Project SAINT

Theoretical and empirical economic analysis on the issue of co-operation in the IT Sector
WP 3 Economic Analysis

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Deliverable D3.1 Basic characteristics of research

Scope of research

Issue of co-operation between firms and how it influences economic performance

Main concept

Co-operation enhances overall economic efficiency of the firm in the allocation of its resources.

The evolving learning through co-operation increases daily performance and productivity, which results to the minimisation of the production cost.

This provides incentives to firms to participate in co-operation schemes for the profitable exploitation of production inputs and the maximisation of efficiency in the production process.

Basic definitions

Co-operation is defined as information sharing between firms through various channels like their joint participation in electronic data interchange platforms.

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Objective

Analysing potential significance of information sharing, in the reduction of production cost.

Expectation

Information sharing has a negative effect on the production cost.

Theoretical analysis

How information sharing, incorporated in the learning by experience in the production process, affects the production cost of a firm.

Methodology

Microeconomic theory of production and the associated production cost.

Production function of the firm: Cobb-Douglas form of $q = z * k^a * l^b$, $0 < a , b < 1 , a + b = 1$

Constant returns to scale:

→ the size of the firm does not affect the productivity of its factors

→ each one input may be substituted for another, while maintaining a constant level of output

Production technology determines output.

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Firm's cost minimisation problem

Adjust the inputs' bundle in its production function, so as given some particular demand prices of the production factors, to produce certain quantity of output at a minimum cost.

Minimum production cost under constraint of constant output – Lagrange Methodology

$L = w*l + r*k - \lambda*(z*k^{a}*l^{b} - q^{c})$

Optimality conditions

$\partial L/\partial l = w - \lambda*b*z*k^{a}*l^{b-1} = 0$

$\partial L/\partial k = r - \lambda*a*z*k^{a-1}*l^{b} = 0$

$\partial L/\partial \lambda = z*k^{a}*l^{b} - q^{c} = 0$

Cost minimisation constant-output demand functions for the inputs of labour and capital

$l = (b*r/a*w)^{a/a+b}*(q^{c}/z)^{1/a+b}$

$k = (a*w/b*r)^{b/a+b}*(q^{c}/z)^{1/a+b}$

Cost function

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Cost function

$c = w*l + r*k$

$c = w^b * r^a * [(a/b)^b + (a/b)^{-a}] * q^c * 1/z$

$log(c) = b*log(w) + a*log(r) + log[(a/b)^b + (a/b)^{-a}] + log(q^c) - log(z)$

Difficulty in finding comprehensive statistical data → assumptions

Production of input prices and production efficiency parameters

→ ratio of intermediate inputs cost deflator to production gross output deflator

Production technology level

→ ratio of added value deflator on learning by experience in the production process multiplied exponentially be a learning efficiency parameter factor

$log(c) = log(iicdfltr/qdfltr) + log(q^c) - log(avdfltr/n)^m$

$log(c) = log(iicdfltr/qdfltr) + log(q^c) - m*log(avdfltr/n)$

$log(acdfltd) = - m*log(avdfltr/n)$

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Elasticity of real long-run average production cost to the real added value in the output, which is gained from the learning by experience in the production process.

Percentage change in the real long-run average production cost from a percentage change in the real added value in the output, which is gained from the learning by experience in the production process.

If the learning efficiency parameter *m*, is statistically significant and negative, this means that the introduction of learning by experience in the production process is associated with decreased deflated long-run average production cost.

Learning by experience in the production process contributes to a higher production technology level and a higher added value being incorporated in the output, causing long-run average production cost to decrease gradually.

In our present case study, learning by experience in the production process is depicted as a process of information sharing between firms that exchange relevant to production information, through electronic data interchange platforms and is represented by the respective relative percentages of the firms participating in such electronic data interchange platforms, in each cross-sectional country unit.

