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Modelling the value of external networks for knowledge realisation, innovation, organisational development and efficiency in SMEs

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Abstract: A 3D folded pseudo-Markov net is presented that illustrates a knowledge-based theory of the growth of SMEs via their knowledge assets. Modelling using Markov chain Monte Carlo methods (i.e., shooting virtual balls down the fold and plotting their final scatter distribution) has indicated significant financial gains if 50% individuals in management were 'innovators' but those results did not account for external networks of the managers involved. Results show for improved performance, the possession of relevant networks to realise 'just-in-time' knowledge from external sources appears approximately as important as internal innovation. With open internal information gatekeeping, the ratio of innovators in management can be as low as 1:6. It is known that start-ups with a large proportion of innovators are likely to perform better than those where innovators are added later on, but these results indicate that the difference can be evened out if latecomers can access external 'just-in-time knowledge'.

Keywords: financial returns; growth; innovation; just-in-time knowledge; management; Markov; modelling; networks; organisation; SME.

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Biographical notes: Robert B. Mellor is a Fellow of the Royal Institution. He possesses doctorates in various academic disciplines including innovation, computing and biology and is the author of over 120 scientific publications in reputable journals, including e.g., *Nature*. In addition to his scientific publications, he has written ten books, including four on knowledge management, innovation and entrepreneurship and three of his books have appeared in foreign translations. He has won a number of international prizes for his works. He is an active consultant with 12 years industrial experience and has been expert advisor to several national governments and to the European Union for over 20 years.

1 Introduction

For the majority of the last century the supremacy of the large corporation as the economic driver for national wealth (see e.g., Galbraith, 1967) led to the dominant theory of the firm being the resource-based view (RBV). This theory argues that the basis for any competitive advantage of a firm lies within valuable tangible and/or intangible resources that are at the firm's disposal (for one review, see e.g., Wernerfelt, 1984). The distinction between tangible and intangible was first investigated in depth by Amit and Schoemaker (1993), who divided resources generally into resources (goods that are tradable and available to many firms) and capabilities, which are more specific to a particular firm. This latter division has become the tentative basis of the knowledge-based view (KBV) of the firm; its supporters (e.g., Spender, 1996) believe, probably correctly, that knowledge-base(s) and the capability of utilising suchlike within an organisation will affect overall organisational performance.

The roots of the KBV of the firms can be found in classical economics (e.g., Penrose, 1959) but in the 1960s, uncertainty amongst the 'smokestack' industries was widespread and may have partly been due to the unwarrented assumption that there only are a certain number of branches of industry and that therefore understanding and controlling these will inevitably lead to optimal performance (for review see e.g., Mellor, 2003). However the IT revolution of the 1990s showed that, against dogma, it was possible to make business where no previous industry or business existed, leading to the so-called 'sunrise' industries, of which software (e.g., Microsoft®) and biotech (e.g., Genentech®) are widely cited examples. Furthermore, recombining knowledge in an entrepreneurial way led to more innovation, where existing business process were radicalised to form new 'value chains', involving the faster delivery of products that were both better and cheaper, with e-commerce being a prominent example. Many scholars believe that this break-up of markets – the so-called 'post-Fordist era' – was actually the natural result of the downswing in the last Kondratieff cycle (Kondratieff, 1935), which introduced a period of 'creative destruction' (Schumpeter, 1942). Certainly the 'dot-com bust' of the year 2000 and the major world recession barely a decade later changed the national and international economic landscape radically away from one featuring the large corporations, to a situation where large enterprises (defined as those employing more than 250 individuals) are well outnumbered by small and medium sized enterprises (SMEs) by a factor of over 1: 500 (exact figures vary according to source and probably by the hour) and SMEs anecdotally account for 60–75% of national employment; the Bank of Montréal (http://www.bmo.com/) in 2005 highlighted the role of SMEs in the Canadian national economy.

The constant churn in the SME environment against an uncertain economic background has led several authors to point out the importance of harnessing and managing innovation (e.g., Kotler and Trias de Bes, 2003) to better enable agile responses to changes in the mercantile ecosystem (Senge, 1990 – or for a more recent contribution see Garvin et al., 2008). Broadly speaking, SMEs reap relatively short-term Schumpeterian profits by means of incremental innovation, where managing internal knowledge networks for 'mutual inspiration' can give rise to transient yet often significant competitive advantages (see e.g., Mellor, 2003). However given the massive changes that have occurred in the intervening time since the acceptance of RBV, it would be a dangerous proposition to pursue a RBV 'policy' today and even the main KBV theoreticians like Nonaka and Takeuchi (1995) and the late Max Boisot (e.g., Boisot, 1998) do not address this new environment.

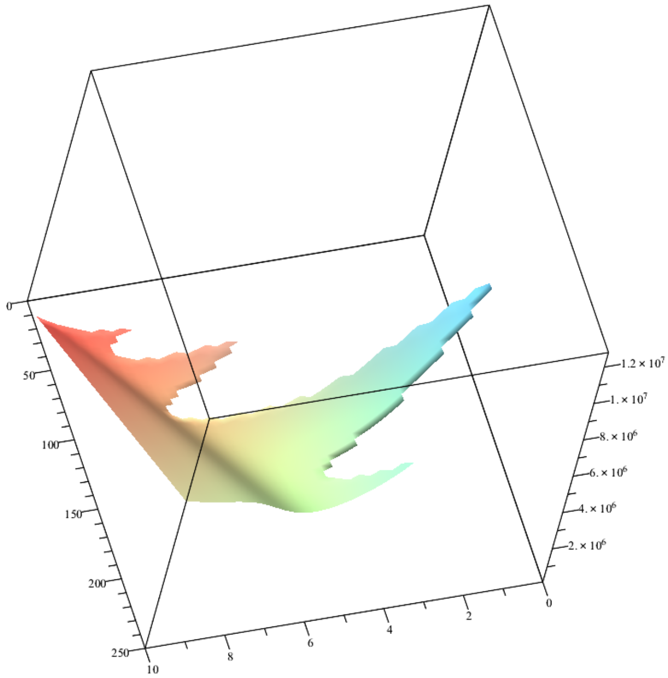
Against this background Mellor (2011a, 2011b) published an attempt at updating KVB especially for SMEs by aligning knowledge management with innovation and securing these in a framework of entrepreneurship: the first model (Mellor, 2011a, 2011b) was an 3D landscape showing the potential for innovation in a growing organisation and was called 'knowledge valley theory' (KVT). Computer-aided mathematical modelling later showed that KVT successfully accounted for all major aspects of the evolution and development of the SME (Mellor, 2011a, 2014a) from start-up and during its growth. Later, Mellor (2014b) used Markov chain Monte Carlo (MCMC) methods in virtual simulations to put financial values on the effect of adding innovation in high-innovation and low-innovation environments. However the figures resulting from the first Mellor (2014b) model indicated that a rather unrealistically high proportion (50%) of employees should be innovators i.e., that a half of the management should be innovators in order to reproducibly realise significant financial gains. One possible explanation for this high figure is that the Mellor (2014b) model only took internal networks into account and neglected the effect of external networks, the importance of which has been understood in a qualitative sense for some time (e.g., Kogut, 2000). Thus this work uses MCMC techniques similar to before (Mellor, 2014b) to model and quantify the effects that the possession of external knowledge networks by individuals may have, on the potential performance of the firm.

2 Modelling

The 3D fold 'knowledge valley' used is shown in Figure 1 and has previously been described in Mellor (2011a, 2011b, 2014a).

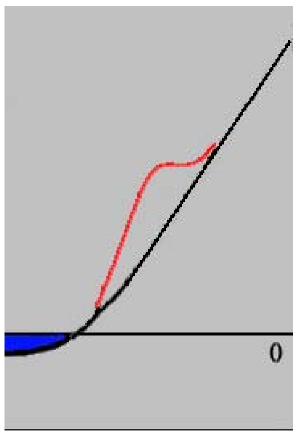
MCMC involves recognising the 3D fold as a Markov net. In Monte Carlo modelling virtual 'balls' are bowled along the net, usually from the origin and a scatter plot is made of their impact on the opposing side, which for ease of viewing are typically represented as impact density functions (Mellor, 2014b). Figure 2 provides an example of this, derived from the results described previously in Mellor (2014b).

Figure 1 The 3D fold also known as knowledge valley with on the abscissa the origin at 0 employees and that x-axis extending to 250 employees (see online version for colours)



Notes: The ordinate y-axis represents annual turnover in GBP (value at 2008) and the Z-axis is benchmarked openness to innovation, with 0 (zero hindrance) being very innovative, representing the 'Schumpeterian' side of 'knowledge valley' and the opposite end of the scale (10) representing the 'Dickensian' side

Figure 2 The density function derived from the scatter plot obtained on the Schumpeterian side of the 3D fold when innovators were added to middle management layer at a ratio of 50: 50 (see online version for colours)



Note: Zero indicates the (horizontal) boundary of profitability

With two important exceptions, the Monte Carlo modelling in the present communication was performed as in Mellor (2014b): the modelling consists of injecting virtual 'Monte Carlo' balls randomly down the valley from the origin along connections between nodes whilst distorting the net (the fabric of the valley) according to selected variables which can be programmed into the algorithm being investigated and then plot the result so that trends can be discerned. Since all nodes are directly connected to each other, they are always 'nearest neighbour' and sweeper code was thus added prevented to prevent balls going backwards, as described previously (Mellor, 2011b). The experimental run ends when the last of 1,000 balls reach the right-hand side of the valley – their exit points being impressed as a scatter plot on the J-curve (the Z-axis of the 3D fold). Monte Carlo balls bowled down the valley from the origin and where the valley consists of a completely uniform net, will arrive in a random fashion i.e., they will arrive on the Z-axis showing no peaks or troughs. Plots are derived by graphing the number of impacts per unit length against unit on the Z-axis. The Z-axis represents value, so a peak of Monte Carlo balls arriving there strongly implies an increase in value for the organisation. It is possible to distort the net – add variables – and then see by analysing the resulting scatter plot if the factor under investigation has added any value or not. Each experimental run was repeated ten times.

The two important exceptions to the above are: firstly, in order to economise on the considerable computing power needed, modelling was performed only on that side of the valley called 'Schumpeterian'. This was because the difference in gradient between the curves of the 'Schumpeterian' and 'Dickensian' sides of the 3D fold is known (e.g., Mellor, 2011b), thus knowing the result (in terms of the scale parameter of the scatter plot) on the 'Schumpeterian' side, the corresponding values on the 'Dickensian' side can be relatively easily calculated using Fourier transformation.

The second exception is that MCMC was performed as before but previously all Monte Carlo balls started at the origin of the fold and a variable number of 'innovators' were placed in a band corresponding to a middle-management salary as described before (Mellor, 2014b). However in the experiments described in this communication, the focus is on packets of useful information arriving from individuals outside of the organisation. Thus in the modelling reported here, the same overall number of balls were rolled down a fold in an exactly similar way as before, except that a variable proportion of these balls appeared 'spontaneously' in a random fashion within the innovator band. Experiments tested the proportion of balls at 33: 66, 50: 50 and 66: 33. This is meant to simulate the number of innovations (number of balls) being constant while the number of innovators responsible for them was varied, the balls appearing at random represent inspiration coming in from outside the organisation (and thus can appear anywhere along the band). The ratios represent one innovator using their network to harvest two innovations (33.3: 66.6), one innovator bringing in one inspiration from outside (50: 50) and finally the network value being one inspiration from outside for every two innovators in the organisation (66.6: 33.3).

3 Analysis and findings

So-called ‘normal’ probability density functions of (Gaussian) distributions exhibit a scale parameter (σ, or ‘small sigma’) of 1.0. For this type of Function, values of scale parameter of 3.0 and above do not in practice exist, because curves with such large scale parameter values would essentially be flat. Scatter plot distributions resulting from MCMC experiments recorded to date in this system have been found to be platykurtic (i.e., flattened) and exhibiting a scale parameter of typically between 1.5 to 2.9, depending on the number and placing of innovators in the 3D fold (Mellor, 2011b, 2014a, 2014b). Even placing 100% innovators in a continuous band did not drive the value of the scale parameter to reproducible values under 1.12. It is assumed that optimisation of the innovation process will result in values of scale parameter approaching unity (one) although there are presently no theoretical grounds to assume that values of scale factor less than one can be achieved. Never the less, values of scale parameter that are nearer to unity (one) are taken to mean an improved optimisation of the innovation process.

Experimental runs were similar to those described previously (Mellor, 2014b) starting with every second individual in the management band being regarded as a double-node innovator. Innovators are placed randomly within this band and in this scenario the value of the scale parameter scores around 1.5. This value thus functions as the control value.

Experimental runs were then performed using the same number of Monte Carlo balls in each run but of which 33.3%, 50% and 66.6% started from the origin and the remainder started from any random point within the band. This represents the situation of one innovator using their network to harvest two external innovations (33.3: 66.6), one innovator bringing in one inspiration from outside (50: 50) and one inspiration from outside for every two innovators in the organisation (66.6: 33.3). The resulting values of scale parameter are shown in Table 1.

Table 1 The effect of changing the proportion of MC balls starting at the origin of the fold on the scale parameter of the resulting scatter plot

Source mix	*Scale parameter (value)*
One innovator abd two external sources	1.12
One innovator and one external source	1.38
Two innovators and one external source	1.46
Innovators only	1.50

Note: Please note that these results only apply to the ‘Schumpeterian’ slope of the knowledge valley fold (as shown in Figure 2)

It can be seen from Table 1 that innovators capable of effectively calling in ‘just-in-time knowledge’ dramatically tightened the scatter plot distribution, indicating that they can indeed add significant value to the organisation. The ‘innovators only’ score represents the situation where half of all individuals in middle management are innovators, often exhibiting multi-skilling (‘T-shaped’ or ‘A-shaped’ skills, for further explanations see e.g., Katz, 2004; Tsai and Huang, 2008; Mellor 2011b, 2014b). This value was taken rather serendipitously and largely because the lowest value of scale parameter obtained to date was using 100% of individuals being innovators (Mellor, 2014b) and this was regarded as being so seldom in practice as to be highly unrepresentative. The value obtained for 100% innovators was 1.12 (Mellor, 2014b), from Table 1 it can be seen that this value is exactly similar to that obtained using highly externally-linked innovators. This shows that the ratio of innovators in management can be as low as 1: 6 of all individuals provided that the innovators have active external networks to gather relevant 'just-in-time knowledge' as well as clear open internal information gatekeeping, enabling solutions, suggestions etc. to be acted upon in an effective way.

How many external network contacts an individual needs is of course a moot point; certain individuals may have 100s or thousands of contacts but the absolute number will of course be relatively meaningless if they are not relevant to the problem at hand. Action on these 'mutual inspirations' must also be effective; Kirton (2003) also showed that problems with information gatekeeping will grow to significant proportions for those innovative individuals outside the 'consensus group'.

None the less, Table 1 does show that individuals with only a half chance of realising an action using information or knowledge obtained from an external source can have a modest effect on the potential performance of the organisation. This was raised considerably when the innovators internal and external conditions were such that each innovator could achieve an average of one effectively actionable solution or inspiration per innovator.

In the MCMC modelling, the number of external solutions harvested per individual could have been made to be higher than two per innovator (the 33.3: 66.6) situation e.g., to 25: 75 but this was not modelled in this work because an organisation that has so many problems that one out of every four problems (or indeed even more) need to be solved using outside sources, will be an organisation that has poor long term prospects of survival.

In a previous work, Mellor (2014b) kept the number of innovators constant, but changed their placing upstream (earlier in the organisations development) or downstream (later in the organisations development) in a Pareto distribution. The results indicated

> "… placing innovators upstream and downstream (i.e., historically earlier or later in a developing organization) strongly imply that hiring innovative managers into an existing and expanding medium-sized organization that is already populated by a well-established class of less innovative managers can add value. The results also however imply that putting an innovative middle-management in place early in the development of an SME is significantly more likely to result in adding value for the organization. Thus adopting high innovators from the very start implies the highest potential returns…." (Mellor, 2014b)

The lowest value of scale parameter obtained in those experiments was 1.21 and Table 1 shows that well-connected innovators can bracket this value (1.12–1.38). This implies that the statement of Mellor (2014b) quoted above should be modified to:

> "Organizations launched with a large proportion of innovators and where in the later growth stages few innovators are added, are still likely to perform better than those where innovators are added later over an earlier less innovative layer. However the difference can be evened out if latecomers are able to access and effectively use inspiration or 'just-in-time knowledge' gathered from their external networks."

The results presented here (Table 1) show that multi-skilled innovators with good networks are much more valuable than being a multi-skilled innovator alone. Indeed, it may be that a non-innovator with a good network is as valuable as a multi-skilled innovator lacking an effective network and that a reasonable mix may be innovators together with well-connected non-innovators.

In the same paper Mellor (2014b) also noted that "…adding innovators to high-innovation SMEs does not provoke an absolute increase in returns, but performance levels are reached earlier…." and added in relation to high-innovation environments that "…the only point however where innovators can be added and the shape of the scatter plot exceeds the base curve is right at the very tip; the highest paid executive. Even at this point gains using the current model appear marginal, however as described below the current model contains constraints, and thus future experiments may clarify if adding innovators to top positions does in fact add value and may indicate how much…" (Mellor, 2014b). Since the simulations reported here were already running on the 'Schumpeterian' side of the fold, it was irresistibly tempting to perform this modelling. To put it in layman's terms is it 'what you know' or 'who you know'? How exactly do the very highest paid directors of innovative companies earn their lucrative salaries, or are they over-paid? The figures used previously imply that for a company of 250 employees the financial difference in annual organisational performance that adding innovators at the very top could make, will mostly be zero, but around 25% of the area represents added value up to approximately £$9*10^5$. This figure thus represents what a particular top director of the largest SME may earn without negatively affecting organisational performance, but it does not indicate if this figure has be 'earned' by dint of work or network. Indeed, the question 'what fraction of top directors are innovators' becomes meaningless. None the less, modelling was attempted in order to investigate this point further and distinguish between the two possibilities but the results were not statistically meaningful due to too few numbers of points at that narrow part of the curve i.e., while a max salary of £900.000 in maximum one quarter of cases would appear to be a correct result, no absolute veracity could be attached to that figure due to the lack of sufficient numbers of individuals in this position and furthermore it could not be verified if that amount was justified by the possession of networks. That is not to say that achieving sufficient statistical significance to satisfy e.g., a t-test is not theoretically possible, but simply that repeating the run so often so as to be able to achieve this number would far exceed the computational power available at the present time. Thus in practice it would be easier to adopt a completely different approach e.g., to determine the salaries of top SME directors (by industry sector) as a proportion of the company turnover.

Table 2 Calculated values of scale parameters of scatter plot distributions imitating the effect of changing the proportion of MC balls starting at the origin of the fold

Source mix	*Calculated scale parameter (value)*
One innovator and two external sources	1.15
One innovator and one external source	1.41
Two innovators and one external source	1.49
Innovators only	1.50

Note: Note that these results apply to the 'Dickensian' side of the knowledge valley slope only

To consider the value of 'innovators' versus 'networkers' in low-innovation SMES: Table 1 showed the values of scale parameter were obtained on the 'Schumpeterian' side of the Knowledge Valley fold. Although in the experiments reported here no modelling was performed on the low innovation/'Dickensian' side, Fourier transformations of values from the 'Schumpeterian' side do however make it relatively simple to imply what they would be on the Dickensian side (Table 2).

