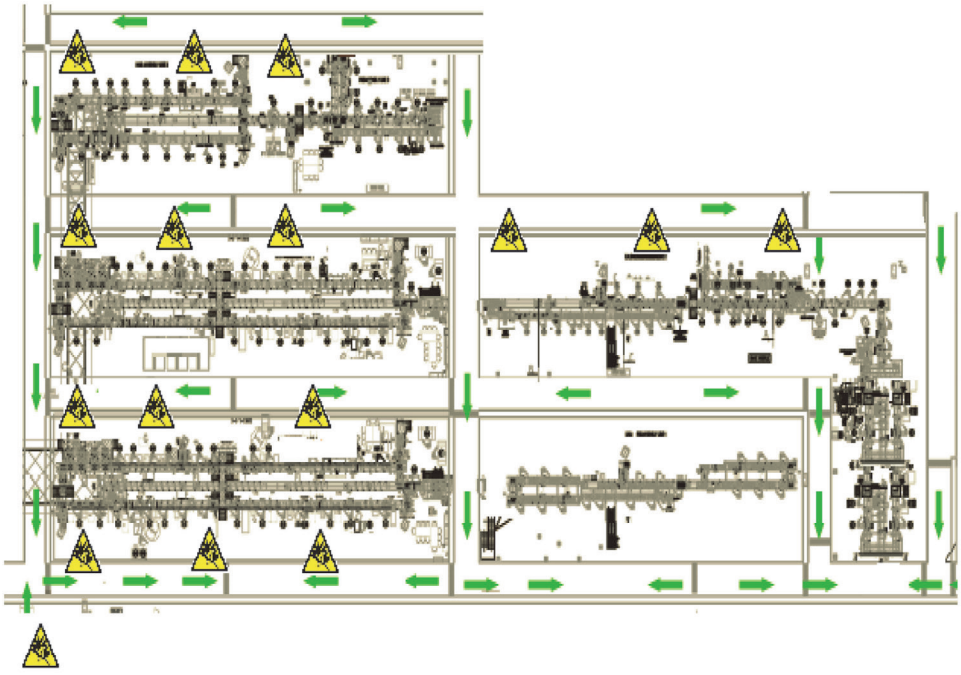
For years the management supervising the projects has believed that extra working costs in accordance with work and safety regulations can contribute to many benefits. Therefore in the unit are used:
- motivating systems in the social insurance,
- economic analyses in the entire area of the health and safety at work,
- cooperation with foreign companies, e.g. Japanese.

Frequent employees remarks about feeling the exaggerated noise in the production halls and warehouses caused making immediate decision by the management to exam this occurrence. An awareness was an additional motive for the management action, that amongst occupational diseases which in Poland annually are stated a few thousand, where on the third position is a long-lasting double-sided hearing loss.

Describing the reasons and sources for the exaggerated noise during the internal transport of parts, sub-assemblies and production elements from warehouses to production halls was the research purpose. Transportation equipments put through an examination are tractors and carts pulled by them. For determining costs incurred essential costs were taken for the project implementation. For determining the benefits experiences of such counties as USA, Germany, Switzerland were used.

2. Characteristics of studied area

Internal communications roads in the factory are assigned to the transport between warehouses and the production halls in which the assembly lines are situated. Mainly tractor carts with wagons and occasionally forklift trucks move on these routes. Communication roads are clearly signed with appropriate lanes and permanently marked by paint, warning and information boards. For the movement safety light and signal signs are used. Communication is held with the help of mechanical means of transport which in studied area once in 15-30 minutes cross over the roads providing the production components to the assembly lines. The main harmful factor to the health in studied area is the noise. 15 sites, in which exceeding of the NDS and NDN pulses weren't stated were controlled. However a very high noise level close to acceptable was reported.



Picture 1. Site plan of studied area. On the plan points of the noise measurement were marked.

Source: own study.

In studied area in the hall where the transport road is situated from which the noise source comes works about 100 people, including 15 people in the transport. Along transport roads tractors with wagons and forklift trucks are moving with maximum with speed up to 8 km/h and at intervals of about 30 minutes.

In studied area the internal transport infrastructure includes:
- internal roads,
- tractors (CXT) towing wagons (picture 2),
- wagons and carts - to transport production parts and details – 5 kinds,
- auxiliaries.

Picture 2. CXT tractor with wagons of different type in the production hall

Wagons and carts which are used to transport:
- small details - in containers of the gitterbox type or cartons,
- electric engines,
- panels (picture 3),
- blanks,
- casings,
- other components.

Picture 3. Cart for the panel elements transport

Achieved results required implementing new standards. Effects of the project were organized by establishing uniform standards for multiple applying by employees in the scope described in the picture 4.

Picture 4. Standardization for the fulfilled purpose.

Source: own work according to the results of executed project.

In the framework of new standards after eliminating noise causes and reducing it to level of 77 dB the following standards were implemented:

- sharing the knowledge - spreading the knowledge in all areas where the same problem appears,
- monothematic lessons - internal training to reinforce the knowledge concerning only this problem
- before and after - shows the state of the problem before revealing the problem and after its solving in order to show clearly what has changed as a result of solving the problem,
- TPM card - is a help in conservation and inspections. It determines how to perform activities properly, with the help of what tools but also when the activity should be performed (More: Abramowicz, 2015), (1)
- inspections schedule.

As a result of standardization another appearance of the solved problem is prevented, however it requires entering into DTR additional legacies associated with adapting carts to requirements established as the project result.

3. Research methodology

Unit internal transport supports mainly the core activity process and is closely associated with it (Abt S., 2001). The system of spatial-temporary goods change determines logistic processes occurring in production companies (Pfohl, H.CH., 2001)

Production companies focus on the effectiveness of logistic processes, managing them and in connecting with other companies (Pisz I, Sęk T., Zielecki W., 2013). To solve the problem pointed in the article the case study approach was applied.

