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Empirical Evaluation of ICT Adoption in Australian SMEs: Systemic Approach

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***Abstract* — Many SMEs are adopting information and communication technology (ICT) and services based on them. However, there is little systematic research into how they are doing this and what the organisational and environmental factors associated with the adoption are. That is, hardly there is any study in the literature which is looking at the overall firm's performance and if, once adopted, ICT fulfil expectations of their adopters.**

The growing importance of SMEs and ICT in contemporary economics and IS and management theory have been a subject of large static research. In this paper we have adopted a dynamic approach to evaluate adopted ICT in a firm as a complex adapting system (CAS).

Thus, here an organisation is studied as complex social system, because complexity provides an explanatory framework of how organisations behave; as well as how individuals and organisations interact, relate and evolve within a larger social and environmental system. Complexity also explains why ICT adoption may have un-anticipated consequences on firm's performance and inter-relationships of elements within a complex system which give rise to multiple chains of dependencies.

In this article authors evaluate factors for ICT adoption in Australian SMEs in the post-adoption period. The methodology in this article was based on interpretative action research based on "soft systems thinking", because the setting up an information technology system is itself a social act, requiring some kind of concentrated action by many people.

However, the formal method is the case study method which answers the question how these factors are interacting in the particular firm.

After the introduction, a general framework, based on recent literature review, was used to identify necessary factors for the ICT adoption. Those factors are then evaluated in an Australian company (case study) using systemic (five stage) approach and its tools.

Preliminary results of this study confirmed that entrepreneurial ICT adoption initiative is not only subjected to selection as a result of environmental pressures but also is strongly subjected to the sub-systems influences and inter-dependencies.

Thus from the complex and adaptive systems perspective we may infer that necessary factors are not all (and always) sufficient factors for the full utilisation of ICT and achievement of firm's goals.

***Keywords* — ICT, complex systems, systemics, SMEs, factors for ICT adoption and utilisation**

I. INTRODUCTION

In this article authors analyse factors for ICT adoption in Australian SME, their empirical validity and relevance for the firms' performance in the post-adoption period. We recognise that ICT is not a value per se, but only becomes a value in the interaction with the users of ICT. Therefore, many aspects of ICT need to be assessed in interaction with other parts and the organisation itself to fully understand its utilisation that influences firms' overall performance and profitability. Thus, using a case study research method and applying holistic/systemic approach we will try to answer the following questions:

- How does interaction of ICT factors impact company's overall performance measured by the relative advantage in the market by adopting and fully utilising ICT?
- What are the factors in the company that influence the extent of ICT utilisation?

The units of analysis for this Australian – based study were small to medium enterprises (SMEs). Criteria for choosing the company for this study were the levels of ICT adoption. In the first stage we approached and worked on five Australian SMEs which adopted ICT. Those companies were part of an earlier investigation about models of ICT adoption [1]. However, results presented here are those from analysing one case study only.

II. BACKGROUND

There are enormous investments in ICT - over $316 billion is spent annually on ICT in the US alone, and the world's IT spending now exceeds US $2 trillion annually. In 1999, the share of ICT investment was 4.54% of GDP in the US, up from 2.60% in 1992. For the EU as a whole, the corresponding estimated GDP share is 2.42% in 1999, up from 1.81% in 1992 [2]. In 2000, the share of the ICT investment was particularly high in the US, Finland and Australia.

Intangible effects of ICT found in the literature are an increased variety and quality of products/services, improved timelines of delivery, personalised customer service, improved employee' expectations and motivation. All of these benefits are poorly represented in productivity statistics because it is hard to measure the intangible and indirect costs and benefits of ICT [3]. Studies done so far

mainly applied traditional statistical methods to establish the correlation between the investment in ICT and the productivity or profit growth, in order to determine the value of ICT. However, correlations between IT/ICT investment and organisational performance and productivity do not necessarily imply causation, according to [4]. Those applied methods did not take into account most of the intangible effects and/or contexts of ICT. Therefore, using 'hard numbers' only is not capturing all the effects and values brought about by the ICT investment, which as a consequence has appeared to lower revenue, increase production time, and reduce the firm's productivity and overall performance. Hence, the values of investment in ICT fall short of profitable investment creating the "*productivity paradox*".

