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Capital-labor substitution impact in the business performance of the firms in the European Union

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ABSTRACT

The recent improvements in new technology and the increase of capital investments have brought new attention to the extent that labour can be substituted by capital in firms in the European Union. As the substitution of labour by capital is increased, the interest of this paper is to observe the impact of the capital-labour substitution on the business performance of the firms in the European Union from 1990 until 2018. By using an unbalanced panel data of 18988 observations, this paper takes into account random effect regression model, country fixed effect regression model, year fixed effect regression model and industry fixed effect regression model. It yields into the conclusion that capital-labour substitution has a negative significant effect on the return on assets of the firms in the European Union from 1990 until 2018. However the substitution between labour and capital has the least negative significant effect in the Manufacturing Industry. The main limitations of this paper are the low number of data for some of the countries in the European Union and the endogeneity of the data. However, his paper adds value to the current literature by bringing an insight to the optimal investment strategy that should be implemented by the firms in the European Union in the new century.

I. Introduction

The recent investments in new technology and the changes in employment policies have brought new attention in firms' investment strategies. Frey and Obsorne (2017) study in their paper the future of employment and the risk of digitalisation in the future. They study the jobs with the highest content of routine and analyse how many jobs could be substituted by new investments in capital. They yield into the conclusion that around 48% of the labour force in the United States is at risk of being replaced by digitalisation in the future. Acemoglu and Autor (2011) mention in their paper that new investments in capital will increase the demand for high skilled labour while decreasing the demand for middle skilled labour. According to the authors this will lead to a job polarisation and will have an impact in the business performance among all the firms, especially in those who belong to the manufacturing industry. The Financial Times (2018) announced that the Deutsche Bank is planning to replace and remove the job of 98000 people in their firm, by bringing an automation change in their company. KPMG as well announced its plans of an "invisible bank" where the need for labour would not exist. It is of importance to realise that the abundance of capital and the substitution of labour by capital influences the productivity of an industry. Various rates of productivity change across industries influence the firm's unit costs, product prices and the abundance of resources in an industry. Arrow, Chenery, Minhas and Solow (1961) find in their paper that the capital-labour substitution is less than unity in the manufacturing companies. They yield into the conclusion that given that the elasticity of substitution between labour and capital is less than one, the share of capital in the overall production should fall.

In many sectors of the economy it is important to make some estimations about the extent to which the substitution of labour by new capital can affect business performance. The new century brought new changes concerning the labour market but it also brought new changes concerning the investments strategies of the firms. Therefore, the purpose of this paper is to measure the effect of capital-labour substitution on the business performance among all industries in the European Union in the last 28 years. This paper brings an insight into the impact of capital-labour substitution in the business performance of the firms in the European Union from 1990 until 2018. The question this paper aims to answer is:

What is the effect of capital-labor substitution on the business performance among all the industries in the European Union from 1990 until 2018?

The significance of automation and new machineries in assessing a firm's competitive health and capacity for future business performance has been growing rapidly. Professionals are considering a firm's capacity to invest in technologies critical in determining the firm's future growth. In the mid 1980s, Solomon brothers yielded into the conclusion that "automation transformation" was an important difference between the banks that were performing well compared to those which were not performing with the same profitability (Nolan 1994).

Different firms in the European Union can use the findings of this paper in order to make optimal investment decision for their firm in the future. This paper is highly relevant because it extends the works of previous authors by bringing an insight into the capital-labour substitution impact in the business performance in the new century, after the introduction of the new policies concerning the labour market, and after the developments in new technology. The existing literature is mostly focused in the

Canadian and US market. This paper extends the relevant literature, by focusing in the industries in the European Union. This paper gives an insight into the optimal capital-labour ratio that the industries in the European Union should consider in the future by improving their hiring policies and by making the optimal investment strategies. Following an empirical, analytical method this paper aims to answer the research question based on two hypotheses.

The main conclusions of this paper show that one unit increase of capital at the expense of labor decreases the return on assets by 0.154 units on average. The results show that among these three industries: Manufacturing Industry, Service Industry and Trading Industry, capital-labor substitution has the most significant and largest effect on return on assets (ROA) in the Manufacturing Industry.

This paper is structured as follows: In section II the literature review is laid out. In Section III the research question with the hypotheses is presented. In Section IV and V the data and methodology is described. In Section VI the results are presented. Section VII presents the Robustness check and in the last section the interpretation and the conclusion of this paper are elaborated.

II. Literature Review

Capital-labor substitution has encouraged many papers to study the effect of this event on the business performance of many firms in different industries. The literature review of this paper summarizes some of the studies, which aim to bring an insight into the effect of capital-labor substitution elasticity in the performance of all the sectors of an economy. This section will bring an insight into the models that previous papers have used in order to measure the substitution effect between the labor and the capital. Firstly, this paper will present the proxies that previous papers have used to measure the labor input and the capital input. Then, this section will present different proxies that authors have used in order to measure firm performance. Lastly, this section will introduce control variables that previous authors have used in their analysis that can affect the firm's performance besides capital and labor.

Different authors have used different production functions in their paper in order to measure the capital-labor substitution effect in the firm's output, among them: the Cobb-Douglas production function, the CES production function and the Leontief production function. The Cobb-Douglas production function is a type of production function, which represents the relationship between two or more inputs and the amount of the total output produced by the combination of the inputs. It is homogenous of the first degree. Cobb and Douglas (1928), presented the Cobb-Douglas production function in its most basic form as:

$Q(L,K) = AL^{\beta}K^{\alpha}$, *where:*

Q = total amount of output
L = total labor
K = total capital
A=a positive constant
β and α = constants, which take values between 0 and 1

The Constant Elasticity of substitution (CES) production function combines two or more inputs of production into one function. Solow (1956) introduced this model first then Arrow, Chenery, Minhas and Solow(1961) established a more complete model. In the CES production function, the elasticity of substitution between capital and labor is not strict to one or zero. It assumes constant elasticity of substitution, which implies that any change in input factors would cause a constant change to total output. The CES production function looks according to Arrow, Chenery, Minhas and Solow(1961) looks as follows:

$V = \Upsilon [\delta K^{-p} + (1-\delta)L^{-p}]^{-1/p}$ *,where:*

V= Total Output
K= Total Capital
L= Total Labor
ϒ = the efficiency parameter, every change in inputs will change the output in the same proportion
δ= the distribution parameter, determines the distribution of income
p=the substitution parameter, a transformation of the elasticity of substitution

The Leontief production function is a model of production function where no substitutability between the two factors of production is assumed. It assumes that the inputs in the production function will be in fixed amounts. It is a limitation of the Constant elasticity of substitution (CES) production function. Leontief (1947) presents the following model for the Leontief production function:

Q=min (K,L), where:
Q= Total Output
K=Total Capital
L=Total Labor
The model of this production function implies that capital and labor are used in fixed amounts and they cannot be substituted with each other. Capital and Labor are perfect complements, given the structure of this production function.