There are many methods which are possible to apply to analyze the correctness of applied solutions in the outside and internal transport. Methods allow to identify problems with different tools like e.g.:

- 6S+1 system (More:Abramowicz,2014),
- Kaizen,
- supermarket,
- spaghetti diagram,
- Ishikawa diagram,
- 5W + 1H,
- standardization.

The three last tools mentioned above (Ishikawa diagram, 5 in +1 H, standardization) will be applicable in the project which is described later in the article. Tool 5 in + 1 H collects and organizes data and information, making analysis and establishing causes of the examined problem, which causes risk in the workplace and threats from the work and safety point of view. Name of 5 of W+1 H method comes from English words: What? Who? When? Where? Why? and How? Answering individual questions towards the mistake, or a problem appeared in the analyzed process. Answers to questions are given according to evidence of different kind, facts and figures. Usually before applying 5 in + 1 H tool so-called Ishikawa diagram is applicable which consists determining the examined problem on the principle „from general to detail". This tool is also known as 5 M which means: men, methods, machines, materials, management. In practice the Ishikawa diagram establishes the hierarchy of causes, which means that it divides them according to importance of appearing.

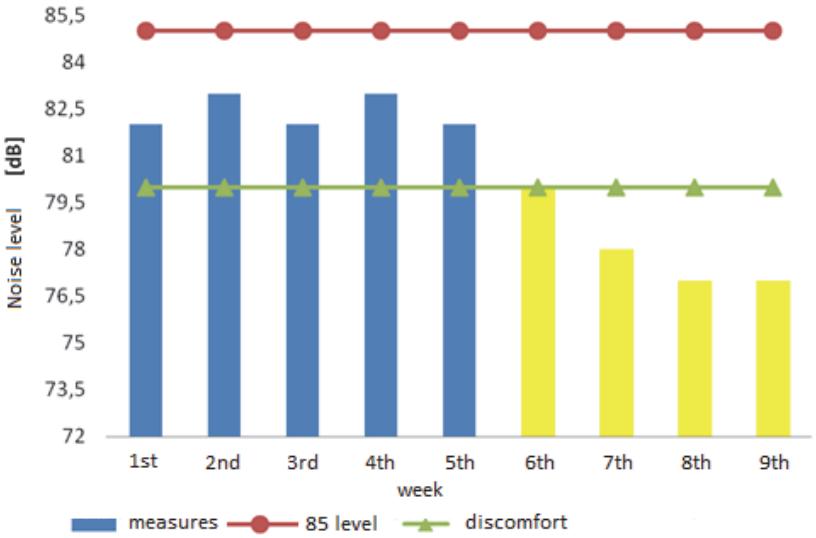
4. Research results

For examining the problem duration was planned for 8 weeks. In five first weeks the research of the noise level of noise in 15 sites of the production hall and warehouses was planned. Moreover at that time analysis, location of sources and detailed noise causes were taken. During next 3 weeks removing stated irregularities and lowering the noise level according to the established purpose were planned.

The research was conducted step by step according to the following scheme:

– applying the Ishikawa diagram for analysis of source causes,
– the indicator definition to monitor and the purpose,
– analysis of source causes of the occurrence of the exaggerated noise. 5 in + 1 h,
– analysis of source causes (method 5 x why),
– planning and implementing actions eliminating source causes,
– monitoring of project results with reference to the established purpose,
– standardization,
– the purpose accomplishment,
– effects verification.
– costs and benefits.

As a result of made 5 M analysis (because of the place thinness the Ishikawa diagram wasn't presented in the article) is that the source of the problem are 1 M – materials and 2 M – machines – carts. Remain M didn't appear. In order to define the aim of the project measurements to find the noise level were made. In the area of tractors with wagons ride 15 sites were set. Measurements let to establish that 4 kinds of tractor compositions generate the maximum noise on 83dB level. Consolidated results of the noise measurement were shown in picture 5. According to the work and safety principles of the noise, even though the norm allows noise of 85 dB level. a noise exceeding 80 dB causes discomfort in employees feeling. And so for the threshold of the adverse impact to the man 80 was accepted on 80 dB level. In that case an aim of achieving soundproofing the noise which doesn't exceed 80 dB was presented to the team.



Picture 5. Monitoring the noise level in individual weeks (the first 5 weeks) and average weeks measurement results.

Source: own study based on measurement results.

In order to describe the detailed reasons for the set noise level following analyses listed in tables 1 and 2 were made.

Table 1. Analysis of source causes of the exaggerated noise occurrence. 5 in + 1 H

5 W	Supporting questions	Answers
What?	1. What is the problem?	1. Noise emitted by the tractor.
	2. What has happened?	2. Employees complaints about feeling the high noise level on the hall and in the warehouse.
	3. What specific thing/ the occurrence is it about?	3. Healable noise measured in dB
	4. Does the problem change depending on applied materials, parts, their shapes or sizes?	4. The noise level changes depending on the pulled cart type. (Stil, Techmasz, Bewatec).
	5. Are there any differences between provided parties?	5. No.
Where?	1. In which process does the problem occur?	1. It occurs by each completion of carts.
	2. In which part/ section of the machine?	2. The noise is generated by: carts platforms, packages, connecting carts with shafts, wheels on dilatations
	3. Does the problem change depending on applied machines/ tools?	3. The noise level changes depending on the pulled cart type: quiet - Stil, noisy - Techmasz, very noisy - Bewatec.
When?	1. Does the similar occurrence appear on other machines?	1. No.
	2. Has the occurrence the constant character?	2. Yes.
	3. Does the occurrence appear at the beginning, in the middle or at the end of shift?	3. During the entire shift.
	4. Does the occurrence appear after rearming the set of carts, of loading etc?	4. No.
	5. During which operations does the occurrence of the exaggerated noise appear?	5. During delivery the part by carts,
	6. Does the problem appearing depend on the shift/season?	6. No.
Why? What for??	1. Why does the problem appear? Causes.	1. The noise level increases along with growing the number of pulled carts as a result of the rising purchases.
How?	1. How does it come to appearance of increased noise?	1. The occurrence of the noise is as a result of tractors with carts rides.
	2. Does the noise increase or reduce? and does it occur often or occasionally?	2. The noise occurs in the interval of 30 minutes, during the tractor with carts ride
	3. Does the noise occur suddenly or is it intensifying?	3. The noise occurs constantly,
	4. Were there any changes of tools, materials, parts before the problem occurred?	4. No.