As shown in Table 2, the effects of individuals on the 'Dickensian' side of the Knowledge Valley fold possessing networks enabling the effective use of external 'just-in-time' knowledge, basically parallels that seen on the 'Schumpeterian' side. It is not immediately clear why the values are slightly different – implying a lower efficiency in every case – but this effect has been observed before (see the Pareto distribution experiment described in Mellor, 2014b) and ascribed to the generally slower 'mercantile metabolism' of 'elephants' (for nomenclature regarding SMEs, see Birch, 1989), which are regarded as large SMEs on the slopes of low-to-medium innovation (Mellor, 2011b).

4 Conclusions

There are many reports in the management literature pointing out the value of multi-skilling (also known as 'T-shaped' or 'A-shaped' skills, for further explanations see e.g., Katz, 2004; Tsai and Huang, 2008) in adding innovation and thus potential value to organisations (e.g., Hitt et al., 2001; and more recently Østergaard et al., 2011). More recently, MCMC modelling has largely confirmed that professionals that are innovators by virtue of multi-skilling have the potential to add value to SME-sized organisations (e.g. Mellor 2011b). The knowledge valley fold (Mellor, 2011b) moreover makes it possible to distinguish between how many innovators, how much they innovate (and how) and where they are in the organisation – and indeed where the organisation is on a Schumpeterian scale. This is in contrast to all previous studies that are unable to distinguish between these variables and do not consider the environment that such individuals are embedded in.

Using MCMC modelling, Mellor (2011a, 2014a) explained the evolution and development of the SME. Continuing with the model, Mellor (2011b, 2014b) reported that adding innovators at middle management level to highly innovative environments does not increase total financial performance but rather enables the organisation to realise the theoretical higher financial performance faster. One exception to this could be using intrapreneurship i.e., the corporate spinning out of areas not aligned with the core competencies of the parent organisation. Results from MCMC have also indicated that adding middle-management innovators to low-innovation SMEs can contribute rapidly and markedly to potential financial performance; however caution is required to avoid unwittingly precipitating a dangerous process in the organisation akin to business process reengineering (Mellor, 2014b).

The major topic of the present work deals with the importance of external networks. It has been known for some time that these are very important for the innovation process (e.g., Granovetter, 1983) but the effect was not previously quantifiable. More recently it was thought that every second manager needed to be an innovator if significant advantage were to be obtained (Mellor, 2014b), but the present work refines this result and shows that by accounting for 'just-in-time' knowledge to arrive via networks and then being effectively acted upon, the ratio of innovators in management can be as low as 1: 6. The value of active external networks – when combined with clear open internal information gatekeeping – appears to be around the same value as the innovation arising from multi-skilling itself. Previous studies were largely case-based (e.g., Hitt et al., 2001;

Katz, 2004; Tsai and Huang, 2008; Østergaard et al., 2011) and thus have been unable to differentiate between these two factors because multi-skilling probably implies a larger and more diverse network for the individual involved anyway. The value of 'just-in-time' knowledge is so great that it may even be able to compensate for non-innovative management, always providing that the internal information gatekeeping is open to change.

Adding more innovators to high-innovation SME middle management does not improve financial performance; merely it shortens the time need to achieve it. Nevertheless there may also be special situations where total financial performance in high innovation organisations could be improved upon, which is not by having more and more innovators in middle management, but namely by having highly networked individuals in the very highest paid positions. At this high position on the 'peaks of performance' (Mellor, 2011b) there will be few individuals, highly networked externally to the organisation, with clear vertical information gateways internally within the organisation so that problems can be clearly communicated upwards, solved in the external network and the solution transmitted down again. Such individuals may be 'multi-skilled', although this factor is – relatively speaking – of lower importance.

5 Future directions

Previous modelling has accounted for an ″innovation-driven' model of the evolutionary stages of the SME (Mellor, 2011a, 2011b, 2014a), has contributed to explaining the effects of an innovative management structure (Mellor, 2014b) and the effects of external networks (this communication). In this work the assumption has been that operational problems can rise 'bottom up' to well-connected senior positions, be communicated to others in different organisations (individuals and innovators presumably equally well-anchored internally) in a communication flow relatively unhindered by information gatekeepers. However the factors affecting external networks (density, flux, support mechanisms etc.) are unknown. What is known is that with intensified competition and globalisation, national and regional systems are increasingly hoping on being able to create specific 'knowledge ecosystems' that together with public/private business incubators and venture capital should be able to connect a reputable science-base with advanced knowledge and business to foster what the European Commission calls Technological Districts (European Commission, 2013) along the lines of previous and apparently-serendipitously successful examples like Silicon Valley, Silicon Fen, Silicon Corridor, Silicone Roundabout and many other place names that omit reference to the tetravalent metalloid element 14 (for a recent review see Lerro and Jacobone, 2013). Unfortunately both research and everyday experience agree that successful technological districts with high levels of competitiveness and growth are not the automatic result of clustering knowledge-intensive organisations in any given geographic proximity (e.g., Agarwal et al., 2010). Thus a Markov analysis of the nature of the matrix in which the organisations are embedded may explain the success (and failure) of initiatives concerning 'economic clusters' and help in the planning of new ones.

Consequently future models and modelling will investigate the density, strength, flux and, support mechanisms etc. of external networks between organisations and the ability of many organisations to cluster together to successfully form a 'meta-organisation'.

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Relation between intellectual capital and the product process innovation

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Abstract: This study aims to identify the influence of intellectual capital on product and process innovation. To do so, we have administered a survey to 68 firms that belong to the auto components sector, located in Northern Spain and Northern Portugal. In our study, we identified three dimensions within the intellectual capital components. Human capital: formation and knowledge creation, innovative attitude and innovate incentive; structural capital: culture of innovation, the trust and creation and knowledge development, finally, relational capital: collaboration networks, clients and alliances. The elements of intellectual capital with a direct and positive influence in the product-process innovativeness were the human capital and the relational capital. However, not all dimensions of these components have a direct and positive influence. Concerning human capital, only the innovative attitude and innovation incentive dimensions seem to directly and positively influence the product-process innovativeness. The relational capital has influence in the product-process innovativeness; only through clients and collaboration networks.

Keywords: intellectual capital; innovation; human capital; structural capital: relational capital.

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1 Introduction

Kane et al. (2005) defend that knowledge in the new economic landscape is a critical ingredient to reach the competitive advantage. The survival of companies, in an increasingly globalised world, depends on their capacity to innovate resulting from their organisational intelligence, represented by their information and knowledge systems, the competencies of their employees, the quality of their production processes and their customer service (Carbone et al., 2005). Agreeing with this idea, Govindarajan and Trimble (2005) affirm that to succeed or simply remain viable, companies must reply with innovation.

The creation and management of intangible assets, frequently grouped under the generic term 'knowledge', 'intangibles' or 'intellectual capital' is the source of economic value and wealth (Lev, 2001). Therefore, knowledge has come to be seen as a major production differential and the determinant for growth and firm sustainability (Carbone et al., 2005). It is important to recognise that knowledge is a critical input in the production processes and the capability of the firm to use and blend many sources of knowledge could transform intangible resources into value, creating a competitive advantage. At this point, many authors study the relation between the intellectual capital and innovation as a source of competitive advantage. Some authors argue that innovation is a result of the intellectual capital (Tsai and Ghoshal, 1998; Santos-Rodrigues et al., 2011); others authors consider that intellectual capital is an innovation' input (Subramaniam and Youndt, 2005; Nahapiet and Ghoshal, 2002; Ahuja, 2000) or that the different innovative capacities vary on the type of knowledge needed (Cardinal, 2001).

Previous research on organisation's intellectual capital (IC henceforth) has usually focused on one IC component, while IC has actually diverse dimensions. Meanwhile, research on innovation has usually focused on one type of innovation output (products). Our research question deals with the lack of empirical research on the dynamic of the IC components and their influence on three types of innovation: product, process and management. This multidimensional capacity should lead to increased rates of innovation-driven growth, following the suggestions of González-Loureiro and Pita-Castelo (2012).

Damijan et al. (2012) find that innovation has an impact on organisation's productivity, but only significant in the case of enterprises with low productivity growth rates. Therefore, some antecedents seem to be hidden in the linkage between a productivity-driven growth and innovation. We argue that innovation and its intangible antecedents are essential to understand innovation-driven economic growth.

This paper aims to research the connection between intellectual capital and the innovation of the firm by exploring the impact of the human capital, as well as structural and relational capital, on the firm's innovation. In this sense, it attempts to increase the knowledge in this field and to understand whether the human, structural and relational capital influence the innovation of the firms. Therefore, the research question that we propose to answer is: *Does the intellectual capital influence the product and process innovation? Which intellectual capital elements are relevant for product and process innovation?*

In this paper, we try to identify what are the components of each dimension of the intellectual capital that determine the product or process innovation in a company and how the process that explains the relationships between these components. Consequently, we can determine what innovation triggers in each component of intellectual capital to enhance their development in order to be more innovative are.

In order to achieve this objective, the methodology has two parts: first, we should find out what the components of each dimension of intellectual capital are. Then we study the relationships among these components and the components of innovation.

The structure of this article starts with an introduction and follows with the bibliographical review, where the conceptualisation of intellectual capital and innovation is addressed. Based on this bibliographical review, the research hypothesis to be subsequently tested is formulated. Next, the research methods adopted are described. Then, the data collected are analysed and the research hypotheses are tested. By way of conclusion, final conclusions are presented and future research steps are recommended to assist in testing the exploratory propositions formulated in this work.

2 Intellectual capital and innovation

Measuring, communicating and interpreting the intangible resources of a company is possible through the concept of intellectual capital (Roos et al., 2005; Andriessen, 2004). However, the categorisation of the different strategic knowledge assets gathers no consensus. Even though the debate about the components of the Intellectual Capital is still partially open, the intellectual capital components, recognised and mainly accepted in most of the literature, are human capital, structural capital and relational capital (Edvinsson and Malone, 1997; Sveiby, 1997; I.A.D.E.-C.I.C., 2003; Santos-Rodrigues et al., 2011).

Human capital is characterised by the value of the knowledge and talent inherent in the people who make up the organisation, representing its know-how, capacities, talent, attitude, knowledge, intellectual agility, competence, creativity, and others (Santos-Rodrigues et al., 2011; Davenport et al., 2003; I.A.D.E.-C.I.C., 2003; Bontis and Fitz-Enz, 2002). The relationship between human capital and innovation has been investigated in some recent studies.

Structural capital is defined as "knowledge, skills, experiences and information, institutionalised, codified, and used by databases, patents, manuals, structures, systems, routines and processes" (Youndt et al., 2004). This makes it possible to access and use the knowledge in the innovative capability. There are a number of considerations relevant to the innovative capacity.

Relational capital is considered as the result of competitive and social intelligence made by the value of relations and actions of the company shared with external or social workers (I.A.D.E.-C.I.C., 2003). The knowledge of the customers, market and supplier channels along with the knowledge of the impact of government or industry associations are examples of relational capital (Bontis, 1999). In summary, it represents all relations with stakeholders. This capital is more individual than organisational, as it is based on relations between persons outside of the company.

An *innovation* "is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" [OCDE/UE, (2005) p.33]. The innovative firm is one that has implemented an innovation (product, process, marketing or organisational innovation) during the period under review (OCDE/UE, 2005). In this paper, we focus on the process and product innovation specifically.

Firm knowledge assets are positively related to their level of innovation (Thornhill, 2006). Chen et al. (2006) analyse the influence of IC on the organisation's innovative competence. They find a significant positive correlation among the three dimensions of IC (human capital – HC, structural capital – SC and relational capital – RC) and the innovative efforts of organisations. As empirical studies have proven, organisations with higher levels of IC have a superior innovation performance/output (Santos-Rodrigues et al., 2011). Additionally, intangible assets show a most relevant influence on innovation and performance than tangible ones (Bueno et al., 2010).

So, to create new or better products, firms must reallocate resources, combine new resources or combine existing resources both inside and outside firms in new ways (Tsai and Ghoshal, 1998).

The firms with highly skilled and knowledgeable employees have higher levels of human capital and are more likely to create knowledge, make correct decisions and hence result in better organisational innovation (Hitt et al., 2001).

The value of creativity lies in the combination and complementarity of technology and skills-not just human, but requires human motivation (Mouritsen et al., 2001). Plus, da Cunha (2005) found evidence that multidisciplinary groups contribute to innovation because:

1 facilitate interaction and exchange of information between areas

2 promote the exchange of experiences and nurture creative ideas.

Thus, we predict the following:

H_1 Human capital is positively related to the product, process innovation of the firm.

Most papers do not directly analyse the effect of capital structure on innovation, but some of the aspects that comprise it. Rouse and Daellenbach (1999) consider that innovation is driven by *culture*. The skills and knowledge embedded in physical systems and management of a company are formed by the culture of the company. There is evidence of a strong correlation between corporate culture and innovative performance (Hii and Neely, 1999). A business culture that encourages risk (Wan et al., 2005) and encourages the development of new ideas, supporting innovation supports controlled error (Farson and Keyes, 2002). The culture can be developed to foster innovation and learning (Denisi et al., 2003). Jassawalla and Sashittal (2003) define the culture of innovation as the social environment where participants believe on their interaction with each other, this shapes the behaviour of a pervasive and resistant to change. The most effective culture of knowledge creation is when we verify the identification of people with the company; trust and sense of efficacy (Sveiby and Simons, 2002). The technology is also critical for innovation. Proper management of technology resources improves performance of machinery, production processes, systems and even performance of human resources. It also increases the production capacity, reduces costs, and facilitates the adaptation to customer needs, improving company innovation (Zhang et al., 2003). We propose

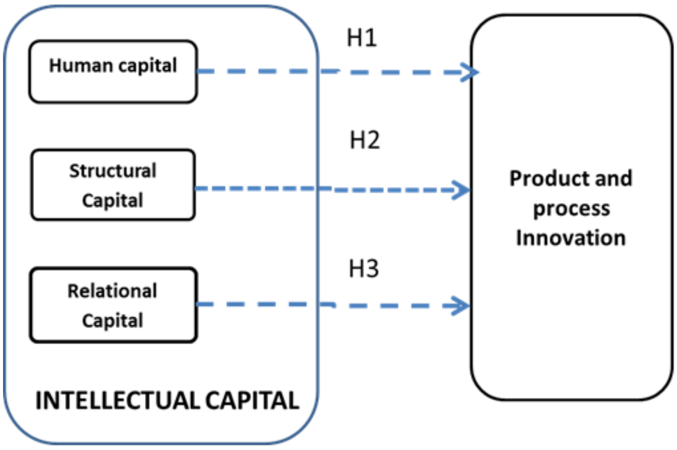
H_2 Structural capital is positively related to the product, process innovation of the firm.

Generally, the collection of resources for innovation derives from the establishment of technological cooperation agreements between different companies, as a strategy to tackle high-cost technology projects (Klofsten and Scheele, 2003). This cooperation is achieved primarily through partnerships between enterprises at local level, i.e., by so-called business clusters. Collaboration with suppliers can contribute to the innovation of SMEs, because it suggests information to adopt innovations (Kaminski et al., 2008). Collaboration with customers can be a source of improved technology because they experience first-hand products and services (Radas and Božić, 2009). Strategic alliances are also shown to be important influences of innovative efforts when they are an integral part of the company's development plan.

From a practical perspective, small companies have limited financial capacity, suggesting that they lack the financial resources to capitalise on innovative opportunities that can become very risky and costly (Sivadas and Dwyer, 2000). On the one hand, availability of R&D funding to influence innovative efforts was shown to be a key factor for SMEs (Radas and Božić, 2009), and it was found that the financial resources are generally available in the nearby territory. On the other hand, small entrepreneurs are risk averse and conservative. Since the processes of innovation adoption involve risks, risk-aversion and conservative reduce innovation (Hausman, 2005). It becomes necessary to improve the ability to risk assess, but it has not been shown if and how these elements, combined as core competencies, improve innovation. Consequently, we set the following hypothesis:

H_3 Relational capital is positively related to the product, process innovation of the firm.

Figure 1 Shows the model and hypothesis of the research (see online version for colours)



3 Method

To test these hypotheses, we use a survey distributed to companies registered on the main and most representative associations of the automotive sector in Galicia (Spain) and North Portugal. In the region of northern Spain (Galicia), we surveyed the firms registered in "Fundación Clúster de Empresas de Automoción de Galicia" (CEAGA); and, in North Portugal, we surveyed firms registered in "Associação de Fabricantes de Industria Automóvel" (AFIA).

The data collection took place in June 2007 by e-mailing the questionnaire to 135 companies, 66 of them from Galicia and 69 from the north of Portugal. We received 68 responses, which mean the response rate was 50.37%. From the Galicia firms, we received 45 responses and from Portuguese firms we received 23 responses. According to the 68 received responses, our effective sample size is 68.

The survey was prepared in Portuguese (to the Portuguese firms) and in Spanish (to the Spanish firms), as the firms were established in two different countries. The survey was firstly tested with some scholars and specialist of the sector. Each participation request included a description of the study, a statement of confidentiality, and a pre-stamped return envelope. Our key expert informants were upper managers, as they help to establish practice in organisational research and give us the opinion of those aware of the strategic choices.

3.1 Measures

The questionnaire uses a Likert scale to measure the constructs. The components of intellectual capital and innovation have been treated as multidimensional constructs, and we had to develop new scales for intellectual capital and innovation based on scales in the literature (Bontis et al., 2000; González-Loureiro and Pita-Castelo, 2012; Jardon and Martos, 2012).

To measure the main human capital dimensions relevant to firm innovation, we considered the following dimensions:

- 'formation and knowledge creation' as a representation of the employees' knowledge (Popadiuk and Choo, 2006)
- 'innovative attitude' representing the commitment and willingness to innovate (Ireland and Webb, 2007)
- 'creativity and incentive to innovation' as the personal and material incentives regarding an innovative behaviour of the employees and representing the employees' creativity (Hausman, 2005).

To measure the main structural capital dimensions relevant to the company innovation, we considered:

- 'Culture and trust', culture reflecting the existence of an innovation-oriented department in the company, as well as the processes designed to foster innovation or a collection system to support the implementation of new ideas, and trust, reflecting the trust between employees and the confidence they have on the company and on its management. It also contains the confidence environment within the company and the role played by the leader (Sanzo et al., 2011).
- 'Firm characteristics', reflecting the formalisation of the firm, represented by the existence of job descriptions, centralisation and the structural characteristics of the company (Lado and Wilson, 1994).
- 'Creation and knowledge development', which includes institutional support for the creation of knowledge through the existence of improvement groups and a system to foster employee suggestions or suggest improvements (Forsman and Rantanen, 2011).

To measure the main relational capital dimensions relevant to the company innovation, we considered:

- 'Networks of collaboration', representing the formal or informal knowledge input from customers, suppliers and competitors conducive to innovation in the company and the use of networking with suppliers to innovate (Russo and Rossi, 2009).

- ‘Clients’, which is particularly focused on the contributions and importance of clients for the innovative capacity (Martín De Castro et al., 2010).
- ‘Competitors alliances’, reflecting the importance and structure of partnership agreements with competitors (Ireland et al., 2002).

Our study focuses on the product-process innovation performance measures (Ahuja, 2000; Hii and Neely, 2000; Ravichandran, 1999). Regarding the innovation, we considered the relative innovation, meaning that an innovation is considered new if it is new to the company, regardless of whether or not it is new to the world or industry.