In this study we will try to explain those multiple aspects of ICT not taken into account in the literature (together with taken ones) in order to understand the whole, dynamic picture and relations between ICT, its stakeholders and organisation.

III. Conceptual framework

There is replete of literature available on the adoption of information technology in small business ([5]-[9]). Most recent literature which looked into the necessary and sufficient factors leading to adoption of IS/IT by SMEs formed the basis for the empirical component of this study (see Fig. 1).

ICT can impact a company on three different levels: individualistic or user level, organisational level and external or environmental level. In addition, technological and economical contexts are of great importance in facilitating organisational decision regarding which ICT to adopt, how to use it, and should be taken into account as well. Therefore, influencing factors for ICT adoption examined across a range of contexts suggested by the literature ([1],[10]) can be organised within five contexts: technological, organisational, environmental, individualistic, and economic context.

The *technological context* such as compatibility with existing technology in an organisation is one of the reasons why ICT can be underutilised and lead to the *legacy system* issue. Technological characteristics of ICT influence the choice and use of ICT and explain the occurrence or absence of certain effects related to the use of ICT.

Organisational context is usually considered in many empirical studies. Factors such as organisational culture, readiness to change, size and others play important roles in ICT adoption and utilisation.

The *external environment* has a significant role in the adoption of new technologies but was not included in many IT/ICT empirical studies. One of studies which took this context into account was the study by [9]. They found that competition insignificantly influenced ICT adoption in small businesses, while on contrary [8] found that competitive pressure was the only factor influencing IT/ICT adoption. As [11] emphasised the role of the government policy in fostering an environment enables firms to make effective use of ICT.

The *individualistic context* (employees, managers) is crucial to take into account since individuals use ICT for their everyday work and know best how ICT influence them and processes in the company. [12] emphasised the importance of a manager's characteristics such as education, age, experience, and psychological traits which have been found to strongly influence innovation adoption. They found that the manager's innovativeness and IT/ICT knowledge had a positive effect on IT/ICT adoption.

The *economic context* is important for a company since ICT costs are not just related to hardware and software, but also to employees and organisational changes that are taken in order to make ICT effective in the workplace. These complementary investments usually cost much more than the initial ICT investment itself.

Similarly to the previous conceptual framework, [1] developed an adoption model of ICT by applying the Qualitative Comparative Analysis (QCA) and its formal language - Boolean algebra. Using that as a departure point in this study we are extending the investigation process of finding the necessary and sufficient factors for ICT adoption in the post-adoption period and argue that adopted ICT itself is not a guarantee for the improved performance of a company. It has to be evaluated and considered as a dynamic part of a complex system, which can be characterised as non-linear, co-evolving, self-organising and which is on the edge of chaos. Considering a company as a complex adaptive system requires mixed, multidimensional, multi-stakeholder, explicitly value-based assessments approaches. ICT depends on many factors and its effects are different for every organisation, since technological systems are socially constructed [13]. As a result ICT needs to be taken into account together with its interactions with people, organisation and processes. Hence many authors are arguing that the only way to consider ICT effects on a company is to use systemic approach [14]. Following that lead we employed the systemic approach with its tools as outlined in the following sections.

IV. Systemic approach

This section describes the systemic approach and its tools, which will be used in this study. According to [15], the five-stage systemic approach consists of five stages each with two sub - stages as listed in Table 1 ().