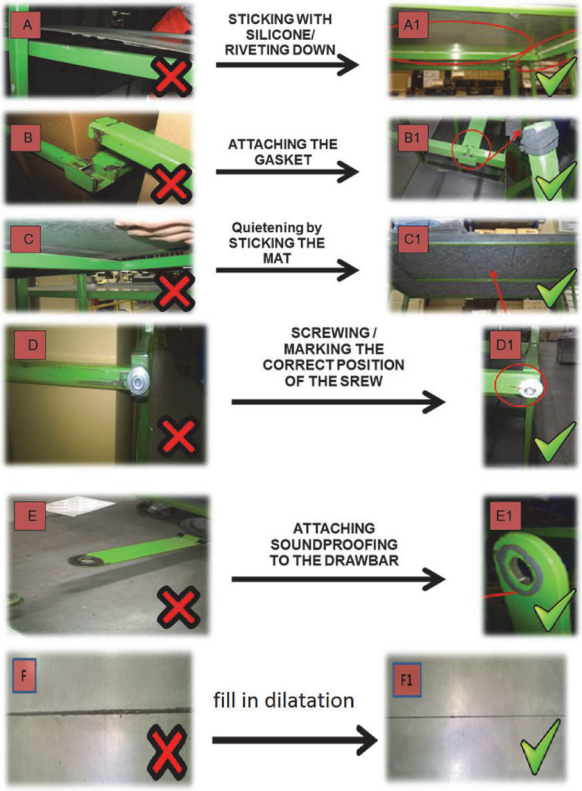
Source: own study based on information from the project.

Table 2. Analysis of source causes (5 of x why method).

5 x W	Answers
What?	Noise of the tractor with carts
Where?	In all tractor compositions
When?	While using carts
Why?	Faulty carts, bad road surface
How?	The noise level increases along with the rise of the number of carts in composed

Source: own study based on information from the project.

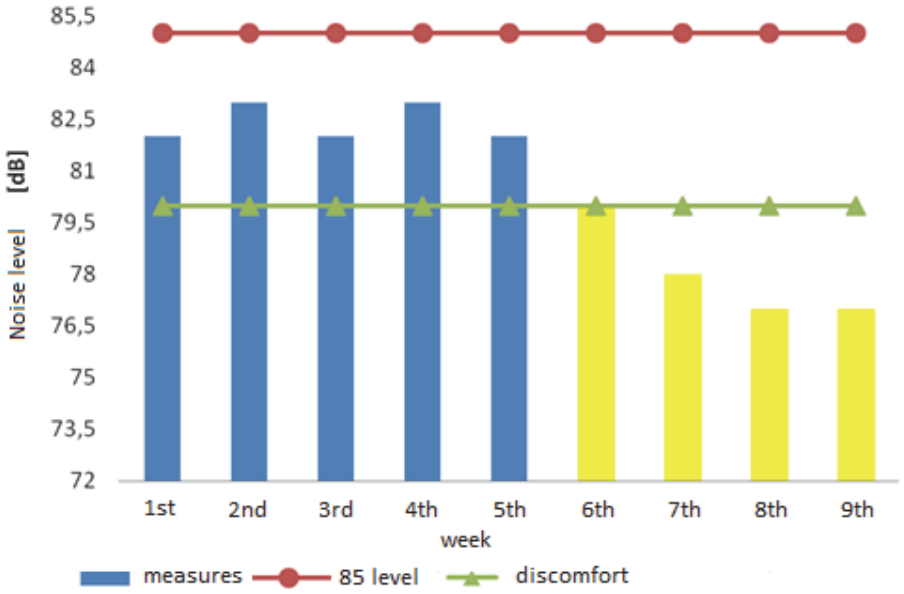
Knowing detailed causes of the searched noise level additional actions in order to eliminate source causes were planned. Next monitoring the project results with reference to the established purpose were made. Sources causes are presented in picture 6 on the left. And the way of establishing preliminaries in analysis of causes is presented in picture 6 on the right.



Picture 6. Planning and implementing actions to eliminate source causes (A, B, C, D, E, F, A1, B1, C1, D1, E1, F1).

Source: own study.

In picture 6 one by one ways of eliminating pulses in the cart connections were presented:
- riveting down and sticking the tin-shelf which by pulses would cause unnecessary noise,
- adding the gasket on the connection which mutes pulses and its fastening,
- adding the soundproofing mat to the shelf from its bottom side which mutes pulses of the shelf,
- screwing - establishing the stable correct position of the screw,
- adding the muting gasket of the cart shaft,
- repairing backer cracks in internal routes.



Picture 7. Results of noise measurements before the removal (the first 5weeks), during removing (6, 7 and 8 week) and after removing the occurrence of the exaggerated noise (9th week).

Source: own study based on project data.

As a result of removing the two first irregularities described in pictures 6 point A and B, in 6th week of the project duration a noise level was gained on 80 dB level. In the next, 7th week after removing next irregularities (picture 6 C, D, E) the noise reached a level of 78 dB. In the last week the last irregularity was removed and a noise was on level of 77 dB. To make sure about for the correctness of the received result in the 9th week finishing the project the noise level was checked again. Measurements showed level of 77 dB.