3.2 Statistical techniques

We use the principal components technique to evaluate the different constructs. The variables with communalities less than 0.4 were analysed to be eliminated as they do not contain common information with the rest of the items. Having reduced the information, it is possible to better understand the information’s meaning. To do so, we select a number of factors, using the Kaiser method, the screen plot and those that clarify at least 50% of the total variance.

No information is lost, because we make use of a rotation process, adjusting the original items to the different axes. The Bartlett’s test and the coefficient of Kaiser-Meyer and Okin (KMO) are the two auxiliary instruments that give the degree of validity of this technique. In this study, we calculated the Cronbach alpha coefficient, through which it was determined the internal consistency of the questionnaire. When this coefficient is greater than 0.6 the construct is right (Nunnally and Bernstein, 1994). This was possible through the set of items used for each component, trying to measure a single construct, to establish the reliability of the measuring instrument and data collection. The calculation of the Cronbach alpha coefficient is a method based on the analysis of the average correlations among items related to one theme, from a single administration of a questionnaire.

To see the effect among constructs we make use of the linear regression techniques that allow us to evaluate and compare the direct effect of each independent variable on the dependent variable. For the analysis process, purification and processing of data, determining factors and impact assessment, we used the statistical package for the social sciences (SPSS version 15).

4 Empirical analysis

The analysis have two steps: first analyse the fit between the data and predefined constructs. After, the research studies the relationships among constructs.

4.1 Data analysis

The Cronbach alpha coefficients in the constructs are greater than 0.6 shown in Table 1.

Table 1 Construct reliability

Constructs	*No. items*	*Cronbach α*
Human capital (HC)	16	.750
Structural capital (SC)	20	.901
Relational capital (RC)	10	.838
Innovation (CI)	6	.688

4.1.1 Human capital

Factorial analysis of principal components showed that the 16 initial variables are explained in 53.277% for three common factors obtained from a varimax rotation with Kaiser normalisation converged in five interactions.

Table 2 Human capital component matrix

	Components		
	1	*2*	*3*
Generally, employees are limited to perform tasks showing little motivation to change	.028	–.193	–.722
Our employees have many skills to the activities performed	.098	.711	–.023
The company did not penalise innovation errors committed by employees	.105	–.192	.720
Our highly trained employees are specialised for the task or function they perform in the company	.116	.762	–.034
Our employees are very talented	.151	.730	.166
Our employees are considered the best in our industry by training	.222	.694	–.016
Whether individuals leave the company would have lost creativity problems	.228	–.453	.292
The innovative attitude of our company is the determinant of the satisfaction of our employees with the company	.364	.609	.076
Much of the value of our organisation depends on the innovative attitude of our employees	.585	.200	.181
Our directors are working to influence people to be voluntarily committed and apply their initiative for innovation	.622	.389	–.021
The employees of our company contribute to creative solutions. new ways of doing things and work performance	.661	.231	.332
Innovation and try to change things is a basic principle of our company	.741	.002	.076
Innovation and try to change things is a basic principle of our company	.741	.002	.076
Our directors like change	.757	–.001	–.370
Our company facilitates the emergence of new ideas and development of the inventive	.758	.047	.388
Our executives show greater willingness to innovate	.760	.281	–.266

The KMO indicates a reasonable correlation between the items (KMO = 0.710) and Bartlett's test has an associated level of significance of 0.000 which leads to the rejection of the hypothesis that the correlation matrix is the identity matrix ($p < 0.01$). Both tests allow the continuation of factor analysis. Four indices have been set. This result coincides with the starting model.

4.1.2 Structural capital

Factorial analysis of principal components showed that the 20 initial variables are explained in 55.812% for three common factors obtained from a varimax rotation with Kaiser normalisation converged in eight interactions.

Table 3 Structural capital component matrix

	Component		
	1	*2*	*3*
Our employees trust the organisation	.823	.058	.197
Our partners rely on the company's functional directors	.797	.201	.057
There is a high degree of trust between the people of our company	.758	.220	.018
Our employees trust the people who make strategic decisions	.681	.127	.172
Our company has a work environment that encourages the active participation of people in the company's innovation	.599	.459	.051
All employees are viewed as 'peers'	.592	.225	.242
Our employees are hired and trained to perform a specific task in a specific department.	.563	.045	.003
I see our company as innovative. new experiments will and courage to take risks	.521	.062	.335
Most business decisions must be approved by senior management	.513	–.287	.411
We managed to extract value from the innovation process	.497	.295	.474
Consciously, unconsciously, the culture of our company is a reflection of the leader. or manager	.345	.245	.161
Our employees make innovative suggestions	.083	.810	.257
There are groups of improvements that facilitate business innovation	–.064	.691	.357
Our employees are open to reveal their true thoughts and ideas and innovative solutions through formal and informal interactions with other members	.310	.672	.053
Our employees enjoy participating in creative discussions	.352	.655	.022
The suggestions made by employees are mostly implemented	.150	.654	.295
We use detailed descriptions of the work (job descriptions). procedures and policies to guide the actions of employees	–.064	.307	.821
In our company there is an innovation-oriented department (R&D. Quality. or other)	.216	.090	.710
Our company has a set of processes and procedures focused on promoting learning and innovation	.386	.313	.663
Our company has a good collection system and implementation of new ideas	.162	.466	.611

The KMO indicates a reasonable correlation between the items (KMO = 0.759) and Bartlett's test has an associated level of significance of 0.000 which leads to the rejection of the hypothesis that the correlation matrix is the identity matrix ($p < 0.01$). Both tests allow the continuation of factor analysis. Three indices have been set. This result coincides with the starting model.

4.1.3 Relational capital

Factorial analysis of principal components showed that the ten initial variables are explained in 64.075% for three common factors obtained from a varimax rotation with Kaiser normalisation converged in seven interactions.

Table 4 Relational capital component matrix

	Component		
	1	*2*	*3*
Consciously, unconsciously, the culture of our company is a reflection of the leader, or manager	.345	.245	.161
I see our company as innovative. new experiments will and courage to take risks	.521	.062	.335
Our company has a work environment that encourages the active participation of people in the company's innovation	.599	.459	.051
There is a high degree of trust between the people of our company	.758	.220	.018
All employees are viewed as 'peers'	.592	.225	.242
Our employees are open to reveal their true thoughts and ideas and innovative solutions through formal and informal interactions with other members	.310	.672	.053
Our employees enjoy participating in creative discussions	.352	.655	.022
Our employees trust the people who make strategic decisions	.681	.127	.172
Our partners rely on the company's functional directors	.797	.201	.057
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Our employees make innovative suggestions	.083	.810	.257
The suggestions made by employees are mostly implemented	.150	.654	.295
In our company there is an innovation-oriented department (R&D. Quality. or other)	.216	.090	.710
We managed to extract value from the innovation process	.497	.295	.474
Our company has a set of processes and procedures focused on promoting learning and innovation	.386	.313	.663
Our company has a good collection system and implementation of new ideas	.162	.466	.611
We use detailed descriptions of the work (job descriptions). procedures and policies to guide the actions of employees	–.064	.307	.821
Most business decisions must be approved by senior management	.513	–.287	.411
Our employees are hired and trained to perform a specific task in a specific department.	.563	.045	.003

The KMO indicates a reasonable correlation between the items (KMO = 0.759) and Bartlett's test has an associated level of significance of 0.000 which leads to the rejection of the hypothesis that the correlation matrix is the identity matrix ($p < 0.01$). Both tests allow the continuation of factor analysis. Three indices have been set. This result coincides with the starting model.

4.1.4 Product process innovation

The component matrix shows that the six initial items are explained in 67.562% for two common factors, obtained through a varimax rotation with Kaiser normalisation converged in three interactions.

Table 5 Innovation component matrix

	Components	
	1	*2*
Our company introduces many innovations in management or administration of significant importance	.916	.005
We introduce our company important management innovations that would improve the profits of the enterprise	.858	–.001
Our company introduced many innovations in the product market of significant importance	–.162	.768
The importance of new products in total sales has increased substantially in recent years	–.016	.738
Our company developed and introduced many innovations in the production process of significant importance	.474	.701
Introduced process innovations were critical to reducing costs or other improvements	.491	.600

Table 6 Construct analysis

Constructs		*Cum. expl. var (%)*	*KMO*	*Bartlett's test*	
Human capital (HC)	Formation and knowledge creation Innovative attitude Innovation incentive	53.277	0.710	Chi2 = 429.703	Sig. 0.000
Structural capital (SC)	Culture of innovation Trust Creation and knowledge development	55.812	.759	Chi2 = 701.727	Sig. 0.000
Relational capital (RC)	Collaboration networks Clients Alliances	64.075	.726	Chi2 = 249.279	Sig. 0.000
Innovation (INN)	Product and process innovation Management innovation	67.562	0.536	Chi2 = 150.872	Sig. 0,000

The factor analysis shows a reasonable correlation between the variables included (KMO = 0.536). The test of Bartlett's sphericity is associated with a significance level of 0.000, from which it follows that there is a correlation between some variables. Both tests allow the continuation of factor analysis. Two indices have been set, representing the product-process innovation (solely, as it represents the same) and management innovation.

4.2 Relationships

To study the relation between intellectual capital and the product-process innovation, we have done a regression with all variables of intellectual capital, selecting the B's with values greater than 0.200 demonstrating the existence of robust relationships between the constructs, and the product-process innovation (Table 7).

Table 7 Regression matrix: product process innovation

Model		*Unstandardised coefficients*		*T*	*Sig.*
		B	*Std. error*		
4	Clients	.399	.097	4.096	.000
	Collaboration networks	.288	.098	2.931	.005
	Innovation incentive	.320	.089	3.611	.001
	Innovative attitude	.216	.106	2.034	.046

The results show that the product-process innovation is directly related to some dimensions of human capital and of relational capital (Table 7). The resulting model is:

$$\begin{aligned} \mathrm{CI\_}_{\mathrm{PROD\_PROCE}} &= 0.399 * \mathrm{CR\_}_{\mathrm{CLIENTS}} + 0.288 * \mathrm{CR\_}_{\mathrm{NETWORKS}} \\ &\quad + 0.320 * \mathrm{CH\_}_{\mathrm{INCENT}} + 0.216 * \mathrm{CH\_}_{\mathrm{ATTITUD}} + \varepsilon_{ri} \end{aligned}$$

where

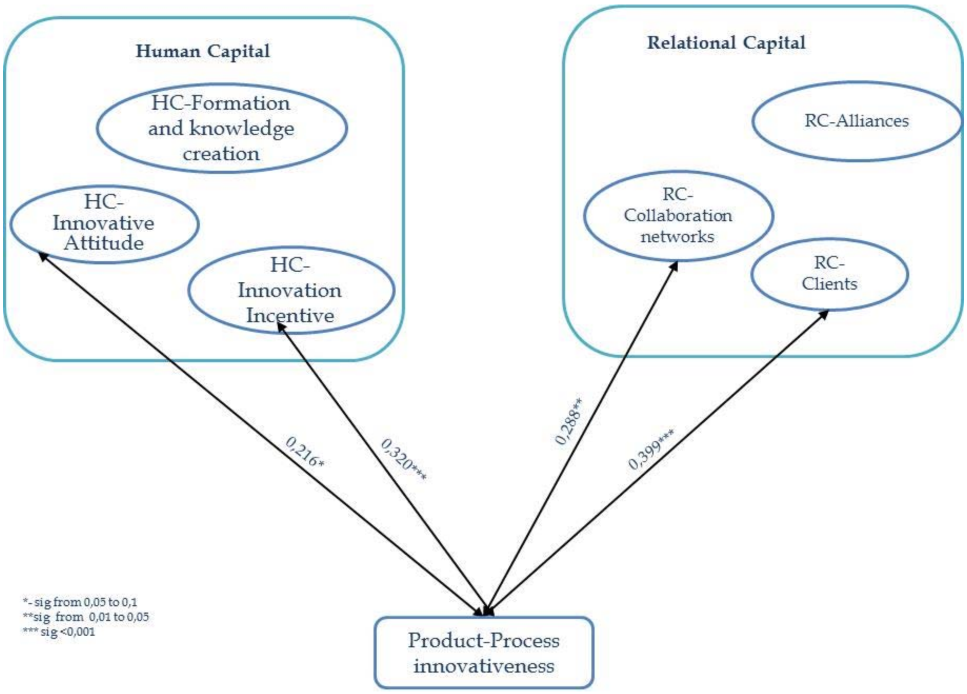
CI_PROD_PROCE	product and process innovation
CR_CLIENTS	clients
CR_NETWORKS	collaboration networks
CH_INCENT	innovation incentive
CH_ATTITUD	innovative attitude.

We conclude that the clients (0.399 sig. 0.000) and collaboration networks (0.288 sig. 0.005) are the relational capital variables with significant and positive effect on the product-process innovation.

On the other hand, the innovation incentives (0.320 sig. 0.001) and the innovative attitude (0.216 sig. 0.046) are the human capital variables with positive and significant effect on the product-process innovation.

We present the conclusions reached in this section in Figure 2.

Figure 2 Results of study (see online version for colours)



According to the findings analysed previously, the hypotheses were tested, and we conclude that only two research hypotheses were validated. We can summarily conclude that our study supports that the intellectual capital influences the innovation of the company, although there are some nuances worth noting, as shown in Table 8.

Table 8 Hypothesis test

Hypothesis		*Situation*
		Product-process innovation
H1	Human capital is positively related to the product, process innovation by the firm.	Accepted
H2	Structural capital is positively related to the product, process innovation by the firm.	*Rejected*
H3	Relational capital is positively related to the product, process innovation by the firm.	Accepted

The Hypothesis 1 was accepted, and it was shown that the human capital is associated with the innovation of the company. The human capital has an important influence in the product-process innovation and in the viewpoint of the intellectual capital, as the inputs to the process of knowledge creation are provided by human capital.

Despite the Hypothesis 2, it was rejected, because the structural capital is not, in our study, directly linked with innovative capacity. These results validate the theoretical arguments (Davenport et al., 2003), as they consider the company to be the one that turns knowledge into performance, defending that the companies must develop a culture that encourages and promotes the retention of human capital (Cabrita and Bontis, 2008). The employees' performance should be supported by businesses through their information systems, infrastructure, routines, culture and trust, enabling the dissemination of knowledge. Some authors consider trust as a fundamental condition to the efficiency of the processes of creation and knowledge transfer (Adler and Kwon, 2002; Ford, 2001), because it facilitates cooperation and creates efficiency in operational work teams. Nevertheless, we did not find a direct relationship between structural capital and innovation.

The Hypothesis 3 was accepted, and it is valid that relational capital is directly related to the product-process innovation. Analysing the results, we verify that they might be influenced by the specificities of the automotive sector, which, through its organisation and management, enhance collaboration between vehicle manufacturers and suppliers to develop components, modules and solutions. Despite this, Hii and Nelly (2000) did not find support in their investigation for the proposition that networks (relational capital) influence the innovative performance of the company, and we verified that the clients (relational capital) are positively and significantly correlated with the product and process innovation.

In our study, we found no direct relationship between alliances (relational capital) and any innovative capacities considered. So, we conclude there is no direct relationship between the contributions from partnerships with competitors and the resulting innovation. Cabrita and Bontis (2008) also found a relationship between relational capital and organisational performance.

5 Conclusions

In summary, our study found important theoretical contributions in two subject areas: the literature of intellectual capital and innovation literature. We can distinguish two contributions to the literature of intellectual capital, as we found some relevant dimensions of intellectual capital for the innovation of the company, and we also found different influences among them.

Concerning the first contribution, some authors suggest that human capital is the central element of intellectual capital (Bontis et al., 2000), and our study confirms that human capital is important for the product-process innovation of the company, especially Innovation incentive and Innovative attitude. The clients and collaboration networks promote process and product innovation, according with Radas and Božić (2009).

Concerning the contribution to the innovation literature, we found that the product and process innovation refer to the same phenomenon, or they are coincident in the automotive industry. This might be explained as, to have a new product innovation, it is necessary to have a new production process; this represents a necessity required for product-process innovation. The two types of innovation are related, and the intellectual capital components are, consequently, differently related.

In this study, we might conclude that, for companies producing components for the automotive sector within the European region of Galicia and Northern Portugal, the Intellectual capital influences the innovation. Through the validation of our research problem, we also conclude that the elements of intellectual capital influence differently the innovation of companies. Among the elements considered of intellectual capital, the human capital seems to be the most relevant in the products and process innovation.

Our study contributes to close the gap between the influence of the intellectual capital and innovation; however, our model could also be tested in different sectors to confirm our findings and better understand this influence. It could be interesting to do a longitudinal study to verify the evolution of the intellectual capital influence on the product-process innovation. Additional contributions may be yielded by testing the influence of human capital on the management innovation or research about the role that intellectual capital plays in the development process stages of new products (Linzalone, 2008).

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Who should really get government support: an analysis of Turkish SME cases

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Abstract: Small firms dominate the economy in terms of their share in employment and enterprise totals in most economies. Despite their central role in economic growth and their potential for innovation, the innovation activities these firms undertake are limited or unknown in contrast to many large firms. Most governments across the globe establish frameworks, create funds and revise their taxation and educational policies to stimulate the innovation activities of small firms. This study concerns the relationship between the innovation policies initiated by the Turkish Government to promote innovation among small businesses and the performance of these organisations at the firm level. We investigate the effect of support funds, for the innovativeness of SMEs given by the public agency of the Small and Medium Enterprises Development Organization, on the firms' net sales with respect to size, sector and location. Our results reveal support funds positively contribute to net sales with higher contributions in manufacturing firms relative to the firms from other industrial sectors. Size and location also matter for net sales. Firms that are relatively larger and those located in industrial zones and technology development centres established by the small business development organisation and universities create higher contributions.

Keywords: R&D; small business; innovation; government supports; firm performance.

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1 Introduction

Small firms are considered the engine of economic development and employment in most economies (Massa and Testa, 2008; Rothwell, 1989). Starting in the 1980s, the UK put significant effort in promoting small businesses where government assistance totalled £1.1 billion between 1980 and 1985, which was maintained during the out years (Curran, 2000). Small firms survive in the market to the extent they engage in innovation. However, small firms face many challenges in comparison to large firms. While large firms have structured processes for organising and managing innovation, small young firms usually do not have the resources or formal strategies for innovation (Bessant and Tidd, 2007). Many new small firms enter the market with new ideas for developing new processes and products, however, they do not last, exiting the markets in few years (De Jong and Marsili, 2006; Audretsch, 1995). Thus, the survival of such firms in the long run has been a challenge as they are the most exposed to the risk of early exit. However, small firms are the ones who most benefit from innovation to survive in the market as time lengthens (Cefis and Marsili, 2003).

Small firms with their small scale can quickly adapt to economic changes especially in the times of crises and they play a critical role in the development and growth of resilient economies throughout the world. However, small firms have difficulty in accessing the new technologies they require to innovate, obtaining finance and they lack the skills, know how and capital investment they need to perform innovative activities (OECD, 2004; Freel, 2000). In this context, national innovation polices play a critical role in SME development. Governments can influence the pace and nature of SME development with few techniques such as the influence on macroeconomic policies, the differential impact of government legislation on firms of different sizes and direct support programmes helping small firms overcome size related disadvantages (Smallbone and Welter, 2001). While governments' influence on the external environment is a more distinctive element in mature market economies, in transition economies direct support programmes and policies are crucial for SME development in the short run.

