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Abstract	This paper analyses the connection between innovation activities of companies—implemented before a financial crisis—and their performance—measured after such a time of crisis. Pertinent data about companies listed in the STAR Market Segment of the Italian Stock Exchange is analysed. Innovation is measured through the level of investments in total tangible and intangible fixed assets in 2006–2007, while performance is captured through growth—expressed by variations of sales or of total assets—profitability—through ROI or ROS evolution—and productivity—through asset turnover or sales/employee in the period 2008–2010. The variables of interest are analysed and compared through statistical techniques and by adopting a cluster analysis. In particular, a Voronoi tessellation is implemented in a varying centroids framework. In accord with a large part of the literature, we find that the behaviour of the performance of the companies is not univocal when they innovate. The statistical outliers are the best cases in order to suggest efficient strategies. In brief, it is found that a positive rate of investments is preferable.

Chapter 1
Simple Approaches on How to Discover Promising Strategies for Efficient Enterprise Performance, at Time of Crisis in the Case of SMEs: Voronoi Clustering and Outlier Effects Perspective

Marcel Ausloos, Francesca Bartolacci, Nicola G. Castellano, and Roy Cerqueti

Abstract This paper analyses the connection between innovation activities of companies—implemented before a financial crisis—and their performance—measured after such a time of crisis. Pertinent data about companies listed in the STAR Market Segment of the Italian Stock Exchange is analysed. Innovation is measured through the level of investments in total tangible and intangible fixed assets in 2006–2007, while performance is captured through growth—expressed by variations of sales or of total assets—profitability—through ROI or ROS evolution—and productivity—through asset turnover or sales/employee in the period 2008–2010. The variables of interest are analysed and compared through statistical techniques and by adopting a cluster analysis. In particular, a Voronoi tessellation is implemented in a varying centroids framework. In accord with a large part of the literature, we

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find that the behaviour of the performance of the companies is not univocal when they innovate. The statistical outliers are the best cases in order to suggest efficient strategies. In brief, it is found that a positive rate of investments is preferable.

Introduction

This chapter is based on three recent papers:

- ([6]) F. Bartolacci, N.G. Castellano, and R. Cerqueti (2015). The impact of innovation on companies' performance: an entropy-based analysis of the STAR Market Segment of Italian Stock Exchange, Technology Analysis and Strategic Management 27, 102–123.
- ([3]) M. Ausloos, F. Bartolacci, N.G. Castellano, and R. Cerqueti (2018). Exploring how innovation strategies at time of crisis influence performance: a cluster analysis perspective, Technology Analysis and Strategic Management 30, 484–497.
- ([4]) M. Ausloos, R. Cerqueti, F. Bartolacci, and N. G Castellano (2018). SME investment best strategies. Outliers for assessing how to optimize performance, Physica A 509, 754–765.

The connection between innovation strategies (usually taken as the investments) of companies if implemented before a financial crisis and their performance measured after crisis time are interesting aspects of small and medium size enterprises (SME) economic life.

In fact, [30], in *"Economic recessions, strategy, and performance: a synthesis"* claimed that

> Despite the episodic pervasiveness of recessions and their destructive impact on firms, a void exists in the management literature examining the intersection between recessions, strategy, and performance.

Therefore, it seems worthwhile to reflect on such connections considering practical cases. Thus, we have considered companies listed in the STAR Market Segment of the Italian Stock Exchange in recent times. SME innovation is here below measured through the level of investments in total tangible and intangible fixed assets in [2006–2007], while performance is captured through (i) growth—expressed by variations of sales (DS) and variations of total assets (DA); (ii) profitability—through returns on investments (ROI) and returns on sales (ROS) and (iii) productivity—through asset turnover (ATO) or sales per employee (S/E) in the period [2008–2010].

In the Milano STAR market, 71 companies of mid-size are listed, at the time of study: their capitalization value was between 40 million and 1 billion euros. Since their activity and innovation levels are different from "industrial companies", whence since their performance should be measured in a different way, we have removed banks and insurance institutes from our analysis. Thus, in the following, the segment is reduced to 62 SMEs.[1] For completeness, the 62 SMEs at the time of study are given in Table 1.1.

We discuss a formal method, based on Voronoi tessellation (Voronoi, 1908), yet we depart from the original formulation of Voronoi by introducing a concept of weighted Euclidean distances, hence leading to asymmetry (see formulas (2) and (3)). In our approach, we a priori define some reference points—so-called "centroids", each centroid identifying a cluster whose elements are at a distance smaller than that of the other centroids.

For more information, let us mention that the use of Voronoi tessellation can be found in [33, 47, 49].

Such a cluster analysis is employed to investigate the determinants of innovation and innovation-performance focused on a single industry [46] or on different industries [11, 32, 39].

Data

A few notations are to be introduced for easy readability of the following tables and figures:

- TIAXyy represents the level of total intangible assets (excluding goodwill) in year 20yy.
- TTAyy is the level of total tangible assets (excluding properties) in 20yy.
- DSyy stands for sales variations in year 20yy.
- DAyy is total assets variations in year 20yy.
- ROIyy means the return on investments in year 20yy.
- ROSyy means the return on sales in year 20yy.
- ATOyy represents asset turnover in year 20yy.
- S/Eyy stands for sales per employee in year 20yy.

- The lowest TTA value is called TTA1, while the highest TTA is TTA2.
- Their average is <TTA>2 = (1/2) (TTA1 + TTA2)

which, in fact, due to the time interval of interest, is equal to (TTA06 + TTA07). Similarly,

- <TIAX>2 is the average total intangible asset (excluding goodwill) over 2 years: [2006–2007]; "obviously", <TIAX>2 = (1/2) (TIAX1 + TIAX2) = (1/2) (TIAX06 + TIAX07).

We provide figures in order to visualize the data range for <TIAX>2 and <TTA>2 shown in Fig. 1.1. In these figures, the SMEs are ranked in increasing order of the *y*-variable value. The range and statistical characteristics are outlined in

[1] The below displayed data can be obtained from the authors upon request as Excel tables.