Tools of the five-stage systemic approach used in this study are explained in the next table (2). Those tools, i.e. tests will be used to check the relevance of the ICT adoption factors in influencing the company's performance, as well as the interaction of the factors. Following the systemic approach rules and its tools, as well as applying systemic data gathering strategies [focus group meetings, the landscape of the mind (LoM), reflect back workshops, in-depth semi-structured interviews, mapping of email

connectivity (NetMap), and participant observation] we have changed factors developed in the conceptual framework to accommodate participants observations. With adjusted factors we have finally constructed the stimulating and inhibiting interrelations (respectively) impact matrices of factors for ICT adoption as presented in Figures 3 and 4.

After constructing those matrices in the following section results are interpreted.

V. RESULTS AND THEIR INTERPRETATION

The results of the systemic analysis are presented in the 'Map of interaction'. This map's goal is to transform the highly concentrated knowledge of the 'Double-cross-impact analysis' to the *right brain-hemisphere* way of thinking, in order to create a picture of different dimensions of the system.

Horizontal axe of the map of interactions (fig. 4) represents the degree of activity of factors of ICT in the system while the vertical axe represents the degree of dynamics (interactions). This map can be also divided into four quadrants.

In our double cross impact analysis factors in the top circle (see Fig. 4) of the map of interaction [(16) *Fast developing new IT solutions*, (4) *Adoption costs*, (1) *Relative advantage in the market by adopting ICT* and (5) *Perception of company image*)] are the components that are the most connected factors in the system. The factors in the middle circle [(7) *Quality of IS & capabilities*, (15) Managers knowledge of ICT and (2) *Attitude toward adopting ICT*)] are less strongly interacting factors within the system, followed by factors (14) *Managers innovativeness*, and (10) *Top management support* and (3) T*echnological compatibility in the company*. The rest of the analysed factors are much less interacting. They have still roles in the system, although they are moving slower.

The striking characteristic of the double-cross-impact analysis is that there is actually the only one real activator for positive dynamic in the system – factor (16) *Fast developing new IT solutions* – which should be given priority in a constructive and innovative way in order to easy the problem solving process.

An innovative approach to the system – for instance if the company is to define the new contents, then factor (14) *Managers' innovativeness,* combined with factor (9) *Specialization within the company* should be of interest to management. To achieve that goal, one would have to find solutions to influence the activities of factor (14). So, the degree of interaction would be reduced and the system gets more passive, and in that case factor (14) would 'move' into the field of 'goals'. In reality that means that the influence of innovation through management could become less intensive, e.g. managers could become subject to 'the other influences'. Similarly, factor (14) would change from a 'transformation key player' that company relay on to a 'quality indicator' which can be steered and supported.

In the figure 4 we can look at different areas of interactions of factors of ICT, which can be summarised in the following six points (which correspond to the numbers in the figure 4).

Number 1 describes the system as a whole which is well differentiated by the degree of interaction. However, it is less differentiated in the degree of transformation. It means that we have identified the key factors in the system. Apparently, the system has only small negative feedback, meaning the system is a dynamic one – it can be influenced either by enforcing the positive development or lowering the negative one.

The most recognised factors in the system – passive outcome or symptom – are factors (4) *Adoption costs* and (2) *Attitude toward adopting ICT*. Both could be fields of actions for the fast solutions and achieving results. However, both would be only an indication of success, since they do not really change the system as whole. We can use those factors for 'symptomatic solutions' that is, only in the case of 'crisis management' or if the company needs to get recognition in order to continue to operate and to survive. Therefore, we should not be tempted to act upon those kinds of factors. Instead, the company should focus on factors that are stable in the active part in the system. However, those two factors should be measured and controlled regularly, as the best indicators of transformation processes.

Factors that are maintaining processes of transformation are: (1) *Relative advantage in the market by adopting ICT*, (5) *Perception of company image*, (7) *Quality of IS & capabilities*, (15) *Managers' knowledge of ICT*, (14) *Managers' innovativeness* and (3) *Technological compatibility in the company*. Having them in the system, the firm would have troubles to transform new ideas into a new solution. However, without that transformation area the investments would not succeed in the way it is expected. So, if there are problems in this area, the firm should discuss the risks, and make the plans for improvements.