Creating the necessary institutional and legal conditions in terms of establishing frameworks, revising taxation and educational policies is definitely critical for the cultivation of SME innovation. However, the effectiveness of these policies has been uncertain. As Curran (2000) points out, the assessment of such policies has lagged behind their growth because of the difficulty of assessing these policies, as well, the widespread perception these initiatives receive results in economic growth and increased productivity.

This study examines the relationship between support funds for innovation offered to Turkish small and medium-sized enterprises (SMEs) and their performance metrics. Currently, Turkey has a large emerging economy realising rapid economic growth. The country is considered the future production base for medium-high and high-technology production for Europe and Asia putting forward the importance of small businesses in the innovative progress of the country (OECD, 2012). In the Turkish economy, SMEs comprise a large share of the total employment with 99.9% of the total number of enterprises and 81.3% of the total employment according to 2006 statistics provided by the OECD. Although SMEs comprise a large share of the overall employment and businesses in the Turkish economy, their performance is low in terms of the shares in total exports (9%) and value-add (27.3%) compared to their peers elsewhere in the world (Bascavusoglu-Moreau, 2011). The low scores of Turkish SMEs in innovation forced the Turkish Government to re-evaluate and develop new strategies for harnessing innovation and entrepreneurship among all businesses. Turkey is now at a milestone where the Turkish economy can take a step further towards achieving the goal of the Turkey 2023 vision by investing in R&D and innovation policies especially in small businesses that are viewed as the engine of the economy. To boost the exports and decrease the account deficit, the Turkish Government recently initiated various policies and support programmes that will help increase the competitiveness of Turkish companies and differentiate them in terms of new products and services.

The support programme for R&D, innovation and industrial applications, and the support programme for the development of technology and innovation are the two major programmes designed and implemented by the Small and Medium Enterprises Development Organization (KOSGEB) in Turkey. Initiating such support programmes is crucial to support small businesses; yet, there is a need to understand the role of these funds in initiating and accelerating the innovativeness of SMEs particularly in the early stages of their life cycle. While innovation can be linked to the business performance of SMEs based on previous empirical studies of firms across different countries, it is not clear how support funds initiate and foster the innovativeness of SMEs. The funds allocated for the purpose of increasing the innovation activities of SMEs need to be evaluated on an empirical basis to better understand their tangible effects on firm performance measures and their overall effects on the Turkish economy.

2 Research background

Small firms play a key role in today's global economy in terms of their large share of the total workforce and in the number of firms. Although small firms have great potential for innovation, there are many barriers before innovation and growth. First and foremost, these enterprises do not have the financial power to compete with large and global firms. As well, SMEs lag well behind large enterprises based on the use of communication and information technologies, know-how and skill levels. SMEs face additional challenges arising from globalisation and the rate of technological change. These barriers eventually lower the competitive power of SMEs compared to their peers in similar industrial sectors. Thus, it is more difficult for SMEs to engage in research activities. Crepon et al. (1998), in an empirical study, show the chances a firm undertakes to increase its R&D in accordance with the size of the firm, its market share and diversification levels. SMEs naturally confront more obstacles with their lower market share and diversification level.

2.1 Understanding SMEs' Innovativeness

There is no question SMEs' innovativeness is vital for all economies around the globe. Although there are views in the literature stating small firms are more innovative or are more efficient innovators than larger firms (Pavitt et al., 1987; Acs and Audretsch, 1990, 1993), most of these studies are inconclusive (Tether, 1998). It is obvious there is variation in the innovativeness of small firms (Hausman, 2005). These firms definitely face further challenges than do larger firms for expanding their innovative capabilities. Despite the increased policies to promote the innovativeness of SMEs, there is limited knowledge accumulated regarding how SMEs undertake innovative activities (Hoffman et al., 1998). Many questions remain to be answered to understand the forces leading to higher innovation activities in SMEs. Which factors contribute significantly to SMEs' innovativeness and in which ways do they contribute? What are the obstacles preventing innovation for SMEs? And, how different are these factors when compared to large firms?

Hausman (2005) suggests, on the one hand, less bureaucracy, closeness with customers and managers and superior operational experience can translate into greater innovativeness for SMEs. On the other hand, difficulty in adapting to changes in the market, holding the power of decision-making usually given to the owner or manager and the lack of financial resources make these firms less innovate. Turning external weaknesses into strengths can result in higher innovativeness for small firms. In support of this view, based on data collected on Dutch SMEs, Keizer et al. (2002) suggest, among many factors, the links to knowledge centres, entries to governmental innovation subsidy schemes and a relatively high R&D budget contribute significantly to the innovation efforts of the SMEs. It is important to note the first two significant determinants of innovation efforts are external factors and the environment of which SMEs can take advantage. When the innovativeness of the small firms are compared between developed and underdeveloped countries, Radas and Bozic (2009) determine the same factors such as market scope, the firm's market orientation and the presence of strategic, managerial and marketing changes are positively associated with the firm's innovativeness.

In clustering a sample of small manufacturing firms into innovative and non-innovative distinct groups, Khan and Manopichetwattana (1989) argue the distinction appears mostly because of the differences in the entrepreneurial characteristics of these firms. They identify two different groups of small innovative firms where the firms in the first group are significantly younger than average, more proactive, have greater willingness for risk taking and spend more on research. The second innovative group of firms is characterised by higher management quality employing higher scanning for decision-making and analysis, higher environmental dynamism, a higher number of educated executives and less centralised organisational structures. The study concluded that the abundance of resources in general does not correspond to successful innovation; however, the resources in R&D can trigger innovation in small firms.

New and young firms can be very creative as can be seen in the Patent Co-operation Treaty (PCT), which suggests a significant number of patent applications come from new firms with about 14% in the USA, 16% in Denmark and 22% in Norway (OECD, 2010). While young firms that are proactive, have strong external links, spend more on research can be very innovative, in most instances the empirical evidence is limited to the generalisation of these views. On one hand, SMEs are regarded as important developers of radical innovation by entrepreneurs based on self-reported data, but on the other hand, it is difficult to identify SMEs innovativeness based on an object-based approach using the official data (Massa and Testa, 2008). Different perspectives concerning innovation by entrepreneurs, academics and policy makers highlight the difficulty in measuring the innovativeness of firms, especially small firms. As Pavitt et al. (1987) point out “the relationship between innovative activity and firm-size may well be increasingly u-shaped, rather than r-shaped,” strengthening the innovative capabilities of small firms in the earlier stages of their life cycle, which can be critical for boosting the innovativeness of these firms.

2.2 Strengthening the innovative capabilities of SMEs

SMEs are challenged most when accessing resources and new technologies to innovate and commercialise their innovations and to further invest in R&D to stay competitive among their rivals including large enterprises. Finding remedies to SMEs’ challenges on the road to innovation is becoming one of the top priorities in governmental efforts of many countries (Jun et al., 2013; Radas and Bozic, 2009; Hoffman et al., 1998). SMEs should be supported by government policies to some extent at least at the early stages of their life cycle. SME innovativeness can be enhanced through deliberately chosen and practiced innovation directed policies (Keizer et al., 2002).

The comparative disadvantages of SMEs reflect on the failure rates of SMEs as well. According to the statistics by the United States Small Business Administration in 2010, three out of ten new businesses fail within two years of establishment and 49% fail within five years of establishment. The numbers are more or less the same across different countries. SMEs naturally lack abilities with their small scales and scarce resources (human and capital) enabling them to establish links to sources of outside knowledge. The productivity gap between small and large sized companies has been constantly increasing as SMEs lag in the use of innovative and newer technologies. Korea, Japan, Singapore and Israel develop policies to support high-growth SMEs. These high-growth companies are foreseen as the potential high innovators of the future, which can significantly contribute to the economic wealth by creating new jobs that are disproportionately larger than the so called ‘general SMEs’ (Lilischkis, 2011).

A recent study on international benchmarking of countries’ SME support programmes reveals leading countries support programmes have moved from helping SMEs to improve process and product capabilities to supporting their efforts to innovate and commercialise new technologies. Keizer et al. (2002) point to an important issue that SMEs should be encouraged by governments to maintain innovation directed policies to foster the innovativeness of these firms. According to a recent report on ‘International benchmarking of countries’ policies and programmes supporting SME manufacturers’ by the Information of Technology and Innovation Foundation (ITIF), such support programmes in the USA (MES), the UK (MAS) and Canada stimulated new jobs, total new sales and contributed to an increase in R&D growth and the capabilities of SMEs (Ezell and Atkinson, 2011). The Korean government developed an SME technology roadmapping programme in 2007 as a policy promoting the national innovation system. SME technology roadmaps have contributed to the strengthening of the capabilities of human resources, establishing R&D strategies and enhancing the success rate of commercialisation for small Korean firms (Jun et al., 2013). More governments are using R&D tax incentives to make their countries attractive locations for R&D investments, to maintain jobs, to increase R&D intensity and growth performance. R&D tax incentives are especially crucial for small firms and start-ups as such firms will be more credit constrained when investing in new technologies, products and processes (Lentile and Mairesse, 2009; OECD, 2010).

Recently, there has been extensive support from many countries within the EU, Canada and Japan for jumpstarting innovation activities of small businesses (Ezell and Atkinson, 2011). These countries promote the innovativeness of SMEs in the manufacturing sector by offering technology acceleration programmes to promote technology adaption by SMEs and to support technology transfer, diffusion and commercialisation activities. While SMEs are granted R&D funds to back them up financially, next generation technical assistance is also provided in exporting, promoting energy-efficient manufacturing practices and in promoting continuous productivity improvement. Finally, for the practices of the SMEs to be most productive, programmes using multi-firm training are implemented and conference events are organised by a number of countries. Shapira (2008) points out the policies initiated by US and Japan policy makers such as framework actions, industrial services and regional clustering to stimulate innovation among manufacturing SMEs.

The increased interest to support SMEs in encouraging entrepreneurship and improving access to finance and new technologies is obvious; yet, there is a lack of studies that could substantiate the effectiveness of these policies in exploiting the capabilities of SMEs. As noted in the background report entitled 'Promoting entrepreneurship and innovative SMEs in a global economy' (OECD, 2004), there are limited high quality empirical studies allowing the analysis of important economic forces or policies over time making a poor empirical basis for SME policy. Systematic assessment and evaluation of such policies and support programmes are needed to improve the effectiveness of these policies. While, the allocation of funds change considerably even within the same country, it is essential to conduct comparable studies that are country-based and across countries, as well.

2.3 Measuring the Effect of Innovation on Firm Performance

There are many studies in the literature on the relationship among innovation, productivity and firm performance. Although the consensus is around the positive impact of innovation on performance (Lev and Souggianis, 1996; Ettlie, 1998), there are other studies stating the impact is not significant and it is difficult to quantify (Chan et al., 2001; Kandybin and Kihn, 2004; Jaruzelski et al., 2005). While this is the view from the perspective of mostly large and global firms, the situation is less clear from the point of the small and medium-sized firms. It is obvious R&D has been treated as the most common representative of innovation in the literature. Hall and Mairesse (2006) review a significant number of studies, which establish a positive link between R&D and productivity. These studies cover a wide range of firms across countries from the USA to Germany, Norway to Sweden and Italy. R&D definitely affects performance but forming R&D and finding resources to establish R&D is a greater issue on its own for SMEs compared to large and global firms. Hall et al. (2009) point this issue out claiming R&D itself does not capture all aspects of innovation, most of which occurs through other channels. By developing a structural model of innovation Hall et al. (2009) show R&D affects product and process innovation and in turn process innovation improves the firm's productivity where the effect is greater among young SMEs that are relatively smaller in size.

There is empirical evidence in the prior literature on the positive link between innovativeness and business performance and firm productivity of SMEs. Gray (2006) shows firms that innovate operate more profitably compared to firms that do not innovate using a data set of British SMEs. A similar effect of innovation on performance is established among Norwegian SMEs. Robinson and Stubberud (2011) establish the highly important effects of innovation for 3,233 innovative Norwegian SMEs, which are: increased range of goods and services, improved quality in goods and services, entering new markets or increasing market shares and improved flexibility of production or service provision using a survey data from the Eurostat Community Innovation.

Terziovski (2010) points to the disadvantages of SMEs related to innovation compared to large organisations. The resource limitations and informal strategies make SMEs more vulnerable compared to large firms in highly ambiguous business environments. Their results suggest innovation strategy and formal structure are the key drivers of innovation in manufacturing SMEs. Moreover, they conclude SMEs in manufacturing are less innovative than large manufacturing firms. In this direction, Acs and Audretsch (1988) present a model to investigate the degree to which innovative output is affected by different industry characteristics and the differences between small and large firms in response to innovativeness. Using a data set of a fairly large number, 8,074 innovations were released by the US Small Business Administration and the authors showed innovative output increases with the industry's R&D expenditures as well as the extent to which large firms comprise the industry.

3 Data and methodology

Despite the many contributions in the field, there is no clear understanding how the government-initiated policies reflect on small firms' innovativeness and financial performance. Given R&D is linked to increased firm productivity and performance (Hall et al., 2009; Hall and Mairesse, 2006), the investment in small firms' innovativeness should result in innovation outputs and financial performance in some way. We propose an empirical approach to determine the effects of support funds on firm financial performance. We use multiple regression analysis to determine the effects of support funds on the dependent variable, firm net sales. Potentially, there are a multitude factors affecting the financial performance of SMEs besides innovation related measures. To account for this, we control for location, size of the firm and industrial sector in all our empirical models we developed in the following sections.

3.1 Data and descriptive statistics

We obtained firm-level support funds data including firm-level financial data from the KOSGEB. Support funds data were collected from 844 SMEs concentrated in industrial sectors such as manufacturing, construction, wholesale, information and communication technologies and professional, scientific and technological activities. There are only a few firms in some of the industrial sectors that span our firm level dataset; therefore, we classify firms into four main industries by collecting a relatively small number of firms in other industries: manufacturing, information and communication, professional, scientific and technological activities and other.

The main independent variables of this study are the two types of support funds for innovation: the support programme for R&D, innovation and industrial applications (*RDInnovInd*) and the support programme for the development of technology and innovation (*DevTechInnov*). While 581 firms have been granted by the support fund for R&D, innovation and industrial applications between the years 2010 and 2012, 328 firms are supported by the programme development of technology and innovation over the years 2009 to 2011. However, not all firms have been granted by both funds during the three years from 2009 to 2012.

Table 1a Type of support programme versus industrial sector

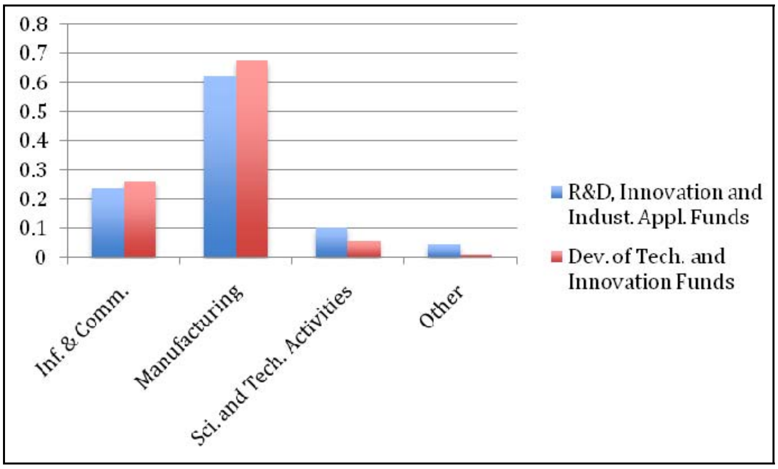
Location	*Type of support programme*	
	R&D, innovation and industrial applications support (% supported)	*Development of technology and innovation support (% supported)*
Manufacturing	361 (62.13)	221 (67.38)
Inf. and comm.	136 (23.41)	85 (25.91)
Sci. and tech. activities	58 (9.98)	18 (5.49)
Other	26 (4.48)	4 (1.22)
Total	581	328

Table 1b Type of support programme versus location

Location	*Type of support programme*	
	R&D, innovation and industrial applications support (% supported)	*Development of technology and innovation support (% supported)*
KOSGEB centre	130 (22.38%)	92 (28.05%)
Industrial zones	146 (25.13%)	65 (19.82%)
Tech. dev. zones and techno parks	108 (18.59%)	54 (16.46%)
Other	197 (33.91%)	117 (35.67%)
Total	581	328

Tables 1a and 1b give the characteristics of the sample, which provide a distribution of the firms with respect to the industrial sector and location for the two types of funds, separately. Figure 1 presents the partition of the funds across different industrial sectors. As Table 1a reveals a high percentage of the firms granted both funds lie within the manufacturing sector i.e., 62.13% and 67.38% for R&D, innovation and industrial applications support programme and development of technology and innovation support, respectively. Firms classified in information and communication sectors follow the manufacturing firms with the respective percentage shares of 23.41% and 25.91% for *RDInnovInd* and *DevTechInnov*, respectively.

Figure 1 Partition of funds for R&D, innovation and industrial applications and development of technology and innovation with respect to industry sectors throughout 2009 to 2012 (see online version for colours)



Location as shown in Table 1b is specified by means of four different levels that are the KOSGEB technology development centres, industrial zones, technology development zones and techno parks and other locations. The KOSGEB established technology centres referred to as *Tekmer* collaborated with prestigious universities in major cities. Industrial zones comprise organised industrial zones and small industry zones. Technology development centres and technoparks are among the important interfaces enabling the knowledge produced at universities to diffuse to the tenants of the technology parks. Identifying location is important here as there are many firms in this data set located in technology development centres and techno parks established by the ministry of science, industry and technology to promote the innovativeness of SMEs. Various grants and soft loans, tax relief, exemptions and other tax-based support are provided to the tenants of these centres to boost their innovation activities.

Table 1b reveals 22.38% of all firms are supported through funds for R&D, Innovation and Industrial Applications are located in the KOSGEB technology development centres, whereas 18.59% are located in technology development zones. Corresponding percentages are 28.05% and 16.46% for firms supported through funds for the development of technology and innovation. There are also significant percentages of firms, respectively, 33.91% and 35.67% for the first and second fund located in other places. More detailed illustrations of the distribution of firms across different industrial sectors and locations are given in Tables 2a and 2b for each support fund separately.

A firm's innovative activities tend to stimulate net sales. Different measures of firm performance used in the previous literature are briefly summarised in Artz et al. (2010). Focusing on the net sales aspect of firm performance, we consider net sales as the dependent variable in this study. Because firm size contributes to the variation in firm performance (Kotabe et al., 2002), we control the firm size measuring the size as the logarithmic function of the total assets. To control the industry effects, we define a dummy variable for each industry. We chose other industrial sectors as base dummies. Thus, three binary dummy variables are defined to indicate the industrial sector of the firm: *DSecMfg*, *DSecInfComm* and *DSecSciTech*. Similarly, a dummy is associated with the location of each firm. Technology development centres and technoparks are designated as the base dummies. Thus, *DKOSGEB*, *DIndustZones* and *DOther* represent the regions of the firms in our data set.