Table 1.1 The 62 STAR company names, at the time of study; alphabetical order and the "supersector" to which they belong; "supersector" abbreviations: Automobiles & Parts (A&P); Construction & Materials (C&M); Industrial Goods & Services (IG&S); Personal & Household Goods (P&HG); Food & Beverage (F&B)

$i =$		Supersector	$i =$		Supersector
1	Acotel Group	Telecommunications	32	Exprivia	Technology
2	Aeffe	P&HG	33	Falck Renewables	Utilities
3	Amplifon	Health Care	34	Fidia	IG&S
4	Ansaldo Sts	IG&S	35	Fiera Milano	IG&S
5	Ascopiave	Utilities	36	Gefran	IG&S
6	Astaldi	C&M	37	I.M.A	IG&S
7	Biancamano	IG&S	38	Interpump Group	IG&S
8	Biesse	IG&S	39	Irce	IG&S
9	Bolzoni	A&P	40	Isagro	Chemicals
10	Brembo	A&P	41	It Way	Technology
11	Buongiorno *	Technology	42	La Doria	F&B
12	Cad It	Technology	43	Landi Renzo	A&P
13	Cairo Communic.	Media	44	Marr	Retail
14	Cembre	IG&S	45	Mondo Tv	Media
15	Cementir Holding	C&M	46	Nice	IG&S
16	Centrale Latte To	F&B	47	Panariagroup	C&M
17	Cobra	Automobiles and Parts	48	Poligraf. S. F	IG&S
18	Dada	Technology	49	Poltrona Frau	P&HG
19	Damiani	Retail	50	Prima Industrie	IG&S
20	D'Amico	IG&S	51	Rdb	C&M
21	Datalogic	IG&S	52	Reno De Medici	IG&S
22	Digital Bros	P&HG	53	Reply	Technology
23	Dmail Group	Media	54	Sabaf	IG&S
24	Dmt	Technology	55	Saes Getters	IG&S
25	Eems **	Technology	56	Servizi Italia	IG&S
26	El.En	IG&S	57	Sogefi	A&P
27	Elica	IG&S	58	Ternienergia	Utilities
28	Emak	P&HG	59	Tesmec	IG&S
29	Engineering	Technology	60	Txt E-Solutions	Technology
30	Esprinet	Technology	61	Yoox	Retail ***
31	Eurotech	Technology	62	Zignago Vetro	IG&S

*Since July 2012, Buongiorno is part of Docomo Digital

**Eems was moved away from Technology in STAR to MTA Market/Segment

***In March 2015, Yoox merged with Net-a-Porter

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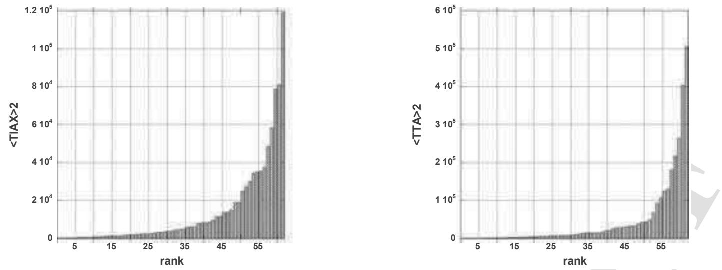

Fig. 1.1 Left panel: <TIAX>2. Right panel: <TTA>2; thus each averaged over 2 years: [2006–2007]; both data are ranked in increasing order—for the 62 SMEs discussed in the text

Table 1.2 Main statistical indicators of the innovation and performance variables; $Tot.Ass.$ = "Total Assets"; $Var.n$ = "variation"; $empl.$ = "employee"; $Ret.on$ = returns on

	Innovation		Performance					
			Growth		Profitability		Efficiency	
	Intangible Assets (TIAX)	Tangible Assets (TTA)	Sales $Var.n$ (DS)	$Tot.Ass.$ $Var.n$ (DA)	$Ret.on$ Invest. (ROI)	$Ret.on$ Sales (ROS)	Asset turnover (ATO)	Sales/ $empl.$ (S/E)
Mean (μ)	12,360.46	29,215.40	9%	6%	5%	5%	0,91	275.77
Std.Dev.(σ)	18,695.11	45,379.80	16%	14%	5%	7%	0,34	231.20
μ/σ	0.66	0.64	0,46	0,57	0,85	0,75	2,68	1.19
min.	180	86.50	−19%	−10%	−8%	−14%	0,15	57.20
Max	80,816	217,237.50	59%	53%	21%	24%	2,04	1,100.76
Q1	1,346.50	3,579.50	−1%	−2%	2%	1%	0,75	148.02
Median	3,584	10,329.00	3%	4%	4%	5%	0,86	188.04
Q3	13,917	31,331.50	12%	16%	8%	9%	1,09	281.07
Skewness	2.28	2.57	1.48	1.32	0.44	0.27	0.78	2.25
Kurtosis	5.14	6.79	3.60	1.07	0.60	0.76	1.76	5.05

Table 1.2. Other displays, e.g. when the SMEs are listed in alphabetical order, on the x-axis can be found in Fig. 1.2.

