# The impact of innovation on companies performance during crisis: an entropy-based analysis of the STAR Market Segment of the Italian Stock Exchange

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**Abstract**
This paper analyzes the links between innovation pre-crisis and performance during crisis for firms listed in the STAR market segment of the Italian Stock Exchange.
The aim is to shed light on the relevant parameters for explaining the relationship between innovation and performance (in terms of growth, profitability and productivity), with special focus on innovation type, innovation level and business size.
An empirical analysis based on the perspective of information theory is carried out by introducing suitable classes of entropy measures on aggregated quantities. In so doing, results are not biased by the probability estimates of the empirical data, in that entropy-type measures involve directly empirical distributions, so no hypothesis test is required and no best fit of known probability distribution of data is considered. The study shows that the type of innovation is significantly linked with the performance: there is evidence that process innovation initiatives imply better performance.

*Keywords:* Innovation, entropy, business performance.

## 1. Introduction

In spite of several empirical studies which have measured the effect of innovation on business performance, the literature still does not provide a convincing analysis of this significant fact. At the international level, some authors identify a direct relationship between product and process innovation, and improvements in productivity, competitiveness and, as final result, in income performance (Griliches 1994, Jin et al. 2004, Parisi et al. 2006, Pianta and Vaona 2007, Hall et al. 2009, Wang et al. 2010, Gunday et al. 2011).
However, the empirical evidence sometimes highlights the negative effects of innovation on performance (Subramanian and Nilakanta 1996) and the inability to achieve competitive advantages solely through product innovation (Friar 1995). In this respect, it is also important to point the attention of the reader to the classic Jevons paradox.
More often, empirical studies motivate the positive effect of innovation by analyzing the impacts of different innovation typologies. Some authors state that product innovation may improve occupation and income perspective (Edquist et al. 2001, Pianta 2005, Artz et al. 2010). It has also been argued that, when process innovation is technological in nature, it might promote the reduction of operating costs and lead times, ensuring a more efficient employment of resources. When process innovation concerns the organization, it may improve the quality of invested capital, internal capabilities and competitiveness in the long term (Geroski et al. 1993, Damanpour 2010).
Some contributions assert that, while product innovation is supposed to produce a positive impact on income and employment growth, a new process can have a more indeterminate effect, because of its cost-cutting nature (Fagerberg et al. 2005). Other studies emphasize that product and process innovations are correlated and their joint implementation is fruitful, since the improvement of the processes is necessary successfully create new products or services (Oke 2007).

On the other hand, for some, organizational innovation – prevalently based on intangible fixed assets – as opposed to technological organization, is the most crucial factor in explaining business performance, especially sales (Therrien et al. 2011, Lin and Chen 2007).
A study on the impacts produced by different innovation types may be useful to assess how they can contribute to improve company performance, even during economic crisis.
Evidence suggests that innovation in organizational processes and knowledge learning represents, over time, an effective strategy, even during economic recession (Antonioli et al. 2010). Conversely, product innovation seems to be more influenced by the effects of the economic crisis (Horta et al. 2012). Some recent studies highlight that the relationship between firm innovation and performance are highly influenced by the economic conditions of the country in which the company is situated (Bong Choi and Williams, 2013).
Therefore, it is important to examine the variables that affect the relation between innovation and performance.
The role played by firm size is particularly relevant. Hall et al. (2009) point out that large firms often implement multiple innovation initiatives, in order to increase their probability of success. Other authors explore the controversial implications of large size on profit and efficiency: on the one hand, large size leads to positive performance thanks to scale and scope economies; on the other hand, the performance may be negatively influenced by the high level of costs due to administrative and bureaucratic constraints (Hall et al. 2009, Irwin et al. 1998, Gopalakrishnan 2000).
The managers of large-sized companies need to spend increasing time solving the problems arising from the existing products and consequently dedicate less time to developing new ones. These arguments are confirmed by empirical research, whose results show a decline in innovation productivity with respect to R&D investment intensity and company size (Acs and Audretsch 1990, Cohen and Klepper 1996, Plehn-Dujowich 2007).
The analysis of business performance is meant to verify whether the more innovative companies are the ones that – during a period of economic crisis – are most likely to show rapid fluctuations in sales (see the Innobarometer 2009 survey) or become vulnerable due to debts caused by new investments and to instability induced by the change. Evidence suggests that relation between innovation and firm performance are mixed, especially when innovations are radical because they entail development risks and market uncertainties (Xin et al. 2008).
Hence, it is worthwhile to explore the connections between company size, innovation initiatives and impact on performance, in particular during a period of economic crisis. This is precisely the scientific ground of the present paper. Companies are classified in terms of: 1) business size, 2) innovation type (product and/or process) and 3) innovation level (level of tangible and intangible fixed assets), in order to emphasize differences or similarities in terms of growth, profitability and productivity in relation to the above variables.
The analysis is carried out on the set of companies listed in the STAR market segment of Italian Stock Exchange, which includes only companies that are mid-size in terms of capitalization.
The choice of this type of mid-sized companies make for clearer results because those companies are more likely to limit their activity to a single business. Moreover, there is a complete and exhaustive availability of financial statements for the STAR market, including the information related to companies innovation type and level.
The analysis is performed by employing only information (quantitative and qualitative) available in consolidated financial statements. Even if this choice may entail certain limitations – the data collected do not allow to detect innovations activities that do not produce an increase in fixed assets (tangible or intangible). Moreover, the adoption of the international accounting principles (IFRS) do not prescribe current expenses on research and development to be a mandatory disclosure – the use of official financial statements allows a complete (even if

synthetic) data collection, which is not subject to the risk of lack and unreliability of responses typical when questionnaires are employed. Thus, the impact produced by innovation on performance should be more evident in companies focusing on a single or on limited fields of operating activity.

Special attention is paid to the current financial crisis. Specifically, the impact on innovative initiatives performed in a pre-crisis period on company performance during the latest crisis triennium is take into consideration. Indeed, the end of 2008 (with the bankruptcy of Lehman Brothers) marks the transition from pre-crisis to crisis, in that the most serious effects on real economy of the financial distress in the U.S. became extremely evident almost worldwide. In the two years preceding the crisis (2006-2007), the propensity of companies to innovate has been assessed by the evaluating their investments on intangible and tangible fixed assets and through information about the type of innovation implemented; for the following three years (2008-2010), performance outcomes in terms of growth (sales variation and number of employees variation), profitability (Return on investment or, briefly, Roi), and productivity (sales per employee) have been measured.

The time-horizon taken for the present study is consistent with the good practice of productivity (effects of innovation on performance). Indeed, the impact of innovation may be delayed (Teece, 1988, Ravenscraft and Scherer 1982, Leonard, 1971), and such a delay is particularly noticeable in organization process innovation. In general, the implementation of innovative long-term investments can be verified over the next 3 years when the investments become productive (see e.g. Cainelli et al. 2004), and this justifies the triennial time horizon taken for the present analysis.

An information theory-based approach is adopted to exploit one of the main characteristics of information theory, i.e. its applicability to several scientific contexts. In this respect, the quality of companies performance is explored as spatial concentration of aggregated indicators related to growth, profitability and productivity. Such a concentration – or, in the language of information theory, *disorder* – varies following changes in tangible and intangible fixed assets, innovation type (product, process or both) and business size, hence providing information on which aspect is more effective for visualizing and analyzing companies performance when innovation occurs. In particular, the analysis of the role of innovation is represented through a localization problem based on a cluster analysis of the data of the companies, and is supported by entropy measures.

This paper intervenes in the debate on complexity in managerial science (Hall 1997, Solvay et al. 2001, Jacobs 2013). Specifically, the reference literature deals with the quantification of the relative spatial concentration of a set of companies with respect to a benchmark universe of units (Ellison and Glaeser 1997, Amiti 1999, Brülhart and Traeger 2005, Cutrini 2009, 2010).

Entropy measures are particularly appropriate in this specific setting. First of all, among the concentration measures, only entropies satisfy a decomposition property, i.e.: the disorder of a set can be written by aggregating the disorders of the elements of a partition of the set (Brülhart and Traeger 2005, Cutrini 2009). This property makes it possible to derive information on specific clusters of the companies listed in the STAR market. Furthermore, entropy measures are rather general, in that they involve directly the empirical distribution of the data under scrutiny. To sum up, entropy measures give a precise description of the localization of data and allow one to explore in depth the considered set of companies.

This paper can be also included in the wide strand of literature dealing with the performance measurement of a system, which represents a crucial task for strategic planning or policy development. In this context, entropy measures have been largely used (see e.g. Chang 2007).

As for companies performance, one of the most influential contribution on entropy-based measurement is the seminal paper of Jaquemin and Berry (1979). The authors adopt entropy as a measure of corporate diversification, and take into account total sales and productivity of a set

of 460 U.S. large industrial corporations. Among Jaquemin and Berry's followers, Matusik and Fitza (2012) should be mentioned, which uses entropy to measure companies diversification and corresponding performance outcomes for a selection of 4,000 firms over a period of forty years (1960-2000).
Entropy measures are here used to show how business size, innovation type, tangible fixed assets and intangible fixed assets can be associated with a homogeneous rather than heterogeneous distribution of companies performance data. In fact, when entropy is low, then analyzed system is regular and perfectly predictable, whereas when entropy is high, the number of future possible configurations grows and the system is less predictable. This, in turn, allows a researcher to identify the parameters that better explain the relationship between innovation and performance. Specifically, entropies measure the spatial concentration of the performance indicators of the companies listed in the STAR market – i.e.: sales variation, number of employees variation, Return on investment and sales per employee, in the triennium 2008-2010 (the crisis period) – with respect to the qualitative parameters – i.e.: business size, innovation type, level of intangible and tangible investments – in the biennium 2006-2007 (the pre-crisis period). The basic assumption is that the parameters describing the companies are "spatial variables", (see the definition of the aggregate quantitative parameters x's provided in Subsection 3.2). Hence, the examination of the concentration of companies involves an aggregate measure of the performance indicators of the dataset, either as a whole and when companies are clustered with respect to size, type of innovation, level of tangible and intangible fixed capital.
The analysis shows that the role played by the type and the level of innovation initiatives on companies performance is particularly important. Results show also that the type of innovation is the most relevant variable, whereas size is significant in companies that do not innovate, at least in terms of tangible assets.
The rest of the paper is organized as follows: Section 2 contains the description of the dataset and the quantitative instruments used to perform the analysis; Section 3 contains the main results of the research, along with a discussion; in the last section, some conclusive remarks and further possible research directions are found. All the Tables and Figures are collected in a separate Appendix.