Balistreri, McDaniel and Wong (2003) analyze in their paper an estimation of US industry-level capital-labor substitution elasticity. This paper uses data from the Bureau of Economic Analysis over the period 1947-1998, for the US economy. By using this data, this paper analyses the long-run and short-run elasticity of substitution for over 28 industries. They focus in the long-run and short-run elasticity given that long-run analyses are more suitable for simulation analysis. This paper concludes that the capital-labor relationship is similar to the Cobb-Douglas model for 20 of the industries involved in their sample. For the other 8 industries this paper fails to reject the Leontief specification. This paper uses the following model to measure the substitution between labor and the capital:

$$\ln y = \beta_0 + \beta_1 \ln x + \varepsilon$$

Where:
y=K/L; the ratio between the capital input and the labor input
x=w/r; the ratio between the wage and rental rates
β_1*= represents the substitution effect between labor and the capital*
Therefore β_1 *is the coefficient of interest.*

Arrow, Chenery, Minhas and Solow (1961), focus in the pure theory of production, the distribution of income, internal differences in efficiency and sources of comparative advantage by focusing in the degree of substitution between capital and labor. This paper starts the analysis by observing that the value added per unit varies with the wage rate within a given industry and they focus in 19 countries all over the world. The same production function is assumed for all the countries. Arrow, Chenery, Minhas and Solow (1961) introduce the constant elasticity of substitution (CES) production function. Like the Cobb-Douglas production function, the CES function assumes constant returns to scale. It allows for other elasticity of substitution besides one and zero. This paper finds that the capital-labor substitution in the manufacturing industry is less than one. They find that if on average the elasticity of substitution is less then one, the share of capital in production should fall, by mentioning that this is what they have observed. However they bring into attention that the increases in real wages might be offset by technological improvements in their effect on relative shares.

Humphrey and Moroney (1975) present in their paper an estimation of elasticity of substitution among capital, labor and natural resources. They collected data for manufacturing companies in the US. They were only interested in the industries that used natural resources as inputs, besides labor and capital. In order to measure the substitution effect, this paper uses both a production and a cost function. This paper concludes that natural resources are not strictly complementary in the production function with labor and capital. Furthermore the authors yield into the conclusion that natural resource products are not less substitutable with capital then with labor. The substitution elasticity from the cost function is less than the substitution elasticity received from the production function.

Solow (1964) in his paper uses a cross-sectional analysis in order to estimate the substitution of elasticity between labor and capital and also time-series analysis for all the industries in the US. The objective of Solow's paper is to estimate production function, capital-labor substitution elasticity, rate of IT developments. This paper uses a different approach than most of the papers by not using a Cobb-Douglas or a Leontief production function. He uses the CES production function, which allows for other elasticity of substitution besides one and zero.

David and Van de Klundert (1965), investigate the production-function, by assuming that the marginal productivity of the inputs does not increase at the same rate through time. This paper looks at the capital-labor substitution, while allowing the production function to have a constant elasticity of substitution (CES), which allows a non-neutral technical change. However, this paper does not explain the growth of the labor inputs or the rising relative abundance of effective capital inputs in the United States. In order to measure the capital-labor substitution, the papers used different methods from each other.

Most of the papers used the CES production function to account for the capital-labor substitution. However a downside of the CES production function is that it is not convenient to use, when more than two inputs enter the production function.

All the papers constructed their model for capital-labor substitution by presenting these five variables: output/income, capital input, labor input, payments to capital, payments to labor. Different papers used different proxies for: capital input, labor input, payments to capital and payments to labor.

Table 1 presents the paper and its corresponding proxy for capital input, labor input, payments to labor, payments to capital and the source.

Table1. Proxy for labor input, capital input, payment to labor, payment to capital

Paper	Labor Input	Capital Input	Payment to Labor	Payment to Capital	Source
Balisteri, Mc Daniel & Wong (2003)	Full-time equivalent employees	Net stock quantity index of private fixed assets	Compensation of employees	Property-type income	the Bureau of Economics Analysis (BEA)
Arrow, Chenery, Minhas and Solow (1961)	Production workers, salaries employees and working proprietors	Not Specified. Defined as Capital Input.	Average annual wage	Rate of return on Capital	the United Nations International Standard Industrial Classification
Humhrey & Moroney (1975)	Man-years of employment	Gross Book Value of capital	Wage rate	Gross quasi-rent/ gross book value of the capital stock	U.S Bureau of the Census
Solow (1964)	Full-time employees	Equipment Capital	Total payroll per employee	Capital Expenditures	The Census Annual Survey of Manufactures
David and Van de Klundert (1965)	Millions of man-hours employes	Unweighted real capital inp	Compensation as a Proportion of U.S Gross Private Business	Rate of return on Capital	Kendrick (1961) and US Department of Commerce

Based on Bliastreri, Mc Daniel and Wong's paper, the capital labor substitution, will be measured as the ratio of capital to labor. Based on the previous literature, this research will proxy the capital as the net value of total equipment, property and plant adjusted for the accumulated depreciation. Labor will be proxied as the total number of employees.

Proxies for firm performance and control variables

Bharadwaj A.S, Bharadwaj S.G and Konsynski (1999) study the effect of information technology on business performance. This paper measures the firm's performance by using the Tobin's q. The Tobin's q is a variable first introduced by (Tobin, 1969), is a variable used to predict the firm's future investments. Chen and Lee introduced it in 1995 as a measurement for the business performance. Bharadwaj A.S, Bharadwaj S.G and Konsynski (1999) calculate the Tobin's q as:

Tobin's q = (MVE + PS + DEBT)/TA, where:

MVE= (closing price of share at the end of the financial year)(Number of the common shares outstanding)*
PS = Liquidating value of the firm's outstanding preferred stock
DEBT= (Current liabilities-Current Assets) +(Book value of inventories)+(Long tern debt)
TA= Book value of total assets
This paper uses the q ratio as a measurement of the firm's performance because the authors believe that the Tobin's q is the most suitable measure for studying IT related benefits. Bharadwaj A.S, Bharadwaj S.G and Konsynski (1999) include different control variables in their analysis that can affect the business performance besides IT investments and these variables are of interest for this paper. They include five firm-specific control variables and four industry-level control variables that can impact the business performance as measured by the Tobin's q. As firm-specific variables they mention: market share, advertising expenditure, R&D expenditure, extent of related diversification and firm size. As industry-specific variables the authors mention: industry concentration, industry capital intensity, industry average q and regulation.

Grinyer and Norburn (1975) study the strategic planning process in different companies in the UK and how these factors that influence the strategic planning process are related to the firm's performance. Although the focus of my paper is not on the different planning strategies in a firm, the paper of Grinyer and Norburn (1975) is relevant, because they mention different proxies for measuring the business performance in a company. For the purpose of their paper, all the measurements they mention are financial and they use as a proxy return on net assets, where:

$$Return\ on\ net\ assets = \frac{Profit\ before\ interest\ and\ tax}{Fixed\ assets + current\ assets - current\ liabilities}$$

Rai, Patnayakuni R. and Patnayakuni N. (1997) study the effect of technology investments in business performance. This paper is relevant because it studies firm performance in terms of firm output, business results and in terms of intermediate performance. It measures firm output in terms of value added by the company and total sales. It measures business results in terms of returns on assets (ROA) and returns on equity (ROE). The intermediate performance is measured in terms of labor and administrative productivity. The results of this paper show that ROA is a better indicator then ROE of the investments in capital. The paper mentions that this might happen because ROE combines the effect of capital investments as well as the financial leverage employed by the firm. This study uses two control variables to measure the effect of IT investments on firm's performance: size (measured by the number of the employees) and sector (coded as a dummy). Hansen, G. S., & Wernerfelt, B. (1989) mention in their paper that there are two major fields of research when studying the main factors that influence the firm's performance. One of them emphasizes the importance of the external market and it presents an economic model and the other one sees the organizational factors that influence the firm's performance. This paper uses as a proxy for the firm performance the return on assets. The economic model classifies the influencers of firm performance as: industry variables; variables relating to its competitors and firm variables. Correspondingly, they study the effect of the following variables: average industry profits, relative market share and firm size. This paper finds that average industry profit and relative market share have a significant positive effect on the firm performance, which is measured by the return on assets.