Next, let us display the performance variables averaged over 3 years, [2008–2010]:

- <DS>3 for the sales variations,
- <DA>3 for the total assets variations,
- <ROI>3 for ROI,
- <ROS>3 for ROS,
- <ATO>3 for the asset turnovers and
- <S/E>3 for the sales per employee,

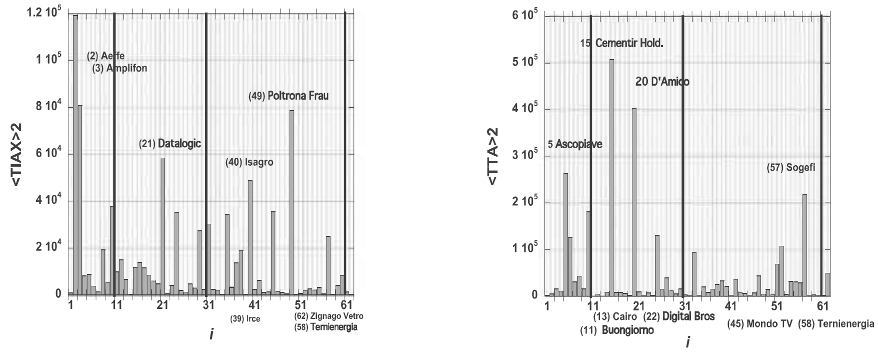

Fig. 1.2 (colour online) Left panel: <TIAX>2. Right panel: <TTA>2; thus each averaged over 2 years: [2006–2007],—for the 62 SMEs, ranked in alphabetical order as in Table 1.1, particularly pointing to a few relevant SMEs of the STAR market so studied

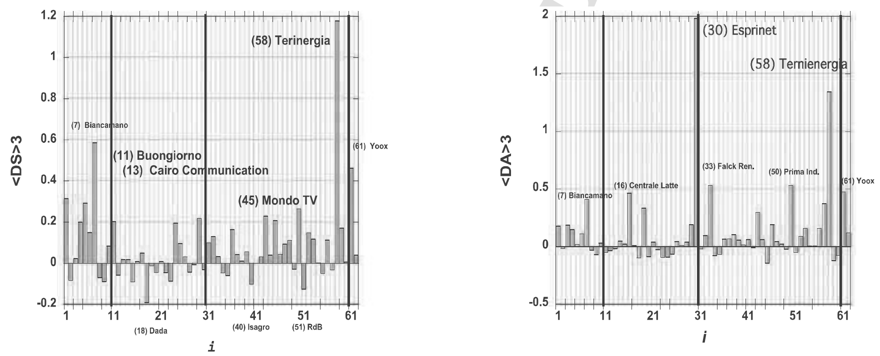

Fig. 1.3 (colour online) Left panel: sales variations <DS>3. Right panel: total assets variations <DA>3; thus each averaged over 3 years: [2008–2010]—for the 62 SMEs, ranked in alphabetical order as in Table 1.1, particularly pointing to a few relevant SMEs of the STAR market so studied

either when companies are listed in alphabetical order, as in Figs. 1.3, 1.4 and 1.5, or ranked in increasing order of the relevant variable, as in Figs. 1.6, 1.7 and 1.8.

versus

Statistical characteristics for the distributions of the averaged innovation and performance indicators are found in Table 1.3.

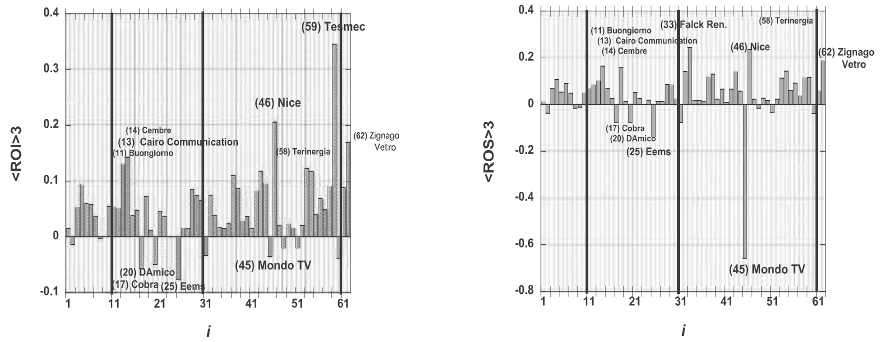

Fig. 1.4 (colour online) Left panel: returns on investments <ROI>3. Right panel: returns on sales <ROS>3. Thus each averaged over 3 years: [2008–2010]—for the 62 SMEs, ranked in alphabetical order as in Table 1.1, particularly pointing to a few relevant SMEs of the STAR market so studied

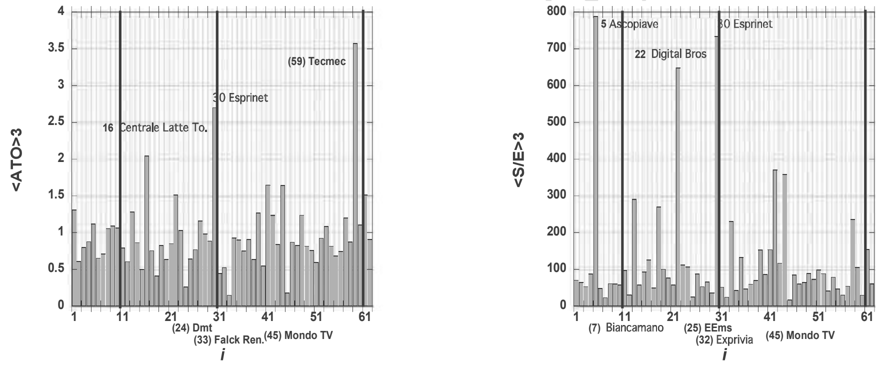

Fig. 1.5 (colour online) Left panel: asset turnovers <ATO>3. Right panel: sales per employee <S/E>3. Thus each averaged over 3 years: [2008–2010]—for the 62 SMEs, ranked in alphabetical order as in Table 1.1, particularly pointing to a few relevant SMEs of the STAR market so studied

Discussion

Many correlations can be searched for, besides those[2] between TTA06 and TTA07, or TIAX06 and TIAX07, shown in Fig. 1.9, one may consider those between the averaged variables, like

- <DS>3 versus <TTA>2
- <DA>3 versus <TTA>2
- <ROI>3 versus <TTA>2
- <ROS>3 versus <TTA>2

[2]Notice that the relationships are not exactly linear.