The only fast driver within the system is factor (16) *Fast developing new IT solutions*. This factor is absolutely crucial and has to be part of the solutions in all scenarios. However, as with all dominant factors, factor (16) could foster good, as well as bad developments. Fortunately for the company it is possible to find other factors in the system that can be acted upon for long term solutions, like factors (11) *Competitive pressure from other firms*, (12) *Competitive pressure (costumer, suppliers*), (8) *Information intensity* and (13) *Public policy and governments roles*. The challenge to develop sustainable solutions is therefore to put factor (16) in a creative and adaptive interaction with (11), (12), (8) and (13) in order to get more successful solutions of the project.

The actual identified structure – without changing factors and interactions – is focused on the goals or results of the ICT adoption process to foster (9) *Specialization within the company,* lower (12) *Competitive pressure (costumer, suppliers)*, (11). *Competitive pressure form other firms* and

increase (8). *Information intensity*. So, if the company was 'happy with this result', which would mean more specialization within the company, less pressure from costumers, suppliers and other firms, and the current level of intensity of information, then, the firm can use the existing structure to succeed working on solution as discussed above under the point 3. However, if a company was not 'happy', then in would be necessary to reorganize the structure which discussed in the following point.

The final reflection on the system is almost as 'painting of dynamical information'. For example, if the firm wants to change the 'field of goals' by accomplishing successful ICT adoption and utilisation, then the firm would have to change the structure in the both active and the passive parts of the system. Or, if the firm would want to make the system more sensitive to changes then they must find new ways of interactions of factor (3) with other factors in the system.

The final principal participant observations and recommendations would be to the company to build a high commitment with all involved in the project in this company. ICT adoption is an innovative part of the process of developing solutions for the full utilisation. So, the firm should be creative and not fixed on the 'actual structure' of the system. It is necessary to understand the wholeness and decide on what to keep and what to change in the actual situation.

VI. CONCLUDING REMARKS

In this article authors by analysing factors of ICT in the post adoption period tried to answer the question how interaction of ICT factors on firm's overall performance. By applying the systemic approach and its tools they identified the key factors and their interaction and influence on the system. The results of the double cross impact analysis revealed six dimensions that can influence the performance of the system. Although they were kept at a very general level, they still can be very instructive for the company wanting to utilise adopted ICT to the full and consequently increase the performance.

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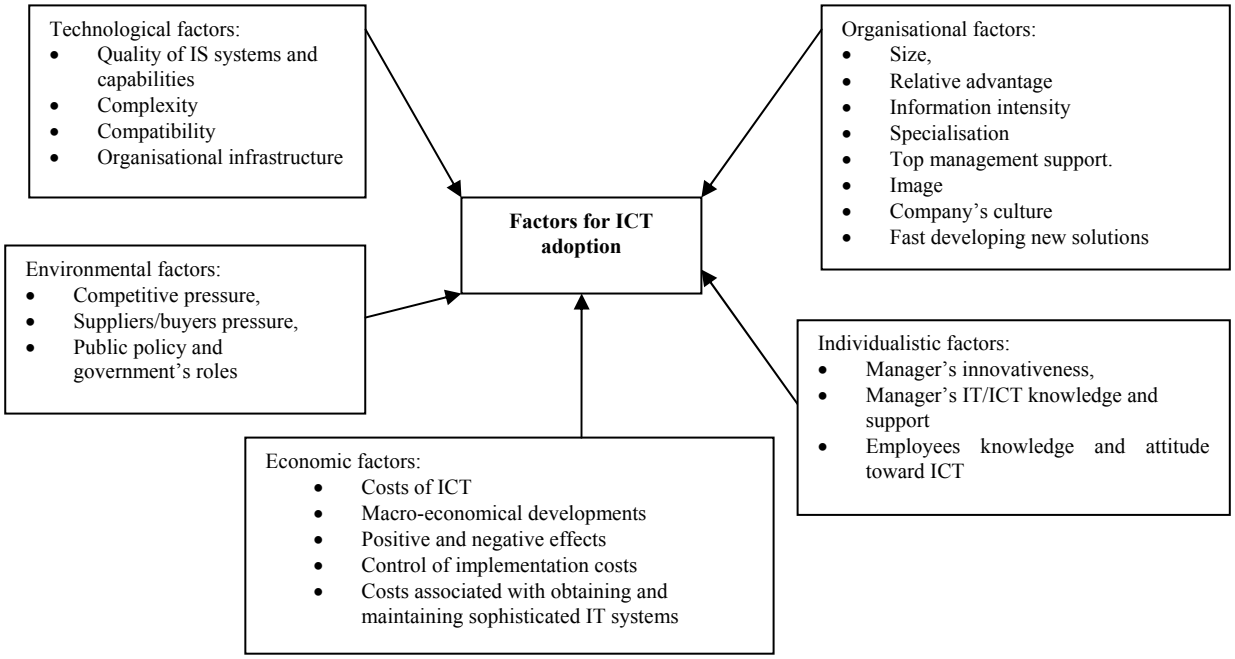