Table 2a Characteristics of the sample granted by the *R&D, innovation and industrial applications* support programme

Industry	*Total number*	*Number of firms with respect to location*			
		KOSGEB centres	*Industrial zones*	*Tech. dev. zones and techno parks*	*Other*
Manufacturing	361	57	138	45	121
ICT	136	46	1	41	48
Sci. and tech. activities	58	23	3	20	12
Other	26	4	6	2	14

Table 2b Characteristics of the sample granted by the *development of technology and innovation* support programme

Industry	*Total number*	*Number of firms with respect to location*			
		KOSGEB centres	*Industrial zones*	*Tech. dev. zones and techno parks*	*Other*
Manufacturing	221	45	64	24	88
ICT	85	38	-	25	22
Sci. and tech. activities	18	9	2	5	2
Other	4	-	1	-	3

Table 3 Descriptive statistics of the major variables

	RDInnov-Ind	*DevTech-Innov*	*Total-funds*	*Net sales (× 1,000)*	*Total assets (× 1,000)*
			Manufacturing		
Mean	54,864	31,853	49,632	2,115	1,948
Min	232	149	149	–61	–10
Max	345,900	210,000	524,460	50,560	29,503
Stdev	61,595	49,723	62,409	4,776	4,039
			Information and communication		
Mean	29,070	9,916	24,101	481	446
Min	750	460	460	0	–18
Max	355,225	35,000	355,225	17,251	14,549
Stdev	34,931	5,786	31,007	1,680	1,522

Notes: *RDInnovInd* represents the funds for R&D, innovation and industrial applications,
DevTechInnov represents the funds for development of technology and innovation,
TotalFunds represent total support funds,
All numbers are given in TL

Table 3 Descriptive statistics of the major variables (continued)

	RDInnov-Ind	*DevTech-Innov*	*Total-funds*	*Net sales (× 1,000)*	*Total assets (× 1,000)*
			Sci. and tech. activities		
Mean	37,846	10,298	33,029	517	364
Min	182	490	182	0	0
Max	198,742	46,886	198,742	26,279	9,327
Stdev	39,114	9,306	37,456	2,818	1,088
			Other		
Mean	40,471	39,932	41,286	337	574
Min	1,125	595	595	0	0
Max	190,151	75,600	190,151	2,897	5,427
Stdev	38,803	38,587	38,715	741	1,269

Notes: *RDInnovInd* represents the funds for R&D, innovation and industrial applications,
DevTechInnov represents the funds for development of technology and innovation,
TotalFunds represent total support funds,
All numbers are given in TL

Descriptive statistics of the major variables are provided in Table 3. We compute the mean, median and standard deviation of the support funds (*RDInnovInd* and *DevTechInnov*), total assets and net sales for samples of firms across different industrial sectors. The average for the funds for R&D, Innovation and Industrial Applications is highest for firms residing in the manufacturing sector with an average support of 54,864TL. Similarly, firms in the manufacturing sector have the highest average amount for the total amount of funds with 49,632TL.

3.2 Regression analysis

We investigated the effects of the support funds (funds for R&D, innovation and industrial applications and funds for development of technology and innovation) on firms' net sales. We tested the effect of two funds separately, which we refer to as model 1 and model 2. While firms in our data set have been granted through two different types of support funds by the KOSGEB, we have only three years of data for each type of the support funds. 581 firms received *RDInnovInd* funds between the years 2010 and 2012 while 328 firms received *DevTechInnov* funds between 2009 and 2011. We investigated the effect of the sum of two funds on firm net sales to increase the time span of the data. The regression equation takes the following form where *InnovFunds* reflects the *RDInnovInd*, *DevTechInnov*, or *TotalFunds*.

$$NetSales_{i,t} = \alpha_0 + \alpha_1 InnovFunds_{i,t} + \alpha_2 Size_{i,ti,t} + \sum_k \alpha_3 Industry_{i,k} + \sum_j \alpha_4 \operatorname{Re}gion_{i,j} + \varepsilon_{i,t}$$

The indices i and t represent the firm and the year, respectively. $\varepsilon_{i,t}$ is the error term. Technology development zones and technoparks were chosen as base dummy for the region whereas firms classified in industrial sectors referred to as *other,* include industrial sectors such as wholesale, construction and electricity, which were chosen as base dummy for the industrial sector.

Table 4 Pooled regression analysis of the support funds

	Model 1	*Model 2*	*Model 3*
RDInnovInd	0.06200		
DevTechInnov		0.00702	
TotalFunds			0.04048**
Size	0.56270***	0.50548***	0.49391***
DKOSGEB	0.10918**	0.15070**	0.08804***
DIndustZones	0.12457**	0.17971***	0.11140***
DOther	0.10130**	0.25713***	0.13343***
DSecMfg	0.09203	0.24588	0.13312**
DSecInfComm	0.07766	0.18771	0.05782
DSecSciTech	0.05376	0.07414	0.03885
Adj. R^2	0.3684	0.3284	0.2965

Notes: Dependent variable = net sales,
Regression coefficients are standardised,
*** (**, *) indicate 1%, (5%, 10%) level of significance

Table 4 provides the parameter estimates of the regression models considered in this study. The positive and significant impact of *TotalFunds* on net sales indicates support funds for national innovation policies resulting in an increase in the net sales of the small firms supported through these funds. Size is also positively related to the net sales of SMEs. According to model 3, while firms in the manufacturing industry have a significant and positive impact on net sales as compared to firms classified in other industrial sectors, we do not observe this significant and positive impact for firms in the information and communication industry. With respect to location, firms located within the KOSGEB technology development centres, industrial zones and in other locations significantly increase the net sales. Firms located in technology development centres and technoparks do not positively contribute to net sales. About 60% of all firms in our data set are classified in the manufacturing sector. This can be partially explained because a significant portion of firms in our data set is classified in the manufacturing sector and most of these firms are located in industrial zones.

4 Discussions and conclusions

Despite the increased policies and support funds for nurturing innovation activities of small firms all around the world, quantifying the effects of these polices on firm productivity or performance has long been neglected. While developing policies and supporting SMEs is crucial for the survival of small firms, systematic statistical measurement of SME policies is needed to improve the effectiveness of these policies. We measure the effectiveness of support funds provided by one of the largest public agencies in this field in Turkey, the KOSGEB. Yet, comparative studies among different sources of this kind of support within Turkey as well as cross-country comparative studies must be prepared to analyse the impacts in the long run.

This research contributes to the literature by examining the effects of support funds on firm net sales. 844 SMEs receiving financial support from the KOSGEB were tracked during the years 2009 and 2012. Most of the SMEs receiving these funds are active in the manufacturing, information and communications sectors. According to the regression results, support funds significantly increased the firms' net sales. In addition, the firm size positively contributes to net sales. Our results also reveal manufacturing firms have higher net sales compared to other firms. Moreover, firms located within KOSGEB centres, industrial zones and other regions have higher net sales than firms located in technoparks and technology development centres. This can partially be explained because most of the SMEs supported by the KOSGEB are manufacturing firms located in industrial zones and KOSGEB centres. A significant portion of the firms that are active in information and communication technologies, although small in number, are located in technoparks and technology development centres. While these knowledge-intensive small firms have more potential in nurturing the innovativeness of the economy by developing value added products and services, most of them are so small they cannot compete with their larger counterparts.

Innovation requires high R&D investments that are typically risky and positive outcomes are uncertain in the short-run. Small firms often lack the resources to invest in R&D and innovation. Nevertheless, our analyses indicate support for innovation pays off in terms of higher net sales for manufacturing SMEs. However, this does not necessarily suggest innovation results in lower or non-significant benefits in financial measures for firms specialised in information and communication technologies. Since the data span of this study was limited to a few years (i.e., from 2009 to 2012), the non-significant effects of other industrial sectors other than manufacturing could only be inferred rather than generalised. Future research should collect longitudinal data on a larger number of firms more balanced with respect to different industrial sectors.

This study has key implications for government agencies, practitioners and researchers. The findings of this study shed light on the essential role of innovation policies and supports fostering the innovation activities of Turkish SMEs. From the Turkish Government's perspective, support funds for innovation results in higher financial performance for SMEs benefiting from these funds. The solid empirical evidence will provide insight to future support programmes within the KOSGEB and other private and public sector agencies. There is need for a more careful distribution of these funds relative to the firm's industrial sector with more special devotion towards technology-based firms having higher potential for innovation, firm size and location of the firms. Location can make a significant contribution to value-added in terms of financial and innovation performance as it has been extensively discussed in the literature concerning on- and off-science or technology park firms (Lindelöf and Löfsten, 2002). However, the small number of firms located in such parks in our sample limit was used to fully observe the effects of these locations on firm financial performance. Given this insight, KOSGEB and similar agencies can improve the effectiveness of the support programmes in the long-term and establish new funds and support programmes to further foster the innovativeness of small firms.

The sample for this study was drawn from the KOSGEB, which was limited to a few years (from 2009 to 2012). Given the short time span of our sample, we investigated the contribution of support funds in current net sales. A longer span of time would allow us to investigate the effect of support funds for innovation on the differences in financial firm performance before and after funding opening a new avenue for future research. The research model could be further tested using samples from other supporting agencies and countries. In this study, the firm's performance was measured using net sales considering the investments in innovation would be reflected in the firm's financial performance. However, there are other important measures of innovation outputs such as patent count and number of new products and services that could be used to test the contribution of support funds in innovation on these measures of innovation outputs. Moreover, there exist other factors such as firm's age, firm's technology and R&D investments and entrepreneurship capital, which could also effect (marginal and joint effects) a firm's innovation performance. Since it is not easy to quantify factors such as entrepreneurship capital, further data needs to be collected through surveys and interviews. Finally, the findings can also be used to compare similar effects in different countries at least from a researcher's point of view.

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Knowledge infrastructure capabilities and knowledge management: case of an Indian public sector undertaking

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Abstract: This paper empirically examines how knowledge infrastructure capabilities play a supportive role in the knowledge management initiatives of a public sector undertaking in India. A single case study strategy has been used in the paper to mainly address a 'how' question, relating to the role of infrastructure capabilities in knowledge management within an organisation embedded in its social context. Future studies can compare the results of the study within the same sector or compare across private sector companies from India in similar industry type. As knowledge management in public sector companies of India is still in the initial stages, this study can help the senior management of these companies to understand the role of knowledge infrastructure capabilities in knowledge management initiatives. This paper adds empirical insight from an Indian point of view to the limited existing literature on KM in public sector companies.

Keywords: knowledge management; knowledge infrastructure capabilities; public sector companies; culture; structure; technology; India.

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1 Introduction

Organisations in the modern era of globalisation and increasing competitiveness are making strides towards knowledge age from information age and knowledge is constantly being regarded as the most important asset that organisations can possess (Davenport et al., 1998; Wiig, 1997). Literature is replete with the scholarly work suggesting the importance of knowledge in gaining competitive edge. For example, Bailey and Clarke (2000) and Cropley (1998) point out that management of knowledge has specific significance in defining managerial work and enabling decision-making. Nonaka (1991, p.96) in his early works claimed that "in an economy where the only certainty is uncertainty, the one sure source of lasting competitive advantage is knowledge". Senge (1997, p.18) also commented that "organizations can't thrive and achieve sustained growth without adapting their attitudes about the value of collective knowledge within an organization".

Effective knowledge management for organisations is indeed very critical as organisations strive to increase their competiveness and gain economic edge. From core competencies of the businesses, knowledge management can be helpful in creating value, achieve goals, develop greater value, and bring innovative solutions (Tiwana, 2000). An increasing number of firms today realise that management of knowledge is a key to business sustainability and competiveness. This has led to increased interest in creating and understanding knowledge which is considered as greatest asset for strategic decision-making (Keskin, 2005). However failed knowledge management programmes and systems far outnumber successful ones because many companies experience unexpected challenge in devising KM strategies and supporting them with the resources available to them (Storey and Barnett, 2000; Braganza and Möllenkramer, 2002). These challenges mainly include managing culture, structure and technology within the firm supporting KM (David and Fahey, 2000; McDermott and O'Dell, 2001; Syed-Ikhsan and Rowland, 2004; Yang and Chen, 2007).

Although these challenges are discussed in the literature with empirical evidence, there is paucity of literature and information on this issue in cases of public sector organisations. Most of the studies concentrate on private sector organisations, as implementation and achievement of goals can easily be identified in case of private sector organisations. A recent study from India by Pandey and Dutta (2013) studied the knowledge infrastructure capabilities in a private IT and ITES company operating globally. Another study by Chawla and Joshi (2010) in India context reported that knowledge management in public enterprises in India is still in its infancy and has a long way to go in order to keep pace with private sector counterparts. In their recent study of Greek public sector companies Tsirikas and colleagues (2012) found that introduction of knowledge management initiatives may significantly improve the workers' productivity and thereby suggesting the importance of such studies in public sector companies. McAdam and O'Dell (2000) in their study found that organisational knowledge is seen to be much more important in the public sector enterprises than in the private sector. This is primarily because for a long time employees in public sector are identified as the key knowledge repository, whereas there is usually a higher attrition in the private sector for better opportunities and higher pay. Hence, the present study concentrates on KM and the capabilities supporting KM in an Indian public sector enterprise, which is characterised by job security and full pay guarantee as per the federal pay commission norms.

2 Objective of the study

The purpose of this study is to explore the role of knowledge infrastructure capabilities in KM in public sector of India. The study aims to understand how cultural, structural and technological capabilities help in supporting KM practices and processes. The research question taken up therefore centres on understanding how knowledge infrastructure capabilities help in achieving KM goals and objective in a public sector company.

3 Theoretical perspective

3.1 Distinction between public and private sector organisations

Scholars have found it important to distinguish between public and private sector organisation. Researchers argue that in order to effectively manage public organisations, a deep understanding of this distinction is necessary. Early works of authors like Rosenbloom and Goldman (1993) suggest that although there are several aspects of management that are common, public and private organisations are quite dissimilar in terms of their constitutions, public interest, markets and sovereignty.

In his book *Understanding and Managing Public Organizations*, Rainey (1997) summarised the distinctive nature of public sector organisations under five points. He claimed that first; "most public organizations do not sell their outputs in economic markets". Second, "distinct nature of transactions with the external environment" (p.171). Third, "greater constraints and diffuse objectives in public organizations allow managers less decision-making autonomy and flexibility than their private counterparts". Fourth, "public employees personality traits, values, needs, and work-related attitudes differ from those of private employees". Fifth, "government organizations do not operate as efficiently and effectively as private organizations". The last characteristic can be taken as a typical feature of an Indian public sector undertaking since they are usually is criticised for being insufficiently effective and efficient. Generally elsewhere in the world, as a response to this criticism new management techniques and effectiveness in operations is being developed by public sector companies. Leaders in public sector organisations are now found to set high standards of effectiveness in their functioning (Fernandez and Rainey, 2006). The need for public sectors to adopt principles and practices of private sectors is concerned with the approach of leveraging on the knowledge existing within the company with the human capital (Brignall and Modell, 2000).

Figure 1 Classification of public sector undertakings in India

Miniratna Category II	Miniratna Category I	Navratna	Maharatna
• Should have made profit for the last 3 years and have a positive net worth • Have not defaulted on loans/interest repayment to the governmnet • No dependency upon budgetary support or Government guarantee. • Induction of at least three non-official Directors as the first step before the exercise of enhanced delegation of authority.	• Should have made profit in the last three years continuously, the pre-tax profit should have been Rs. 30 crore or more in at least one of the three years and should have a positive net worth. • Have not defaulted on loans/interest repayment to the governmnet • No dependency upon budgetary support or Government guarantee. • Induction of at least three non-official Directors as the first step before the exercise of enhanced delegation of authority	• Should be a Minitratna 1 and Schedule A company • Should have "excellent"/"very good" rating in 3 of the last 5 MOU's • Have scored a composite score of 60 or more for 7 identified parameters/ratios.	• Should have a navratna status • Listed on the Indian stock exchange, with a minimum prescribed public shareholding under SEBI regulations • An average annual turnover of more than Rs. 20,000 crore during the last three years • An average annual net worth of more than Rs.10,000 crore during the last three years • An average annual net profit of more than Rs. 2,500 crore during the last 3 years • Significant global presence or international operations

Source: Department of Public Enterprises, Government of India

3.2 *Classification of public sector enterprises in India*

The central public sector enterprises (CPSEs) form an integral part of the Indian economy. Since their evolution these enterprises have played a prominent role in the country's growth and economic development (Agarwal, 2001). Industrial Policy Resolution (IPR) of 1948 emphasised the need of securing increase in production and equitable distribution (Majumdar, 1998). This saw acceleration in the rate of economic growth and rapid industrialisation. Need to participate in global trade and economic crisis in late eighties led to the economic reforms in the year 1991 this resulted in the opening of economy and abolition of license system in many sectors. To remain competitive in the open economy and match the efficiency of private sector companies Department of Public Enterprises (DPE) took up the measure of empowering the profit making CPSEs by granting them operational and financial autonomy. As shown in Figure 1. after assessment based on select criteria, CPSEs are awarded the status of ‘Maharatna’, ‘Navratna’, ‘Miniratna – Category I’ and ‘Miniratna – Category II’ by the DPE, thereby granting enhanced powers.

3.3 Knowledge and knowledge management

Researchers have often found it difficult to define knowledge. Distinctions between data, information and knowledge appear several times in literature of different streams such as philosophy, psychology, information systems and artificial intelligence (Alavi and Leidner, 2001; Bhatt, 2001; Grover and Davenport, 2001); however in practice these three terms are used interchangeably. Data are objective facts; information is considered as structured and organised data; while knowledge can be understood as meaningful and value added information which has been filtered by human minds. When these three are organised in a single continuum knowledge occupies the highest place with greatest relevance and requires maximum human involvement when compared to data and information (Grover and Davenport, 2001).

Discussions on the classification and taxonomies of knowledge are found abundantly in the literature (for e.g., Alavi and Leidner, 2001; Civi, 2000; Lee and Yang, 2000). Widely used and accepted classification suggests that knowledge can be divided into two types primarily:

a tacit knowledge, which mostly resides within the individual in the form of experiences and know-how

b explicit knowledge, which is articulated, codified, stored and formalised in the files and archives in the physical or electronic form.

3.4 Knowledge management

Knowledge management can be viewed as a multi-dimensional, multi-disciplinary and multi-faceted concept. It borrows its meaning and definition from several disciplines such as sociology, psychology, information systems, artificial intelligence, etc. (Kakabadse et al., 2003).

Sabherwal and Becerra-Fernandez (2003) defined knowledge management as “[...] doing what is needed to get the most out of knowledge resources. Knowledge management focuses on organizing and making available important knowledge, wherever and whenever it is needed”. According to Tomas and Hult (2003) knowledge management is “[...] the organized and systematic process of generating and disseminating information, and selecting, distilling, and deploying explicit and tacit knowledge to create unique value that can be used to achieve a competitive advantage in the marketplace by an organization”. Various other definitions abound in the literature. In the broadest sense, however, KM can be considered as an active organisational approach to leverage upon and optimise the knowledge present in the organisation. These organisational approaches may vary from organisation to organisation but aim at increasing competitive advantage through the management of knowledge.

In an effort to manage knowledge, organisations have been adopting the practice of knowledge management thick and fast. However, it has been noted that not all of them achieve the desired result. Lucier and Torsilieri (1997) noted that 84% of KM programmes had no significant impact on the adopting organisation. Chua and Lam (2005) in their study also found that there are few studies reporting the failure of knowledge management, however the number of failed cases is high.