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Empirical analysis

Correlation statistical analysis on the relevant data, regarding the degree of Pearson linear correlation between *log(ac)* and *log(avdfltr/n)*

correlation coefficients

$$r = \frac{\sum_{i=1}^{n} (x_i - x_{mean}) * (y_I - y_{mean})}{[\sqrt{\sum_{i=1}^{n} (x_i - x_{mean})^2} * \sqrt{\sum_{i=1}^{n} (y_i - y_{mean})^2}]}$$

t	2009	2010	2011	2012
r_{xy}	- 0.2395	- 0.0852	- 0.2893	- 0.0238

log(ac) and *log(avdfltr/n)* have a negative linear correlation for the period 2009 – 2012

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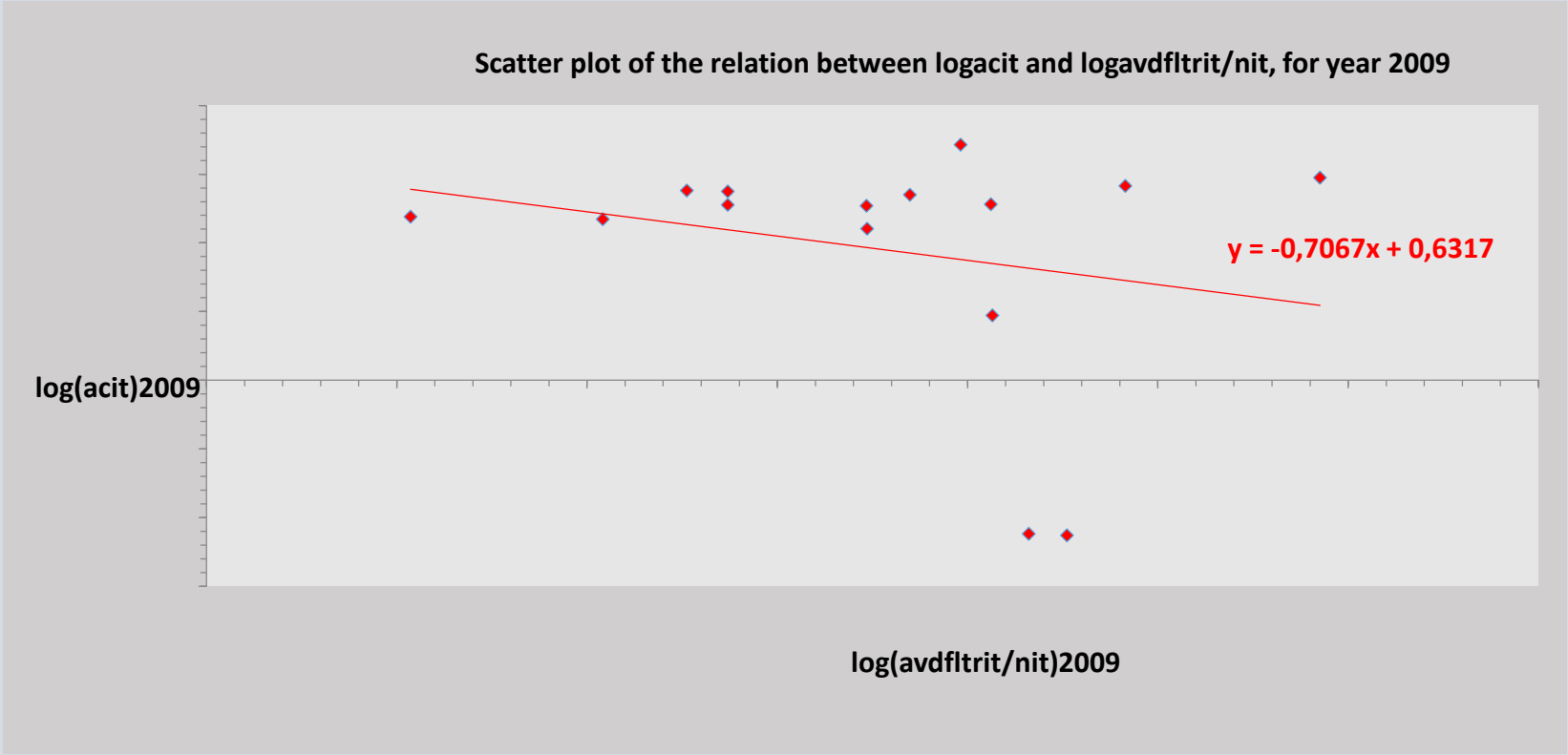
Scatterplots