## 2. Methodological instruments and data

### *2.1 The data.*

The present analysis concerns the companies listed in the STAR market segment of Italian Stock Exchange. The STAR segment included, as of 31 December, 2010, 71 mid-sized companies in terms of capitalization value, which is between 40 million and 1 billion euros. However, to ensure homogeneity and relevance, banks and insurance institutes have been removed from the list, hence letting the final number of studied companies be equal to 62. The data have been manually collected by reading the consolidated financial statements (balance sheet, income statement and descriptive notes) of the 2006-2010 period, as published in the company annual report. The annual reports have been downloaded directly from the analysed companies' websites. The list of companies, along with the websites, is in Table A1, and their classification by industry in Table A2.
The data collected for the 2006-2007 biennium – defined as the *pre-crisis* period – have been employed to establish a classification of companies by size, to detect the presence of innovation initiatives in terms of tangible and intangible fixed assets, and to assess the type of innovation performed (product, process, or both).
As for *size*, companies have been grouped into three categories: small, medium and large. As shown in previous studies (Damanpour 2010) different measurements of size (financial indicators and personnel) may influence the relation between size and type of innovation. In

order to reduce this bias, companies have been classified through a mix of employee number and financial aspects (total sales and total assets).
The thresholds employed for personnel have been defined on the basis of the literature (see among others Acs and Audretsch 1990, Phillips and Kirchhoff 1989, Brock and Evans, 1989 and Baldwin et al. 2002). The classification of companies based on financial measures is controversial. The innovation/size relation has been generally obtained by means of regression models, and the classification of companies into small, medium and large was therefore unnecessary. As a consequence, this paper employs thresholds for total sales and total assets which are reasonable in terms of the empirical evidence of the STAR market case. Indeed, the categories of small, medium and large size describe different levels of complexity and collect a large enough number of companies.
Each company of the STAR market satisfies at least two thresholds conditions for one of the three categories in Table A3, and its size has been identified according to this criterion.
Table A4 contains the clustering of companies by size and industry.
In this paper innovation is analysed by mean of financial measures which may reflect the company engagement in formal innovation initiatives. The adoption of financial measures may produce a bias well known in this field of studies, given by the fact that only a minority of the analysed companies may be engaged in formal innovation initiatives which produce impacts on profit and loss or balance sheet.
Nevertheless financial measures are largely employed (Fritsch and Meschede 2001, Martinez-Ros 2000, Meisel and Lin 1983, Crépon et al. 1998, only to name a few).
Investments in tangible and intangible fixed assets are considered as separate variables. The former mainly express product and process innovations obtained by means of new technologies, while the latter may represent both technological and organizational innovations (Therrien et al. 2011, Lin and Chen 2007).
Tangible fixed assets correspond to the sum of the balance sheet items: plants, machineries and equipment. Properties have been excluded because their variation may not necessarily express an innovation effort.
Intangible fixed assets are computed in the balance sheet, and are mainly composed by development costs, patents, trademarks, licences and concessions.
Goodwill has been not considered in the set of the intangible fixed assets, because its variation is mainly due to mergers or acquisition of new companies. Those initiatives are often the way companies obtain new financial or fiscal advantages rather than product or process innovation outcomes.
Lot of studies employ R&D expenditures as financial input of innovation, but this item covers only a portion of firms innovation efforts (Marsili and Salter 2006). Indeed according to the accounting standards, research and development costs have to be computed adopting different methodologies.
Research costs arise during the initial stages of the innovation process when future benefits from innovation are uncertain. Differently, development costs, patents, trademarks, licences and concessions can be considered as medium-long term investments. Indeed, the company can reasonably demonstrate the existence of all the internal and market conditions to obtain from such expenditures future economic benefits.
The *level of innovation* on tangible and intangible fixed assets has been assessed in terms of *intensity* and *relevance* of the initiatives. The intensity is measured as percentage variation of tangible/intangible fixed assets, while the relevance is the average weight of the tangible/intangible fixed assets on total assets in the biennium 2006-2007.
Companies have been then grouped into two categories: Not Innovative (NI) and Innovative (I). This clustering has been made, as shown in Table A5, by considering the innovation intensity

and innovation relevance, which have been computed as described above. The presence of innovation has been separately measure for intangible and tangible innovation.
Tables A6, A7, A8 and A9 show the distribution of companies grouped by size/industry and innovation level (innovative/not innovative) both for tangible and intangible fixed assets.
The *type of innovation*, as mentioned above, considers three emerging categories: product, process and product/process (i.e.: both). A fourth residual category has been introduced for the cases in which the financial reports do not disclose any information in this regards or when companies explicitly declare they do not carry out any kind of research or innovation activity.
To collect these items, a thorough reading of the descriptive notes, searching for information about research or innovation activities, has been needed. The emerging classification is generally restricted to product and/or process paths. These two general categories then summarize actions which previous studies classify more in detail (Gunday et al. 2011). The distributions of companies by type of innovation and size/industry are shown in Table A10 and A11.
The measure of the impacts produced by pre-crisis innovation initiatives has been formalized through the data referred to the triennium 2008-2010 –which points to the current financial crisis and is then defined as outcome *crisis* period-. The expected outcomes are measured in terms on growth, profitability and productivity.
The *growth* indicators are percentage variations on sales (mnemonically, SalesV) and employees number (EmplV), while Return on investment (Roi) and sales per employee (SpE) have been used to measure *profitability* and *productivity*, respectively.
Specifically, the variations on sales and number of employees could be interpreted as transitory and stable growth, respectively. The profitability is related to the level of Earnings Before Interest and Taxes on total assets and the productivity is the relation between total sales and number of employees.
Some descriptive statistics of the considered data are reported in Table A12.

*2.2 Methodological instruments: preliminary notations.*

To introduce the localization entropy measures here employed, some preliminaries are needed.
The qualitative terms that cluster the set of companies are denoted as follows:

- $i=1,2,3$ is the size of the company, with the specific reference to $i=1,2,3$ for small, medium and large companies, respectively.
- $j=1,2,3,4$ is the type of innovation of the company and $j=1,2,3$ stands for innovation in product, innovation in process, and innovation in product and process, respectively. Case $j=4$ means that the information does not permit to state with a sufficient precision the type of innovation associated with the company. Hence, $j=4$ is reported for the sake of completeness, even if the lack of information on innovation initiatives in the annual report of these companies prevents the discussion of the related obtained results.
- $h=1,2$ is the level of innovation for tangible fixed assets. In this respect, $h=1$ means "Not Innovative", while $h=2$ stands for "Innovative".
- $k=1,2$ is the level of innovation on intangible fixed assets. As in the previous case, $k=1$ stands for "Not innovative" , while $k=2$ stands for "Innovative".

As already mentioned, four indicators for companies business performance are presented: variation in sales and number of employees, Return on investment and sales per employee, in the outcomes 2008-2010 triennium.
The aggregated quantitative parameter of interest will be denoted as $x$, which is the sum of the absolute values of the corresponding indicator for the examined companies. The subscript, when it appears, indicates the considered cluster:

- $x$ is the total value of the indicator. It is the sum of the absolute values of the indicator for the entire set of companies listed in the STAR market segment of the Italian Stock Exchange.

- $x_i$, $x_j$, $x_h$, $x_k$ represent the sum of the value of the absolute values of the indicator for the companies with dimension $i$, type of innovation $j$, level of tangible asset innovation $h$, level of intangible asset innovation $k$, respectively.
- $x_{ij}$ is the sum of the absolute values of the indicator for companies with size $i$ and type of innovation $j$. The same applies for $x_{ih}$, $x_{ik}$, $x_{jh}$, $x_{jk}$ and $x_{hk}$.
- $x_{ijk}$ is the sum of the absolute values of the indicator for companies with size $i$, type of innovation $j$ and level of innovation for intangible assets $k$. The terms $x_{ijh}$, $x_{ihk}$ and $x_{jhk}$ are analogously defined.

*2.3 Methodological instruments: entropy measures.*

As already discussed in the Introduction, the entropies used here are special dissimilarity measures. They are specifically useful for analyzing the spread across given variables. Furthermore, entropy measures are also able to shed light on how the peculiar features of the variables under scrutiny affect localization.

The qualitative parameters of interest are $i,j,h,k$, while the quantitative ones are the $x$'s defined in Subsection 2.2. A list of the entropy measures is provided first; secondly, a discussion on the information contained by each entropy measure is carried out.

The family of mono-subscript entropy measures is introduced at first. Since $h$ and $k$ give information on the innovation level from two different perspectives, it is not logical to consider them jointly, and it is better to avoid clustering companies with respect to both parameters. The proposed measures reflect this concern:

$$H_k^1 = \sum_{i=1}^{3}\sum_{j=1}^{4} \frac{x_{ijk}}{x_k} \ln\left(\frac{x_{ijk}/x_{ik}}{x_{ij}/x_i}\right)$$

$$H_k^2 = \sum_{i=1}^{3}\sum_{j=1}^{4} \frac{x_{ijk}}{x_k} \ln\left(\frac{x_{ijk}/x_{jk}}{x_{ij}/x_j}\right)$$

$$H_j^{1k} = \sum_{i=1}^{3}\sum_{k=1}^{2} \frac{x_{ijk}}{x_j} \ln\left(\frac{x_{ijk}/x_{ij}}{x_{ik}/x_i}\right)$$

$$H_j^{2k} = \sum_{i=1}^{3}\sum_{k=1}^{2} \frac{x_{ijk}}{x_j} \ln\left(\frac{x_{ijk}/x_{jk}}{x_{ik}/x_k}\right)$$

$$H_i^{1k} = \sum_{j=1}^{4}\sum_{k=1}^{2} \frac{x_{ijk}}{x_i} \ln\left(\frac{x_{ijk}/x_{ij}}{x_{jk}/x_j}\right)$$

$$H_i^{2k} = \sum_{j=1}^{4}\sum_{k=1}^{2} \frac{x_{ijk}}{x_i} \ln\left(\frac{x_{ijk}/x_{ik}}{x_{jk}/x_k}\right)$$

By replacing $k$ with $h$, the measures $H_h^1, H_h^2, H_j^{1h}, H_j^{2h}, H_i^{1h}, H_i^{2h}$ are analogously defined.

The quantities introduced above make it possible to evaluate the impact of one of the three parameters *i, j, h/k* when only one of the remaining parameter is assumed to be fixed. $H_k^1$ and $H_k^2$ capture information on the aggregated indicator $x$ for the level of innovation on fixed assets at level $k$, when such an aggregation involves companies with size $i$ and type of innovation $j$, respectively. As the value of $H_k^1 (H_k^2)$ grows, the scatter effect of size $i$ (type of innovation $j$) in the aggregation of the indicators $x$ of companies with a fixed level of intangible assets innovation $k$, also increases. Specifically, the disorder of the companies with regard to the indicator is high, and scarce concentration occurs. Conversely, if the entropy measure has a low value, then the system of companies is rather concentrated with respect to the examined indicator.