Figure 1: Factors and contexts for ICT adoption

TABLE 1. METHODS FOR EACH STAGE USED FOR THE FIVE-STAGE SYSTEMIC APPROACH

Stages	Methods	Description
Stage 1 A	Brainstorming, brain writing, method 635, rich picture, PAT-mirror, Synectic, progressive abstraction	***Stage 1 (a and b): Discover and identify opportunities and problems*** The first contact with a complex phenomenon is done by first describing fuzzy statements or set of factors (1a and b). In this stage different roles and different key players are identified. There are no solutions or interpretations in this stage.
Stage 1 B	Concentrate data to cluster and clear statements: Mindmap, set of factor, role settings, syntegration, dialoguing	
Stage 2 A	Holistic test, holistic potential test, holistic environmental turbulence score, gap-analysis	***Stage 2 (a and b): Reflect wholeness, analyse interactions and tensions*** The goal in this stage is to test the data on wholeness (2a), and then to define and analyse the interactions between the factors (2b). Different tests (from holistic test to double-cross-impact analysis) are completed in order to find the interactions which are normally not seen and therefore left out.
Stage 2 B	Double-cross-impact analysis, loop diagrams, family constellations	
Stage 3 A	Interpretation of systems dynamic, critical systems heuristics, systemics goal definition, Presencing	***Stage 3 (a and b): Work out possibilities of design and steering, understand dynamics*** In this stage information that transforms into knowledge is reflected. Double-cross-impact analysis is interpreted, results are reflected and the goal is (re)defined (3a). From dynamic interpretation to four drive method we achieve a generic playground for new solutions. It is important to stay open for new information in this stage and to ask in order to make statements.
Stage 3 B	10 points for viability, sensitivity analysis, risk analysis, Neuro-Linguistic programming (NLP), four drive method	
Stage 4 A	Synectic, morphology, the six thinking Hats method, precise destroying, Osborn-Checklist	***Stage 4 (a and b): Develop causal solutions and sustainable decisions*** In this stage new knowledge is produced for solutions (4a) and making decisions (4b). These insights are crucial for recognising that all scientific concepts and theories are limited and approximate. Solutions are seen as emerging opportunities.
Stage 4 B	Simulation, scenario technique, holistic value-benefit analysis, four force field reflection	
Stage 5 A	Project management, process couching, balanced scorecard, consultancy, coaching, portfolio of activities	***Stage 5 (a and b): Consolidate commitment and realise viable processes*** In this stage action is being taken (5a), followed by the feedback from the environment. Shift from isolated positions to networks as a metaphor for sustainable solutions: there is no signal "right thing to do", as the strategy includes a network of parallel processing.
Stage 5 B	Micro-article, knowledge management, Network, Lessons learned, EFQM quality model, reflecting groups	

Adopted from [15]