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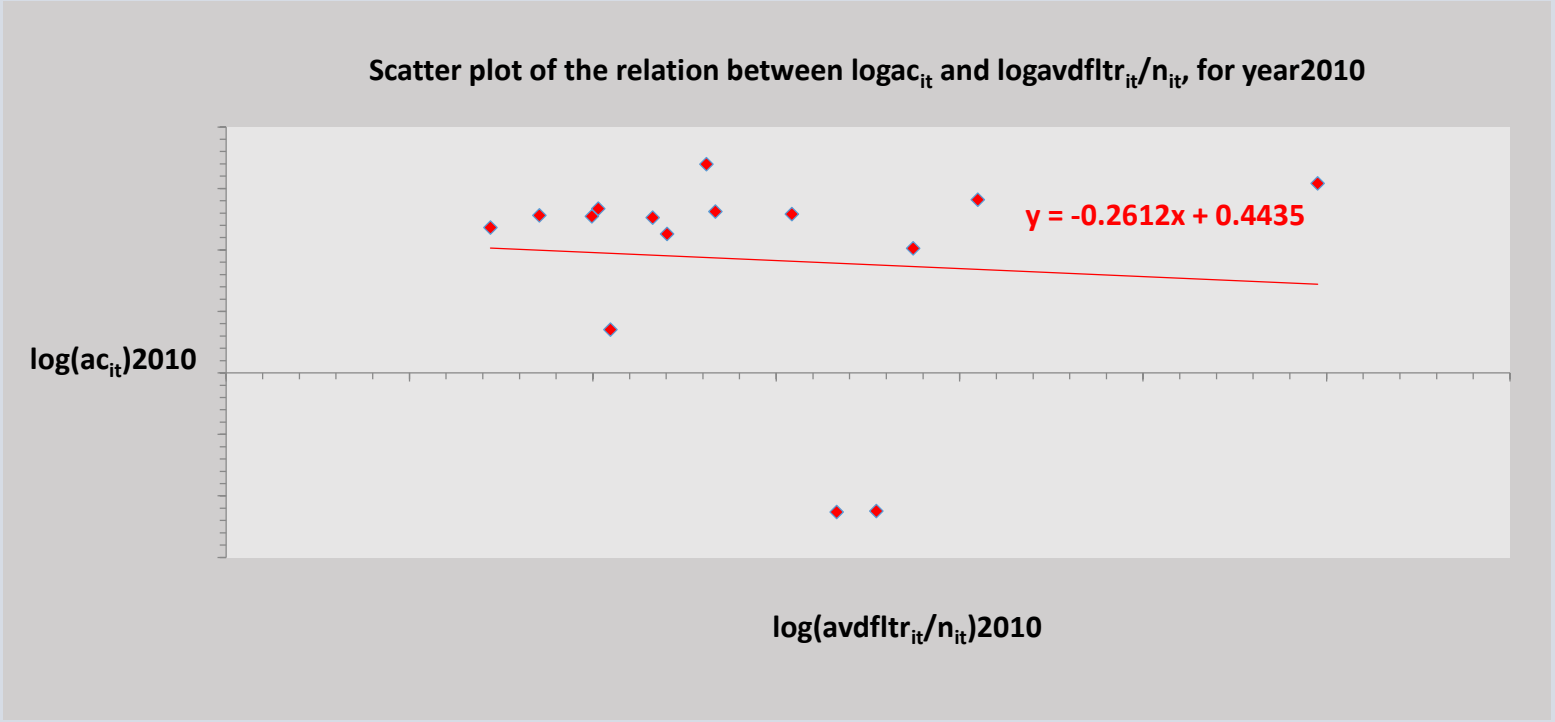
Scatterplots