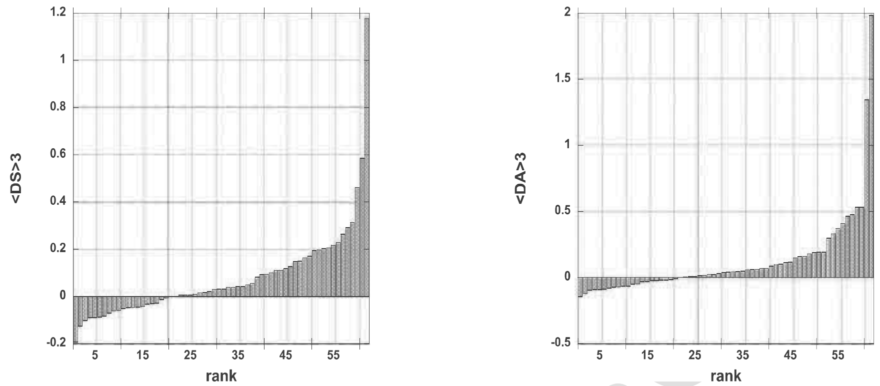

Fig. 1.6 (colour online) Left panel: sales variations <DS>3. Right panel: total assets variations <DA>3; both ranked in increasing order—for the 62 SMEs, particularly pointing to a few relevant SMEs of the STAR market so studied

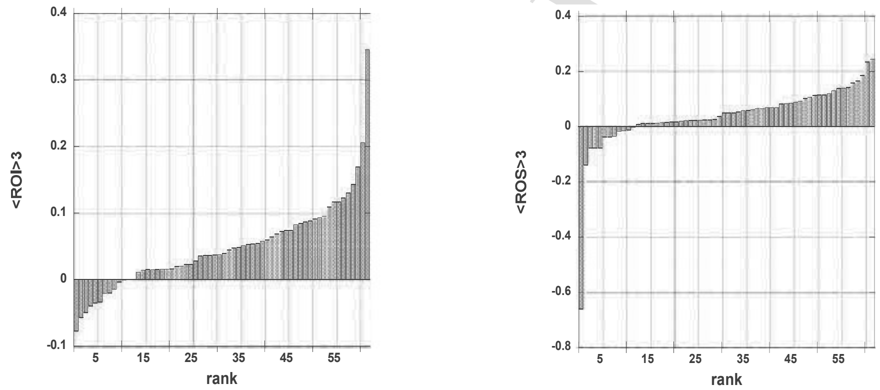

Fig. 1.7 (colour online) Left panel: returns on investments <ROI>3. Right panel: returns on sales <ROS>3; both ranked in increasing order—for the 62 SMEs, particularly pointing to a few relevant SMEs of the STAR market so studied

which can be read in Figs. 1.8, 1.9, 1.10 and fig:11, in [4], whence are not reproduced here. Nevertheless, for completeness, we show

- <ATO>3 versus <TIAX>2
- <S/E>3 versus <TIAX>2
- <ATO>3 versus <TTA>2
- <S/E>3 versus <TTA>2

on Figs. 1.10 and 1.11.

It should be apparent that the data looks pretty scattered, suggesting a "more sophisticated" approach for reaching some conclusion. As an intermediary remark, observe that <ATO>3 and <S/E>3 are all positive; this is not the case for <DS>3,

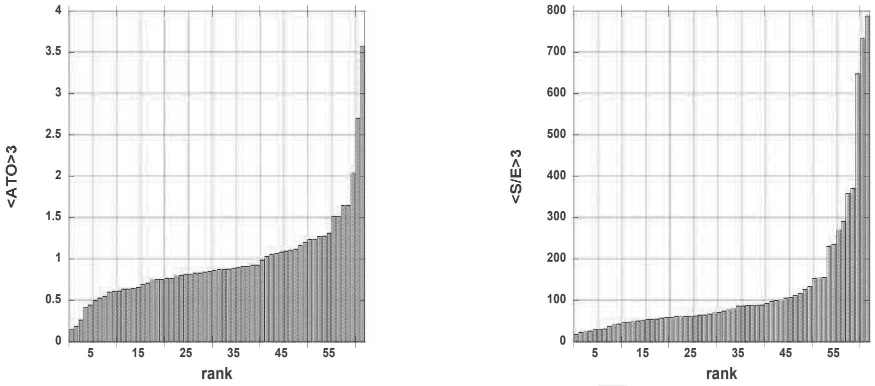

Fig. 1.8 (colour online) Left panel: asset turnovers <ATO>3. Right panel: sales per employee <S/E>3; both ranked in increasing order—for the 62 SMEs, particularly pointing to a few relevant SMEs of the STAR market so studied

Table 1.3 Summary of (rounded) statistical characteristics for the time average distributions of the innovation and performance indicators for the 62 STAR companies, in the centre of the table, in per cent and in 10^6 Euros, respectively; the skewness and kurtosis are dimensionless scalars

Variable	Min.	Max.	Sum	Mean (μ)	StDev (σ)	Skewness	Kurtosis
<TIAX>2	174.5	1.192 10^5	8.421 10^6	13 583	22 513	2.7259	8.0364
<TTA>2	86.5	5.075 10^5	2.746 10^6	44 297	92 600	3.3967	12.062
<DS>3	−0.1924	1.1767	4.9303	0.0795	0.198	3.1414	14.013
<DA>3	−0.1436	1.9818	7.8786	0.1270	0.330	3.8060	16.885
<ROI>3	−0.0768	0.3457	3.0115	0.0486	0.067	1.5342	5.1206
<ROS>3	−0.6609	0.2445	2.5316	0.0408	0.118	−3.505	20.046
<ATO>3	0.1474	3.5673	59.900	0.9661	0.535	2.4625	8.8557
<S/E>3	17.464	787.69	7739.5	124.83	155.6	2.9856	8.7591