Mehran (1995) studies the compensation structure effect in the business performance in 153 manufacturing firms in the United States. Mehran (1995) presents two possible proxies for the firm's performance: the Tobin's Q and the return on assets (ROA). It argues that the Tobin's Q is a better proxy for measuring the firm's growth opportunities rather than its financial performance, therefore the return on assets would be a more convenient measurement for the firm's performance. This paper uses several control variables that can affect the firm's performance. The control variables that the paper includes in its analysis are: growth opportunities, leverage ratio, business risk and firm's size. For all the control variables, the paper finds a significant effect on the firm's performance.

Agrawal and Knoeber (1996) study the firm performance and mechanisms to control agency problems between managers and shareholders. This paper measures the firm performance by using the Tobin's Q and similarly like the previously mentioned papers it includes the following control variables for measuring the firm's performance: leverage, firm R&D, firm advertising and firm's size. All the variables have a significant effect on the Tobin's Q.

Based on the work of the previous literature, this paper will include the following control variables in order to measure the effect of capital-labor substitution in the firm's performance: firm's size; firm's R&D Expenses and firm's Leverage. It would be helpful to include Advertising Expenses as a control variable as well, however no data could be found in Compustat Global for this variable for a certain time period. Table 2 presents the proxy for each control variable, its effect on the firm's performance and the paper where the proxy was taken from.

Table 2. Proxy for firm's size; firm's R&D; and firm's leverage

Control Variables	Proxy	Effect on firm's performance	Bibliography
Firm's size	Log of Total Assets	Positive	Mehran(1995) Agrawal and Knoeber (1996)
Firm's investments in R&D	R&D Expense/Total Sales	Positive	Mehran (1995) Agrawal and Knoeber (1996)
Firm's Leverage	Long-term debt/Total Assets	Negative	Mehran(1995) Bharadwaj and Knsynski (1999)

This paper adds value to the relevant literature in a number of ways. Firstly, although various papers look at the capital-labor substitution elasticity, there does not exist a paper that brings focus to the capital-labor substitution impact in the business performance in the European Union. The existing papers mainly focus in the US and the Canadian market. Also there does not exist a paper that looks at the capital-labor substitution impact in the business performance during the last twenty years. Most of the papers focus on the middle of the 20th century.

III. Research Question and Hypotheses

In order to assess the impact of the substitution of labor by capital in the business performance among all the industries in the European Union from 1990 until 2018, this research paper aims to answer the following research question:

What is the effect of capital-labor substitution on the business performance among all the industries in the European Union from 1990 until 2018?

Arrow, Chenery, Minhas and Solow (1961), find in their paper that the elasticity of substitution between labor and capital is less than one. This would imply that the share of capital relative to the total production should be decreased. Given the time period that their research was studied, my paper aims to add value to the current literature by studying the capital labor substitution effect on the business performance in the new century. The Guardian (2018) mentions that the new century brought advancements in the technology and in the labor productivity, therefore there is reason to believe that the rapid advancements in the capital investments influenced the business performance significantly.

Brynjolfsson and Hitt (2000) study the impact of investments in capital in the business performance and economic growth. In their work they focus specifically in the contribution of investments in new machineries and equipment and in information technology in the productivity and organizational transformation of a firm. This paper yields into the conclusion that investments in new machineries and technology encourage investments in organizational factors and these investments lead to an increased productivity at firm level. As the investments in new equipment and machineries increase, firms increase output quality by decreasing costs in the same time; therefore the overall business performance of the firm increases. Dewan & Min (1997) study in their paper the impact of the substitution of labor by IT capital in the firm productivity. One of the main results of this paper is that IT capital is a net substitute for labor throughout the firms in an economy. This type of substitution is noticed in each industry and the paper concludes that the substitution of IT capital by labor is creating rapid productivity growth in each firm. Based on the findings of previous literature there is reason to believe that the substitution of labor by capital will have a positive contribution to the business performance of firms in all the industries in the European Union. Therefore the first hypothesis of this research paper is:

H1. Capital-labor substitution has a significant positive effect on the business performance of the firms in the European Union from 1990 until 2018.

Arrow, Chenery, Minhas and Solow (1961) study in their paper the capital-labor substitution and economic efficiency in the US. They notice that the substitution effect between the two inputs seems to have a larger contribution to the efficiency of production in the manufacturing industry. In the same way, Hamermesh and Grant (1979) focus only in the manufacturing industry in their paper in order to measure the capital-labor substitution. By studying the substitution only in the manufacturing industry they yield into the conclusion that the substitution effect should be measured by accounting for different ages of labor. Young ages and workers over 45 are more easily substituted by investments in capital than middle-aged workers. Freeman and Medoff (1982) study in their paper the substitution of labor by other factors of production. They imply that the substitution of capital by labor seems to occur more often in the manufacturing industry by impacting the firm's production significantly. Therefore they focus their work only in the manufacturing industry. Based on the previous literature it is noticed that the substitution of labor by capital seems to have a larger effect in the business performance of the firms in the manufacturing industry. Therefore the second hypothesis of this paper is:

H2. The capital-labor substitution has a larger significant effect on the business performance of firms in the manufacturing industry than in the other industries of the European Union from 1990 until 2018.

The data and the methodology of this paper will be adjusted accordingly to test the two hypothesis of this paper.

IV. DATA

The dataset in this research paper is retrieved from Wharton Research Data Service (WRDS), specifically from Compustat Global. Comupstat Global contains financial databases and market information for companies throughout the world. The data of this research paper is firm-specific for the 28 countries of the European Union: Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK.

The data is retrieved for all the industries and it is organized based in the following four groups of industries: Manufacturing Industry, Service Industry, Trading Industry and Other Industries. Based on the relevant literature, the capital-labor substitution seems to have a larger effect on the business performance of the firms in these industries. The industries are filtered in the data by using the US Standard Industry Classification (SIC) codes. SIC codes from 5000-5999 represent Trading Industry. SIC Codes from 2000-3999 represent Manufacturing Industry. SIC Codes from 7000-8999 represent the Service Industry and all the other codes represent the Other Industries besides the Manufacturing, Service and Trading Industry.