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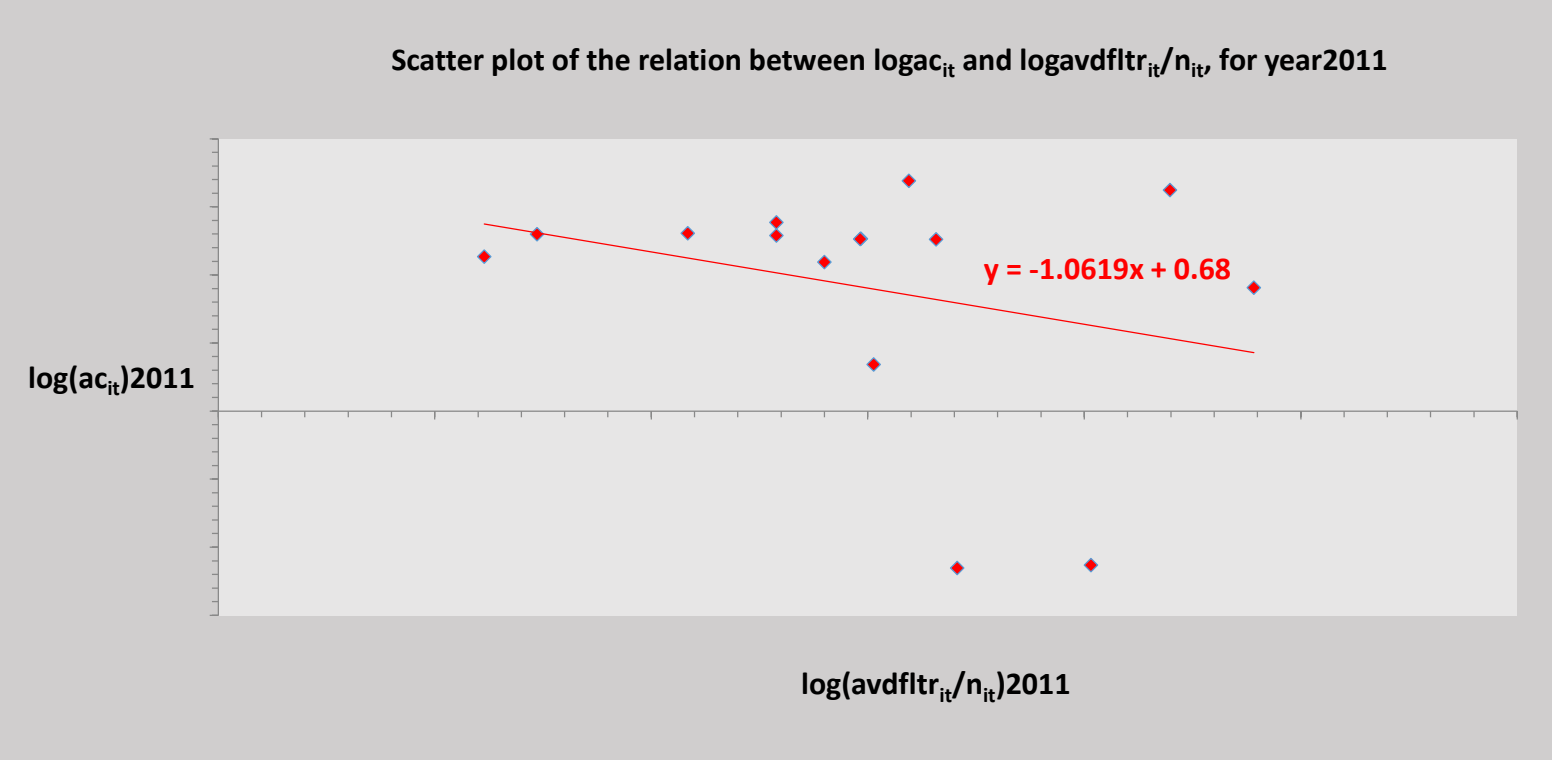