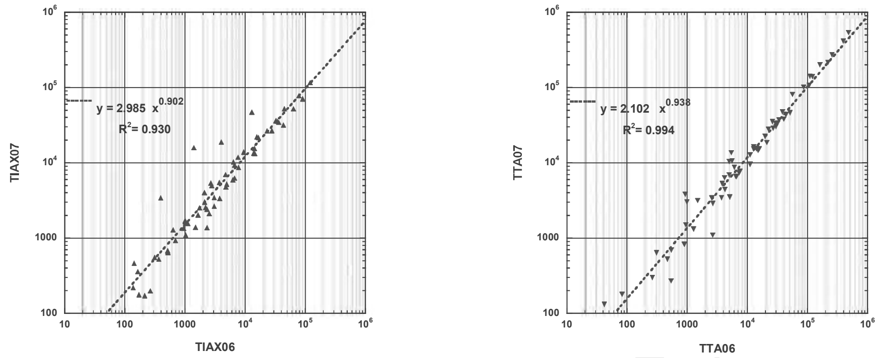

Fig. 1.9 Power law regression analysis for (colour online) left panel: TIAX07 versus TIAX06 and right panel: TTA07 versus TTA06, for the 62 SMEs

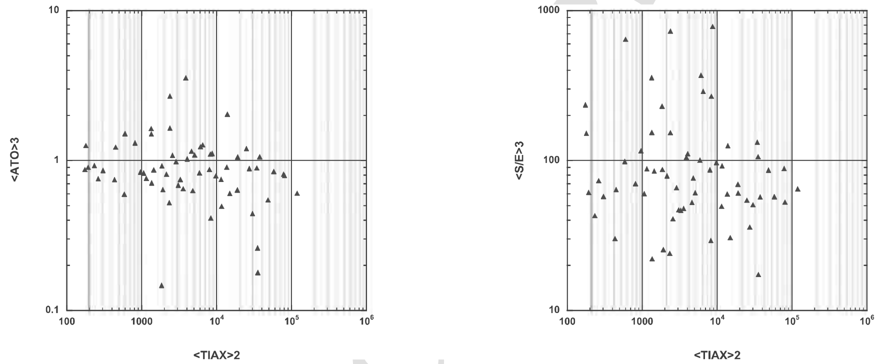

Fig. 1.10 Searching for correlations: (colour online) left panel: <ATO>3 versus <TIAX>2; right panel: <S/E>3 versus <TIAX>2

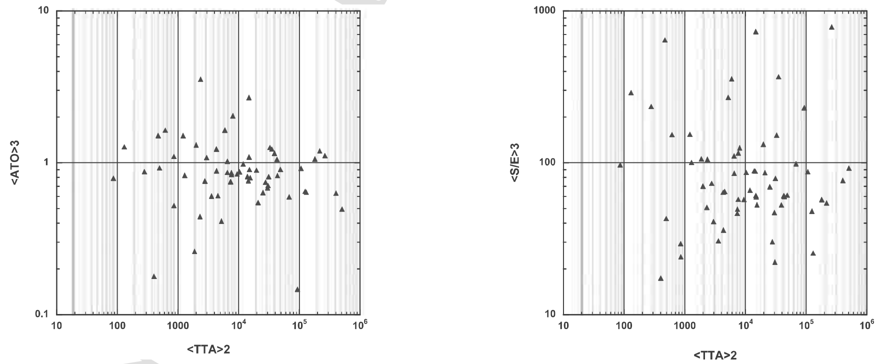

Fig. 1.11 Searching for correlations: (colour online) left panel: <ATO>3 versus <TTA>2; right panel: <S/E>3 versus <TTA>2

<DA>3, <ROI>3 and <ROS>3; some SMEs have negative values in the latter cases; see Fig. 1.6 and on Fig. 1.7, for examples.

A Brief Description of the Voronoi Tessellation

The Voronoi tessellation is a method for decomposing a metric space in non-overlapping subsets. Such a methodology dates back to René Descartes, who informally described it in his Principia Philosophiae (Descartes, 1644). Later, it was formalized in the context of the multidimensional real spaces (Voronoi, 1908). The principles behind the conceptualization of the Voronoi tessellation are grounded on the criterion used for decomposing the space. Some specific points—the so-called "centroids" or "seeds"—are initially selected. In our context, we refer to a finite number of centroids. Then, the space is partitioned into regions, according to the distances from the seeds. Specifically, each point of the space is assigned to the peculiar centroid which is closer to it. In so doing, the points assigned to a given centroid form a region which contains the centroid itself and does not overlap with other regions/centroids. When all the points of the space are assigned to a specific centroid, then the space appears visually as "tesselled"; this intuitively suggests why one refers to the "Voronoi tessellation". The distance employed for the tessellation procedure can be selected in a number of ways, and it is based on the metric. Here and in most applications—and also in the original Voronoi's paper—the considered metric space is the multidimensional Euclidean space. Thus, the natural Voronoi distance is the Euclidean one.

In the present application, we refer to bidimensional Euclidean spaces; the coordinates of the considered points and centroids are x- and y-variables.

Voronoi Correlations Approach

In the context of Voronoi tessellation of the bidimensional Euclidean space, the x- and y-axes correspond thereafter to one of the innovation ($\mathcal{I}$) and one of the performance ($\mathcal{P}$) variables, respectively. It is easily understood that counting only correlations between ($\mathcal{I}$) and performance ($\mathcal{P}$) variables, one has 12 displays; the more so if one considers the log of the variables for display readability ("scaling"), since as pointed out the absolute value of several ($\mathcal{P}$) variables has to be taken before log-scaling, leading to 20 Voronoi maps. This seems to be fine for completeness, but too much for illustrating the purpose and its pedagogical approach at this time. Thus, only a few cases are illustrated thereafter: Figs. 1.12 and 1.13, for the relationship between <TTA>2 and <ROI>3 or <ROS>3. For readability, the x- and y-axes differ (are flipped) depending on the figure panel. However, this allows to observe the size of the extreme regions, in which, in some sense, the whole market is divided. AQ1