5. Technical and economic results

Accomplishment of the purpose even though which involved the need to incur determined costs brought results of lowering the noise level and lowering the increased indicator risk. Results are shown in table 3. The project implementation required investing financial means in amount of 14 500 PLN. Value of labor and applied materials used in the project are shown in table 4.

Table 3. List of achieved results.

No.	Name of the project indicator	Noise value (dB)		
		Before project	Aim	Achieved result
1	Lowering the noise	83	80	77
2	Lowering the increased indicator risk	19	12	12

Source: own study based on findings.

Table 4. List of the project implementation costs for 8 wagons

No.	Material and labours kinds	Material and labor value (in PLN)
1	Metal sheet	340
2	Glue for sticking the metal sheet to the frame	550
3	Soundproofing mat	780
4	Sealing materials	560
5	Nuts and screws	365
6	Rivets (exchange of aluminium rivets into metal rivets)	355
7	Stiffening trusses	1 925
8	Filling the road dilatation in the production hall	2 425
9	Labour (60 x120 hours PLN)	7 200
10	Together	14 500

Source: own study based on data of examined unit.

Indicators calculated for similar „work and safety investments" made in Germany and in Switzerland were used to calculate the estimated profit - benefits from investments made to fulfil the project. In the first case he indicator was 1.6 which means, that each 1 PLN intended to implement the project should give a benefit (profit) of 1.6 PLN in the future. In the second case the estimated benefit will bring 2.2 PLN for each invested 1 PLN. These results are presented in table 5.

Table 5. List of costs and benefits

No.	Amount of the work and safety expenditure (PLN)	Benefit ratio (PLN)	Benefit (PLN)
1	14 500	1.6	23 200
2	14 500	2.2	31 900

Source: own study.

Comparing both results it is possible to state that irrespective of the indicator admitted to estimating benefits are significant.

Summary

Information from employees suing to the excess noise level in the production hall and in the warehouses led to make a rational decision to locate noise sources. For solving this problem a team of employees was appointed which drew up the project of improving existing state of supplying parts and components for production. Presented studies are a result of conducted analysis with use of the Ishikawa Diagram and 5 in + 1 H (five why + they how) tools. The project Implementation let to eliminate the troublesome, high noise level. It is needed to underline the fact of disproportionately low cost of the project implementation compared with costs of possible hearing loss of employees working in the examined area. Issues of the internal transport are these which demand rational decisions in aspirating to improve its functioning. Due to the need of providing safe transport processes.

It is needed to remember, that in processes of the flow being an essence of the contemporary logistics which include transport processes which always, in smaller or larger level, accompany production processes, create about 30% of the company profits (Korzeń Z, 1998). The solution suggested in the article will also constitute the appropriate particle of the company profits.

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USING AKAIKE'S CRITERION AND BORDERED MATRICES FOR INITIAL VARIABLE SELECTION FOR ECONOMETRIC MODEL EVALUATED WITH LEAST SQUARES METHOD

Abstract

In this paper the usage of bordered matrices for selection of independent variables for econometric model evaluated with least squares method is shown. AIC was chosen as criterion of selection. Practical example of the method is also presented.

JEL Classification Code: **C010**, **C120**.

Keywords: Akaike's Information Criterion, least squares method, bordered matrices.

Introduction

Initial selection of explanatory variables for econometric model is really important issue. It often determines the final quality of the model. Therefore, it is essential to use proper variables. At the beginning researcher usually only know the response variable Y, which he tries to explain. Economic theory and intuition suggest what factors may affect the response variable. This way we obtain a set of potential explanatory variables. Often this set is too big and not all of the variables included should be put into the model – thus selection of chosen variables is required. This problem can be solved using numerous methods of variables selection for econometric models. Literature in this area is very extensive, ranging from the classic book by Draper Smith (1973) or Metody doboru zmiennych w modelach ekonometrycznych (Grabiński, Wydymus and Zeliaś 1982). Different model selection criterions are also

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mentioned by Charemza and Deadman (1997). Big popularity in Poland has Helwig's method (Hellwig 1969).

In recent years there is a great interest in the selection of variables for econometric model based on Akaike's Information Criterion as well as comparing it with other criterions – Piłatowska (2011), Rosienkiewicz (2012). This paper focus on the practical aspects of applying and calculating AIC.

Basic considerations

At the beginning let's describe main formulas associated with AIC.

Let's consider a model:

$$Y = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \ldots + \alpha_k Z_k + \xi \tag{1}$$

Parameters are evaluated basing on n observations. Likelihood function for estimated model looks as follows:

$$L = \prod_{t=1}^{n} \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{\left(y_t - \sum_{j=0}^{k} \alpha_j z_{jt}\right)^2}{2\sigma^2}} \tag{2}$$

Thus loglikelihood (see Dorosiewicz and others 1996):

$$\ln L = n \ln\left(\frac{1}{\sigma\sqrt{2\pi}}\right) - \frac{1}{2\sigma^2} \sum_{t=1}^{n} \left(y_t - \sum_{j=0}^{k} \alpha_j z_{jt}\right)^2 \tag{3}$$

For the model estimated with least squares method log likelihood function is equal to:

$$\ln \widehat{L} = -\frac{n}{2}\left(\ln(2\pi) + \ln\left(\frac{u^T u}{n}\right) + 1\right) \tag{4}$$

where u is model (1) residulas column vector. Equality (4) can be transformed into:

$$\ln \widehat{L} = -\frac{n}{2}\left(\ln(2\pi e) + \ln\left(\frac{u^T u}{n}\right)\right) \tag{5}$$

or

$$\ln \widehat{L} = -\frac{n}{2}\left(\ln\left(\frac{2\pi e}{n}\right) + \ln\left(u^T u\right)\right) \tag{6}$$

Let's note that one of measures of quality of the model is the convergence factor φ^2, which is calculated according to the formula:

$$\varphi^2 = \frac{\sum_{t=1}^{n}\left(y_t - y_t^{*}\right)^2}{\sum_{t=1}^{n}\left(y_t - \bar{y}\right)^2} = \frac{u^T u}{\sum_{t=1}^{n}\left(y_t - \bar{y}\right)^2} \tag{7}$$