The time-span of the data is from 1990 until 2018. Each observation, where the value for the employees variable was zero, was excluded from the dataset. These observations were not comparable with the other observations in the dataset, causing in this way outliers to the data. The data was cleared and filtered such that each observation has data on Return on Assets (ROA), Size, R&D Expenses, Capital-Labor Substitution and Leverage. Therefore the observations where data for one of these variables was missing were excluded from the dataset. All the observations of the final dataset contain data for each variable. The final data has the form of an unbalanced panel data, with different number of firms for each of the countries for a different time-period. A panel data is a multi-dimensional data, which contains observations of multiple groups over multiple time periods for each unique observation. (Diggle, Heagerty, Liang & Zeger 2002).

All the variables contain data for 2758 firms operating in all industries from 1990 until 2018. The panel data of this research paper is formed based on two identification variables: Global Company Key and Year. Global Company Key represents the cross-sectional entities and it shows the firm's specific number. Year represents the time-series entities and it shows the fiscal year. The total amount of observations for all the industries is 18988. The unbalanced panel data contains data for 2758 firms for 28 years. Therefore the data is sufficiently large to perform an unbalanced panel data analysis. The number of firms, the number of years and the total number of observations for each industry are presented in Table 3. It should be noticed that, considering that the data has the form of an unbalanced panel data, not all of the firms contain observations for all the 28 years.

Table 3: Number of observations for each industry

Industry	Total number of firms	Total number of years	Total number of observations
Manufacturing	1644	28	12663
Service	670	28	3747
Trading	108	28	500
Other	336	28	2078

The Manufacturing Industry contains the largest number of observations, in contrast to the Trading Industry, which contains the smallest number of observations. In the same way, the Manufacturing Industry contains the largest number of cross-sectional entities, represented by the number of firms. The Trading Industry contains the smallest number of unique firms.

Table 4 shows the overall statistics of the variables of interest for all the industries. The table presents the number of observations, the mean, the standard deviation, the minimum value and the maximum value for: ROA, K/L, Size, RD Expense and Leverage.

Table 4. Overall descriptive statistics of the main variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
ROA	18988	0.017	0.432	-9.418	52.915
	18988				
K/L	18988	0.003	0.030	0	1.921
	18988				
Size	18988	2.730	1.045	-0.037	7.176
	18988				
RDExpense/Total Sales	18988	0.261	8.078	-2.821	848.266
	18988				
Leverage	18988	0.137	0.157	0	9.234

Size measured by the logarithm of Total Assets has the highest mean with a maximum of 7.176 followed by R&D Expenses with a maximum value of 848.266. The variable of interest: Capital Labor Substitution shows the lowest mean of 0.03 followed by the Return on Assets (ROA). R&D Expenses show the largest standard deviation, in contrast to the Capital-Labor substitution, which shows the lowest value for the standard deviation.

It is of interest to observe the differences in variables among the industries. Table 5 presents descriptive statistics of all the variables for the Manufacturing Industry, Service Industry, Trading Industry and Other Industries.

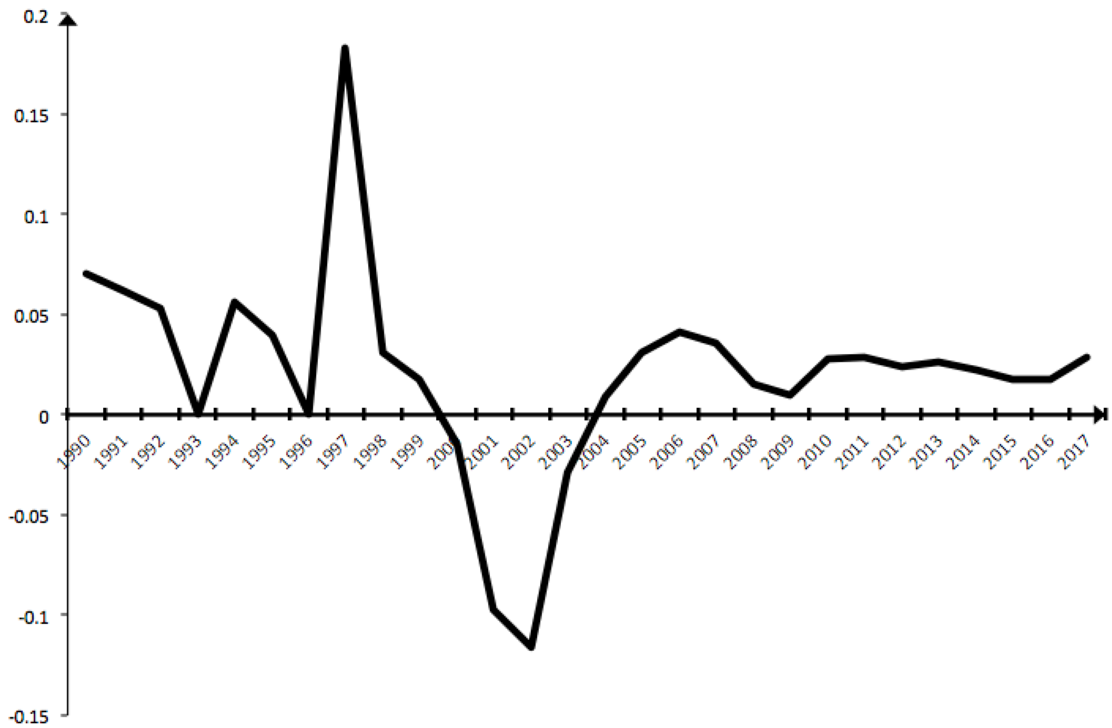
Table 5. Overall descriptive statistics of the main variables for each industry

Industry	Variables	Obs	Mean	Std. Dev.	Min	Max
Manufacturing	ROA	12663	0.027	0.502	-9.418	52.915
	K/L	12663	0.003	0.031	0	1.399
	Size (logTotalAssets)	12663	2.781	0.996	-0.037	6.594
	R&D Expense/Total Sales	12663	0.0347	9.878	-0.053	848.266
	Leverage	12663	0.137	0.151	0	9.234
Service	ROA	3747	-0.020	0.282	-5.160	0.890
	K/L	3747	0.000	0.001	0	0.038
	Size (logTotalAssets)	3747	2.088	0.801	0.046	5.116
	R&D Expense/Total Sales	3747	0.116	0.527	-2.821	28.273
	Leverage	3747	0.091	0.145	0	1.791
Trading	ROA	500	0.023	0.111	-0.706	0.225
	K/L	500	0.001	0.007	0	0.148
	Size (logTotalAssets)	500	2.850	0.985	0.607	5.133
	R&D Expense/Total Sales	500	0.010	0.025	0	0.196
	Leverage	500	0.148	0.137	0	0.706
Other	ROA	2078	0.025	0.139	-2.171	1.135
	K/L	2078	0.008	0.050	0.000	1.921
	Size (logTotalAssets)	2078	3.548	1.050	0.679	7.176
	R&D Expense/Total Sales	2078	0.065	1.021	-0.005	37.340
	Leverage	2078	0.215	0.187	0.000	2.824

The Capital-Labor Substitution shows the largest mean in the Other Industries. It shows the highest standard deviation in the Other Industries group as well. The dependent variable, ROA shows the largest mean in the Manufacturing Industry. ROA reaches the maximum standard deviation in the Manufacturing Industries. In order to study the behavior of ROA more closely, the average ROA per year, the ten companies with the lowest ROA and the average ROA for each Country should be observed.