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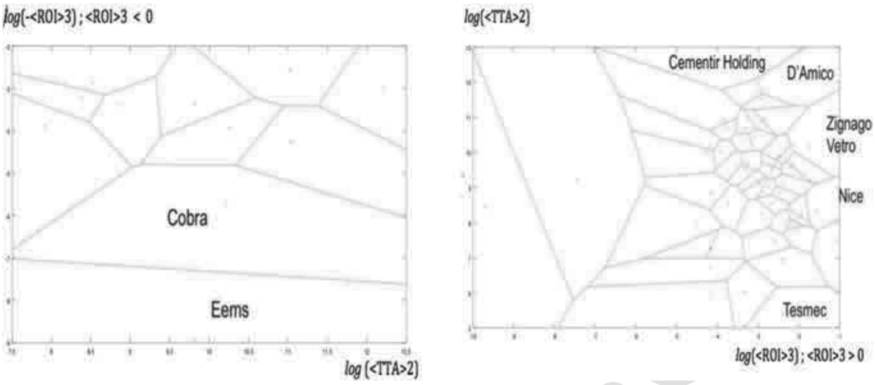

Fig. 1.12 Voronoi tessellation of [log(<ROI>3), log(<TTA>2)] plane. Left panel: when <ROI>3 < 0. Right panel: when <ROI>3 > 0 for the 62 SMEs discussed in the text. A few specific SMEs are pointed out

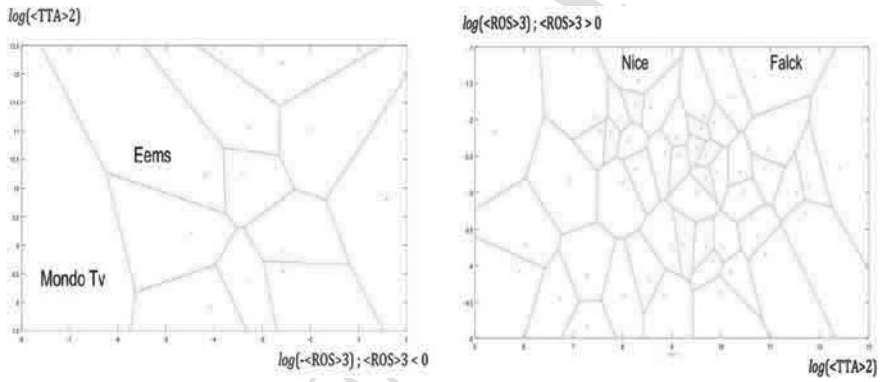

Fig. 1.13 Voronoi tessellation of [log(<ROS>3), log(<TTA>2)] plane. Left panel: when <ROS>3 < 0; Right panel: when <ROS>3 > 0 for the 62 SMEs discussed in the text. A few specific SMEs are pointed out

Voronoi Clustering Approach

In the Voronoi clustering approach, for avoiding scale effect, the variables of interest are first normalized. For each company $j = 1, \ldots, 62$, we define

$$\bar{x}_j = \frac{x_j - m_x}{M_x - m_x}, \tag{1}$$

where x_j represents the value of the variable x for the j-th company and

$$m_x = \min_{j=1,\ldots,62} x_j, \qquad M_x = \max_{j=1,\ldots,62} x_j.$$

Next, in search of clusters, the centroids of the Voronoi tessellation are a priori defined by positive numbers, $\{\phi_h\}_{h=1}^H$ and $\{\psi_k\}_{k=1}^K$, where H and K are a priori chosen integers.

Moreover, we introduce a weighted Euclidean distance, for each innovation variable ($\mathcal{I}$), through

$$d_{\mathcal{I}}(j, \phi_h) = \sum_{x \in \mathcal{I}} \alpha_x (\bar{x}_j - \phi_h)^2, \tag{2}$$

for each centroid ϕ_h and where the α's are the non-negative weights of the norm, which can differ depending on the centroid, but so that

$$\sum_{x \in \mathcal{I}} \alpha_x = 1.$$

Analogously, for each performance variable ($\mathcal{P}$), we define

$$d_{\mathcal{P}}(j, \psi_k) = \sum_{x \in \mathcal{P}} \beta_x (\bar{x}_j - \psi_h)^2, \tag{3}$$

for each centroid ψ_k, imposing

$$\sum_{x \in \mathcal{P}} \beta_x = 1.$$

In so doing, all distances are $0 \leq d_{\mathcal{I}}(j, \phi_h), d_{\mathcal{P}}(j, \psi_k) \leq 1$, for each company j with respect to centroid of coordinates (ϕ_h, ψ_k).

Notice that, even if Eqs. (2) and (3) look mathematically identical, we prefer to write down both formulas in order to point out that the differences may occur between the sets $\mathcal{I}$ and $\mathcal{P}$ and the related centroid coordinates. Indeed, as we will see below, the definition of the coordinates ϕ's and ψ's and the different cardinalities of $\mathcal{I}$ and $\mathcal{P}$ lead to very different settings emphasized in the cases concerning Eqs. (2) and (3).

Three cases of clustering search have been examined in [3], always setting $H = K = 4$, with the centroids regularly distributed on the plane diagonal: $\{\phi_h\}_{h=1}^H = \{\psi_k\}_{k=1}^K = \{1/5, 2/5, 3/5, 4/5\}$. Consider case $[II]$, for discussion, when $\alpha_x = 1/2$ for each $x \in \mathcal{I}$ and an identical weight for the $x \in \mathcal{P}$ variables, i.e. $\beta_x = 1/7$. This is a "uniform in value" case, where the definition of the centroids is made by considering a uniform decomposition of the interval [0, 1] and all the variables are assumed to equally concur in the Voronoi distance (Table 1.4). AQ2

It should be pointed out here that after some simple clustering analysis, so-called case $[I]$, in [3], nine companies are controlling the clustering, and collapsing the whole sample into one single cluster, due to their "outlier aspect". They are (2) Aeffe, (5) Ascopiave, (15) Cementir Holding, (20) D'Amico, (22) Digital Bros, (30) Esprinet, (45) Mondo Tv, (58) Ternienergia, (59) Tesmec. This numerically confirms the few outlined cases seen in the above figures. These nine companies are removed

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Table 1.4 Distribution of companies among the clusters ($cl.$), either for clustering II, as defined in the text and examined in [3]for 53 STAR companies

"II clustering"		Performance				
		$1st\ cl.$	$2nd\ cl.$	$3rd\ cl.$	$4th\ cl.$	Tot.
Innovation	$1st\ cl.$	16	22	7	0	45
	$2nd\ cl.$	2	2	0	0	4
	$3rd\ cl.$	1	3	0	0	4
	$4th\ cl.$	0	0	0	0	0
Tot.		19	27	7	0	53

for the subsequent Voronoi clustering analysis approach. It remains, therefore, 53 companies to be examined.