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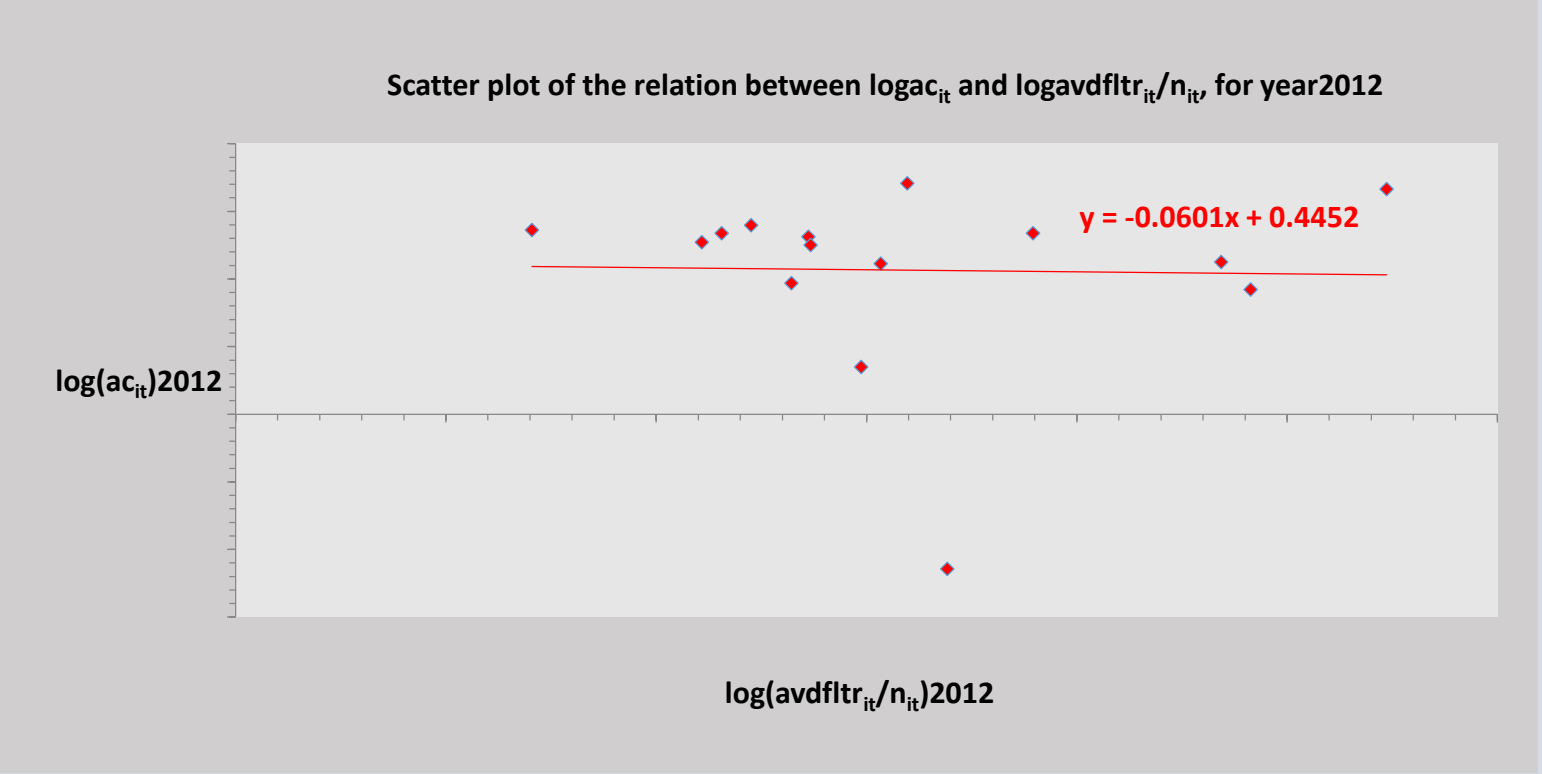

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Empirical analysis

Dependency econometric analysis about the dependence of *log(ac)* on *log(avdfltr/n)*

Dataset in panel format, with pooled data composed of elements of both, time-series data and cross-sectional data.