Using (7), basing on (6) we obtain:

$$\ln \widehat{L} = -\frac{n}{2}\left(\ln\left(\frac{2\pi e}{n}\right) + \ln\left(\varphi^2 \sum_{t=1}^{n}\left(y_t - \bar{y}\right)^2\right)\right) \tag{8}$$

Relationship (8) we can rewrite as:

$$\ln \widehat{L} = -\frac{n}{2}\left(\ln\left(2\pi e S_y^2\right) + \ln\left(\varphi^2\right)\right) \tag{9}$$

where:

$$S_y^2 = \frac{1}{n}\sum_{t=1}^{n}\left(y_t - \bar{y}\right)^2 \tag{10}$$

is the variance of dependent variable Y empirical values.

Formula (9) describes log likelihood function maximum for the model estimated with least squares method.

Akaike's Information Criterion is defined by (Maddala 2008):

$$AIC = -2\ln \widehat{L} + 2(k+1) \tag{11}$$

So for the model estimated with least squares method, basing on (9) and (11) we have:

$$AIC = n\left[\ln\left(2\pi e S_y^2\right) + \ln\left(\varphi^2\right)\right] + 2(k+1) \tag{12}$$

It is worth noting that AIC formulas described in the literature are a little different than (12) (for example Maddala 2008, Górecki 2010, Rosienkiewicz 2012). In most of cases the difference is caused by skipping the first sum component in equation (6) in the brackets.

It is worth adding that calculating AIC according to formula (12) leads to a result identical with that obtained using Gretl and in the case of other models it usually doesn't. Let's notice that if we consider different models with the same number of

variables then according to AIC basing on (12), we choose the model with the lowest convergence coefficient φ^2.

Comparing different models for dependent variable Y, we choose the one with lowest AIC as the best. Therefore with the dependent variable Y and k potential explanatory variables to select the optimum set of variables, according to AIC, one would just estimate 2^k-1 indicators (similarly as in the case of Hellwig's method).

Let's rewrite formula (12), broken down into three components:

$$AIC = n \cdot \ln\left(2\pi e S_y^2\right) + n \cdot \ln\left(\varphi^2\right) + 2(k+1) \tag{13}$$

Let's note that if we have the dependent variable Y, k potential explanatory variables and the empirical data consisting of n observations – then by choosing variables for the model in accordance with the criterion of minimizing AIC given by (13), the first component of the sum occurring in the formula is constant. For various combinations of variables only two other components will change. To compare different subsets of variables - in practice we have to evaluate only convergence coefficients φ^2 for models with this subset used as exploratory variables.

Proposition of variable selection method using AIC

Before algorithm for choosing a satisfactory set of explanatory variables based on AIC will be shown, we will focus on finding the coefficient φ^2 occurring in the formula (13).

Let's denote by $(R(k)\ R_0(k))$ correlation couple describing model (1). As we know (Kolupa, Śleszyński 2010):

$$\varphi^2 = 1 - R_0^T R^{-1} R_0 \tag{14}$$

To compute φ^2 we can use bordered matrix P:

$$P = \left[\begin{array}{c|c} R & R_0 \\ \hline R_0^T & 1 \end{array}\right] \tag{15}$$

If on the matrix P given by (15) we perform elementary transformations which cause that:

- in place of matrix R we we obtain upper triangular matrix with diagonal elements equal to one R^*,
- in place of vector R_0^T we obtain zero vector,

then in place of number 1 we obtain φ^2. As a result matrix P will be transformed into P^*:

$$P^* = \left[\begin{array}{c|c} R^* & R_0{}^* \\ \hline 0,\ldots,0 & \varphi^2 \end{array}\right] \tag{16}$$

For model (1) matrix P given by (15) has degree (k+1). Let's notice that in practice, by transforming it to (16) we take care about each of k columns of correlation matrix R. Thus at the beginning we bring to zero all first columns elements below matrix R diagonal and the first component of vector R_0.

Then in the bottom right corner of the transformed matrix we will receive a number, equal to φ^2 of the model in which the only explanatory variable is the first variable of the model (1) – Z_1. According to formula (13) by substituting k with 1 we can calculate AIC for this model. If now we make similar operations on the second column of the matrix P then in the lower right corner of the transformed matrix we will receive a number, equal to the ratio φ^2 for the model in which the explanatory variables are the first and the second variable from model (1) – Z_1 and Z_2. According to formula (13) by substituting k this time with 2 we can calculate the value of the AIC for this model. Continuing the procedure until transforming the matrix P into P^* (16), as if „by the way" we determine the value of AIC for models in which sets of variables are respectively: $\{Z_1\}$, $\{Z_1, Z_2\}$, $\{Z_1, Z_2, Z_3\}$, …, $\{Z_1, Z_2, Z_3, \ldots, Z_k\}$.

In practice, to end up with sensible set of explanatory variables, according to AIC and described method of proceeding, it is recommended to apply following rules:

1) explanatory variables in model (1) pre-sort by not growing absolute values of these variables correlation with the dependent variable Y,
2) if as the result of computations for s transformed matrix P column AIC value is bigger than the previous one – then in the (s-1) transformed matrix we remove row and column s and continue with the process. In practice it means that ZS won't be in the model
3) the process is finished when all the columns of matrix P are transformed. It is worth noting that proposed method doesn't guarantee that resulting variables combination will have minimum AIC, but it should be close to minimum.

In the next part of the paper numerical example of described process will be shown.

Example

Let's consider dependent variable Y and set of potential explanatory variables

$$A(6) = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6\} \tag{17}$$

where:

Y – GDP in Poland at current prices in millions of $,
Z_1 – consumption at current prices in millions of $,
Z_2 – export at current prices in millions of $,
Z_3 – year,
Z_4 – inflation rate in %,
Z_5 – average annual exchange rate of US dollar in zł,
Z_6 – population in Poland in millions.