TABLE 2. TOOLS OF SYSTEMIC APPROACH

Tool	Description	
Holistic structure test	Using the holistic structure test enables a quick holistic check of any description or analysis by pointing out the blind spots. The distribution of the factors gives valuable information about the structure of the system and reveals the blind spots.	
Holistic potential test – four basic drives	Following [16], factors are tested by four drives: drive to acquire; to bond; to learn; and to defend. This test is basically grouping the factors under appropriate drivers, according to the content of the factor that strengthens specific drives (D1, D2, D3 or D4).	
Holistic environmental turbulence score	This test measures turbulence in the relevant environment to indicate how fast and how much the system needs to change its strategy or products.	
Systemic gap-analysis	At this stage, factors should be described in relation to the real situation in the company. Then they are evaluated on a scale from 1–5 and the variation from the line which present the holistic environmental turbulence score is measured	
Double-cross-impact analysis	After factors for ICT adoption are established from the literature, and tested with holistic tests, their impact on the company in the post-adoption period will be evaluated. The tool for evaluation of those factors on company's goals and performance is called the double-cross-impact analysis. It was developed by Vester and Hesler {[17] order to analyse dynamic systems, and was successful in evaluating key factors for explaining and improving all variety of systems. Double-cross-impact analysis consists of assessing all interrelations between the different factors for ICT adoption. It is based on ADVIAN (Advanced Input Analysis) method developed by [18], were the impact factors are identified and connected. The impact strength of each factor on each other factor is estimated. (see fig. 2)	
	The basic steps of the Double-cross-impact analysis are	Firstly, the system was reduced to a set of relevant key factors for ICT adoption (conceptual framework), An assessment of interrelations between selected key factors was carried out by means of matrices in order to understand the influence exerted and received by each key factor, and Interpretation and discussion of each key factor to identify its potential to influence the entire system. In fact the double-cross-impact analysis is a matrix that facilitates systematic assessment of every single interrelation and of its intensity. In order to take into account the positive and negative interrelations, two matrices are used - one for all the stimulating interrelations and one for the inhibiting interrelations. The interrelations are assessed qualitatively.
	In addition, double-cross-impact analysis provides other important information	The *active sum* - the sum of each line of each key factor. It represents the total influence the factor exerts on the system (stimulation or inhibition). The *passive sum* - the sum of each column of each key factor. It represents the total influence of the system on the factor (stimulation or inhibition). The *degree of interrelation* which is the product of the active sum multiplied by the passive sum. The higher the value, the more the factor is interrelated within the system. The *degree of activity* of each factor - the quotient that is the result of dividing the active sum by the passive sum. A small quotient means that the influence the factor undergoes is greater than the influence the factor exerts on other components. The opposite applies for high quotients. (see fig. 2).