Panel data estimation techniques provide more efficiency in the analysis because:

- by making information available for several units, panel data minimise statistical bias, related to broad aggregates and assure more degrees of freedom, as they are associated with more variability and less collinearity among variables
- mitigate possible multicollinearity phenomena problems by assuring wider and deeper representations of the variables employed in the related econometric models

Estimation method

Pooled Generalised Least Squares with Fixed Effects or Least Squares Dummy Variables cross-sectional weights regression. Estimators obtained satisfy the standard econometric assumptions of the classical linear regression model, being unbiased, linear and best that is having minimum variance.

- take into account, the heterogeneity of firms, states, countries, etc., over time
- better suited to study the dynamics of change
- enable the analysis of more complicated behavioural economic phenomena, such as economies of scale and technological change

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Empirical analysis

$log(acdfltd) = ac_{0mean} + ac_{0i} - m*log(avdfltr/n) + u$

where

- *acdfltd*: deflated long-run average production cost
- ac_{0mean}: intercept denoting the mean autonomous deflated long-run average production cost
- ac_{0i}: intercept denoting autonomous deflated long-run average production
- *avdfltr*: added value deflator
- *n*: learning by experience in the production process due to information sharing
- *m*: learning efficiency parameter denoting the elasticity of production technology level to the added value gained from the learning by experience in the production process due to information sharing
- *u*: idiosyncratic disturbance of the econometric model satisfying the usual econometric assumptions

Mean: $E(u) = 0$

Variance: $E[u - E(u)]^2 = E(u)^2 = \sigma^2$

Covariance: $cov(u, u): E\{[(u - E(u)]*[u - E(u)]\} = E(u*u) = 0 \; \forall \; i \neq j$

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Empirical analysis

The first intercept term represents a mean autonomous deflated long-run average production cost, of the whole sample of cross-sectional countries assumed to be time invariant, for the whole time period 2009 – 2012.

Time effects in panel data models are often viewed as "transitions" or discrete changes of state and they are typically modelled as specific within all cross-sectional units for the whole of the time period in which they occur and are not carried across periods.

In our case study, the effect of time, from year to year, for the time period considered, is very slight, since our sample is composed from Eurozone countries, sharing the same basic general economic conditions, affecting production processes, like currency rates, money supply and money liquidity.

The second intercept term represents the influence of each specific economy's certain individual characteristics, on its autonomous deflated long-run average production cost that vary across the cross-sectional country units.

To the degree that the production processes depend mainly, on the general economic environment and its basic economic conditions, emerging from the regulations and policies of the EC and the ECB for the whole of the Eurozone, these differences show the heterogeneity of the special economic conditions, prevailing inside each country of our sample.

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Empirical analysis

The slope coefficient *m* is constant throughout the four-year period 2009 – 2012, for all countries of our sample, denoting the general homogeneity in the production process, as it concerns the effect of learning on it. The sign of the coefficient is negative, denoting an inverse relationship between learning by experience in the production process and real long-run average production cost.

The economic meaning of this constant elasticity of the real long-run average production cost to the learning by the experience in the production process, is that the influence of the element of learning gained by experience in the production technology level, remains relatively stable, despite the differences in the structure of the economy and in the industrial production efficiency, between the countries of our sample.

Since all countries included in our dataset belong to the Eurozone, the basic general economic conditions prevailing and affecting production processes, do not differ significantly from country to country. Currency rates, money supply and money liquidity are common for the Euro area, emerging from the policies of the ECB and the regulations of EC.