In the model empirical data from statistical yearbooks of Central Statistical Office from years 1995 – 2014 will be used, it means number of observations n=20. Empirical data is shown in table 1.

Table 1. Values of model variables

Y	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6
142 172,50	111 006,43	32 643,54	1 995	27,80	2,42	38 284,00
159 919,15	127 265,34	35 333,58	1 996	19,90	2,70	38 294,00
159 045,05	127 320,17	37 151,91	1 997	14,90	3,28	38 290,00
173 474,83	137 938,29	45 072,27	1 998	11,80	3,49	38 277,00
169 700,57	136 284,56	40 939,38	1 999	7,30	3,97	38 263,00
171 873,73	140 422,42	46 799,42	2 000	10,10	4,35	38 254,00
190 521,26	158 242,26	51 878,65	2 001	5,50	4,09	38 242,20
198 704,99	168 824,86	57 143,77	2 002	1,90	4,08	38 218,50
217 524,24	182 335,11	72 634,16	2 003	0,80	3,89	38 190,60
253 778,33	208 556,38	87 912,97	2 004	3,50	3,65	38 173,80
304 476,01	247 576,67	106 336,40	2 005	2,10	3,23	38 157,10
343 338,92	275 939,73	131 156,81	2 006	1,00	3,10	38 125,50
428 948,93	336 738,71	166 535,95	2 007	2,50	2,77	38 115,60
530 185,12	427 117,30	203 158,31	2 008	4,20	2,41	38 135,90
437 022,66	351 997,30	164 216,35	2 009	3,50	3,12	38 167,30
476 624,66	385 195,48	192 890,54	2 010	2,60	3,02	38 529,90
524 256,60	416 947,43	226 142,61	2 011	4,30	2,96	38 538,40
496 129,57	394 852,63	223 509,67	2 012	3,70	3,26	38 533,30
526 030,75	415 671,03	242 639,21	2 013	0,90	3,16	38 495,70
547 899,15	429 004,63	257 078,54	2 014	0,00	3,16	38 484,00

Source: statistical yearbooks of Central Statistical Office and own calculations.

Basing on data from table 1 we evaluate correlation pair ($R(6)$ $R_0(6)$) describing the model, where Y is dependent variable and $A(6)$ given by (17) are explanatory variables.

$$R = \begin{bmatrix} 1 & 0{,}98944 & 0{,}95704 & -0{,}61549 & -0{,}45475 & 0{,}44239 \\ 0{,}98944 & 1 & 0{,}96481 & -0{,}59626 & -0{,}42943 & 0{,}52192 \\ 0{,}95704 & 0{,}96481 & 1 & -0{,}76070 & -0{,}22645 & 0{,}45566 \\ -0{,}61549 & -0{,}59626 & -0{,}76070 & 1 & -0{,}27107 & -0{,}03352 \\ -0{,}45475 & -0{,}42943 & -0{,}22645 & -0{,}27107 & 1 & -0{,}11313 \\ 0{,}44239 & 0{,}52192 & 0{,}45566 & -0{,}03352 & -0{,}11313 & 1 \end{bmatrix}$$

$$R_0(6) = \begin{bmatrix} 0{,}99937 \\ 0{,}99198 \\ 0{,}95359 \\ -0{,}59935 \\ -0{,}46778 \\ 0{,}45228 \end{bmatrix}$$

It is worth noting that the potential variables of the model have been ordered so that correlation vector components $R_0(6)$ meet recommended first condition (are ordered by decreasing absolute value of the correlation coefficient with the dependent variable Y). We can then build bordered matrix P given by formula (15).

$$P = \left[\begin{array}{cccccc|c} 1 & 0{,}98944 & 0{,}95704 & -0{,}61549 & -0{,}45475 & 0{,}44239 & 0{,}9993681 \\ 0{,}98944 & 1 & 0{,}96481 & -0{,}59626 & -0{,}42943 & 0{,}52192 & 0{,}991981 \\ 0{,}95704 & 0{,}96481 & 1 & -0{,}76070 & -0{,}22645 & 0{,}45566 & 0{,}953594 \\ -0{,}61549 & -0{,}59626 & -0{,}76070 & 1 & -0{,}27107 & -0{,}03352 & -0{,}599355 \\ -0{,}45475 & -0{,}42943 & -0{,}22645 & -0{,}27107 & 1 & -0{,}11313 & -0{,}46778 \\ 0{,}44239 & 0{,}52192 & 0{,}45566 & -0{,}03352 & -0{,}11313 & 1 & 0{,}45228 \\ \hline 0{,}9993681 & 0{,}991981 & 0{,}953594 & -0{,}599355 & -0{,}46778 & 0{,}45228 & 1 \end{array}\right] \tag{18}$$

To compute φ^2 for the model with one explanatory variable Z_1 – we perform elementary transformations on matrix P given by (18) – bringing first column elements below diaginal to zeros. As a result:

$$P_{(Z_1)} = \left[\begin{array}{cccccc|c} 1 & 0{,}9894 & 0{,}9570 & -0{,}6155 & -0{,}4547 & 0{,}4424 & 0{,}99937 \\ 0 & 0{,}0210 & 0{,}0179 & 0{,}0127 & 0{,}0205 & 0{,}0842 & 0{,}00317 \\ 0 & 0{,}0179 & 0{,}0841 & -0{,}1717 & 0{,}2088 & 0{,}0323 & -0{,}00284 \\ 0 & 0{,}0127 & -0{,}1717 & 0{,}6212 & -0{,}5510 & 0{,}2388 & 0{,}015744 \\ 0 & 0{,}0205 & 0{,}2088 & -0{,}5510 & 0{,}7932 & 0{,}0880 & -0{,}01331 \\ 0 & 0{,}0842 & 0{,}0323 & 0{,}2388 & 0{,}0880 & 0{,}8043 & 0{,}010170 \\ \hline 0 & 0{,}0032 & -0{,}0028 & 0{,}0157 & -0{,}0133 & 0{,}0102 & 0{,}00126339 \end{array}\right] \tag{19}$$