Table 1, Appendix A presents the Average ROA and Average Total Assets for each of the countries of the European Union. Figure 1 shows the average ROA over the 28 years, from 1990 until 2018.

Figure1. Average ROA over the years



As noticed in Figure 1, ROA reaches its maximum value in 1998 and it has been decreasing since then, reaching its minimum value in 2002. During the recent 13 years ROA shows a steady pattern with small fluctuations from 2008 until 2011. This graph gives an important insight into the differences of average ROA among the years. Table 2, Appendix A lists the Average ROA for each year from 1990 until 2018.

Table 7 presents the 10 lowest ROA values with the corresponding Country and Company Name.

Table 7. The ten companies with the lowest ROA

Global Company Key	Year	Company Name	Country	Industry	ROA
221062	2010	GEOSENTRIC OYJ	Finland	Manufacturing	-9,418
224800	2002	B&S BANKSYSTEME AKTIENGES	Deutchland	Services	-5,160
207383	2001	BALTIMORE TECHNOLOGIES PLC	the United Kingdom	Services	-4,897
204683	2002	INGENTA PLC	the United Kingdom	Services	-4,443
231537	2002	AORTECH INTERNATIONAL PLC	the United Kingdom	Manufacturing	-4,260
215660	2002	PORTRAIT SOFTWARE PLC	the United Kingdom	Services	-3,907
221062	2003	GEOSENTRIC OYJ	Finland	Manufacturing	-3,375
239601	2002	INNOVATION GROUP PLC	the United Kingdom	Services	-3,335
285295	2011	GECI AVIATION	the United Kingdom	Manufacturing	-3,283
233216	2002	IQE PLC	the United Kingdom	Manufacturing	-2,904

The lowest values for ROA are mostly noticed in the United Kingdom, in the Geosentric Oyj firm, where it reaches its lowest value of -9.418 in 2010. The ROA seems to show the lowest mean in the Service Industry. The ten lowest value of ROA are not noticed in the Trading Industry.

An important phenomenon that can affect the regression results is multicollinearity. Multicollinearity occurs when one explanatory variable has predictive power over another explanatory variable. In this way the regression coefficients of the explanatory variable can be very fluctuated to changes in the model or in data (Gujarati & Porter 2003). One way to detect multicollinearity is by calculating the Pearson correlation of the explanatory variables. If the correlation coefficients are 1 or -1, this would present a case of perfect multicollinearity and thus would present a problem to the regression model. Table 6 presents the Pearson correlation values for the variables in regression (1).

Table 6. Pearson Correlations among the variables.

	ROA	K/L	Size	R&D Expense	Leverage
ROA	1.000				
K/L	0.0060 0.408	1.000			
Size	0.081*** 0.000	0.159*** 0.000	1.000		
R&D Expense	-0.042*** 0.000	-0.001 0.850	-0.014* 0.054	1.000	
Leverage	-0.084*** 0.000	0.019*** 0.008	0.261*** 0.000	0.036*** 0.000	1.000

Note: *p<0.1 **p<0.05 ***p<0.01

As noticed, in Table 6, none of the correlation coefficients is close to -1 or 1, therefore multicollinearity is not a problem for the regression model and dataset of this paper.

Another method to check for multicollinearity is by checking for *Variance Inflation Factors (VIF).* A variance inflation factor exists for each of the variables in a regression model. The variance inflation factor (VIF) shows the fluctuations of the regression coefficients in case of multicollinearity. Taking an explanatory variable and regressing it against every other explanatory variable in the model estimate VIFs. As a rule of thumb a Vif above 4,10 ore even 30 would be problematic and it would indicate a problem of multicollinearity in the model (O'brien, 2007).

After running an Ols. Regression, with ROA as the dependent variable, capital-labor substitution, Size R&D Expense and Leverage as the independent variable, the command *Vif* was performed in Stata. Table 7 shows the result of *Vif.*

Table 7: VIF values for each variable

Variable	VIF	1/VIF
Size	1.10	0.908
Leverage	1.08	0.930
K/L	1.03	0.974
R&D Expens(	1.00	0.998
Mean VIF	1.05	

As noticed by Table 7, the VIF values for each vaariable are very close to one, therefore the multicollinearity phenomenon is not an issue for the dataset of this paper.

The characteristics of the data of this research paper give an orientation to the methodology that is needed to measure the impact of capital-labor substitution in the business performance of all firms in the European Union.

V. METHODOLOGY

In this paper, an empirical-analytical method will be approached in order to study the impact of capital-labor substitution in the business performance of all the industries in the European Union from 1990 until 2018. A quantitative approach will be followed, by manipulating the data into numerical forms.

The dataset of this research paper is in the form of panel data. A panel data contains both cross-sectional and time-series entities. The cross-sectional entity in this paper as mentioned in the Data section is the Global Company's Key and the time-series entity is the Year. Hsiao (2007) mentions that panel data has several advantages over cross-sectional and time-series data:

i) Panel data consists of more degrees of freedom and it allows for more sample variance, therefore the econometric analysis is more efficient.
ii) It controls for the effect of omitted variables and it provides micro foundations for aggregate data analysis.
iii) Panel data simplifies computation and statistical inference.

An assumption used when working with panel-data is the stationarity of the data. The data is stationarity when its unconditional joint probability distribution is constant through time.

There are several methods to check for stationarity in Stata, with the *xtunitroot* command, however the Fisher-Type and Im-Pesaran-Shin test are appropriate for testing for stationarity in unbalanced panel data.

After testing for the data for stationarity, the regression used in this research paper is presented. The following regression will be used in order to test the impact of the capital-labor substitution in the business performance of the firms in the European Union from 1990 until 2018:

$$ROA = \beta_0 + \beta_1 \frac{K}{L} + \beta_2 Size + \beta_3 Leverage + \beta_4 R\&D\ Expenses + \varepsilon \qquad (1)$$

Where:

- *ROA* is the dependent variable as a proxy for the business performance and it is the abbreviation for: the return on assets. ROA is computed in this paper as the ratio of Net Income to Total Assets. Mehran (1995) argues that the Tobin's Q is a better business performance measurement for the firm's growth opportunities and ROA is a better proxy for measuring the financial performance. Rai, Patnayakuni R. and Patnayakuni N. (1997) mention that ROA is a better measurement for firm's performance than ROE, because ROE combines the effect of capital investments as well as the financial leverage employed by the firm.
- β_0 is the constant, which shows the expected mean value of dependent variable (ROA) when all the dependent variables are 0.
- $\frac{K}{L}$ measures the substitution effect between capital and labor, and it is divided by 100000. It is divided by 100000 given that the value of capital relative to the number of employees is very large. Therefore $\frac{K}{L}$ is divided by 100000, because working with small numbers would make the analysis in Stata easier. The division of the capital-labor substitution by 100000 would not change the interpretation of the results because the impact of $\frac{K}{L}$ on ROA would still be constant over time.
- *K* is the capital and it is measured by the property, plant, and equipment-total at net value. It represents the tangible fixed property used in production at the cost value minus the accumulated depreciation.
- *L* represents the labor, which is identified by the number of employees. The number of employees includes all part-time, seasonal and full-time equivalent employees. It includes the number of employees of consolidated subsidiaries but it excludes the employees of unconsolidated subsidiaries.