The same arguments apply to the other *H*'s. Table 1 summarizes the action of each mono-subscript entropy measure defined above.

| Entropy measure | $H_k^1$ | $H_k^2$ | $H_j^{1k}$ | $H_j^{2k}$ | $H_i^{1k}$ | $H_i^{2k}$ | $H_h^1$ | $H_h^2$ | $H_j^{1h}$ | $H_j^{2h}$ | $H_i^{1h}$ | $H_i^{2h}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fixed parameter | *k* | *k* | *j* | *j* | *i* | *i* | *h* | *h* | *J* | *J* | *i* | *I* |
| Scatter parameter | *i* | *j* | *i* | *k* | *j* | *k* | *i* | *j* | *I* | *H* | *j* | *h* |

*Table 1: Action of the mono-subscript entropy measures. Given the companies with a fixed parameter (second line), the corresponding entropy (first line) is measured for companies clustered with respect to the scatter parameter (third line).*

Now the family of entropy measures with double subscript is defined. In this case, the scatter effect of one of the three parameters *i, j, h/k,* when the other parameters are assumed to be fixed is explored.

$$H_{ij}^{k} = \sum_{k=1}^{2} \frac{x_{ijk}}{x_k} \ln\left( \frac{x_{ijk} / x_k}{x_{ij} / x} \right)$$

$$H_{ik} = \sum_{j=1}^{4} \frac{x_{ijk}}{x_j} \ln\left( \frac{x_{ijk} / x_j}{x_{ik} / x} \right)$$

$$H_{jk} = \sum_{i=1}^{3} \frac{x_{ijk}}{x_i} \ln\left( \frac{x_{ijk} / x_i}{x_{jk} / x} \right)$$

As already done in the mono-subscript case, *k* is replaced with *h* to define $H_{ij}^{h}, H_{ih}, H_{jh}$.

$H_{ij}^{k}$ is the entropy measure that gives information on the value of the aggregate indicator *x* related to companies with innovation type *j* and size *i* as the level of innovation in intangible fixed assets *k* varies. More precisely, as $H_{ij}^{k}$ grows, the scatter effect of the level of innovation in intangible assets increases when size and type of innovation are fixed. The disorder of the system of companies is high for great levels of entropy, and scarce concentration takes place. When the entropy measure admits a small value, then companies are clustered through similar values by the related scatter parameter. A similar discussion can be applied to the remaining double-subscript entropy measures. Table 2 synthesizes how each double-subscript entropy measure works.

| Entropy measure | $H_{ij}^{k}$ | $H_{ik}$ | $H_{jk}$ | $H_{ij}^{h}$ | $H_{ih}$ | $H_{jh}$ |
|---|---|---|---|---|---|---|
| Fixed parameters | *i,j* | *i,k* | *j,k* | *i,j* | *i,h* | *j,h* |
| Scatter parameter | *k* | *j* | *i* | *h* | *J* | *I* |

*Table 2: Action of the double-subscript entropy measures. Given the companies with a fixed couple of parameters (second line), the corresponding entropy (first line) is measured for companies clustered with respect to the scatter parameter (third line).*

## 3. Results and discussion

The entropy measures capture the localization of companies with respect to performance indicators. The higher the value of entropy, the more scattered the results achieved by the companies. Such a concentration property depends strongly on the way in which companies are clustered. In this paper, subfamilies of the original set of companies that are determined by a fixed value of one (or two) of the parameters *i,j,k,h*, are considered and the concentration of the

performance indicators when such subfamilies are clustered with respect to one of the remaining parameters is then measured.
As the value of the entropy increases, the disorder of the system grows. In financial terms, this means that the performance indicators of the companies are highly inhomogeneous, i.e. they are highly volatile as the scatter parameter changes. This evidences a meaningful relation between scatter parameter and companies performance.
Conversely, a low level of entropy indicates that companies share similar absolute values of performance indicators, and this fact could be associated to a low level of uncertainty in the system.
However, in the low-entropy case, a statistical analysis of the disaggregated performance indicators must be carried out, the reasoning being that, if the entropy is low, then absolute values are concentrated, but no information on the real data can be derived. Obviously, this argument applies only to growth. If the statistical analysis confirms low entropy for the data, then companies performance do not exhibit variability, and the scatter parameter is not considered significant in terms of performance. The reason for this is that, low entropy indicates the existence of a common behavior, when all the companies are sorted through a specific item (for example small size). It is also worth noting that the situation in which concentration level is high – i.e. entropy is small – can be particularly useful for predictions.
Tables A13 and A14 contain the values of the mono - and double-subscripts entropy measures, respectively.
As for mono subscript entropy measures, as clearly shown in Figure A1, the dimension which generates the lower entropy is the level of innovation in intangible assets ($k$) when the type of innovation is assumed as fixed (rows nr 9-12 in Table A13).
According to the results, a low level of entropy indicates that when clustering companies based on a fixed type of innovation ($j=1,2,3,4$), the comparison between sub-clusters determined by the level of innovation on intangible assets does not show significant variability. In other words, given a particular type of innovation, the performance, in terms of sales % variation, of innovative companies in terms of intangible assets do not differ significantly by those of the non innovative ones. This means that the distributions in the principal cluster and in the sub-clusters do not show significant changes, therefore the scatter parameter (in this case the level of innovation on intangible assets $k$) is not supposed to be a significant interests for the investigation of the relation between innovative initiatives and company performance.
As shown in Table A13 the same results are confirmed for all the three output years covered and for all the performance indicators considered.
Additional considerations on the fixed parameter $j$ can be carried out. Low entropy is measured and then also high homogeneity in the grouped companies performance inside each cluster created by considering the type of innovation. Based on this evidence, the different clusters can be compared to search for significant differences.
Figure A2 shows the average deciles of the % Sales variation, calculated inside the four clusters referred to the different types of innovation. The deciles make it possible to overcome the bias represented by the different company size when calculating central tendency measures based on financial ratios (Lev and Sunder 1979).
Cluster 2 –comprising companies that implement process innovation initiatives- shows higher performance in terms of average sales % variation for all the three output years. The low entropy value ensures that the average should be highly representative of the general level of performance among the clustered companies. Thus, the result is coherent with studies asserting that process innovation initiatives make it possible to achieve better results (Antonioli et al. 2010). Moreover, as shown in Figures A6, A7 and A8, companies implementing process innovation initiatives perform better also in terms of profitability, productivity and growth.

The relevance of the type of innovation is strongly confirmed also by the double sub-script indexes in Table A14. Rows nr 39-43 show remarkably high level of entropy for all the performance indicators considered and for every year covered. In particular, rows 39-42 have as common feature the scatter parameter *j*, i.e. the type of information. In particular the indexes strongly evidence that for each cluster based on size and level of innovation in tangible assets, company performance is highly volatile in relation to the the type of innovation.
The examination of the quantitative results shown in Table A13 suggests that, the index that attains a high level of entropy in all three years for most all of the performance measures considered is nr. 19. This index considers non innovative companies, in terms of tangible assets as fixed parameter, and company size as scatter parameter. The results show high levels of entropy when size change in companies that do not innovate in tangible assets. Therefore, size could be a relevant explaining variable of company performance, for companies that are not innovating in their tangible assets.
This finding is of particular interest when compared to that of index nr. 20, which shows lower entropy in companies defined as innovative in terms of tangible assets. The innovation in tangible assets seems to produce higher homogeneity in company results while, when innovation in tangible assets is not occurring, company size can influence the performance.
A final consideration involves the effectiveness of the performance indicators selected. Referring to index 19., the results show higher levels of entropy for sales variation and employee variation and lower levels for profitability and productivity (measured as the sales per employee ratio). The same consideration is applicable, in general, for most of the entropy indexes considered. Studies of the economic crisis aimed at creating effective predictive models (case of low entropy) to meaningfully represent the possible effects of innovative actions should therefore employ profitability and productivity as performance indicators. Instead, when investigating the factors that can produce different performance (case of high volatility) in presence of innovation, it is preferable to refer to sales and employee variations.

## 4. Conclusions

The analysis of the performance of the STAR market segment of the Italian stock exchange has been carried out in this research with a specific focus on the current financial crisis. The introduction of entropy measures makes it possible to consider the "disorder" of this set of listed firms, offering insights on the distribution of growth, profitability and productivity. By taking into account the statistical properties of the data, the central characteristics of the performance of companies can be inferred, along with information on the impact of innovation on them. In this respect, the present paper can be used as the basis of further studies on management, industrial economics and innovation.
The technicalities used in this work may be adopted to explore the structure of different data, including those related to other indices in the Stock Exchange as well as the entire set of companies listed in a market. In this respect, a comparative analysis between indices, including the industrial sectors of the single components as well as the impact of the current financial crisis on companies performance could provide several insights.
It is worth noting that some specific contexts may require the use of different entropies to carry out the analysis. In this regard, Tsallis entropy (Tsallis, 1988) is one of the most powerful tools. A link could be established between the Theil indexes used here and Tsallis entropy (see the q-Theil index introduced in Ausloos and Miskiewicz 2009).

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# APPENDIX

| Nr. | Company name | Internet website | Headquarter address | City | Postal code |
|---|---|---|---|---|---|
| 1 | Acotel Group | www.acotel.com | Via Della Valle Dei Fontanili, 29 | Roma | 00168 |
| 2 | Aeffe | www.aeffe.com | Via Delle Querce 51 | San Giovanni In Marignano | 47842 |
| 3 | Amplifon | www.amplifon.com | Via Ripamonti, 131/133 | Milano | 20141 |
| 4 | Ansaldo Sts | www.ansaldo-sts.com | Via P Mantovani 3-5 | Genova | 16151 |
| 5 | Ascopiave | www.ascopiave.it | Via Verizzo, 1030 | Pieve Di Soligo | 31053 |
| 6 | Astaldi | www.astaldi.it | Via G. V. Bona, 65 | Roma | 00156 |
| 7 | Biancamano | www.gruppobiancamano.it | Strada 4, Palazzo Q6, Milanofiori - Rozzano | Rozzano | 20089 |
| 8 | Biesse | www.biesse.com | Via Della Meccanica, 16 | Loc. Chiusa Di Ginestreto | 61122 |
| 9 | Bolzoni | www.bolzoni-auramo.com | I Casoni | Podenzano | 29027 |
| 10 | Brembo | www.brembo.com | Via Brembo, 25 | Curno | 24035 |
| 11 | Buongiorno | www.buongiorno.com | Borgo Masnovo 2 | Parma | 43100 |
| 12 | Cad It | www.cadit.it | Via Torricelli, 44/a | Verona | 37136 |
| 13 | Cairo Communication | www.cairocommunication.it | Via Tucidide, 56 | Milano | 20134 |
| 14 | Cembre | www.cembre.com | Via Serenissima, 9 | Brescia | 25135 |
| 15 | Cementir Holding | www.cementirholding.it | Corso Di Francia, 200 | Roma | 00191 |
| 16 | Centrale Latte Torino | www.centralelatte.torino.it | Via Filadelfia 220 | Torino | 10137 |
| 17 | Cobra | www.cobra-at.com | Via Astico, 41 | Varese | 21100 |
| 18 | Dada | www.dada.eu | Piazza Annigoni, 9/b | Firenze | 50122 |
| 19 | Damiani | www.damiani.com | Piazza Damiano Grassi "damiani" N.1 | Valenza | 15048 |
| 20 | D'Amico | www.damicointernationalshipping.com | 25c Boulevard Royal | Luxembourg | L-2449 |