Using the first column from table 1 we compute:

$$S_y^2 = \frac{1}{20}\sum_{t=1}^{20}(y_t - \bar{y})^2 = 22878724746 \tag{20}$$

Thus:

$$20 \cdot \ln\left(2\pi e S_y^2\right) = 533{,}827007 \tag{21}$$

Basing on (19) and (21), using (13) we have:

$$AIC_{(Z_1)} = 20 \cdot \ln\left(2\pi e S_y^2\right) + 20 \cdot \ln(0{,}00126339) + 2(1+1) = \\ 533{,}827007 + (-133{,}47909) + 4 = 404{,}347917 \tag{22}$$

To compute φ^2 for the model with Z_1 and Z_2 as explanatory variables – on matrix $P_{(Z1)}$ given by (19) we perform elementary transformations bringing second columns elements below diagonal to zeros. This time we receive:

$$P_{(Z_1,Z_2)} = \left[\begin{array}{cccccc|c} 1 & 0{,}9894 & 0{,}9570 & -0{,}6155 & -0{,}4547 & 0{,}4424 & 0{,}99937 \\ 0 & 1 & 0{,}8509 & 0{,}6055 & 0{,}9763 & 4{,}0076 & 0{,}150775 \\ 0 & 0 & 0{,}0689 & -0{,}1825 & 0{,}1913 & -0{,}0394 & -0{,}00554 \\ 0 & 0 & -0{,}1825 & 0{,}6135 & -0{,}5634 & 0{,}1878 & 0{,}013826 \\ 0 & 0 & 0{,}1913 & -0{,}5634 & 0{,}7732 & 0{,}0058 & -0{,}016406 \\ 0 & 0 & -0{,}0394 & 0{,}1878 & 0{,}0058 & 0{,}4668 & -0{,}002526 \\ \hline 0 & 0 & -0{,}0055 & 0{,}0138 & -0{,}0164 & 0{,}0025 & 0{,}00078572 \end{array}\right] \tag{23}$$

Basing on (23), using (22) we have:

$$AIC_{(Z_1,Z_2,Z_3)} = 20 \cdot \ln\left(2\pi e S_y^2\right) + 20 \cdot \ln(0{,}00034001) + 2(3+1) = \\ 533{,}827007 + (-159{,}73062) + 8 = 382{,}096384 \tag{24}$$

As AIC value has lowered – we add one another explanatory variable Z_3. After transforming the third column of matrix (23) we have:

$$P_{(Z_1,Z_2,Z_3)} = \left[\begin{array}{cccccc|c} 1 & 0{,}9894 & 0{,}9570 & -0{,}6155 & -0{,}4547 & 0{,}4424 & 0{,}99937 \\ 0 & 1 & 0{,}8509 & 0{,}6055 & 0{,}9763 & 4{,}0076 & 0{,}150775 \\ 0 & 0 & 1 & -2{,}6502 & 2{,}7785 & -0{,}5719 & -0{,}080456 \\ 0 & 0 & 0 & 0{,}1299 & -0{,}0564 & 0{,}0834 & -0{,}000856 \\ 0 & 0 & 0 & -0{,}0564 & 0{,}2416 & 0{,}1152 & -0{,}0010144 \\ 0 & 0 & 0 & 0{,}0834 & 0{,}1152 & 0{,}4443 & -0{,}0056945 \\ \hline 0 & 0 & 0 & -0{,}0009 & -0{,}0010 & -0{,}0057 & 0{,}00034001 \end{array}\right] \tag{25}$$

Thus:

$$AIC_{(Z_1,Z_2,Z_3)} = 20 \cdot \ln\left(2\pi e S_y^2\right) + 20 \cdot \ln(0{,}00034001) + 2(3+1) = \\ 533{,}827007 + (-159{,}73062) + 8 = 382{,}096384 \tag{26}$$

Also this time AIC value has lowered – we add one another explanatory variable Z_4. By transforming 4-th column of matrix (25) we have:

$$P_{(Z_1,Z_2,Z_3,Z_4)} = \left[\begin{array}{cccccc|c} 1 & 0{,}9894 & 0{,}9570 & -0{,}6155 & -0{,}4547 & 0{,}4424 & 0{,}99937 \\ 0 & 1 & 0{,}8509 & 0{,}6055 & 0{,}9763 & 4{,}0076 & 0{,}150775 \\ 0 & 0 & 1 & -2{,}6502 & 2{,}7785 & -0{,}5719 & -0{,}080456 \\ 0 & 0 & 0 & 1 & -0{,}4341 & 0{,}6423 & -0{,}006592 \\ 0 & 0 & 0 & 0 & 0{,}2172 & 0{,}1515 & -0{,}001386 \\ 0 & 0 & 0 & 0 & 0{,}1515 & 0{,}3907 & -0{,}005145 \\ \hline 0 & 0 & 0 & 0 & -0{,}0014 & -0{,}0051 & 0{,}00033437 \end{array}\right] \quad (27)$$