- β_1 is the coefficient of interest; it shows how many units the return on assets change on average, when capital-labor substitution changes by one unit, holding the other factors constant.
- *Size* of the firm is represented by the logarithm of Total Assets based on Mehran (1995) and as the size grows the return on assets are expected to increase.
- *R&D Expenses* measure the firm's investments in R&D. Based on Agrawal and Knoeber (1996), this variable is measured as the ratio of R&D Expense to Total Sales. As the firm's investments in research and development relative to the total sales increase, the return on assets are expected to increase, therefore R&D Expense is expected to have a positive impact on the return on assets.
- *Leverage* of the firm is measured as the ratio of Long-term debt to Total Assets. Bharadwaj A.S, Bharadwaj S.G and Konsynski (1999) in their paper yield into the conclusion that firm's leverage has a negative impact on the firm's performance.

In order to test for the first hypothesis this regression will be first performed for all the industries. In order to test for the second hypothesis, this regression will be performed for each of the following group of industries separately: Manufacturing Industry; Service Industry; Trading Industry and Other industries.

Panel Data allows for different types of regression models, among them: Random-effects (RE) model and Fixed-effects (FE) model.
The random-effect regression model does not account for individual effects of the variables. Therefore the differences among the entities in the cross-sectional data of the panel data are not controlled for. The differences among the cross-sectional entity are considered random. Fixed-effect regression model allows for individual effect of the variables. Some parameters in this model are fixed or non-random. The group means of the variables in the fixed-effect regression model are fixed in contrast with the random-effect model, where the group means are random. Each cross-sectional entity in the dataset might impact the variables differently. In the Fixed Effect regression model, the heterogeneity of a particular cross-sectional entity is controlled

for, by allowing in this way variation between the entities of the cross-sectional data in order to estimate accurately the casual relationship between the variables. (Torres-Reyna, 2007).

In order to approach the first hypothesis of this paper eight different models of regression for regression 1 will be performed. The models for the regression will be: without any fixed effect, with country fixed effect, with years fixed effect, with industry fixed effect, with country and industry fixed effect, with country and years fixed effect, with years and industry fixed effect and with country, years and industry fixed effect all at the same time.

In order to approach the second hypothesis of this paper four different models of regressions for regression (1) will be performed for each of the four groups of industries: without any fixed effect, with country fixed effect, with years fixed effect, with both country and years fixed effect.

VI. Results

In order to analyze the impact of the capital-labor substitution in the business performance of the firms in the European Union from 1990 until 2018, the panel data should be checked for stationarity as mentioned in the Methodology section. The Augmented Dickey-Fuller (ADF) test was performed in order to check whether ROA, $\frac{K}{L}$, Size, Leverage and R&D Expenses are stationary. Table 3 in Appendix A, shows the results of the ADF test. The results show that the hypothesis that the variables contain unit roots is rejected.

The question this paper aims to answer is:

What is the effect of capital-labor substitution on the business performance among all the industries in the European Union from 1990 until 2018?

The approach to answering the research question will be by testing the two hypotheses of this research paper presented in Section III.

The first hypothesis of this research paper is:

Hypothesis one: *Capital-labor substitution has a significant positive effect on the business performance of the firms in the European Union from 1990 until 2018.*

In order to see the impact of capital-labor substitution in the business performance of the firms in the European Union, eight models of regressions were performed for regression (1): the first regression does not account for the Country, Year or Industry Fixed Effect, the second regression accounts for the country fixed effect, the third one accounts for the year fixed effect, the fourth one accounts for the industry fixed effect, the fifth one accounts for country and years fixed effect at the same time, the sixth regression model accounts for both country and industry fixed effect, the seventh regression model accounts for both the years and industry fixed effect and the last regression model accounts for country, year and industry fixed effect. Table 8 presents the results of regression (1) for the eight regression models.

Table 8: Regression (1) results for eight different regression models

	Regression 1	Regression 2	Regression 3	Regression 4	Reggresion 5	Regression 6	Regression 7	Regression 8
Constant	-0.065***	-0.081***	-0.063***	-0.057***	-0.068***	-0.077***	-0.064***	-0.067***
K/L	-0.136***	-0.120***	-0.154***	-0.131***	-0.128***	-0.103***	-0.154***	-0.127***
Size	0.046***	0.053***	0.045***	0.043***	0.047***	0.051***	0.045***	0.047***
R&D Expense	-0.002**	-0.002**	-0.002**	-0,011**	-0.002**	-0.002**	-0.002**	-0.002**
Leverage	-0.065**	-0.081**	-0.308**	-0.310**	-0.305**	-0.333**	-0.307**	-0.305**
Number of observations	18988	18988	18988	18988	18988	18988	18988	18988
Number of firms	2758	2758	2758	2758	2758	2758	2758	2758
Adjusted R-Squared	0.020	0.021	0.028	0.020	0.021	0.020	0.026	0.021
Country Fixed effects	No	Yes	No	No	Yes	Yes	No	Yes
Year Fixed effects	No	No	Yes	No	Yes	No	Yes	Yes
Industry Fixed effect	No	No	No	Yes	No	Yes	Yes	Yes

Note:1) All data regression are including robust standard errors.
2) *p<0.1 **p<0.05 ***p<0.01

As noticed in Table 8, the adjusted R-Squared is relatively small for each regression model. The R-Squared shows how well the estimated model fits the actual model. This paper is interested to observe the impact of capital-labor substitution on return on assets and not in finding the perfect model for estimating ROA. Therefore a small R-Squared does not present a problem for this paper. However, the preferred model is the one with the largest R-Squared. As noticed in Table 8 the regression model with the largest R-Squared is the one, which accounts for the Year fixed effect. Therefore the regression model that should be interpreted in order to approach hypothesis one, is regression 3 in Table 8. In all the regression models the impact of capital-labor substitution, size, R&D Expense and Leverage on ROA is always significant. Size has a positive significant effect in ROA, as predicted by the relevant literature. This means that a 1% increase in the Total Assets is associated with an increase of the return on assets by 0.01 x 0.045 units on average, holding the impact of the other explanatory variables constant. R&D Expense shows a negative significant effect on ROA. This means that when R&D Expense increases by one unit relative to the Total Sales, the return on assets decreases by 0.002 units on average, holding the impact of the other explanatory variables constant. As predicted by the relevant literature, Leverage shows a negative significant effect on ROA in all the regression models. As noticed in regression 3, one unit increase of the Long-term Debt relative to the Total Assets decrease the return on assets by 0.308 units on average. The variable of interest, the capital-labor substitution shows a negative significant impact on the return on assets in all of the regression models. The results of Regression 3 in Table 8 show that one unit increase of capital at the expense of labor decreases the return on assets by 0.120 units on average, holding the impact of the other independent variables constant. The results in Table 8 show different results than those assumed by Hypothesis one. Although the impact of capital-labor substitution in ROA is significant, the results show that it has a negative impact on ROA. Therefore the first hypothesis of this research paper is rejected.