3.5 Knowledge infrastructure capabilities: preconditions to success of KM

Gold et al. (2001) argue that not all firms are equally predisposed to launch and maintain the knowledge management initiatives and hence they vary in achieving the objective. Therefore, it becomes important for firms to identify and access the preconditions to achieve the desired outcome. Literature in organisational behaviour and strategic management describe these preconditions as capabilities (Kelly and Amburgey, 1991; Leonard-Barton, 1998), which can be primarily considered as infrastructural in nature with respect to KM. To leverage upon the knowledge present, key infrastructural capabilities are cultural, structural and technological (Gold et al., 2001).

These infrastructural capabilities are termed as knowledge infrastructure capabilities. These capabilities form the basis of this paper and are discussed in the following subsection.

4 Research approach

4.1 Research design

Yin (1989) posits that one of the important factors to choose research methodology is the objective and nature of the research problem or question. Yin (1989) also suggests that ‘how’ questions are exploratory ones and methods such as case studies, histories, and experiments are well suited to find preliminary insights to such questions where the phenomenon has been subjected to much systematic study.

Thus this paper used an exploratory single case study design. Klein and Myers (1999) also maintained that case study approach is better equipped to allow us to capture the organisational dynamics of the phenomenon. Supporting Klein and Myers (1999) argument, Langley (1999) suggests that, case study method is found to be appropriate way of inquiry when the complex phenomenon at hand cannot be easily separated from the organisational context.

4.2 Selection of case

Selection of the case for this study was made on the criteria that the public sector company should have a declared knowledge management system in place. The case company, National Thermal Power Corporation (NTPC), is a representative case with relative stable set of knowledge management practices and processes in place. The human resource vision of the company also clearly states the achievable objective of becoming a learning organisation.

4.3 Data collection and analysis

Multiple sources of evidence were used for this study which involved in-depth interviews, documentation, archival data, direct non-participant observations, and examination of organisational physical artefacts. Analysis of the data proceeded in the following order. Firstly, the interview transcripts were made. Secondly, according to the existing theories and perspectives, key themes were identified and classified into the groups and matched with archival data and organisational artefacts. Thirdly, by examining the role of capabilities in knowledge management, the findings were discussed.

5 Company overview

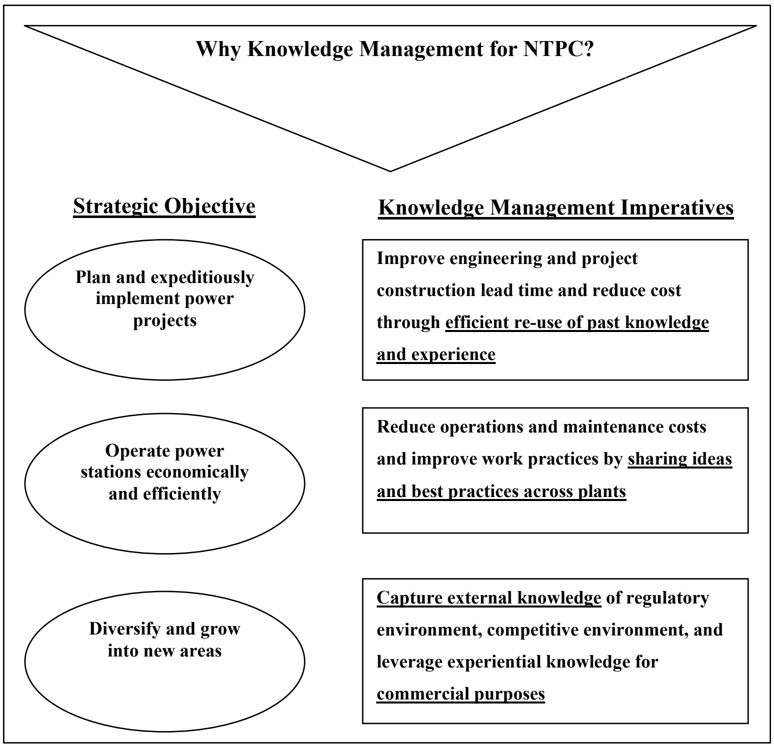
NTPC Limited is the largest thermal power generating company of India. It was incorporated as a public sector company in 1975, to accelerate power development in the country. At present, the Government of India holds 89.5% of the total equity shares of the company and foreign institutional investors, domestic banks, general public and others hold the balance 10.5% equity shares. Within a span of 30 years, NTPC has emerged as a truly national power company with power generating facilities in all the major regions of the country. NTPC was ranked 337th in the 2012, Forbes Global 2000 ranking of the World's biggest companies. With a current generating capacity of 39,674 MW, NTPC plans to become a 128,000 MW company by 2032. NTPC Limited has been ranked 3rd in the Top 10 Great Places to Work (GPTW) and has the distinction of being only public sector undertaking in the Top 10 Best Companies to Work for[1].

5.1 Knowledge management in NTPC

NTPC's knowledge management imperatives are derived from its strategic objectives and HR vision of becoming a 'learning organisation'. HR vision of NTPC states "to enable our people to be a family of committed world class professionals, making NTPC a learning organization". Knowledge management in NTPC is designed around three strategic objectives of planning and expediting in implementation of power projects, economic and efficient operation of power stations, and diversification and growth into new areas (see Figure 2).

Across its value chain of power generation business (this includes all backward and forward integration) NTPC has accumulated a vast knowledge base of power generation business from planning, engineering, power generation, etc. (see Figure 3). This knowledge base exists in the form of documents in the virtual as well physical libraries. For example regulatory requirement forms an integral part of planning for NTPC. Any expansion, modification, reconstruction or altercations in the power plants require several policy requirements to be taken into consideration. In NTPC, knowledge existing in the knowledge bases act as an instant guide to achieve multistage clearances in various operations of the company. Knowledge base serves as a tool of 'know-what' and 'know where' form of knowledge within the company.

Figure 2 Knowledge management at NTPC: objectives and imperative



Source: Company document

5.2 Cultural capability and knowledge management

According to Schein (2006), organisational culture refers to shared assumptions, values and norms. Barney (1991) suggests that culture is a source of sustained competitive advantage. Empirical research also supports this argument by making it as a key factor to knowledge management success and thereby contributing towards organisational effectiveness.

Adaptability, consistency, involvement and mission have been identified and validated as key dimensions of organisational culture that helps in organisational effectiveness (Denison and Mishra, 1995; Fey and Denison, 2003). Adaptability refers to the extent to which an organisation is able to alter its behaviour, structure and systems in the changing environment. Case insights revealed that NTPC has consistently evolved and adapted itself to the changing conditions from a monopolistic market to a highly competitive market. NTPC responded to the call of change in the knowledge dominated era of the decade of 2000 by adopting the KM systems and practices. It studied and understood KM in utility companies from early adopters and pioneers such as British Petroleum (BP), Pacific Gas and Electrical Company, Texaco and Chevron.

Figure 3 Knowledge accumulation across value chains in NTPC

	Planning	Engineering	New Capacity Creation	Power Generation & Dispatch	Collection
Key Business Processes and Activities	• Government liaison • Strategy formulation • Annual plans • New business development	• Feasibility reports • Plant configuration design; package definition • System engineering quality control • Technical evaluation of vendors	• Project planning • Project execution • Project commissioning	• Operations and dispatch • Maintenance • Procurement and inventory management	• Billing and collection • Tariff setting and filing
Residing Knowledge Base in NTPC (examples)	• Explicit and tacit stakeholder requirements • Regulatory requirements	• Cost engineering for feasibility reports • Plant performance specifications • Product specifications • Detailed engineering plan of civil, mechanical and electrical • Quality tests and clearance points for QA	• Package wise project execution activities • Activity dependence-serial vs parallel • Timelines for each activity; key milestones • Testing and schedules • Commissioning schedules	• Operations and maintenance procedures • Troubleshooting	• Regulatory guidelines • Customer requirements

Source: Company document

Consistency in organisational culture refers to the extent to which values, beliefs and expectations are held by the members in the organisation. NTPC being a public sector undertaking has consistency engrained in its organisational fabric, values beliefs and expectations to do public good is highly held by employees across its value chain. As stated earlier, a characteristic of public sector organisation is consistency in the values; the case company has systematically distributed organisational values within through a code of conduct which is highly held by all its employees. Involvement in organisational culture can be understood as participation in decision making by members in the organisation. Post KM system implementation NTPC has undertaken certain structural changes (discussed in the following section) which allow a greater share of members in the decision making. Creation of domain leaders in various functions and core groups allow a greater participation and involvement.

Embracing common mission is of paramount importance in success of knowledge management initiative, NTPC has ensured that mission is consistently shared and understood by individuals in the organisation to achieve a holistic support. In this line NTPC had some latitude to develop to share the mission thereby enabling knowledge sharing and creation. The framework was designed and implemented to facilitate the creation of domain knowledge repository comprising of members from previously unrelated entities. This further led to building of trust amongst key members and leaders of various power plants of NTPC to share best practices amongst them. With the main thrust on effective power generation and distribution this culture of knowledge sharing amongst various power plants has helped NTPC to become one of the best and largest power sector companies in the world.

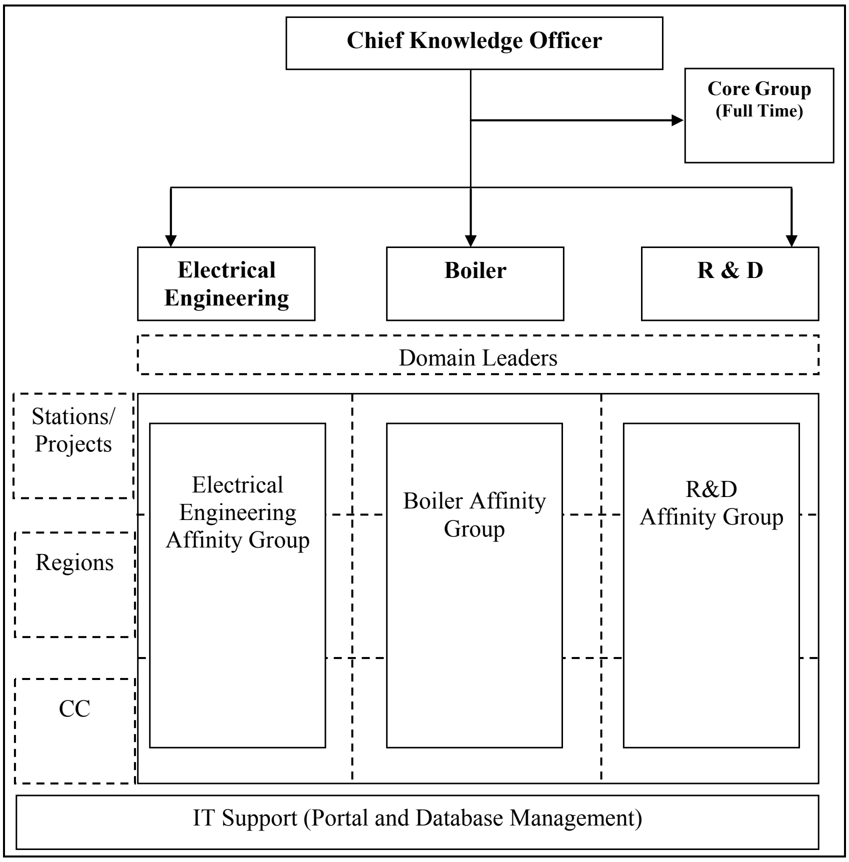
5.3 Structural capability and knowledge management

Besides organisational culture, organisational structure is also likely to affect the knowledge management initiatives in the organisation. Organisational structure usually refers to the formal operation and command structure (O'Dell and Essaides, 1998); it also constitutes the presence of trust and norm (Gold et al., 2001). Structure plays a crucial role in knowledge management in several ways; it institutes a reporting relationship conducive for sharing of knowledge, it helps the technological infrastructure to thrive and also enables decision making. Findings from this study suggest that organisation structure of NTPC is formalised and bureaucratised. Here formalisation refers to the degree of standardisation of jobs and employee behaviour being guided by rules and procedures (Andrews and Kacmar, 2001; Robbins et al., 2005). Operational procedures are highly ordered at plant level; however that does not restricts sharing of knowledge and generating new knowledge. To institutionalise knowledge management practice in the organisation, NTPC changed its organisation structure and added an additional vertical function of knowledge management headed by a chief knowledge officer (CKO). Figure 4 shows the reporting hierarchy to the CKO. Core Group reports directly to the CKO which is again divided into technical group and the services group.

As is clear from Figure 4, the Domain leaders from the pilot domain report to the CKO about the new and innovative practices in the power projects and in the regions of the power plant. In turn, CKO manage and monitor internal knowledge collection and management process through these domain leaders and core group. CKO is also responsible for managing external knowledge collection and assimilation through the support of core group. Rewards and employee motivation for KM process are defined and designed by CKO in consultation with the core group.

Role of core group: core group play a crucial role in the knowledge management at NTPC. It forms the central part of KM function and is responsible for managing both external and internal knowledge. Role of core group in external knowledge management is in assimilating external knowledge requirements from all domain leaders and identify user needs. Core group scans the external environment and identify external sources of knowledge/information; they focus upon procurement of this external knowledge through subscriptions, memberships, negotiations, payments, renewals, etc. Assimilated pieces of knowledge are uploaded on the knowledge portal and queries and needs are addressed by the core groups. In the internal knowledge management, core groups manage the overall design and structure of the knowledge base in consultation with the domain leaders. Core group supports CKO and domain leaders in the internal knowledge collection, categorisation, and uploading processes.

Figure 4 CKO and reporting relationships



Source: Company document

Role of domain leader: domain leaders are responsible for creating affinity groups in each plant for his/her domain. Upon creation of such affinity group domain leaders are required for development of a detailed knowledge map in consultation with the affinity group members and domain leaders of other power stations/regions. Management of identification, collection, assimilation, approval and giving access to the domain is also a responsibility of domain leader. Motivational process for KM is communicated to the CKO and core group by the domain leader to facilitate greater knowledge sharing.

Role of affinity groups: affinity groups identify potential sources of knowledge (individual employees) for internal knowledge capture. Members of the affinity group seek contribution from other employees for managing digitisation of the documents.

5.4 Technological capability and knowledge management

Technological capability for an organisation can be understood as its fundamental IT structure, which includes hardware, software, internal and external systems, networks and databases (Yang and Chen, 2007). Several authors have found technology as an important enabling feature in knowledge management systems. It helps in quick storage and retrieval of knowledge which enables innovation. NTPC implemented a strong knowledge management system based on its technological capability. In the year 2004, on the recommendation of AT Kearney NTPC launched project Disha, deploying a companywide knowledge management portal called 'Lakshya'. Lakshya is a one stop portal for all the needs of knowledge creation, sharing and application and is accessible from an integrated central source.

A companywide IT architecture at NTPC strongly supports the knowledge management system. Users at power plants, region and CC level have access to this KM system which works on an Internet Explorer (IE)-based browser. Database in NTPC is referred to as central knowledge database (CKD) which is linked to an application server and a search engine for query and retrieval. CKD is again divided into domains of engineering, operations, maintenance, project planning and HR. Knowledge documents are made available and updated on a continuous basis under each of the domains. For example for engineering domain knowledge documents of design specification, vendors data and quality plans are available. Similarly documents of procedure manual, best practices, troubleshooting are available under operations domain. Core group is responsible for codification, indexing, uploading, query handling, maintenance and access. Role of backend support in knowledge management system is that of database, application and network maintenance. Maintenance of CKD is handled at the corporate level while at plant level the system administrators look after the query generation and retrieval.

6 Discussions and conclusions

Through a single case study this paper provides an empirical insight into knowledge management systems in a top performing public sector undertaking in India. Deriving from the existing literature on capabilities and knowledge management, findings of this paper suggest that the three capabilities as discussed in this paper namely, cultural, structural and technological play a significant role in knowledge management implementation and working.

Though not a benchmark, KM in NTPC has done sufficiently well. As this study reveals that it has prevented the "re-invention of wheel" time and again thereby reducing employee effort to seek knowledge and experience. Case findings also reveal that KM in NTPC is now focusing on improving efficiency manifold times by making information readily available to the employees as users. This will enable more analysis of information rather than searching for information.

The current study is important for managerial considerations as well because it points out that KM being a business imperative also needs to be present in the greater philosophy of the organisation (becoming a learning organisation as in case of NTPC). Also it is important for knowledge managers and functional heads to understand that these capabilities work in close collaboration with each other. Success of KM initiatives depend largely upon the three capabilities a working together culture of sharing that is embedded in the organisational fabric of structure which allows knowledge sharing (for e.g., affinity groups in NTPC), specialised KM leaders like CKO and strong IT architecture which can lead to superior technological capability in the management of knowledge.

6.1 Limitations of this study

As pointed out by Hodkinson and Hodkinson (2001), by definition, case studies can make no claims to be typical. Single case setting is a limitation of this paper as it is embedded into a particular context that reflects the phenomenon of particular interest. Therefore, the case site chosen for this study cannot be declared as a model organisation in the public sector. However, this does not prevent from making theoretical generalisations, that can be extended to similar such organisational contexts and phenomena of interest. As pointed out by Yin (2003), case research designs can make theoretical generalisations but is not suitable for making statistical generalisations.

6.2 Recommendations for future research

Future studies can consider comparing organisations from public sector and private sector. This will enable a greater understanding of differences in the knowledge infrastructure capabilities in both the sectors. This distinction will prove to be helpful for managers in both the sectors as it will lead to adoption of best practices of managing capabilities from each other.

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When the Oryx takes off: Doha a new rising knowledge hub in the gulf region?

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Abstract: With accelerating pace in the past years, Qatar has strategically pushed forward its economic diversification. According to Qatar's long-term development vision, the knowledge-economy is taking a key role within this economic diversification process and the transformation of its capital into a regional as well as global service-hub. This paper aims at identifying emerging knowledge-based patterns that drive the Qatari space economy. We apply a research concept that brings together two different scientific angles: relational economic geography and physical urban development aspects. The results indicate first a subsidiary role for the Qatari knowledge intensive firms within the Gulf region; second their predominant connectivity patterns to Europe and South-East Asia; third as a distinct lack of urban amenities and qualities for knowledge workers.

Keywords: knowledge economy; Doha; Qatar; gulf; advanced producer services; APSs; high technology; urban hierarchy; urban development; economic geography; interlocking network analysis; space syntax.

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1 Introduction

'When the Oryx takes off' stands for a widespread process where globalisation has entailed a reorganisation of spatial development processes on a global, European, national and regional scale. The Oryx antelope is the iconic logo of Qatar Airways, which can be regarded as one epitome of Doha being a new rising hub in the Gulf region. One consequence of this global transformation is the emergence of a new spatial logic in which the structures of whole societies, economies and national states are determinate by different kinds of flows, such as information, capital and power flows. New forms of hierarchical and network developments and functional differentiation between cities can be observed (Hales and Pena, 2012; Sassen, 2001; Friedmann, 1986). As engines of wealth creation, cities have advanced to the position of global economy focal points. In this context, two competing interpretations of global trends in spatial development are identifiable. On one side of the debate is Friedman (2005), who takes the position that the world has become increasingly flat. According to Friedman, geography no longer matters. In opposition to his is Richard Florida, who claims that 'the world is spiky' (Florida, 2005). According to his point of view, a diminishing number of cities must compete for the talent and global business elites that drive the world's economy. And indeed, spikiness appears to have reignited the debate: developments in information and communications technology may have shrunk the world, but there appears little evidence that this is the end of geography or the 'death of distance' (Cairncross, 1997).