These are conditions that have a long-term influence character over the production processes, especially as it concerns the production technology level and its added value incorporated in the output.

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Empirical analysis

The idiosyncratic disturbance captures slight unobserved differences in the production process, between the countries of our sample for the whole period 2009 – 2012.

It is time-invariant and it accounts for any individual-specific cross-sectional effect that is not included in the regression.

In our present case study, the idiosyncratic disturbance term depicts the unobserved ability in learning by experience in the production process and effects of this learning, when applied, on the entrepreneurial or managerial skills of the executives of firms.

Since in general, the basic economic conditions shaping the production processes in the Euro area do not differ significantly from country to country, especially with respect to the production technology level and its added value incorporated in the output, the idiosyncratic disturbance could be assumed as being correlated with learning by experience in the production process that may be different for each country's specific conditions shaping the structure of production in this particular economy.

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Empirical analysis

$log(acdfltd_{it}) = 0.9458\ (\pm 0.0295) + ac_{0i,\ i = 1-15} - 0.0887\ (\pm 0.0340) * log(avdfltr_{it}/n_{it})$

$R^2 = 0.9982$

$R^2_{adj} = 0.9976$

F-statistic = 1631.548

Prob(F-statistic) = 0.000000

R^2 and R^2_{adj} show a good fit of the model on the data, while the F-Statistic of the probability that all estimators are equal to zero, denotes the significance of the estimations.

Austria ac_{01}	**0.4122**
Belgium ac_{02}	**0.1393**
Estonia ac_{03}	**0.0479**
Finland ac_{04}	**0.3186**
France ac_{05}	**0.2721**
Germany ac_{06}	**0.337**
Greece ac_{07}	**0.6068**
Italy ac_{08}	**0.2984**
Latvia ac_{09}	**0.6957**
Luxemburg ac_{010}	**-0.5313**
Netherlands ac_{011}	**0.1555**
Portugal ac_{012}	**-1.453**
Slovenia ac_{013}	**0.3053**
Slovakia ac_{014}	**0.2936**
Spain ac_{015}	**-1.898**

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Empirical analysis

Our analysis shows the importance of learning by experience in the production process, in the reduction of the real long-run average production cost.

The results of our model show that for the specific time period 2009 – 2012, for a representative industry, in a sample of 15 European countries all belonging to Eurozone, which means, same basic economic conditions, the elasticity of the real long-run average production cost to the ratio of the added value (incorporated in the produced output) to learning by experience in the production process, is almost -9%.

In other words, there is an almost minus nine per cent negative effect of the added value, gained from learning by experience in the production process, on the real long-run average production cost.

As the firm absorbs new technological information, experience is building up and this learning process results to production cost savings.

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Empirical analysis

One form of introducing learning by experience in the production process is information sharing between firms, in areas related to their daily working routine.

Information sharing between firms can significantly enhance the learning by experience element in their daily production processes and contribute to the minimisation of their production cost and consequently to the enhancement of their economic efficiency.

This provides economic incentives to support and promote the development of co-operation and to give priority to building relevant co-operational schemes.

Each firm, given its production technology, produces various levels of output using different combinations of inputs, under a limited budget. This cost constraint sets a very strict limit to unfavourable changes in the production function, like those occurring due to breaches from cyber-attack incidents.

Considering cyber-security as an element of the technology production factor that shapes the production function of the firm, it allows the firm's optimised operational performance, within the feasible technical boundaries, contributing to the efficient allocation of resources, minimisation of the production cost and overall firm profitability.

New learning affects cyber-security against existing and new cyber-threats, with information flow between the various firms, on these issues, helping them to choose the best combination of cyber-security inputs, by taking into account not solely their prices, but also the different levels of technology they use in producing their output. Co-operation between the firms' cyber-security teams, is very important, in order to deal with their vulnerabilities and build an efficient cyber-defence.

End of Presentation

thank you for your attention