In order to see the impact of capital-labor substitution separately in the following four groups: Manufacturing Industry, Service Industry, Trading Industry and Other Industries, the following second hypothesis needs to be tested:

Hypothesis two: *The capital-labor substitution has a larger significant effect on the business performance of firms in the manufacturing industry than in the other industries of the European Union from 1990 until 2018.*

In order to approach the second the hypothesis the following four regression models will be performed for each of the industries: the first regression will be without any fixed effect, the second regression will include the country fixed effect, the third regression will include the year fixed effect and the last regression will include both the country and the year fixed effect.

Table 1, Table 2, Table 3 and Table 4 in Appendix B, present the regression results for each of the four groups of industries. Table 9 presents the preferred model for each of the industries based on the highest R-Squared value.

Table 9: The preferred regression model for each of the industries

	Manufacturing Industry	Service Industry	Trading Industry	Other Industries
Constant	-0.036***	-0.131***	-0.029	-0.036***
K/L	-0.0173***	-2.467*	-0.043**	-0.048
Size	0.043***	0.065***	0.022***	0.023***
R&D Expense	-0.002***	-0.028	-0.434	-0.018***
Leverage	-0.403**	-0.233***	-0.046	-0.094***
Number of observations	12663	3747	500	2078
Number of firms	1644	670	108	336
Adjusted R-Squared	0.023	0.139	0.094	0.092
Country Fixed effects	No	No	Yes	No
Year Fixed effects	Yes	Yes	No	Yes

Note:1) All data regression are including robust standard errors.
2) *p<0.1 **p<0.05 ***p<0.01

As noticed in Table 9, the preferred model for the Manufacturing Industry, the Service Industry and the Other Industries is without the country fixed effect, but with the year fixed effect. The preferred regression model for the Trading Industry is without the year fixed effect but with the country fixed effect. As noticed in Table 9, among all the variables, Size measured by the logarithm of the Total Assets has a significant positive impact in each group of the industries. The variable of interest, capital-labor substitution shows the most significant effect in the Manufacturing Industry and it does not show a significant effect in the Other Industries group. Among all of the industries, the substitution of labor by capital shows the largest negative impact in the Service Industry and it has the lowest negative impact in the Manufacturing Industry, compared to the other groups of industry. Therefore the substitution of labor by capital shows the largest significant impact in the Manufacturing Industry. The second hypothesis is not rejected.

VII. Robustness

A Robustness test is performed in order to check for the results presented in Section VI. The results of Table 8 are significant; one problem is the low R-Squared Value. The results of Table 9 are somewhat more problematic, because some of the variables do not have a significant impact on Return on Assets.

In order to check for robustness another proxy is used for four of the main regressions of this research paper. The proxy for ROA in this paper is the ratio of Net Income (Loss) to Total Assets. In order to check for robustness, the proxy for ROA in this section will be the ratio of EBITDA to Total Assets based on Anderson and Reeb (2003). EBITDA is the abbreviation for: Earnings before interest, taxes, depreciation and amortization.

Table 10 shows the results for the robustness test for the four main models of regression for all the industries: without any fixed effects, with country fixed effect, with industry fixed effect and with year fixed effect.

Table 10: Regression results for the robustness test

	Dependent variable: ROA			
Robustness Test	Regression 1	Regression 2	Regression 3	Regression 4
Constant	-0.017***	-0.033***	-0.015***	-0.012***
K/L	-0.131***	-0.112***	-0.142***	-0.126***
Size	0.037***	0.043***	0.036***	0.034***
R&D Expense	-0.002**	-0.002**	-0.002**	-0,002**
Leverage	-0.208**	-0.219**	-0.209**	-0.210**
Number of observations	18988	18988	18988	18988
Number of firms	2758	2758	2758	2758
Adjusted R-Squared	0.078	0.088	0.112	0.080
Country Fixed effects	No	Yes	No	No
Year Fixed effects	No	No	Yes	No
Industry Fixed effect	No	No	No	Yes

Note:1) All data regression are including robust standard errors.
2) *p<0.1 **p<0.05 ***p<0.01

As noticed in Table 10, the preferred model remains the regression model, which accounts only for the Year fixed effect. The impact of all the variables on ROA remains significant in all of the regression models. The substitution of labor by capital shows to have a negative significant effect in ROA, as estimated in Section VII. Size remains to have a positive significant in ROA. In the same way R&D Expenses and Leverage remain to have a significant negative effect on ROA in all industries.

A significant difference between the results in Table 9 and Table 10 is the value of the R-Squared. When the ratio of EBITDA over the Total Assets is used as a proxy for ROA, the Adjusted R-Squared shows a greater value than the Adjusted R-Squared when the ratio of Net Income to Total Assets is used as a proxy for ROA. This implies that the estimated model in Table 10 fits the actual model better than the estimated model in Table 9. This implies that changing the proxy for ROA could give more reliable results for this paper. However, in both cases the significance and the sign of the variables does not change, therefore the difference in R-Squared between the two models does not present a big concern to this paper.

VIII. Discussion and Conclusion

This research paper studied the impact of capital labor substitution in the business performance among all the firms in the European Union from 1990 until 2018. Two hypotheses were tested in order to give an answer to the research question of this paper. In order to test the first hypothesis eight different regression models were presented in order to study the impact of capital-labor substitution in the business performance of the firms in all the industries of the European Union. In order to test the second hypothesis, the dataset was separated based on four groups: the Manufacturing Industry, the Service Industry, the Trading Industry and the Other Industries.

The results showed that capital-labor substitution, measured as the ratio of property, plant and equipment to employees had a negative insignificant impact on the business performance of all the firms in the European Union from 1990 until 2018 on average. When the dataset was separated based on four groups of Industries, the capital-labor substitution seemed to have a larger significant impact in the Manufacturing Industry compared to the other groups of industries. The results show that as the amount of property, plant and equipment is increased relative to the number of employees in all the firms working in the manufacturing industry, the return on assets are decreased. This contradicts the theory. However, on the other hand the theory is mostly focused in the replacement of labor by investments in new technology rather than the investments in total capital. Therefore there is a difference between the substitution of labor by total capital and the substitution of labor by capital investments in new technology. The fact the capital-labor substitution has a negative effect on the business performance of the all the industries in the European Union can be related to the law of diminishing marginal productivity. In economic theory, diminishing return refer to the decrease in the marginal output of production as the amount of one of factor of production is increased while the amount of the other factors of production is held fixed (Samuleson & Nordhaus, 1995). Doms (1997) and Bresnahan (1999) provide evidence in their paper by using firm level data, that as the investments in new machineries and computers are increased, a larger employment of high skilled labor should be implemented in all firms. Therefore in this research paper, an increase of capital relative to the employees impacts the return on assets negatively, because as the equipment and new properties increase, they might not be able to replace labor, but instead high skilled labor might be needed in order to make an efficient use of the investments in capital. Bresnahan, Brynjolfsson and Hitt (2002), explain that the negative impact of capital-labor substitution in the return on assets can be interpreted by two possible explanations:

1. The increase of capital cannot substitute the labor force, but instead its abundance can decrease the marginal labor productivity by causing a decrease in the firm's production.
2. The increase of capital requires high skilled employees that know how to use the capital in its most optimal way. In case there is an increase of capital, which cannot be fully absorbed by the labor force, the abundance of capital leads to a decrease in the firm's performance.