| | | | | | |
|---|---|---|---|---|---|
| 21 | Datalogic | www.datalogic.com | Via Candini, 2 | Lippo Di Calderara Di Reno | 40012 |
| 22 | Digital Bros | www.digital-bros.net | Via Tortona, 37 | Milano | 20144 |
| 23 | Dmail Group | www.dmailgroup.it | Corso Vittorio Emanuele Ii, N.15 | Milano | 20122 |
| 24 | Dmt | www.dmtonline.com | Via Zanella, 21 | Lissone | 20851 |
| 25 | Eems | www.eems.com | Via Delle Scienze 5 | Cittaducale | 02015 |
| 26 | El.En | www.elengroup.com | Via Baldanzese, 17 | Calenzano | 50041 |
| 27 | Elica | www.elicagroup.com | Via Dante N. 288 | Fabriano | 60044 |
| 28 | Emak | www.emak.it | Via Fermi, 4 | Bagnolo In Piano | 42011 |
| 29 | Engineering | www.eng.it | Via San Martino Della Battaglia, 56 | Roma | 00185 |
| 30 | Esprinet | www.esprinet.com | Via G. Saragat, 4 | Nova Milanese | 20834 |
| 31 | Eurotech | www.eurotech.com | Via Fratelli Solari 3/a | Amaro | 33020 |
| 32 | Exprivia | www.exprivia.it | Via Adriano Olivetti , 11/a | Molfetta | 70056 |
| 33 | Falck Renewables | www.falckrenewables.eu | Corso Venezia, 16 | Milano | 20121 |
| 34 | Fidia | www.fidia.it | Corso Lombardia, 11 | San Mauro Torinese | 10099 |
| 35 | Fiera Milano | www.fieramilano.it | Piazzale Carlo Magno, 1 | Milano | 20149 |
| 36 | Gefran | www.gefran.com | Via Statale Sebina, 74 | Provaglio D'iseo | 25050 |
| 37 | I.M.A | www.ima.it | Via Emilia, 428-442 | Ozzano Dell'emilia | 40064 |
| 38 | Interpump Group | www.interpumpgroup.it | Via E. Fermi, 25 | Sant'ilario D'enza | 42049 |
| 39 | Irce | www.irce.it | Via Lasie, 12/a | Imola | 40026 |
| 40 | Isagro | www.isagro.com | Via Caldera, 21 | Milano | 20153 |
| 41 | It Way | www.itway.com | Via L. Braille, 15 | Ravenna | 48124 |
| 42 | La Doria | www.ladoria.it | Via Nazionale, 320 | Angri | 84012 |
| 43 | Landi Renzo | www.landi.it | Via Nobel N? 2 | Cavriago | 42025 |
| 44 | Marr | www.marr.it | Via Spagna, 20 | Rimini | 47921 |
| 45 | Mondo Tv | www.mondotv.it | Via Brenta, 11 | Roma | 00198 |

| | | | | | |
|---|---|---|---|---|---|
| 46 | Nice | www.niceforyou.com | Via Pezza Alta, 13 | Oderzo | 31046 |
| 47 | Panariagroup | www.panariagroup.it | Via Panaria Bassa, 22/a | Finale Emilia | 41049 |
| 48 | Poligraf. S. F | www.psf.it | Via Valenca, 15 | Castrezzato | 25030 |
| 49 | Poltrona Frau | www.poltronafraugroup.com | Via Vincenzo Vela 42 | Torino | 10100 |
| 50 | Prima Industrie | www.primaindustrie.com | Via Antonelli,32 | Collegno | 10097 |
| 51 | Rdb | www.rdb.it | Via Dell'edilizia, 1 | Pontenure | 29010 |
| 52 | Reno De Medici | www.renodemedici.it | Via Durini, 16/18 | Milano | 20122 |
| 53 | Reply | www.reply.eu | Corso Francia, 110 | Torino | 10143 |
| 54 | Sabaf | www.sabaf.it | Via Dei Carpini, 1 | Ospitaletto | 25035 |
| 55 | Saes Getters | www.saesgetters.com | Viale Italia, 77 | Lainate (mi) | 20020 |
| 56 | Servizi Italia | www.si-servizitalia.com | Via San Pietro 59 B | Castellina Di Soragna | 43019 |
| 57 | Sogefi | www.sogefi.it | Via Ulisse Barbieri, 2 | Mantova | 46100 |
| 58 | Ternienergia | www.ternienergia.com | Strada Dello Stabilimento, 1 | Nera Montoro (fr. Narni) | 05035 |
| 59 | Tesmec | www.tesmec.com | P.zza Sant' Ambrogio 16 | Milano | 20123 |
| 60 | Txt E-Solutions | www.txt.it | Via Frigia, 27 | Milano | 20126 |
| 61 | Yoox | www.yooxgroup.com | Via Nannetti, 1 | Zola Predosa | 40069 |
| 62 | Zignago Vetro | www.zignagovetro.com | Via Ita Marzotto 8 | Fossalta di Portogruaro | 30025 |

*Table A1: Companies listed in the STAR market with websites and localization information.*

| Industries | Nr of companies | % |
|---|---|---|
| Hotels & Restaurants | 1 | 1,61% |
| Manifacturing Companies | 28 | 45,16% |
| Construction Companies | 3 | 4,84% |
| Energy Suppliers | 3 | 4,84% |
| Health Care Providers | 2 | 3,23% |
| ICT Companies | 7 | 11,29% |
| Industrial and commercial services | 3 | 4,84% |
| Hi-Tech Producers | 14 | 22,58% |
| Overseas Transportation Servises | 1 | 1,61% |
| **Totals** | **62** | **100,00%** |

*Table A2: Classification of companies by industry.*

| Size groups | Nr. employees | Total Sales (€/1.000) | Total Assets (€/1.000) |
|---|---|---|---|
| Small | < = 500 | < = 150.000 | < = 140.000 |
| Medium | < = 1.000 | < = 500.000 | < = 400.000 |
| Large | > 1.000 | > 500.000 | > 400.000 |

*Table A3: Threshold values employed for size classes identification.*

| Industries | Nr of companies | % | Total Sales (€ millions) | | | Total Assets (€ millions) | | | Nr of employees | | | Size | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 - 150 | 150 - 500 | > 500 | 0 - 140 | 140 - 400 | > 400 | 0 - 500 | 500 - 1000 | > 1000 | Small | Medium | Large |
| Hotels & Restaurants | 1 | 1,61% | | | 1 | | | 1 | | 1 | | | | 1 |
| Manifacturing Companies | 28 | 45,16% | 8 | 17 | 3 | 9 | 13 | 6 | 5 | 13 | 10 | 8 | 13 | 7 |
| Construction Companies | 3 | 4,84% | | 1 | 2 | | | 3 | | | 3 | | | 3 |
| Energy Suppliers | 3 | 4,84% | 2 | 1 | | 1 | | 2 | 3 | | | 2 | 1 | |
| Health Care Providers | 2 | 3,23% | 1 | | 1 | | 1 | 1 | | | 2 | | 1 | 1 |
| ICT Companies | 7 | 11,29% | 5 | 2 | | 4 | 3 | | 6 | 1 | | 5 | 2 | |
| Industrial and commercial services | 3 | 4,84% | 2 | 1 | | 2 | 1 | | 1 | 1 | 1 | 1 | 2 | |
| Hi-Tech Producers | 14 | 22,58% | 7 | 6 | 1 | 7 | 5 | 2 | 4 | 6 | 4 | 7 | 5 | 2 |
| Overseas Transportation services | 1 | 1,61% | | | 1 | | | 1 | | | 1 | | | 1 |
| **Totals** | **62** | **100,00%** | **25** | **28** | **9** | **23** | **23** | **16** | **19** | **22** | **21** | **23** | **24** | **15** |
| | | | **40,3%** | **45,2%** | **14,5%** | **37,1%** | **37,1%** | **25,8%** | **30,6%** | **35,5%** | **33,9%** | **37,1%** | **38,7%** | **24,2%** |

*Table A4: Classification of companies by industry and size attributes.*

| | Innovation intensity | | |
|---|---|---|---|
| | **Negative variation of fixed assets** | **Low intensity (variation between 0% and 20%)** | **High intensity (variation above 20%)** |
| **Low relevance (average weight below or equal 10%)** | Not Innovative | Not Innovative | Innovative |
| **High relevance (average weight above 10%)** | Not Innovative | Innovative | Innovative |

*Table A5: Criteria for intangible and tangible innovation clustering*

| | Intensity | | | Relevance | | Level of Innovation | |
|---|---|---|---|---|---|---|---|
| | **High** | **Low** | **Negative** | **High** | **Low** | **I** | **NI** |
| **Small** | 7 | 12 | 4 | 7 | 16 | **1** | **14** |
| **Medium** | 8 | 10 | 6 | 3 | 21 | **10** | **14** |
| **Large** | 1 | 5 | 9 | 2 | 13 | **10** | **13** |
| | **25,8%** | **43,6%** | **30,6%** | **19,4%** | **80,6%** | **33,9%** | **66,1%** |

*Table A6: Distribution by size of the level of innovation in intangible fixed assets*

| Industries | Intensity | | | Relevance | | Level of Innovation | |
|---|---|---|---|---|---|---|---|
| | High | Low | Negative | High | Low | I | NI |
| Hotels & Restaurants | 1 | | | | 1 | **1** | |
| Manifacturing Companies | 6 | 11 | 11 | 5 | 23 | **7** | **21** |
| Construction Companies | | 2 | 1 | | 3 | | **3** |
| Energy Suppliers | 1 | 2 | | | 3 | **1** | **2** |
| Health Care Providers | 1 | | 1 | | 2 | **1** | **1** |
| ICT Companies | 2 | 3 | 2 | 1 | 6 | **3** | **4** |
| Industrial and commercial services | 1 | 2 | | 1 | 2 | **2** | **1** |
| Hi-Tech Producers | 4 | 7 | 3 | 5 | 9 | **6** | **8** |
| Overseas Transportation Services | | | 1 | | 1 | | **1** |
| **Total** | **16** | **27** | **19** | **12** | **50** | **21** | **41** |
| | **25,8%** | **43,6%** | **30,6%** | **19,4%** | **80,6%** | **33,9%** | **66,1%** |