To provide comments on the following results, we call *first* cluster the one associated with the $\{\phi_h\}_{h=1}^{H} = \{\psi_k\}_{k=1}^{K} = \{1/5\}$ centroid and, in an increasing way, the *second* and the *third* cluster, so that the *fourth* cluster is the one associated to the values $\{\phi_h\}_{h=1}^{H} = \{\psi_k\}_{k=1}^{K} = \{4/5\}$.

In Table 1.5, a description of the clusters of the sample companies is provided.

Referring to innovation clustering, the greatest number of companies (45 out of 53) is located in the first cluster, meaning that, in relative terms, companies undertake low-value innovation initiatives (at least those which produce reflections on tangible and intangible assets). Total sales and total assets, which are measures largely employed in literature for company size, show that the higher the intensity of innovation, the higher the size, or conversely. Also the incidence of both tangible and intangible assets (as percentage of the total assets) is increasing in the three innovation clusters, meaning that in highly innovative companies, tangible and intangible assets represent a relevant portion of the disclosed total assets. The mean/std. dev. ratio shows that the composition of the clusters is rather heterogeneous except for the third innovation cluster which is composed of companies whose size is fairly concentrated around the mean. For what concern performance, the distribution of companies among the clusters is quite different from that of innovation.

This provides evidence that the association between innovation and performance is not self-evident. The averages in the performance clusters also do not allow to appraise significant differences neither in terms of company size nor in terms of incidence of tangible and intangible assets.

Table 1.6 shows the averages of innovation and performance drivers for the entire sample and so-called clustering II analysis approach [3] for innovation and performance.

For completeness, we reproduce comments from such a publication. In the first cluster, the averages of innovation for tangible and intangible assets are below the general averages of the entire sample, whereas all performance indicators are above the full sample averages. In the second cluster, a general under-the-general-average

Table 1.5 Statistical description of the companies, as if one full sample, or "belonging" to a cluster $cl.$ (see text); the number (N) of companies in each cluster is given; $Tot.Ass.$ = "Total Assets"

			$Tot.Ass.$ 2006–2007 (€/1,000)	Total Sales (€/1,000)	Intangible Assets on $Tot.Ass.$	Tangible Assets on $Tot.Ass.$
	N:	Mean	303,053	267,689	5%	10%
	53	Std.Dev.	304,144	261,828	6%	12%
"II clustering" Innovation						
		Mean	241,199	210,452	4%	8%
$1st\ cl.$	45	Std.Dev.	190,099	187,814	5%	8%
		Mean/St.Dev.	1.27	1.12	0.88	1.04
		Mean	731,745	467,442	8%	16%
$2nd\ cl.$	4	Std.Dev.	798,924	469,023	8%	22%
		Mean/St.Dev.	0.92	1.00	0.97	0.73
		Mean	570,226	711,853	12%	22%
$3rd\ cl.$	4	Std.Dev.	261,414	329,233	9%	27%
		Mean/St.Dev.	2.18	2.16	1.39	0.82
"II clustering" Performance						
		Mean	210,607	157,375	8%	10%
$1st\ cl.$	19	Std. Dev.	130,310	118,218	7%	11%
		Mean/St.Dev.	1.62	1.33	1.14	0.94
		Mean	385,628	354,434	3%	9%
$2nd\ cl.$	27	Std.Dev.	387,615	293,834	3%	13%
		Mean/St.Dev.	0.99	1.21	0.90	0.71
		Mean	235,476	232,525	3%	10%
$3rd\ cl.$	7	Std.Dev.	228,112	340,089	5%	12%
		Mean/St.Dev.	1.03	0.68	0.62	0.85

performance is associated to an above-the-general-average innovation. In the third cluster, the performance averages are mixed: some of them are above the mean, while the others are below.

Specifically, the μ/σ ratio points that the cluster's homogeneity is rather low, meaning that extremely different companies lie within the same cluster both from innovation or performance perspective. The only exception is represented by ATO, since the σ is remarkably concentrated around the average μ. This could be interpreted as a possible association between innovation and asset turnover. However, its direction remains unclear, since a high ATO is associated to a low innovation in the first cluster, whereas a low ATO is associated to a medium innovation in the second cluster, while high ATO is associated to high innovation in the third cluster.

Table 1.6 Main statistical characteristics of the innovation and performance variables for the whole sample (Ent.) or inside the clusters (*cl*.); the number (N) of companies inside each cluster is recalled