In order to understand the competitive nature of cities, especially those exposed to global competition, it is essential to understand the character of their networks. Manuel Castells published one of the most influential academic works in the recent past about this topic. According to Castells' (1996) seminal work on space of flows, societies are centred around a variety of flows: "flows of capital, flows of information, flows of technology, flows of organizational interactions, flows of images, sounds and symbols". They are the expression of the process dominating our economic, political and symbolic life. Thus, we propose the idea that there is a new spatial form characteristic of social practices that dominates and shapes the network society: the space of flows" (Castells, 1996). Castells develops a new perception of spatial and urban development by identifying the space of flows as the underlying concept of spatial developments rather than the space of places, represented by world cities and other territorial spaces: the global city is not a place, but a process (Castells, 1999). The rise of the networked economy, the space of flows and the growing spikiness of the global urban hierarchy is fuelled by advances in transport and telecommunication technologies in addition to the growing mobility of global business elites. In this context, the development of cities is increasingly dependent on their position in international flows of capital, knowledge, foreign direct investments and commodities.

In recent years the global economy has found itself in a transitional phase, "with an accent shifting in the sense that knowledge is steadily gaining weight as a production factor" (van den Berg et al., 2005; Rollwagen and Voigt, 2012). Today knowledge is considered a key driver for innovation, economic growth and spatial development. Moreover, it has become an integral part to not only those companies engaged in producer services and advanced manufacturing, but also to "firms in traditional industries in order to stay ahead of international competitors, occupy markets niches and maintain a competitive advantage" (Bathelt and Glückler, 2011; Rollwagen and Voigt, 2012). Although its rise has been noted since the 1960s, research still lacks a commonly accepted definition of what the knowledge economy exactly is. We use the definition by Lüthi (2011) who describes the knowledge economy as the "part of the economy, in which highly specialized knowledge and skills are strategically combined from different parts of the value chain in order to create innovations and to sustain competitive advantage" (Lüthi, 2011). In accordance with Thierstein et al. (2006) the knowledge economy is characterised by three important pillars: advanced producer services (APSs), high-tech industries and knowledge-creating institutions, such as universities and research establishments (Thierstein et al., 2006).

Following Polanyi's seminal classification, knowledge itself can be distinguished into codified or explicit knowledge on the one hand and tacit knowledge on the other (Polanyi 1966). As opposed to tacit knowledge, explicit knowledge is codifiable, articulable and storable – verbally, visually and symbolically. New information and communication technologies increasingly offer the opportunity to codify and commodify knowledge and make it tradable across time and long distances, which means that codified knowledge is becoming more and more de-territorialised. This enables companies to outsource activities and inputs globally and to benefit from relational proximity and international knowledge spillovers. Contrastingly, tacit knowledge is highly contextualised and not effectively transferable between individuals via certain media. With his well-known phrase 'we know more than we can tell' (Polanyi 1966), Polanyi illustrates the fundamental idea of the distinction between explicit and tacit knowledge (Gertler, 2003). Tacit knowledge in combination with personal experience is considered an essential prerequisite in creative processes and innovation and therefore as a foundation of the knowledge economy (Schamp, 2003).

Thus a key driver behind the development of spatial hierarchies is the functional logic of the knowledge economy. Firms that are engaged in innovation processes need constantly to create new knowledge and to manage these knowledge resources in an appropriate organisational structure. Knowledge creation requires both tacit and explicit knowledge since tacit insights are needed to interpret explicit knowledge meaningfully (Lambregts, 2008). Most corporations in the knowledge economy develop their location networks as part of their overall business strategy. Thereby, they can split their activities into units and localise them in the most favourable places in terms of local knowledge resources and industrial culture (Dicken, 2007). Boschma (2005) argues that the importance of geographical proximity cannot be assessed in isolation, but should always be examined in relation to other dimensions of proximity, relational proximity in particular (Boschma, 2005). Thus an empirical analysis of the relative importance of knowledge intensive firms acknowledges that local clustering and global sourcing are compatible and mutually reinforcing business strategies (Lüthi et al., 2013).

The objective of this paper lies in the exploration of the emerging knowledge-based pattern in the case of an emerging city in the Global South. The significance of cities on the Arabian Peninsula in global knowledge economy networks has grown rapidly (Schein, 2009). In contrast to cities like Dubai or Abu Dhabi (Blum and Neitzke, 2009), Qatar's capital Doha had attracted little global attention in international research in spite of its rapid urban growth in recent years. The combination of still remaining wealth of fossil fuels, a progressive governance and a fortunate geopolitical location have led to a unique form of urbanism in Qatar. Wiedmann et al. (2014) highlight that the new strategy of developing Doha into a service and knowledge hub as well as a cultural hub for the entire gulf region replaced the previous local understanding of cities. This change was accompanied by a reinterpretation of governance in a more entrepreneurial sense instead of the former conception of being a 'rentier state' based on fossil fuels (Wiedmann et al., 2012).

In this paper we hypothesise that emerging knowledge economies have become visible in the case of Doha by forming strongly established firm networks on a regional and global scale in spite of the fact that economic diversification strategies have only been initiated since 1995, when a new ruler introduced a new economic development vision. We test this hypothesis by applying a comprehensive research concept that analyses the intra-firm and extra-firm linkages of knowledge intensive firms – APSs and high-tech sectors. We then map the physical and non-physical functional connectivity of the knowledge economy firms in the case of Doha on different spatial scales, which will produce three main findings: first, the relative significance of the knowledge economy within the long-term development strategy of Qatar will be discussed; second, the spatial patterns of intra- and extra-firm networks on a supra-regional, European and global scale will be analysed; third, we will briefly shed some light on the inter-relationship between the relational proximity – the connectivity analysis – and the physical proximity in terms of office location patterns of the knowledge economy within the built environment. The next section introduces our research methodology that brings together the locational behaviour of multi-branch, multi-location firms with a value chain approach and it looks at the extent to which this hierarchy is associated with the networking activities of APSs and high-tech firms.

2 Methodology

To understand the structure of the current patterns of knowledge-based companies in Doha it is necessary to investigate their functional logic and the networks in which the firms interact. This paper analyses the networks of multi-branch firms and measures the flows of information between business partners and their locations on different spatial scales. Thus, strength of this research is its multi-scalar approach. It is important to understand that cities or national states are not self-contained entities but rather connected to other places in the world in multitudinous ways through a broad spectrum of different actors. A particular strength of the network approach is that it integrates various spatial scales rather than giving preference to just one (Dicken, 2011). With the proposed research we apply an innovative approach that uses a triangulation of methods consisting of an interlocking network analysis, a value chain approach and a qualitative network analysis.

Table 1 Operationalisation of the knowledge-economy with NACE-codes

High-tech	*Advanced producer services (APS)*
Chemistry and pharmacy	Banking and finance
2,330, 2,413, 2,414, 2,416, 2,417, 2,420, 2,441, 2,442, 2,451, 2,461, 2,463, 2,464, 2,466, 2,511, 2,513, 2,615	6,511, 6,512, 6,521, 6,522, 6,523, 6,711, 6,713, 7,011, 7,012
Machinery	Advertising and media
2,911, 2,912, 2,913, 2,914, 2,924, 2,931, 2,932, 2,941, 2,942, 2,943, 2,952, 2,953, 2,954, 2,955, 2,956, 2,960	7,440, 2,221, 2,212, 2,213, 2,214, 2,215, 9,211, 9,200, 9,240
Electronics	Information and communication services
3,110, 3,120, 3,140, 3,150, 3,161, 3,162, 3,210, 3,320, 3,330	6,430, 7,221, 7,230, 7,240, 7,260
Computer hardware	Insurance
3,001, 3,002	6,601, 6,602, 6,603
Telecommunication	Logistics
3,220, 3,230	6,030, 6,110, 6,220, 6,230, 6,340
Medical and optical instruments	Management- and IT-consulting
3,310, 3,340	7,210, 7,222, 7,413, 7,414, 7,415
Vehicle construction	Design architecture and engineer
3,410, 3,430, 3,511, 3,520, 3,50	7,420, 7,430
	Law
	7,411
	Accounting
	7,412

Source: Lüthi (2011, p.126)

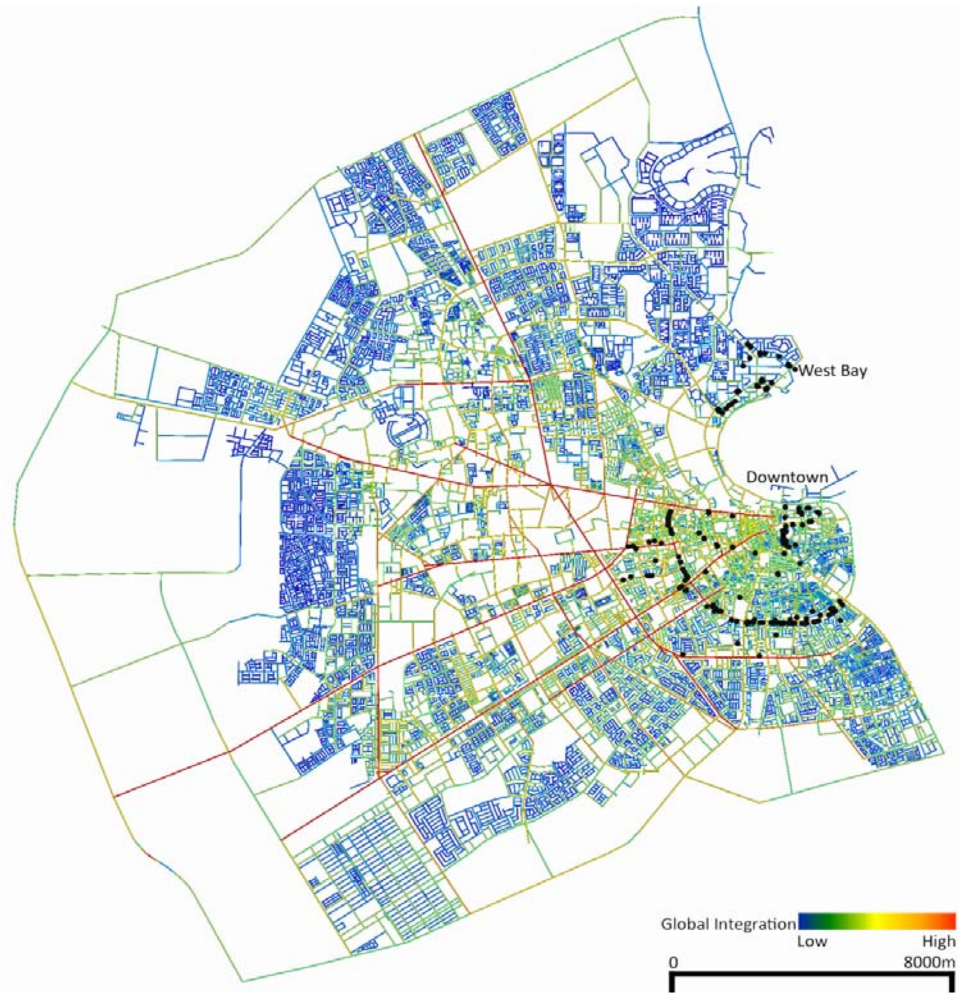
The first pillar of our methodology is the analysis of the intra-firm networks, developed by the GaWC Research Network at Loughborough University. This approach estimates city connectivities from the office networks of multi-location APS-firms. These services are described as advanced because they sell high-value information and knowledge

(Taylor and Evans, 2005). The basic premise of the model is that the more important the office, the greater its flow of information to other office locations.

In the first stage of this empirical work, a reliable company database had to be created. To identify knowledge-based firms within the emerging city of Doha the Zawya database was used. Zawya is one of the most exhaustive company databases in the middle eastern regions providing around 12,500 company profiles. The firms were allocated to the sectors using its (NACE) codes. The following lines of business have been analysed in the present research project:

In addition to this, the collected firms were cross-checked and where necessary completed with a company list provided by the GaWC Research Group (Taylor et al., 2011) and by Forbes. All in all, 162 companies have been identified whose office locations are mapped in Figure 1.

Figure 1 Selected knowledge-intensive companies and its location in Doha (see online version for colours)



Source: Authors' visualisation (2013)

Carrying out an interlocking network analysis requires the construction of the so-called service activity matrix. Each cell in the matrix is a service value (v_{ij}) that indicates the importance of the location *i* to firm *j*. The importance is defined by the size of an office location and its function. By analysing the firms' website, all office locations were rated on a scale of zero to five. In the first step, the connectivity between two locations (*a*, *b*) of a certain firm (*j*) is analysed by multiplying their service values (*v*). In this respect, the following equation respects the so-called elemental interlock between two locations for one firm:

$$r_{abj} = v_{aj} * v_{bj} \tag{1}$$

To calculate the total connectivity between two locations, the elemental interlock for all firms located in these two locations have to be summarised. This leads to what is known as the city interlock (r_{ab}):

$$r_{ab} = \sum r_{abj} \tag{2}$$

Aggregating the city interlocks for a single location produces the interlock connectivity (*Na*). This describes the overall importance of a location within the network:

$$Na = \sum rai \quad (a \neq i) \tag{3}$$

Finally, if we relate the interlock connectivity for a given city to the city with the highest interlock connectivity, we gain an idea of its relative importance in respect to the other cities that have been analysed. These scores, creating a scale from 0 to 1, are used to indicate hierarchical tendencies.

The second pillar of our methodology acknowledges that knowledge exchange and business activities do not come about through intra-firm branch office networks alone, but also from the division of labour between companies. In many cases, outsourcing strategies with respect to single activities are often efficient and lead to a higher quality of products and services. It is assumed that these extra-firm networks are strongly anchored within cities due to the quality of existing infrastructures like airports, universities with good reputation and large settlements of leading global companies, which all provide a wealth of specific knowledge (Lüthi et al., 2010). We asked firms located in Doha via a web survey to localise and assess the importance of their extra-firm relations to other APS and high-tech firms. In order to relate the extra-firm relationships to a stylised value chain, the responding firms have to localise their business activities along the individual value chain elements of 'research and development', 'processing', 'marketing', 'sales and distribution' and 'customers' (Lüthi et al., 2010). With this procedure, we obtained a comprehensive picture about the spatial value chain patterns of APS and high-tech firms on the global and supra-regional scale.

The third pillar of our methodology consists of a qualitative network analysis. Seven in-depth, face-to-face interviews with senior business practitioners and organisations were conducted. The interviews provided qualitative evidence complementing our two quantitative data approaches. This produced an extensive and rich data source on the actual changes and issues relevant to the study that could not have been created by alternative means. The next section presents the study area of our empirical research.

3 Introducing the case study: the capital city of Doha

Especially during the last decade, Qatar's economy has dramatically prospered with continued high real GDP growth rates. In contrast to 2007, when the real GDP growth reached 18%, in 2012 the GDP slowed down to a still high rate of 6.2% [GSDP, (2012), p.10]. The tremendous economic development in the recent past has led to a population explosion. Between 2004 and 2011 the total population more than doubled from about 700,000 to over 1.6 million inhabitants. Currently, approximately 1.9 million people are residing in Qatar [GSDP, (2012), p.22], 90% of them expatriates with a temporary residency status. It is expected that the robust economic environment, performance and the ongoing diversifying process of the national economy will likely continue to drive population growth and the demand for employees (Qatar National Bank, 2012). This tremendous transition has a deep impact on both the spatial morphology and the country's economic landscape. Doha, Qatar's capital city, has been undergoing a new period of urbanisation that has created a new perception of the city as an emerging urban centre in the gulf region (Wiedmann et al., 2012).

Parallel to its growing political engagement, various projects were launched to develop the capital city of Doha into a global hub. Investments in Al-Jazeera Broadcasting Station to establish an international media hub were followed by mega projects in the education and science sector as initiatives of the Qatar Foundation (Miles 2005). Additionally, new airport and harbour developments aim to turn Doha into an international transit hub, which is furthermore accelerated by the public engagement to establish Qatar Airways as one of the leading global aviation providers. Various public investments in real estate projects have moreover established Doha as one of the major investments hubs in the region (Adham, 2008). A very distinct development strategy has been the launch of diverse projects to establish Doha as a new tourism and cultural hub in the Middle East by investing in international sports events and cultural projects, such as the redevelopment of the historic city centre (Wiedmann et al., 2012).

In the recent past, economic policy has advanced the idea of a service-based economy to shift away from oil and gas dependency (Qatar National Bank, 2012). In terms of a knowledge-based economy, Qatar is still weak but increasingly enhancing its global position as the World Banks knowledge economy index (KEI) indicates. The KEI takes into account whether the environment is conductive for knowledge to be used effectively for economic development (World Bank, 2013). It is "constructed as the simple average of the normalized values of 12 designated key knowledge indicators, with three indicators representing each of the four KE pillars" (Byrnes, 2012), which are the economic and institutional regime pillar, innovation pillar, education pillar and information and technology pillar (World Bank, 2013). With a KEI value of 5.84 Qatar is ranked 54th among 145 countries. Compared to other gulf region countries, Qatar comes above Kuwait which is ranked 64th but below Bahrain (43rd), Oman (47th) and Saudi Arabia (50th) (World Bank, 2013). The country with the best performance in the gulf region is the United Arab Emirates, which ranks 42nd with a KEI value of 6.94 (World Bank, 2013). For the time period until 2030, it is expected that Qatar will continue the diversification process of its economic landscape towards a more knowledge-based economy. In this context Qatar's aim is to boost the share of services to GDP and the raising of research and development spending to 2,8% of GDP (Qatar National Bank, 2011).

4 Doha's position within functional networks

We first look at the spatial dimension of intra-firm connectivity for Doha. Table 2 shows the 20 most intensively connected locations on an international scale. In our analysis New York, as the world's most important financial centre, shows the highest interlock connectivity value for APS firms based in Doha. This finding indicates that these APS firms most often choose New York as their second most important location. APS firms based in Doha show a strong orientation towards Europe and Asia. Of the top 20 agglomerations, two are located in the Americas, six are located in Asia, one in Australia and however ten cities are situated in Europe. With the listings of Moscow, Sao Paulo, Shanghai/Hong Kong and Mumbai, four cities of the emerging BRIC-States are represented among the 20 most connected cities. Within the gulf region, Doha's neighbouring city Dubai, the region's top economic centre (Thierstein and Schein, 2008), shows the most intensive connectivity patterns with Doha.