*Table A7: Distribution by industry of the level of innovation in intangible fixed assets*

| | Intensity | | | Relevance | | Level of Innovation | |
|---|---|---|---|---|---|---|---|
| | High | Low | Negative | High | Low | I | NI |
| **Small** | 8 | 8 | 7 | 3 | 20 | **9** | **14** |
| **Medium** | 2 | 17 | 5 | 13 | 11 | **12** | **12** |
| **Large** | 1 | 9 | 5 | 6 | 9 | **5** | **10** |
| | **17,7%** | **54,9%** | **27,4%** | **35,5%** | **64,5%** | **41,9%** | **58,1%** |

*Table A8: Distribution by size of the level of innovation in tangible fixed assets*

| Industries | Intensity | | | Relevance | | Level of Innovation | |
|---|---|---|---|---|---|---|---|
| | High | Low | Negative | H | L | I | NI |
| Hotels & Restaurants | | 1 | | | 1 | | **1** |
| Manifacturing Companies | 3 | 17 | 8 | 12 | 16 | **9** | **19** |
| Construction Companies | | 2 | 1 | 1 | 2 | **1** | **2** |
| Energy Suppliers | | 3 | | 2 | 1 | **2** | **1** |
| Health Care Providers | | 1 | 1 | 1 | 1 | **1** | **1** |
| ICT Companies | 3 | 1 | 3 | 1 | 6 | **3** | **4** |
| Industrial and commercial services | 1 | 1 | 1 | 1 | 2 | **2** | **1** |
| Hi-Tech Producers | 4 | 7 | 3 | 3 | 11 | **7** | **7** |
| Overseas Transportation Servises | | 1 | | 1 | | **1** | |
| **Total** | **11** | **34** | **17** | **22** | **40** | **26** | **36** |
| | **17,7%** | **54,9%** | **27,4%** | **35,5%** | **64,5%** | **41,9%** | **58,1%** |

*Table A9: Distribution by industry of the level of innovation in tangible fixed assets*

| | Product | Process | Product & Process | Not Declared | Totals % |
|---|---|---|---|---|---|
| **Small** | 11 | 2 | 5 | 5 | **37,1%** |
| **Medium** | 9 | 4 | 7 | 4 | **38,7%** |
| **Large** | 9 | 2 | 2 | 2 | **24,2%** |
| | **46,8%** | **12,9%** | **22,6%** | **17,7%** | **100%** |

*Table A10: Companies classification by dimension and type of innovation*

| | | | Type of Innovation Initiave | | | |
|---|---|---|---|---|---|---|
| **Industries** | **Nr of companies** | **%** | Product | Process | Product & Process | Not Declared |
| Hotels & Restaurants | 1 | 1,61% | 1 | | | |
| Manifacturing Companies | 28 | 45,16% | 14 | 1 | 10 | 3 |
| Construction Companies | 3 | 4,84% | 3 | | | |
| Energy Suppliers | 3 | 4,84% | 1 | 2 | | |
| Health Care Providers | 2 | 3,23% | | 1 | | 1 |
| ICT Companies | 7 | 11,29% | 2 | 1 | 2 | 2 |
| Industrial and commercial services | 3 | 4,84% | 1 | 1 | | 1 |
| Hi-Tech Producers | 14 | 22,58% | 7 | 2 | 2 | 3 |
| Overseas Transportation Servises | 1 | 1,61% | | | | 1 |
| **Totals** | **62** | **100%** | **29** | **8** | **14** | **11** |
| | | | **46,8%** | **12,9%** | **22,6%** | **17,7%** |

*Table A11: Company classification by industry and type of innovation*

| | **Average** | **Std. Dev.** | **Skewness** | **Kurtosis** |
|---|---|---|---|---|
| Total Assets 2007 (€/1.000) | 356,154 | 381,872 | 2.70 | 8.92 |
| Total Assets 2006 (€/1.000) | 317,603 | 337,945 | 2.56 | 8.03 |
| Total Sales 2007 (€/1.000) | 329,896 | 395,774 | 3.04 | 12.23 |
| Total Sales 2006 (€/1.000) | 289,186 | 358,457 | 3.14 | 13.11 |
| Nr. of Employees 2007 | 1,281 | 1,570 | 2.84 | 9.38 |
| Nr. of Employees 2006 | 1,143 | 1,350 | 2.54 | 6.80 |
| Intangible Assets 2007 (€/1.000) | 14,196 | 21,868 | 2.64 | 8.20 |
| Intangible Assets 2006 (€/1.000) | 12,970 | 23,214 | 2.89 | 8.99 |
| Tangible Assets 2007 (€/1.000) | 46,341 | 95,328 | 3.48 | 13.31 |
| Tangible Assets 2006 (€/1.000) | 42,252 | 88,494 | 3.48 | 13.05 |

| | | | | |
|---|---|---|---|---|
| % Intangible Assets on Total Assets 2007 (Relevance of Intangible Assets) | 5.35% | 7.53% | 2.28 | 5.64 |
| % Intangible Assets on Total Assets 2006 (Relevance of Intangible Assets) | 5.10% | 7.75% | 2.71 | 8.72 |
| % Tangible Assets on Total Assets 2007 (Relevance of Tangible Assets) | 10.07% | 12.37% | 2.13 | 4.80 |
| % Tangible Assets on Total Assets 2006 (Relevance of Tangible Assets) | 10.52% | 13.91% | 2.20 | 4.64 |
| Sales % Variation 2008 | 16.56% | 37.32% | 1.84 | 8.97 |
| Sales % Variation 2009 | -5.95% | 25.42% | 2.11 | 6.82 |
| Sales % Variation 2010 | 13.24% | 25.40% | 1.94 | 6.99 |
| Nr Employees % Variation 2008 | 23.60% | 74.93% | 6.16 | 43.79 |
| Nr Employees % Variation 2009 | 1.39% | 23.04% | 4.45 | 31.96 |
| Nr Employees % Variation 2010 | -0.17% | 13.51% | -0.03 | 10.01 |
| Roi % Variation 2008 | 6.11% | 6.96% | -0.04 | 2.03 |
| Roi % Variation 2009 | 2.60% | 6.96% | -0.07 | -0.60 |
| Roi % Variation 2010 | 5.87% | 10.82% | 5.25 | 35.43 |
| Sales per employee 2008 | 374 | 463 | 3.06 | 9.61 |
| Sales per employee 2009 | 347 | 421 | 2.87 | 8.51 |
| Sales per employee 2010 | 377 | 431 | 2.77 | 8.29 |

*Table A12: Descriptive statistics of the considered parameters.*

| | | | | Growth | | | | | | Profitability | | | Productivity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nr | | F | S | SalesV 08 | SalesV 09 | SalesV 10 | EmplV 08 | EmplV 09 | EmplV 10 | Roi 08 | Roi 09 | Roi 10 | SpE 08 | SpE 09 | SpE 10 |
| 1 | H^1_k(k=1) | k | i | -14% | -5% | -11% | -12% | -12% | -11% | -16% | -19% | -12% | -11% | -12% | -11% |
| 2 | H^1_k(k=2) | k | i | 28% | 21% | 19% | 16% | 22% | 37% | 12% | 17% | 17% | 39% | 44% | 41% |
| 3 | H^2_k(k=1) | k | j | 22% | 9% | 18% | 11% | 17% | 13% | 6% | 5% | 15% | 13% | 11% | 12% |
| 4 | H^2_k(k=2) | k | j | 51% | 38% | 37% | 31% | 26% | 30% | 25% | 29% | 30% | 33% | 34% | 33% |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | H^1k_j(j=1) | j | i | 1% | 2% | 7% | 0% | 25% | 0% | 1% | 3% | 5% | 4% | 4% | 4% |
| 6 | H^1k_j(j=2) | j | i | 21% | 41% | 25% | 24% | 13% | 41% | 28% | 32% | 45% | 52% | 51% | 52% |
| 7 | H^1k_j(j=3) | j | i | 78% | 18% | 20% | 31% | 20% | 45% | 6% | 5% | 16% | 33% | 40% | 43% |
| 8 | H^1k_j(j=4) | j | i | 1% | 14% | 6% | 7% | 19% | 34% | 5% | 5% | 5% | 13% | 14% | 11% |
| 9 | H^2k_j(j=1) | j | k | -180% | -206% | -210% | -177% | -230% | -200% | -208% | -203% | -216% | -228% | -227% | -227% |
| 10 | H^2k_j(j=2) | j | k | -101% | -108% | -106% | -129% | -61% | -159% | -180% | -192% | -193% | -113% | -120% | -123% |
| 11 | H^2k_j(j=3) | j | k | -185% | -177% | -179% | -148% | -207% | -122% | -165% | -171% | -127% | -177% | -174% | -170% |
| 12 | H^2k_j(j=4) | j | k | -152% | -129% | -151% | -189% | -132% | -162% | -203% | -202% | -140% | -183% | -185% | -185% |
| 13 | H^1k_i(i=1) | i | j | 26% | 12% | 21% | 17% | 29% | 12% | 17% | 16% | 25% | 26% | 22% | 21% |
| 14 | H^1k_i(i=2) | i | j | 40% | 22% | 24% | 11% | 10% | 30% | 3% | 7% | 12% | 17% | 18% | 18% |
| 15 | H^1k_i(i=3) | i | j | 39% | 29% | 41% | 43% | 31% | 27% | 22% | 18% | 30% | 14% | 14% | 14% |
| 16 | H^2k_i(i=1) | i | k | 26% | 16% | 21% | 26% | 40% | 12% | 12% | 10% | 15% | 27% | 23% | 23% |
| 17 | H^2k_i(i=2) | i | k | 28% | 17% | 12% | 17% | 9% | 33% | 8% | 9% | 16% | 18% | 20% | 19% |
| 18 | H^2k_i(i=3) | i | k | 7% | 19% | 11% | 15% | 36% | 10% | 14% | 9% | 20% | 33% | 33% | 34% |
| 19 | H^1_h(h=1) | h | i | 73% | 71% | 35% | 75% | 50% | 46% | 52% | 40% | 26% | 33% | 29% | 28% |
| 20 | H^1_h(h=2) | h | i | -8% | 19% | 7% | -7% | 44% | -14% | 7% | 11% | 66% | 17% | 27% | 31% |
| 21 | H_h^2(h=1) | h | j | 14% | 11% | 19% | 11% | 23% | 5% | 4% | 6% | 9% | 17% | 19% | 20% |
| 22 | H_h^2(h=2) | h | j | 39% | 15% | 20% | 16% | 15% | 17% | 4% | 10% | 7% | 6% | 7% | 9% |
| 23 | H^1h_j(j=1) | j | i | -36% | -36% | -37% | -25% | -11% | -33% | -42% | -44% | -39% | -34% | -34% | -33% |
| 24 | H^1h_j(j=2) | j | i | 13% | 18% | -1% | 25% | 11% | -17% | -17% | -27% | -3% | -14% | -16% | -15% |
| 25 | H^1h_j(j=3) | j | i | -33% | -24% | -18% | -5% | -13% | -14% | -25% | -35% | -4% | 3% | 2% | -4% |
| 26 | H^1h_j(j=4) | j | i | 3% | 10% | -20% | -16% | 11% | 11% | -16% | -9% | -26% | -32% | -26% | -25% |
| 27 | H^2h_j(j=1) | j | h | 12% | 11% | 11% | 6% | 44% | 10% | 5% | 2% | 5% | 8% | 9% | 11% |
| 28 | H^2h_j(j=2) | j | h | 39% | 48% | 26% | 48% | 31% | 24% | 8% | 13% | 32% | 5% | 3% | 5% |
| 29 | H^2h_j(j=3) | j | h | 16% | 10% | 12% | 21% | 23% | 17% | 10% | 7% | 27% | 16% | 16% | 15% |
| 30 | H^2h_j(j=4) | j | h | 31% | 25% | 11% | 44% | 40% | 9% | 16% | 13% | 9% | 9% | 13% | 12% |
| 31 | H^1h_i(i=1) | i | j | 17% | 10% | 20% | 8% | 23% | 5% | 2% | 4% | 5% | 8% | 10% | 12% |
| 32 | H^1h_i(i=2) | i | j | 30% | 19% | 18% | 9% | 13% | 16% | 4% | 8% | 4% | 7% | 9% | 11% |
| 33 | H^1h_i(i=3) | i | j | 22% | 10% | 22% | 34% | 21% | 13% | 7% | 15% | 22% | 22% | 24% | 21% |
| 34 | H^2h_i(i=1) | i | h | 18% | 12% | 8% | 19% | 39% | 7% | 4% | 5% | 11% | 3% | 5% | 6% |
| 35 | H^2h_i(i=2) | i | h | 35% | 17% | 12% | 17% | 23% | 20% | 9% | 7% | 13% | 5% | 7% | 7% |
| 36 | H^2h_i(i=3) | i | h | 26% | 32% | 37% | 46% | 62% | 30% | 14% | 9% | 22% | 26% | 26% | 26% |
| F = Fixed parameter; S = Scatter Parameter | | | | | | | | | | | | | | | |