		TIAX	TTA	DS	DA	ROI	ROS	ATO	S/E
Ent.	Mean (μ)	12,360	29,215	6%	9%	5%	5%	0.91	275.77
	Std.Dev.(σ)	18,695	45,380	14%	16%	5%	7%	0.34	231.20
N = 53	μ/σ	0.66	0.64	0.46	0.57	0.85	0.75	2.68	1.19
Innovation II clustering									
$1st$	Mean (μ)	7,127	18,554	7%	9%	5%	6%	0.93	293.83
$cl.$	Std.Dev.(σ)	9,311	24,023	15%	17%	6%	7%	0.36	248.53
N=45	μ/σ	0.77	0.77	0.49	0.55	0.87	0.79	2.57	1.18
$2nd$	Mean (μ)	28,081	71,512	4%	3%	2%	2%	0.67	165.90
$cl.$	Std.Dev.(σ)	29,505	65,192	11%	7%	6%	10%	0.13	58.91
N=4	μ/σ	0.95	1.10	0.34	0.35	0.25	0.16	5.36	2.81
$3rd$	Mean (μ)	55,511	106,862	1%	14%	4%	5%	0.97	182.49
$cl.$	Std.Dev.(σ)	28,454	107,418	5%	18%	1%	2%	0.20	48.84
N=4	μ/σ	1.95	0.99	0.19	0.81	3.00	2.57	4.91	3.73
Performance II clustering									
$1st$	Mean (μ)	16,356	22,484	−2%	−4%	0%	0%	0.79	222.75
$cl.$	Std.Dev.(σ)	20,762	31,548	10%	4%	4%	7%	0.28	157.65
N=19	μ/σ	0.79	0.71	0.21	0.83	0.05	0.05	2.85	1.41
$2nd$	Mean (μ)	11,930	35,841	9%	12%	7%	8%	0.94	262.81
$cl.$	Std.Dev.(σ)	19,346	56,259	9%	13%	4%	5%	0.25	232.07
N=27	μ/σ	0.62	0.64	0.94	0.92	1.54	1.46	3.77	1.13
$3rd$	Mean (μ)	3,174	21,931	20%	35%	9%	12%	1.11	469.70
$cl.$	Std.Dev.(σ)	4,744	32,962	24%	17%	6%	9%	0.65	332.70
N=7	μ/σ	0.67	0.67	0.84	2.02	1.49	1.26	1.71	1.41

It is worth noticing that in the third cluster, companies appear rather homogeneous in terms of performance, particularly for profitability (both ROI and ROS) and efficiency (ATO and S/E). One can argue that, above a particular "threshold of innovation intensity", the level performances seem rather homogeneous.

Indeed, similar considerations can be made for performance clustering: the performance averages gradually increase from the first to the third cluster, whereas innovation averages decrease (TIAX) or fluctuate (TTA). The relation innovation-performance seems, then, quite puzzling. Even for performance clustering, heterogeneity generally occurs within the clusters except for ATO.

Evidence from Outliers Approach

Since there is a negative minimum for each DS, DA, ROI and ROS, one may guess that some board innovation strategies were rather failures.[3] One observes also some outliers from simple Voronoi analysis; see case "Clustering I" in [3]. From Table 1.2, one observes that the kurtosis is always positive and large, indicating lesser chances of extreme negative outcomes. The skewness is also positive, indicating a long upper tail (many small losses and a few extreme gains) and a long lower range tail (many small gains and several extreme losses).

The performance efficiency ratios of the (62) companies, taken one by one, one observes several outliers, i.e. when the SME efficiency value falls outside the relevant $]\mu - 2\sigma, \mu + 2\sigma[$ interval. There are three SMEs which are positive outliers: (58) Terrienergia, (11) Buongiorno, (13) Cairo Communications, and 1 SME which is systematically a "negative outlier": (45) Mondo TV, confirming the Voronoi analysis of "Clustering I".

It should occur to the reader that those four companies are those with very low TTA. Moreover, Mondo TV is the only one among the outliers which has a TTA06 lower than its TTA07—this SME had about a 50% decrease in investment before the crisis. In contrast, Terrienergia, Buongiorno and Cairo Communications have a relatively high TTA increase.

One can observe, respectively, from Figs. 1.12 and 1.13, for example, see also Figs. 1.5 and 1.6 in [4].

- the relationship between <ROI>3 and <TTA>2: a weak <ROI>3 for Cementir Holding and Ascopiave; a negative but with a large absolute value occurs for D'Amico; in contrast, a large <ROI>3 occurs for Tesmec, while the negatively largest <ROI>3 is for Eems—both firms have a rather low <TTA>2;
- the relationship between <ROS>3 and <TTA>2 indicates a moderate <ROS>3 positive effect for Sogefi, Ascopiave, D'Amico and Cementir Holding, the four largest TTA companies, "imposing" a single cluster in the "Clustering I" Voronoi analysis; a large negative <ROS>3 effect occurs for Mondo TV; on the other side, the most positive <ROS>3 is for Falck Renewables, Zignago Vetro and Nice.

Observe that these companies cover various sectors of activity. Nevertheless, there are differences: Terrienergia and Cairo Communications have very dissimilar performance efficiency behaviours, the former performing better for "growth", the latter for "profitability". Since Terrienergia, Buongiorno and Cairo Communications have a high increase in TTA, one might reach some advice concerning innovation strategy. Let TTA increase for better performance.

As an a posteriori" analysis "proof", observe that Mondo TV did not increase its TTA, TTA07<TTA06, pointing to a deficient strategy. This is pointing to the timing of "investment" relevance—not fully clear from the Voronoi analysis. Moreover, observe that the average values are not the critical quantities.

[3] In fact, it is not absolutely sure that innovation strategies were "failures", since one has no definite proof that innovations have been truly implemented.

Conclusions

Justifying an investment is superb challenge for board members—the more so at financial crisis time. Payback is unsure; one needs criteria for obtaining efficiency (performance) measures, whence modelling strategies and forecasting. Usually one demands that the level of investments be low and the returns be high. We have here proposed a set of measures for such "research questions". We have outlined means for finding correlations and looked for clustering of performance ratios, whence the specific companies "obeying" strategies based on such ratios. But from the Voronoi clustering approach, it is not obvious that high innovation leads to high performance.

We have found that the timing of investment is very relevant from observing outliers, with either positive or negative results. Extreme values show best strategies!

The Voronoi approach is nevertheless of interest: Within the clusters, one can compare the characteristics and performance of companies holding the same innovation model, whereas between the clusters high heterogeneity should occur assuming that different innovation models might be suitable for different company profiles and/or could be associated to different level of performance.

In this respect, cluster analysis seems to be particularly effective in providing a global analysis of the relationship between innovation and performance. Notice that the study allows three considerations from extreme value analysis: not only the investment evolution—up or down, low or high—but also through their average, serving as a control kind of test. It should be obvious that the best performance should be better appreciated when (unexpectedly?) the investment is low, but regularly implemented.

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