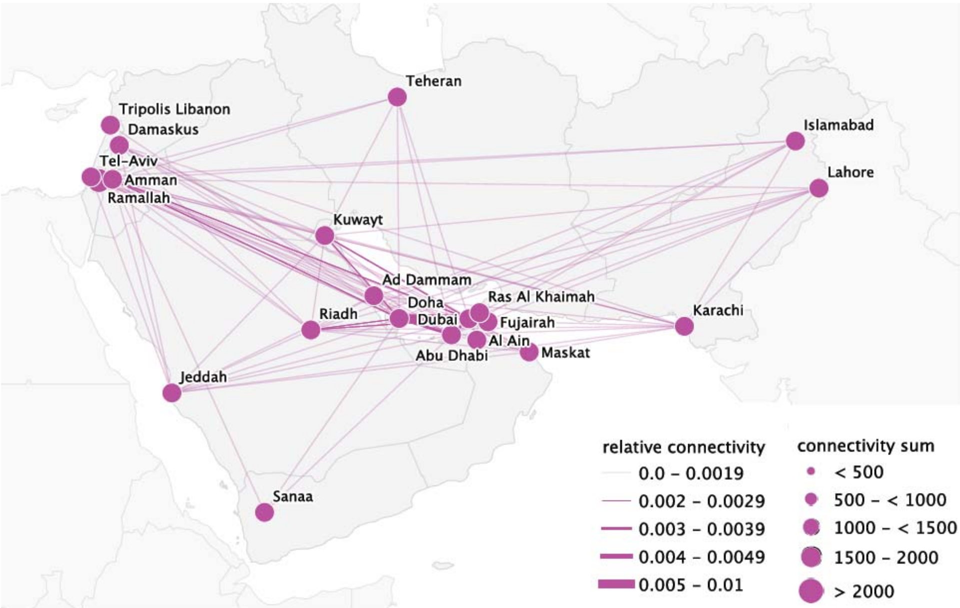
Table 2 Numerical values of global connectivity of APSs in Doha

Rank	*City*	*Country*	*Gross connectivity*	*Proportionate connectivity (1 = New York)*
1	New York	USA	60,747	1.00
2	London	UK	59,431	0.98
3	Hong Kong	China	49,972	0.82
4	Tokyo	Japan	49,216	0.81
5	Paris	France	48,042	0.79
6	Singapore	Singapore	47,210	0.78
7	Sydney	Australia	47,056	0.77
8	Frankfurt	Germany	46,364	0.76
9	Milan	Italy	46,124	0.76
10	Shanghai	China	45,474	0.75
11	Sao Paulo	Brazil	44,515	0.73
12	Vienna	Austria	44,171	0.73
13	Dubai	United Arab Emirates	43,684	0.72
14	Hamburg	Germany	42,838	0.71
15	Istanbul	Turkey	41,961	0.69
16	Moscow	Russia	41,811	0.69
17	Copenhagen	Denmark	41,772	0.69
18	Madrid	Spain	41,771	0.69
19	Mumbai	India	41,302	0.68
20	Prague	Czech Republic	41,030	0.68

Source: Authors' calculation and visualisation (2012)

Taken together, Doha's APS economy shows a strong spatial linkage to major European cities. The high number of cities ranked among the top 20 in terms of the interlocked connectivity of APS firms underlines this. For US cities, New York is ahead in the ranking, but it is the only American city to be in the top 20. This finding confirms previous analysis showing surprisingly low levels of connectivity for US cities (Taylor and Aranya, 2008). According to Taylor (2011), this tends to be related to the high national demand for services in the USA itself, which has resulted in a much more nationally-oriented connectivity pattern than in other countries (Taylor, 2011). On this global scale of analysis for Doha, only Dubai appears as a gulf location, notably a finding that supports previous studies that compared Doha, Bahrain and Dubai as potential knowledge economy hubs in the gulf region (Thierstein and Schein, 2008).

Figure 2 Regional connectivity of APS companies based in Doha (see online version for colours)



Source: Authors' calculation and visualisation (2012)

We now zoom in on a supra-regional scale of analysis – Figure 2 – and find the broader Middle-East-gulf region as characterised by a high amount of very well connected cities. Bassens et al. (2011) explain this empirical finding, especially with respect to the gulf cities along the shoreline, by stating that the "fragmentation of the narrow strip along gulf into small emirates and kingdoms". (…) "Except for Dammam, all Cities on the list are state capitals (Abu Dhabi, Doha, Kuwait City, Manama, Muscat) and/or emirate capitals (Abu Dhabi, Dubai), and they quite often occupy a large proportion of the state territory (except for Muscat). As a result, these cities are often the main foci of economic development and are in fact run as city-states, locked in a competition for regional dominance as nodes in global flows of capital such as the attraction of foreign direct investments (FDI), trade and tourism" [Bassens et al., (2011), p.285].

Figure 2 shows the spatial patterns of the intra-firm connectivity between APS firms on a supra regional scale. The thickness of the lines and the darkness of the colour illustrate the relative connectivity between the different cities on a supra-regional scale. These connectivity values are standardised to the highest interlock connectivity of the case study, which is the connection between Doha and Dubai. On the supra-regional level, connections to the United Arab Emirates' cities of Dubai, Abu Dhabi, Al-Ain and

Sharjah seem to play the biggest role: taken all together, the UAE accounts for 30% of overall connectivity, followed by Saudi Arabia with 15% and Lebanon with 10%. A very pronounced degree of linkages can be seen with Riyadh and Jeddah and to the Lebanese cities of Beirut and Tripoli. In contrast to this, Kuwait and Manama account for 8% each, Jordanian cities like Amman come up to 7%, while 6% of the total connectivities can be ascribed to Omani cities. Weaker connections of approximately 5% exist with cities Israeli cities like Tel Aviv or Haifa. Damascus and Tehran with 3%, Ramallah and Sana with 2% each and Bagdad with 1% are nearly not integrated within the Qatari regional network. Towards a regional orientation, Doha shows the strongest connections with Dubai, the regional leader and according to the GaWC Research Network, the internationally best-connected city of the gulf region (GaWC 2000–2010). The high value is due to the fact that many APS companies have relatively important and highly rated offices in Dubai and Doha.

Table 3 Numerical values of global connectivity of high-tech firms in Doha

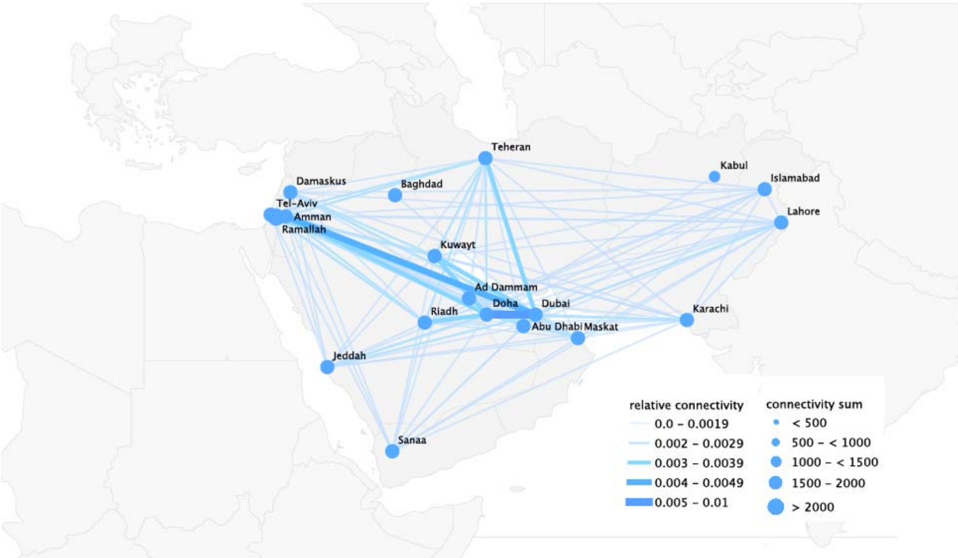
Rank	*City*	*Country*	*Gross connectivity*	*Proportionate connectivity (1 = Singapore)*
1	Singapore	Singapore	30,462	1.00
2	Moscow	Russia	28,478	0.93
3	Paris	France	28,034	0.92
4	Sao Paulo	Brazil	27,756	0.91
5	Buenos Aires	Argentina	27,067	0.89
6	Shanghai	China	27,037	0.89
7	Brussels	Belgium	26,610	0.87
8	Vienna	Austria	26,415	0.87
9	Seoul	South Korea	25,788	0.85
10	Beijing	China	25,518	0.84
11	Tokyo	Japan	25,364	0.83
12	Prague	Czech Republic	25,147	0.83
13	Milan	Italy	24,764	0.81
14	Johannesburg	South Africa	24,505	0.80
15	Hong Kong	China	24,367	0.80
16	Bangkok	Thailand	23,991	0.79
17	Istanbul	Turkey	23,506	0.77
18	Budapest	Hungary	22,904	0.75
19	Madrid	Spain	22,552	0.74
20	Mexico City	Mexico	22,480	0.74

Source: Authors' calculation and visualisation (2012)

These results confirm earlier findings by Schein (2009), where she identified similar connectivity patterns and connectivity intensities, revealing Dubai, Kuwait and Riyadh as the most connected cities (Schein, 2009). Following Schein, the strong connectivity between Doha and Riyadh results from Saudi Arabia's sales market size, the biggest on the Arabian Peninsula and the fact that Riyadh is one of the region's strongest financial locations in term of total annual GDP (Schein, 2009).

Looking at high-tech firms they seem to be networked much more with Asian locations than APSs, while North-American locations play no role (Table 3). Singapore, Moscow, Paris, Sao Paulo and Buenos Aires are the most connected cities for high-tech and at present the most important region is still Europe. However, there are also two Latin American cities among the top ranked cities, Sao Paulo ranked fifth and Buenos Aires ranked sixth and both cities represent the economic gateway to their respective countries.

Figure 3 Regional connectivity of high-tech companies based in Doha (see online version for colours)



Source: Authors' calculation and visualisation (2012)

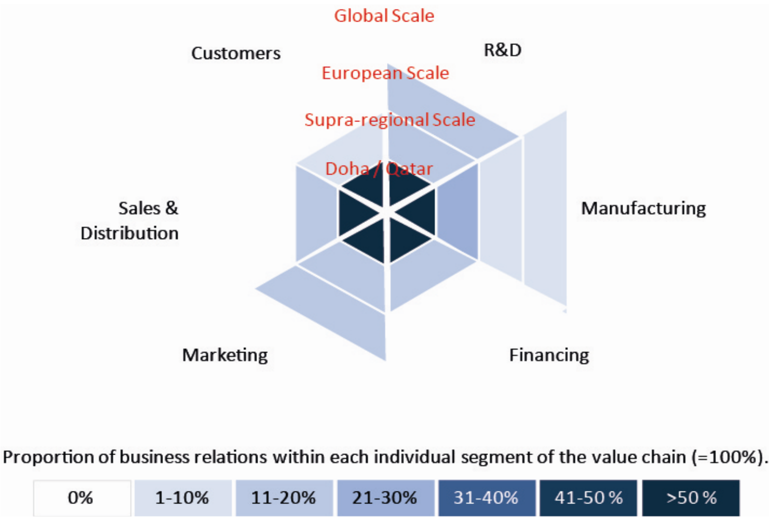
Figure 3 visualises spatial ranges and importance of spatial scales for high-tech companies. For high-tech firms located in Qatar we see on the global scale the relevance of the European and Asian spatial scale within their value chain processes. More than 46% of all connectivity is with firms in Europe. Contrastingly, Asia only accounts for 27%, North America for 11%, South America for 7%, Australia and Oceania for 3% and Africa for 6% of all connectivity.

On a supra-regional spatial scale, Doha shows the strongest connection with firms in the United Arab Emirates and Saudi Arabia. While the United Arab Emirates account for approximately 20%, Saudi Arabia accounts for around 17% of all connectivities. In contrast, Syria accounts for 5%, Israel, Lebanon and Kuwait for 8% each, Palestine 1%, Bahrain and Oman for 6% each, Iran for 7% and finally Yemen for 4% of all connectivities. Comparing the global spatial patterns of high-tech firms with APS we observe a distinct pattern. high-tech firms located in Doha are much more connected globally with strong investment goods markets, production locations and locations that serve a larger area in terms of after-sales services. APS firms in contrast are still oriented to some of the Old World global cities, mainly due to the sub-branches that dominate the Doha case: banking, finance, consulting and engineering.

5 Doha as localised system of value chains

Value added is always created by a combination of in-house and external competencies. The firms analysed in Doha have backgrounds such as accounting and finance, real estate as well as information and communication services. Figure 4 shows our findings for extra-firm relations of knowledge-intensive companies in Doha. APS firms most frequently interact with other APS firms in Qatar, particularly insurance, law, advertising and media companies. Even for knowledge intensive firms a considerable amount of back- and forward linkages along a firm's individual value chain are organised locally respectively nationally. These branches assume an important role as an entrepreneurial support network within the city and thus these findings support other studies (Goebel and Thierstein, 2006; Lüthi et al., 2010). Beyond local sourcing and physical proximity, multi-branch multi-location firms need expert inputs along their value chains from wherever the most suitable partners are located. The supra-regional spatial scale shows that quite some interactions along the value chain are organised within the larger Middle-East gulf region, while on the global scale, only some relationships in manufacturing are reported. In other words, very many knowledge intensive firms in Doha/Qatar rely on local and regional exchange, especially in financing and end customers. Albeit many of these firms are internally linked globally, their external exchange predominantly serves the Qatar and supra regional markets; we only find very limited interaction concerning the extra-firm linkages with companies outside Qatar.

Figure 4 Extra-firm relations of knowledge-intensive companies in Doha (see online version for colours)



Notes: Sample: 19 firms, 55 business relations

Source: Authors' calculation and visualisation (2012)

6 Potentials and challenges for knowledge-intensive firms in Doha

In order to identify the various potentials and challenges for knowledge-intensive firms in Doha from the vantage point of internationally acting business practitioner, seven face-to-face interviews were carried out. According to the interviewees, Doha offers a unique combination of strengths that are very helpful in establishing and promoting the emergence of Doha as an influential city on the regional and global stage. The tremendous wealth from and around oil and gas industries makes Qatar one of the richest economies in the world. During the current global economic downturn, Doha is still characterised by a prospering economic landscape with economic growth rates that are far above average. The revenues of the oil and gas production permit large-scale infrastructure developments, including the construction of a new port and new international airport. The ability to embark on new projects and far reaching development activities of the urban landscape in times of a global crisis and global instability illustrates the power and potentials of Qatar. The economic potentials of Doha are thus found along two key dimensions. One is capital, which permits state-of-the-art infrastructure and the ability to launch various new initiatives, such as Education City, one of the five hub strategies of Qatar (Wiedmann et al., 2014). The second is the fortunate geopolitical location of Doha within the gulf region, finding it positioned between the Kingdom of Bahrain and Kuwait in the north, main urban centres in Saudi Arabia in the west and the UAE and Oman in the south.

Nearly all companies interviewed are exclusively focusing their activities on the local market and more often than not, cooperating with companies and research institutes located in Doha. Most of the companies have established their own independent entities that are fully responsible for the domestic market. Cooperation on shared projects can happen but are not usual. Based on the estimation of the interviewed companies, Qatar has such an attractive and extremely fast growing domestic market that there are enough projects and business opportunities to go around and therefore no need for an international acquisition of further projects.

None of the firms interviewed assume a function as supra local headquarter for a larger market are like the gulf region. Instead, offices that serve such a regional headquarter function are operating out of the Emirate of Dubai. According to the interviewed executives it is not expected that Doha will serve the function as regional business hub in the nearer future. With regard to project collaborations these firms often prefer digital communication. Nevertheless there are differences between the internal and external forms of communication, for example with business partners or other companies. While a firm’s internal communication mostly happens digitally via internet and conference calls, external communication mostly happens face-to-face. Only if the external relationship has been established over a long time, especially to Arab business customers and clients, the form of communication might switch to digital forms of communication. However, all firms interviewed have underlined that face-to-face contacts is of absolute importance in the Arab business context.

Many knowledge-intensive firms are currently facing severe challenges to establish businesses in Doha. The main problem identified by interviewees is that of attracting skilled, gifted and talented people for long-term employment. Although attractive and far above average compensation packages are offered by the companies, other aspects and incentives seem to be important, for example urban amenities and design qualities, facilities for families and an adequate form of housing. The fact that more than 86% of the people who live in Qatar are expatriates documents that Qatar can attract people. However the problem is that the pool of human capital includes very few people from the knowledge economy. Wiedmann et al. (2014) underscore these assessments: “the urban quality of diversity is mainly dependent on the spatial practice of investors, companies and inhabitants. In the case of Doha, developers and their investors play the most decisive role in diversifying the urban environment, because their speculative interests have been the driving force of the recent urbanization process” (Wiedmann et al., 2014). All interviewees agree that presently, Doha cannot be considered as a hub for knowledge-based activities in the gulf region. But the ambition for the near future is clearly articulated by decision makers: to become a service centre for regional as well as global markets.

7 Concluding remarks and outlook

Cities can be regarded as nodes in a space of flows. Although our study focuses on a particular case on the Arabian Peninsula, the location cannot be studied in isolation. Each city is inserted in a broader network of exchange, connected to other cities and locations around the world and thus is part of an overarching urban hierarchy The knowledge economy is said to alter the urban hierarchy significantly and turn it more spiky (Florida, 2005). Eventually the urban form will reflect this seminal change, driven on the one hand by the knowledge workers and their demand for urban amenities and qualities, on the other hand by location choice of knowledge intensive firms, real estate developers, international financial flows and development-friendly regulations. Large-scale public investments initiated by Qatar’s rulers have shaped contemporary Doha into one of the fastest growing cities in the world and a serious contender as an emerging regional hub city, see discussion on the role of hub cities in the knowledge economy: (Conventz et al., 2014). However the various public development strategies initially followed no cohesive development vision or plan. These activities are often carried out in a rather isolated manner, based on top-down and case-by-case decision-making. In contrast to other gulf cities such as Dubai, where the trading sector played a major role in the beginning of economic diversification, the real estate boom in Doha was mainly ignited by public investments in five development strategies (Wiedmann et al., 2012).

Consequently, Doha/Qatar has experienced a rapidly growing number of knowledge-based firms, especially in the services sector, which have opened permanent or temporally project-related offices in Doha. Most of these firm establishments are part of dynamic multi-branch, multi-location companies that optimise their location network according to market opportunities and availability of qualified personnel. Our intra-firm and extra-firm network analysis shows that knowledge intensive firms in Doha/Qatar – be it APS or high-tech firms – are strongly connected to Europe, Asia and USA, while regional headquarters remain in Dubai and international headquarters outside the wider gulf region. Doha’s knowledge intensive firms organise their external-firm linkage predominantly either on a local spatial scale or on a supranational scale; spatial scales beyond these scales play nearly no role. In other words these firms focus their activities mainly on local markets rather than on using their location for doing business beyond the borders of Qatar.

The outlook for Doha is therefore ambiguous. The reliance of knowledge intensive firms on local projects thus builds upon continuous urban growth in Doha. So far, public authorities do not manage to integrate a coherent urban development strategy. The economic potential of Doha goes along two key dimensions: one is the availability of capital, which allows cost intensive infrastructure investments and the ability to launch various new knowledge initiatives, such as Education City. The second key dimension is the geographical position of Doha within the gulf region itself as well as markets in Asia and Europe. Based on our research results the rapid urban growth in recent years has led to an increasing connectivity of knowledge economies situated in Doha. This however was mainly the result of extensive public investments into local projects. Consequently, Doha was able to reposition its status through its high integration into supra-regional urban networks and its strong linkages to European and Asian Cities. Despite Doha's rather strong integration in the global urban hierarchy the role of its knowledge intensive firms remains restrained to a local or supra-local spatial realm. For the gulf region Doha seems to be not even a regional knowledge economy hub but a globally connected location. Subsequently, Doha's emerging multi-national and multi-cultural society will be tested to transform an 'instant city' – phenomenon based on public investment strategies into an actual hub city, used as operative centre of international knowledge economies. This transition will heavily rely on the successful implementation of state-of-the-art infrastructure as well as new immigration policies permitting the gradual integration of foreign communities. In future the main decisive factor for consolidating knowledge economies in the case of Doha will be the long-term commitment of a highly educated workforce to stay and to develop a functioning self-contained service economy in Qatar. The ever-changing composition of Qatar's society can thus be identified as the main threat for any successful economic diversification based on knowledge intensive sectors.

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