*Table A13: Values of the mono-subscript entropy measures*

| | | | | | Growth | | | | | | Profitability | | | Productivity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nr. | | F1 | F2 | S | SalesV 08 | SalesV 09 | SalesV 10 | EmplV 08 | EmplV 09 | EmplV 10 | Roi 08 | Roi 09 | Roi 10 | SpE 08 | SpE 09 | SpE 10 |
| 1 | H_ij^k(i=1,j=1) | i | j | k | 0% | -2% | 1% | -8% | 1% | -3% | -5% | -2% | 2% | 1% | 0% | 1% |
| 2 | H_ij^k(i=2,j=1) | i | j | k | 15% | 10% | 20% | 5% | 15% | 16% | 7% | 4% | 8% | 6% | 5% | 5% |
| 3 | H_ij^k(i=3,j=1) | i | j | k | -2% | -1% | -2% | 0% | -6% | 1% | -1% | 0% | 0% | -1% | -1% | -1% |
| 4 | H_ij^k(i=1,j=2) | i | j | k | 2% | -3% | -6% | 6% | 0% | -1% | -1% | 0% | 9% | -1% | -1% | -1% |
| 5 | H_ij^k(i=2,j=2) | i | j | k | 5% | 7% | 7% | 4% | 19% | 7% | 3% | 2% | -5% | 3% | 4% | 4% |
| 6 | H_ij^k(i=3,j=2) | i | j | k | 3% | -1% | 1% | 5% | 2% | 1% | 3% | 2% | 5% | 7% | 7% | 6% |
| 7 | H_ij^k(i=1,j=3) | i | j | k | 9% | 4% | -1% | 16% | 1% | 6% | 16% | 16% | 0% | 0% | 1% | 0% |
| 8 | H_ij^k(i=2,j=3) | i | j | k | -2% | -2% | -2% | 0% | -3% | -3% | -5% | -3% | -4% | 2% | 5% | 4% |
| 9 | H_ij^k(i=3,j=3) | i | j | k | 31% | 15% | 21% | 17% | 55% | 4% | 4% | 6% | 4% | 37% | 34% | 32% |
| 10 | H_ij^k(i=1,j=4) | i | j | k | 15% | 17% | 17% | 2% | 1% | 49% | 12% | 10% | 6% | 10% | 14% | 16% |
| 11 | H_ij^k(i=2,j=4) | i | j | k | -3% | -6% | -4% | -3% | -2% | -2% | 0% | 1% | 31% | -2% | -3% | -3% |
| 12 | H_ij^k(i=3,j=4) | i | j | k | 4% | 14% | 10% | 4% | -1% | 0% | -1% | 0% | -1% | -6% | -6% | -6% |
| 13 | H_ik(i=1,k=1) | i | k | j | 21% | 33% | 18% | 20% | 56% | 91% | 37% | 20% | 15% | 11% | 15% | 16% |
| 14 | H_ik(i=1,k=2) | i | k | j | 52% | 21% | 25% | 6% | 43% | 44% | 5% | 6% | 16% | 41% | 47% | 54% |
| 15 | H_ik(i=2,k=1) | i | k | j | 34% | 7% | 7% | 38% | 13% | 0% | 6% | 0% | 26% | 34% | 29% | 23% |
| 16 | H_ik(i=2,k=2) | i | k | j | 9% | 46% | 15% | 21% | 25% | -1% | 13% | 22% | 44% | 22% | 21% | 21% |
| 17 | H_ik(i=3,k=1) | i | k | j | 7% | -2% | 7% | 31% | 31% | 5% | -4% | -1% | 4% | 0% | 0% | 0% |
| 18 | H_ik(i=3,k=2) | i | k | j | 1% | 0% | 2% | 0% | 4% | 1% | 4% | 5% | 9% | 13% | 15% | 15% |
| 19 | H_jk(j=1,k=1) | j | k | i | 20% | 46% | 37% | 2% | 64% | 35% | 23% | 10% | 23% | 15% | 13% | 14% |
| 20 | H_jk(j=1,k=2) | j | k | i | 5% | 2% | 9% | 22% | 6% | 1% | 1% | 1% | 1% | 23% | 20% | 18% |
| 21 | H_jk(j=2,k=1) | j | k | i | 18% | 5% | 6% | 10% | 8% | 28% | 7% | 6% | 22% | 2% | 4% | 3% |
| 22 | H_jk(j=2,k=2) | j | k | i | 22% | 6% | 10% | 45% | 24% | 0% | 3% | 3% | 6% | -3% | -3% | -3% |
| 23 | H_jk(j=3,k=1) | j | k | i | 10% | 3% | 0% | 10% | 1% | 5% | 4% | 8% | 3% | 15% | 18% | 17% |
| 24 | H_jk(j=3,k=2) | j | k | i | 42% | 16% | 28% | 12% | 51% | 13% | 6% | 7% | 12% | 19% | 18% | 17% |
| 25 | H_jk(j=4,k=1) | j | k | i | 6% | 5% | 7% | 6% | 4% | 7% | 10% | 8% | 7% | 8% | 7% | 9% |
| 26 | H_jk(j=4,k=2) | j | k | i | 2% | 9% | 8% | 3% | 1% | 2% | 5% | 4% | 24% | 2% | 1% | 2% |
| 27 | H_ij^h(i=1,j=1) | i | j | h | 0% | 1% | 3% | 1% | 0% | 9% | 1% | 0% | 1% | 0% | 0% | 0% |
| 28 | H_ij^h(i=2,j=1) | i | j | h | 1% | 0% | 1% | 0% | 5% | -1% | 0% | 3% | 1% | 3% | 2% | 1% |
| 29 | H_ij^h(i=3,j=1) | i | j | h | 0% | 0% | 0% | 0% | 2% | 0% | 1% | 1% | 7% | 12% | 11% | 10% |
| 30 | H_ij^h(i=1,j=2) | i | j | h | 9% | 4% | 11% | -1% | 7% | 8% | -1% | 2% | 2% | -3% | -2% | 0% |
| 31 | H_ij^h(i=2,j=2) | i | j | h | 34% | 7% | 11% | 11% | 19% | 2% | 0% | 1% | 0% | 5% | 4% | 5% |
| 32 | H_ij^h(i=3,j=2) | i | j | h | 2% | 1% | 3% | 4% | 3% | 3% | 1% | 2% | 3% | 5% | 5% | 4% |
| 33 | H_ij^h(i=1,j=3) | i | j | h | 0% | 6% | 4% | 3% | 4% | 1% | 1% | 2% | 8% | 8% | 7% | 7% |
| 34 | H_ij^h(i=2,j=3) | i | j | h | 2% | 0% | 0% | 3% | 1% | 0% | 0% | 0% | 5% | 7% | 6% | 4% |
| 35 | H_ij^h(i=3,j=3) | i | j | h | 0% | 2% | 4% | 0% | 0% | 4% | 0% | 0% | 0% | 0% | 0% | 0% |
| 36 | H_ij^h(i=1,j=4) | i | j | h | 6% | 0% | 1% | 2% | 6% | 10% | 2% | 14% | 21% | 0% | 0% | 0% |
| 37 | H_ij^h(i=2,j=4) | i | j | h | 6% | 11% | 11% | 5% | 3% | 4% | 10% | 15% | 11% | 12% | 13% | 15% |
| 38 | H_ij^h(i=3,j=4) | i | j | h | 1% | 1% | 2% | 1% | 0% | 3% | 2% | 0% | 0% | 0% | 0% | 0% |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | H_ih(i=1,h=1) | i | h | j | 309% | 321% | 215% | 93% | 164% | 191% | 67% | 81% | 63% | 627% | 696% | 804% |
| 40 | H_ih(i=1,h=2) | i | h | j | 128% | 94% | 98% | 105% | 94% | 104% | 47% | 60% | 100% | 408% | 428% | 414% |
| 41 | H_ih(i=2,h=1) | i | h | j | 203% | 97% | 99% | 250% | 72% | 59% | 106% | 90% | 106% | 566% | 557% | 503% |
| 42 | H_ih(i=2,h=2) | i | h | j | 119% | 199% | 211% | 176% | 143% | 26% | 77% | 54% | 93% | 1318% | 1209% | 1224% |
| 43 | H_ih(i=3,h=1) | i | h | j | 125% | 60% | 65% | 179% | 52% | 62% | 49% | 53% | 54% | 370% | 381% | 397% |
| 44 | H_ih(i=3,h=2) | i | h | j | 33% | 45% | 80% | 33% | 69% | 30% | 29% | 13% | 19% | 234% | 206% | 213% |
| 45 | H_jh(j=1,h=1) | j | h | I | 16% | 93% | 22% | 17% | 56% | 38% | 92% | 62% | 79% | 96% | 95% | 89% |
| 46 | H_jh(j=1,h=2) | j | h | I | -19% | 75% | 6% | 10% | 25% | -1% | 21% | 5% | 1% | 33% | 27% | 19% |
| 47 | H_jh(j=2,h=1) | j | h | I | 23% | -12% | 19% | 16% | 3% | 30% | -14% | -2% | 0% | 10% | 9% | 9% |
| 48 | H_jh(j=2,h=2) | j | h | I | 51% | 4% | 56% | 10% | 109% | 12% | 3% | 8% | 18% | 56% | 37% | 32% |
| 49 | H_jh(j=3,h=1) | j | h | I | 11% | -2% | 17% | 4% | -8% | 24% | 30% | 40% | 30% | -15% | -15% | -12% |
| 50 | H_jh(j=3,h=2) | j | h | I | -10% | 10% | -1% | -12% | -21% | 20% | 12% | 5% | 6% | -16% | -15% | -15% |
| 51 | H_jh(j=4,h=1) | j | h | I | 46% | 24% | -5% | 49% | 63% | -6% | -4% | -7% | -14% | 0% | 7% | 9% |
| 52 | H_jh(j=4,h=2) | j | h | I | 19% | 12% | 6% | 10% | 15% | 2% | 4% | 22% | 106% | 29% | 31% | 30% |
| F1 = Fixed Parameter nr.1; F2 = Fixed Parameter nr.2; S = Scatter Parameter | | | | | | | | | | | | | | | | |