Has this research paper, provided evidence on the impact of capital-labor substitution in the business performance of the firms in the European Union? There are certain limitations in this paper that can impact the answer to this question. The low number of control variables can cause a significant endogeneity problem if this paper. This paper used three firm-related control variables: R&D Expense, Leverage and the Size of the firm. There can be other control variables at the firm level that can impact the return on assets, such as: market share, advertising expenditure and extent of related diversification. Except firm-level control variables there might be industry control variables that can affect the return on assets significantly such as: industry concentration, industry capital intensity, industry average q and regulation. This paper did not include any control variable for the industry. Including control variables for the country differences can also be important. The explanatory power of the regression was not very high, given that the R-squared was not high. The main limitation of this paper is the low number of data for some of the countries in the European Union. Even though limited to some extents, this research shows some relationships between the capital-labor substitution and the firm's performance.

There are several suggestions that this paper would make to the future literature. There can be other more appropriate measurements for the capital-labor substitution and there needs to be some detailed research for the country and industry variables that might influence the effect of capital-labor substitution in the business performance of firms in the European Union. The methodology could as well be improved in the future literature by including time-lag variables where necessary and reasonable.

Appendix A

Table1. Average ROA and Average Total Assets for each Country

	Country	Obs.	Average ROA	Average Total Assets
1	Austria	446	0.022	2809.064
2	Belgium	543	0.017	5990.502
3	Bulgaria	7	0.003	87.050
4	Croatia	25	0.023	4651.878
5	Cyprus	7	0.055	240.984
6	Czech Republic	33	0.013	157150.7
7	Denmark	496	0.031	11762.77
8	Estonia	37	0.120	736.875
9	Finland	1102	0.067	2553.312
10	France	2301	0.006	13447.11
11	Germany	3030	0.006	9326.007
12	Greece	232	0.015	1646.89
13	Hungary	52	0.074	286344
14	Ireland	302	0.015	1359.187
15	Italy	506	0.034	47547.66
16	Latvia	59	0.053	54.162
17	Lithuania	28	0.019	349.480
18	Luxembourg	132	-0.001	11983.78
19	Malta	15	-0.060	75.973
20	Netherlands	668	0.000	9.786.459
21	Poland	102	0.052	17467.11
22	Portugal	51	0.027	2848.18
23	Romania	41	0.050	1.323.638
24	Slovakia	20	0.069	10491.01
25	Slovenia	41	0.036	34264.9
26	Spain	310	0.027	12886.22
27	Sweden	1211	0.037	33822.94
28	United Kingdom	7198	0.012	3807.847

Table2. Average ROA for each year

Year	Average ROA
1990	0,07
1991	0,062
1992	0,053
1993	0.059
1994	0,056
1995	0,04
1996	0.044
1997	0,183
1998	0,031
1999	0,018
2000	-0,015
2001	-0,097
2002	-0,116
2003	-0,029
2004	0,009
2005	0,031
2006	0,041
2007	0,036
2008	0,015
2009	0,01
2010	0,028
2011	0,029
2012	0,024
2013	0,026
2014	0,022
2015	0,018
2016	0,018
2017	0,029

Table3. Augmented Dickey-Fuller (ADF) test

Table 2:	ADF test statistic		
H0:	Panels contain unit roots		Nr. Panels= 3251
Ha:	Panels are stationary		Avg. nr. of periods=6.92
Variables	**Inverse chi-squared P**	**Inverse Normal Z**	**P-value**
ROA	1.36E+04*	-42.905*	0.000
K/L	1.09E+04*	-12.008*	0.000
Size	9800.5206*	-3.602*	0.000
R&D Expense	1.29E+04*	-25.068*	0.000
Leverage	1.16E+04*	-26.770*	0.000

Note: (i) All tests use zero lags (ii) * indicates significance at 1%

Appendix B

Table 1

Manufacturing Industry	Dependent Variable: Return on Assets			
	Regression 1	Regression 2	Regression 3	Regression 4
Constant	-0.33***	-0.052***	-0.036***	-0.035***
K/L	-0.152***	-0.095***	-0.0173***	-0.136***
Size	0.042***	0.050***	0.043***	0.042***
R&D Expense	-0.002***	-0.002***	-0.002***	-0.002***
Leverage	-0.408**	-0.427**	-0.403**	-0.402**
Number of observations	12663	12663	12663	12663
Number of firms	1644	1644	1644	1644
Adjusted R-Squared	0.020	0.021	0.023	0.02
Country Fixed effects	No	Yes	No	Yes
Year Fixed effects	No	No	Yes	Yes

Note:1) All data regression are including robust standard errors.
2) *p<0.1 **p<0.05 ***p<0.01

Table 2

Service Industry	Dependent Variable: Return on Assets			
	Regression 1	Regression 2	Regression 3	Regression 4
Constant	-0.146***	-0.154***	-0.131***	-0.136***
K/L	-3.811**	-2.397	-2.467*	-1.902
Size	0.072***	0.077***	0.065***	0.068***
R&D Expense	-0.036	-0.035	-0.028	-0.033
Leverage	-0.206***	-0.229***	-0.233***	-0.209***
Number of observations	3747	3747	3747	3747
Number of firms	670	670	670	670
Adjusted R-Squared	0.044	0.043	0.139	0.083
Country Fixed effects	No	Yes	No	Yes
Year Fixed effects	No	No	Yes	Yes

Note:1) All data regression are including robust standard errors.
2) *p<0.1 **p<0.05 ***p<0.01

Table 3

Trading Industry	Dependent Variable: Return on Assets			
	Regression 1	Regression 2	Regression 3	Regression 4
Constant	-0.016	-0.029	-0.016	-0.021
K/L	-0.093	-0.043**	-0.270*	-0.109
Size	0.018***	0.022***	0.018***	0.018***
R&D Expense	-0.792*	-0.434	-0.751*	-0.707
Leverage	-0.021	-0.046	-0.016	0.004
Number of observations	500	500	500	500
Number of firms	108	108	108	108
Adjusted R-Squared	0.071	0.094	0.044	0.039
Country Fixed effects	No	Yes	No	Yes
Year Fixed effects	No	No	Yes	Yes

Note:1) All data regression are including robust standard errors.
2) *p<0.1 **p<0.05 ***p<0.01

Table 4

Other Industries	Dependent Variable: Return on Assets			
	Regression 1	Regression 2	Regression 3	Regression 4
Constant	-0.028	-0.051***	-0.036***	-0.035*
K/L	-0.017	-0.063	-0.048	-0.013
Size	0.021***	0.029***	0.023***	0.023***
R&D Expense	-0.017***	-0.017***	-0.018***	-0.017***
Leverage	-0.098***	-0.111***	-0.094***	-0.097***
Number of observations	2078	2078	2078	2078
Number of firms	336	336	336	336
Adjusted R-Squared	0.051	0.072	0.092	0.054
Country Fixed effects	No	Yes	No	Yes
Year Fixed effects	No	No	Yes	Yes

Note:1) All data regression are including robust standard errors.
2) *p<0.1 **p<0.05 ***p<0.01

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