Basing on matrix (27) we can see that convergence rate for model with $\{Z_1, Z_2, Z_3, Z_4\}$ as explanatory variables has lowered (it is now 0,00033437), but AIC is equal to:

$$\begin{aligned} &AIC_{(Z_1,Z_2,Z_3,Z_4)} = 20 \cdot \ln\left(2\pi e S_y^2\right) + 20 \cdot \ln(0{,}00033437) + 2(4+1) = \\ &533{,}827007 + (-160{,}06529) + 10 = 383{,}761716 \end{aligned} \quad (28)$$

so is bigger than for the previous model (compare with (26)). It means that Z_4 shouldn't be taken into the model. We replace the variable Z_4 with another explanatory variable Z_5. In practice this means that we get back to bordered matrix given by (25), remove 4-th row and column and make elementary transformations of fifth column. As a result we have:

$$P_{(Z_1,Z_2,Z_3,Z_5)} = \left[\begin{array}{cccccc|c} 1 & 0{,}9894 & 0{,}9570 & -0{,}6155 & -0{,}4547 & 0{,}4424 & 0{,}99937 \\ 0 & 1 & 0{,}8509 & 0{,}6055 & 0{,}9763 & 4{,}0076 & 0{,}150775 \\ 0 & 0 & 1 & -2{,}6502 & 2{,}7785 & -0{,}5719 & -0{,}080456 \\ 0 & 0 & 0 & 0{,}1299 & -0{,}0564 & 0{,}0834 & -0{,}000856 \\ 0 & 0 & 0 & -0{,}0564 & 1 & 0{,}4770 & -0{,}0041981 \\ 0 & 0 & 0 & 0{,}0834 & 0 & 0{,}3893 & -0{,}0052106 \\ \hline 0 & 0 & 0 & -0{,}0009 & 0 & -0{,}0052 & 0{,}00033575 \end{array}\right] \quad (29)$$

Received in the lower right corner of the matrix (29) convergence coefficient is greater than the value obtained in the matrix (27) and the models have the same number of variables – thus we can already say that the AIC value will be higher than the value of the formula (28), and so than the (26):

$$\begin{aligned} &AIC_{(Z_1,Z_2,Z_3,Z_5)} = 20 \cdot \ln\left(2\pi e S_y^2\right) + 20 \cdot \ln(0{,}00033575) + 2(4+1) = \\ &533{,}827007 + (-159{,}98269) + 10 = 383{,}844312 \end{aligned} \quad (30)$$

It means that also variable Z_5 shouldn't be taken into the model. This time in matrix (25) we remove 4-th and 5-th row and column and run elementary transformations on 6-th column of the matrix. As a result:

$$P_{(Z_1,Z_2,Z_3,Z_6)} = \left[\begin{array}{cccccc|c} 1 & 0{,}9894 & 0{,}9570 & -0{,}6155 & -0{,}4547 & 0{,}4424 & 0{,}99937 \\ 0 & 1 & 0{,}8509 & 0{,}6055 & 0{,}9763 & 4{,}0076 & 0{,}150775 \\ 0 & 0 & 1 & -2{,}6502 & 2{,}7785 & -0{,}5719 & -0{,}080456 \\ 0 & 0 & 0 & 0{,}1299 & -0{,}0564 & 0{,}0834 & -0{,}000856 \\ 0 & 0 & 0 & -0{,}0564 & 0{,}2416 & 0{,}1152 & -0{,}0010144 \\ 0 & 0 & 0 & 0{,}0834 & 0{,}1152 & 1 & -0{,}01281066 \\ \hline 0 & 0 & 0 & -0{,}0009 & -0{,}0010 & 0 & 0{,}00026703 \end{array}\right] \quad (31)$$

$$AIC_{(Z_1,Z_2,Z_3,Z_6)} = 20 \cdot \ln\left(2\pi e S_y^2\right) + 20 \cdot \ln(0{,}00026703) + 2(4+1) = 533{,}827007 + (-164{,}56317) + 10 = 379{,}263837 \quad (32)$$

The resulting value of AIC given by (32) is smaller than all the values obtained previously and Z_5 is the last one variable from the set of possible explanatory variables $A(6) = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6\}$. This means the end of our proceeding. The chosen set of variables, according to the illustrated method is a 4-piece set $\{Z_1, Z_2, Z_3, Z_6\}$. It should be noted that in practice, according to the algorithm of the method, we analyzed only 6 out of 63 possible combinations of the variables but it can be easily noticed that the resulting subset has the lowest AIC value of all 63 possible subsets of the set *A(6)* given by (17). This does not mean that it must always be, but set of variables selected according to the proposed method should be satisfactory. It should be added that the resulting model in the following steps should be verified.

At the end, in order to confirm the correctness of the calculations presented in the example, we attach Table 2 – printout of the Gretl program, together with evaluated AIC values.

Table 2. Model 1: Least squares method, using observations 1995-2014 (T = 20), Dependent variable: Y

	Coefficient	Std. error	t-Student	p-value
const	5,12693e+06	953663	5,3760	0,00008
Z_1	1,03609	0,0463455	22,3557	<0,00001
Z_2	0,533522	0,0827506	6,4474	0,00001
Z_3	-2302,74	432,336	-5,3263	0,00008
Z_6	-13,6178	6,72551	-2,0248	0,06107
Dependent variable average	322581,4		Dependent variable std dev	155186,6
Sum of squared residuals	1,22e+08		Residues standard error	2854,062
R square	0,999733		Adjusted R square	0,999662
F(4, 15)	14039,74		P value for test F	1,34e-26
Log likelihood	184,6319		**AIC**	**379,2638**
Bayes. Schwarz Criterion	384,2425		Hannan-Quinn Criterion	380,2357
rho1	-0,088852		Durbin-Watson Criterion	2,136946

Source: output from Gretl basing on data from tab 1.

Summary

The problem of initial selection of variables into an econometric model is an important issue. Among the numerous methods AIC has high popularity. Author thinks that formula (13) is important as it allows to effectively determine the value of this criterion for the model estimated by least squares. For this purpose it is necessary to calculate the values of φ^2 for the analysed models. Application of boundary matrix in the presented algorithm definitely simplifies the process of calculations. It should be added that the necessary elementary transformations, even for a high degree of matrix are easy to perform using for example MS Excel spreadsheet. The empirical example illustrates this. It is worth noting that the selection procedure gave an optimal set of variables but this is not the rule and in the author's opinion it requires further simulation studies.

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