*Table A14: Values of the double-subscript entropy measures*

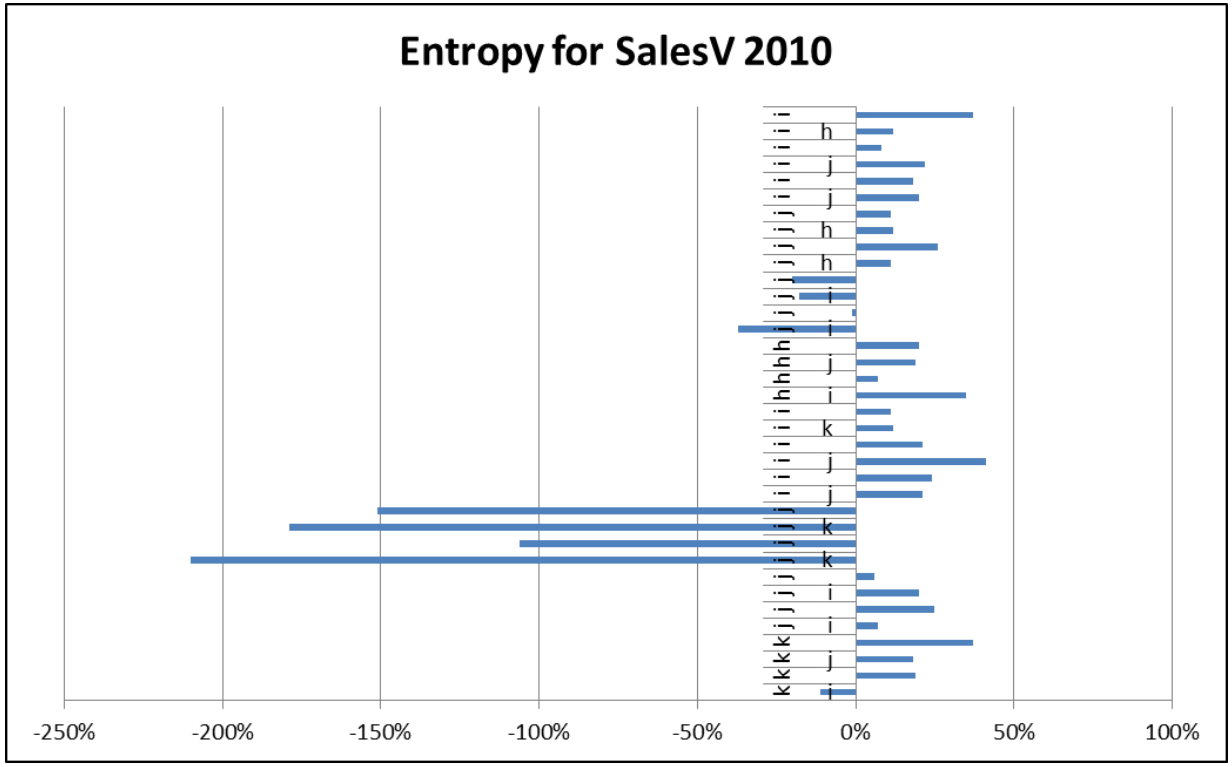


*Figure A1: Monosubscript Entropy Measures (on the x-axis) for Sales % Variation 2010*

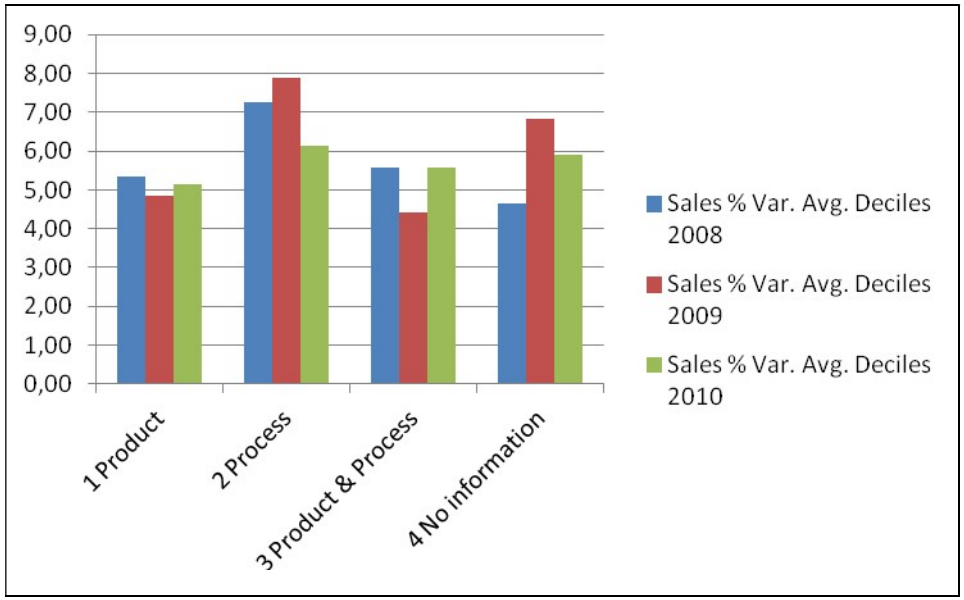


*Figure A2: Sales % variation average deciles 2008-2010 for type of innovation clusters*

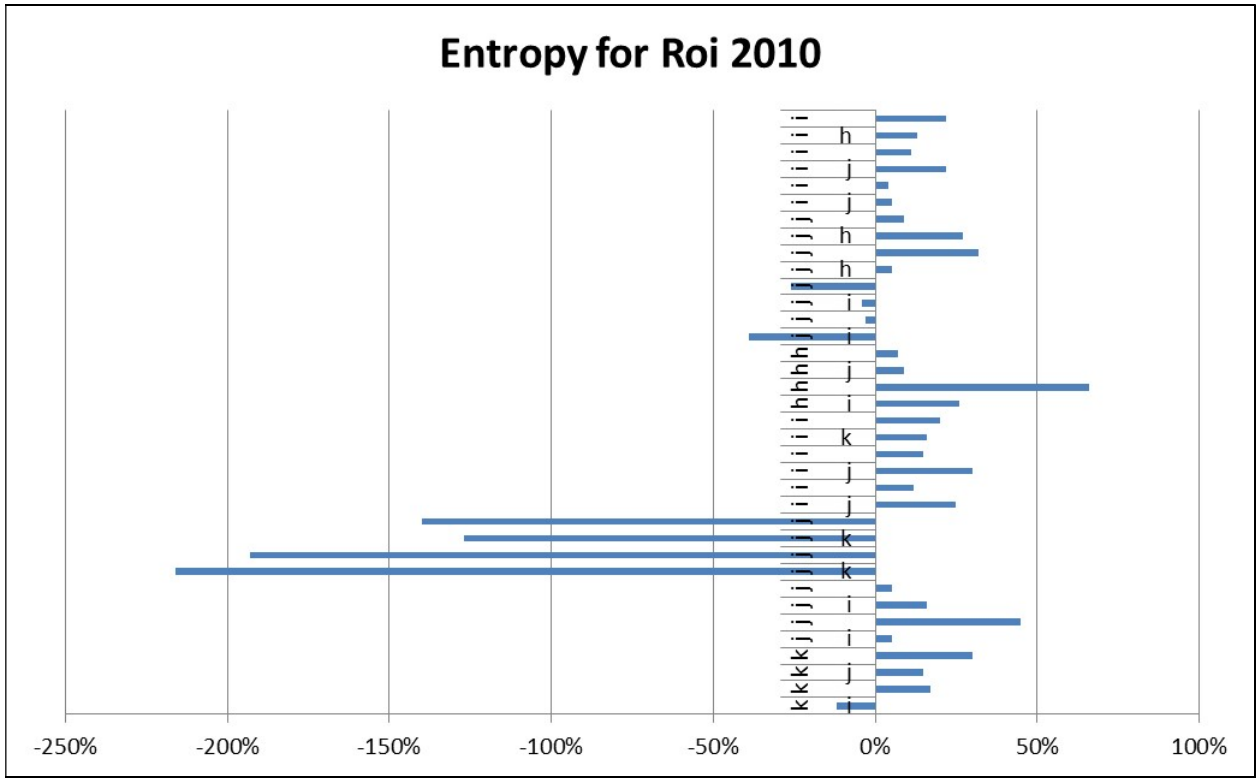


*Figure A3: Monosubscript Entropy Measures (on the x-axis) for Roi in 2010*

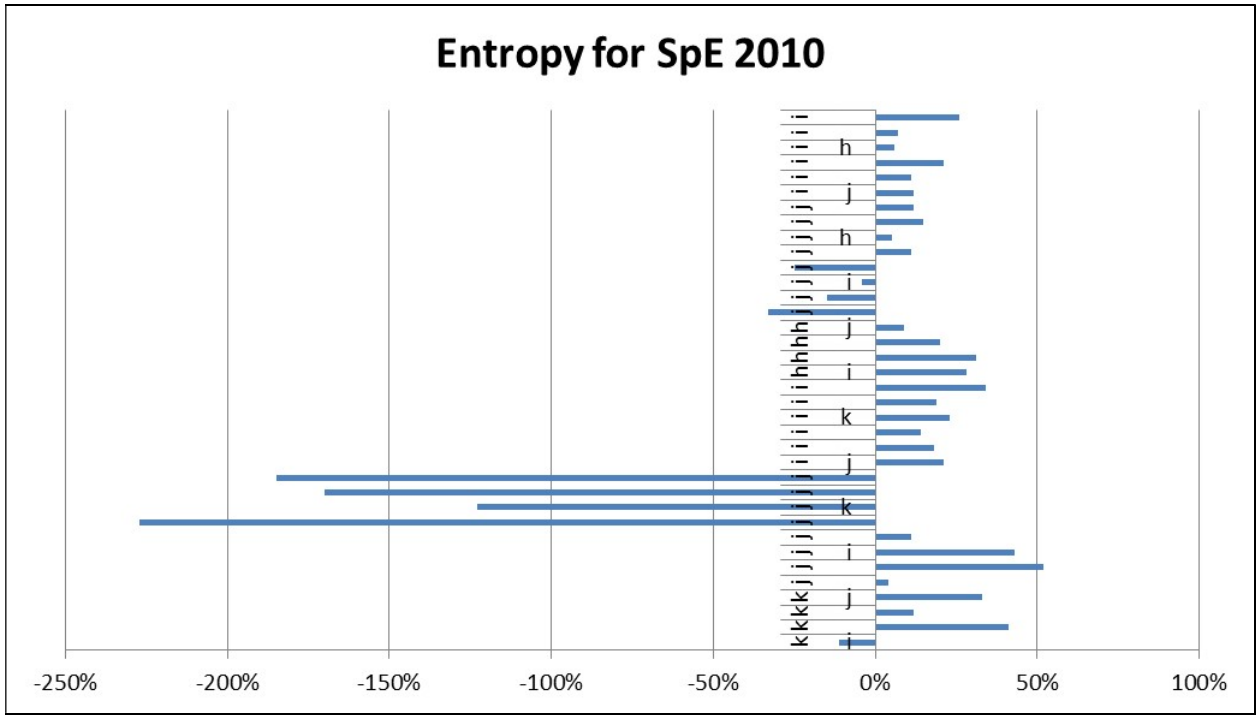


*Figure A4: Monosubscript Entropy Measures (on the x-axis) for sales per employee in 2010*

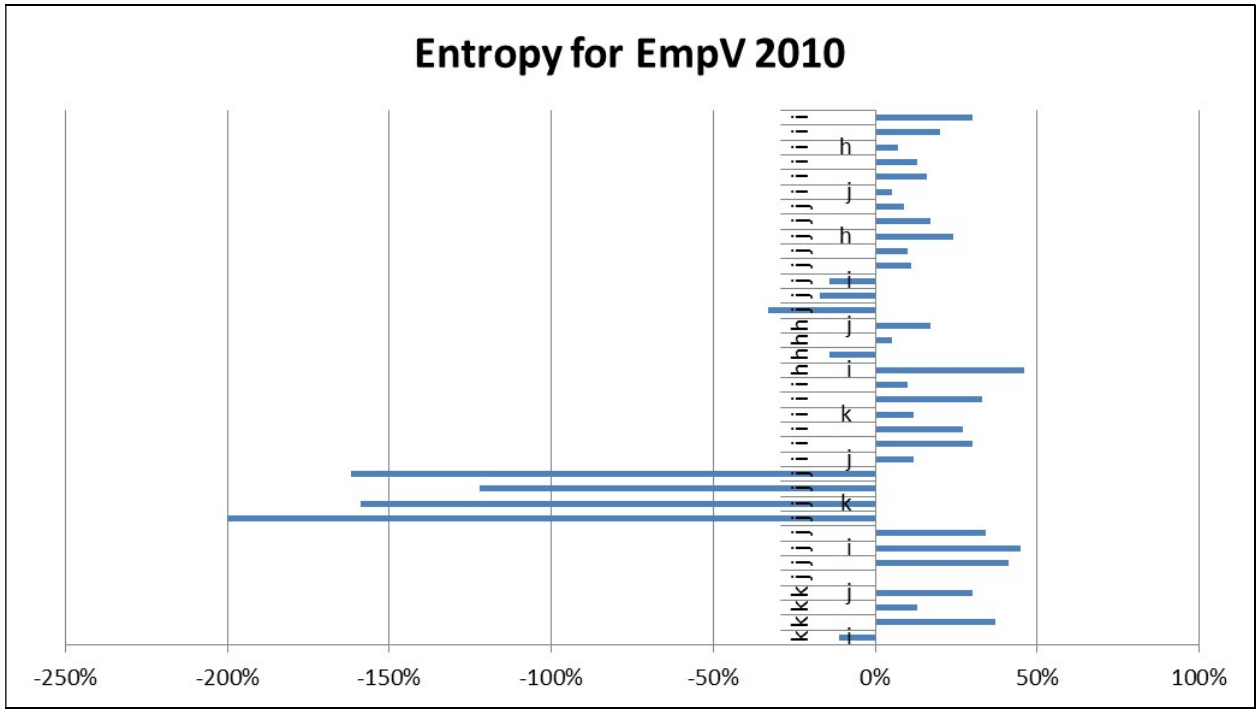


*Figure A5: Monosubscript Entropy Measures (on the x-axis) for employee variation in 2010*

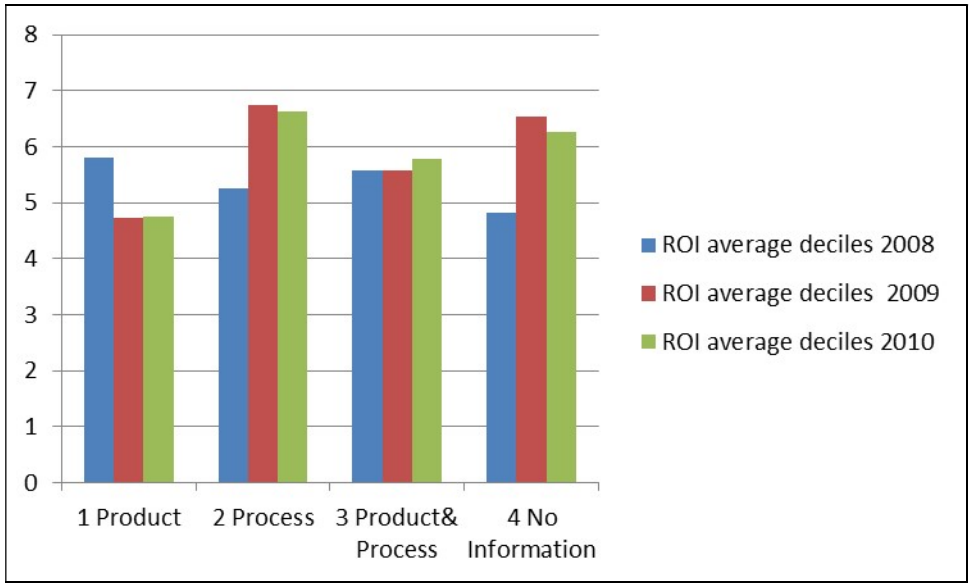


*Figure A6: Roi average deciles in 2008-2010 for type of innovation clusters*

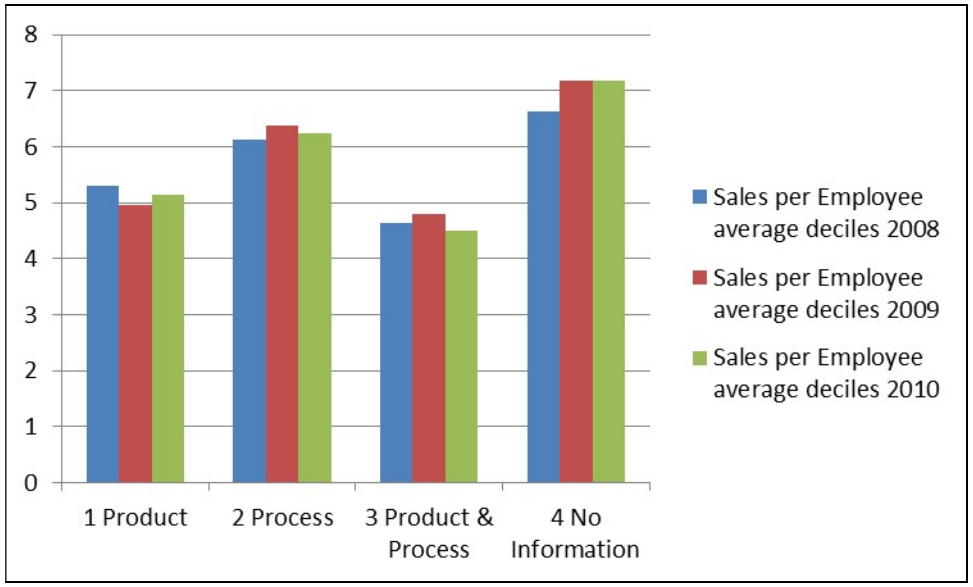


*Figure A7: Sales per employee average deciles in 2008-2010 for type of innovation clusters*

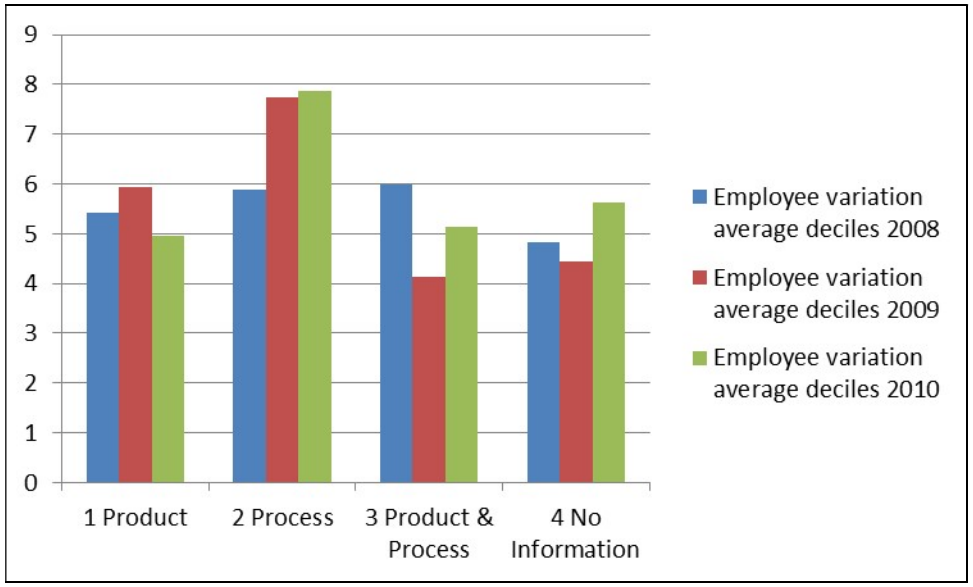


*Figure A8: Employee Variation average deciles in 2008-2010 for type of innovation clusters*