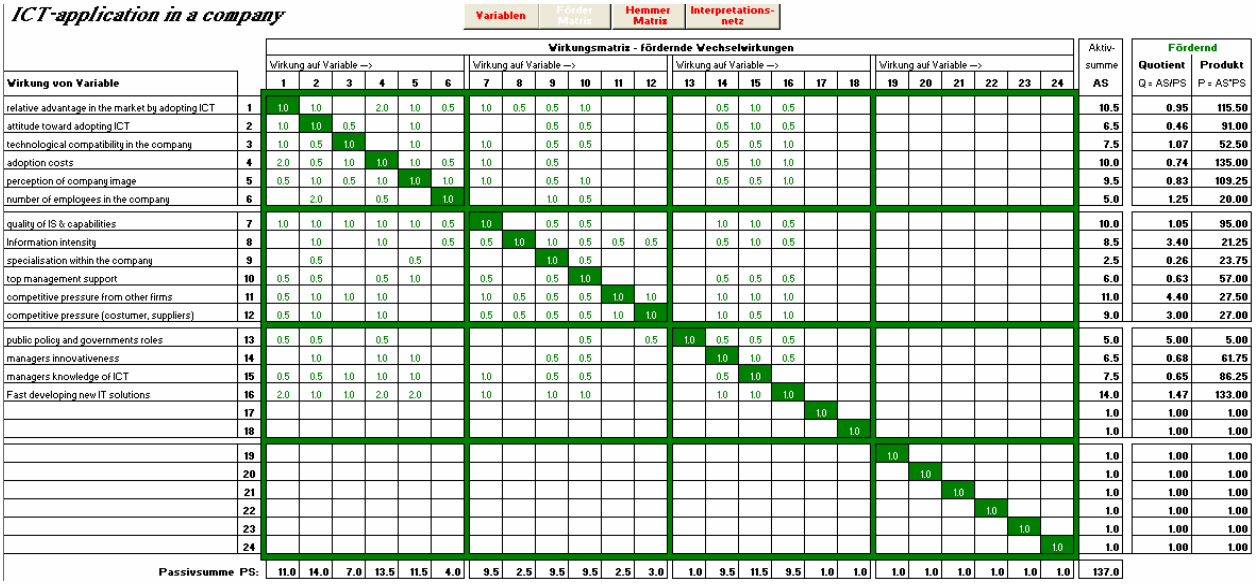

Figure 2. Impact matrices of stimulating interrelationships

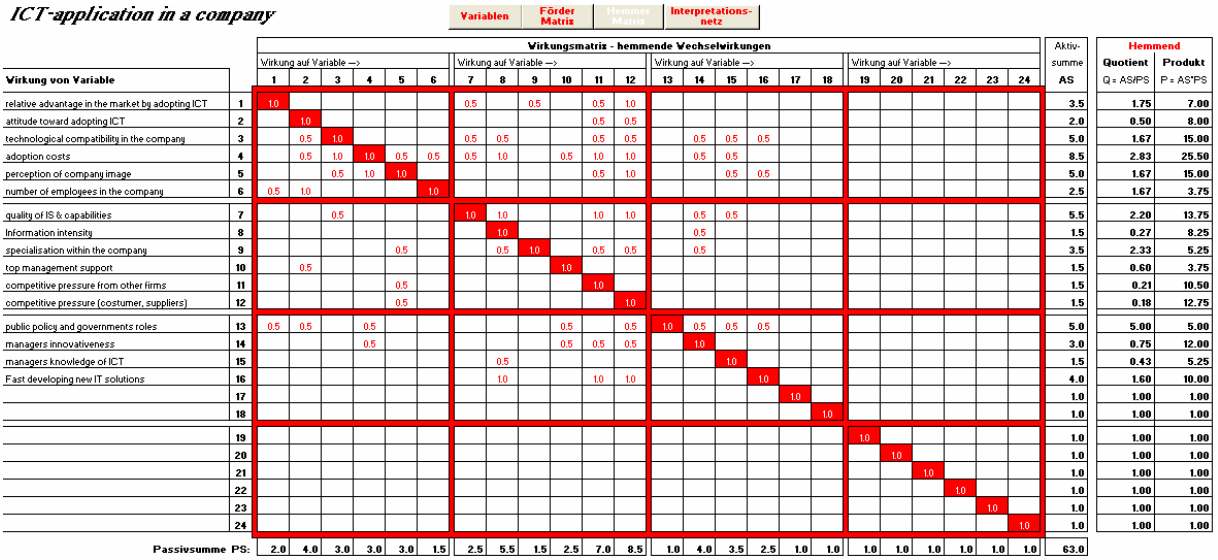

Figure 3. Impact matrices of inhibiting interrelationships

TABLE 3. QUADRANTS OF THE MAP OF INTERACTION

Passive and highly interactive factors These factors are influenced by and interact with the rest of the system	**Active and highly interactive factors** These factors influence and interact with the rest of the system
Passive and less interactive factors These factors are influenced by and are less interactive with the rest of the system	**Active and less interactive factors** These factors influence but less interact with the rest of the system

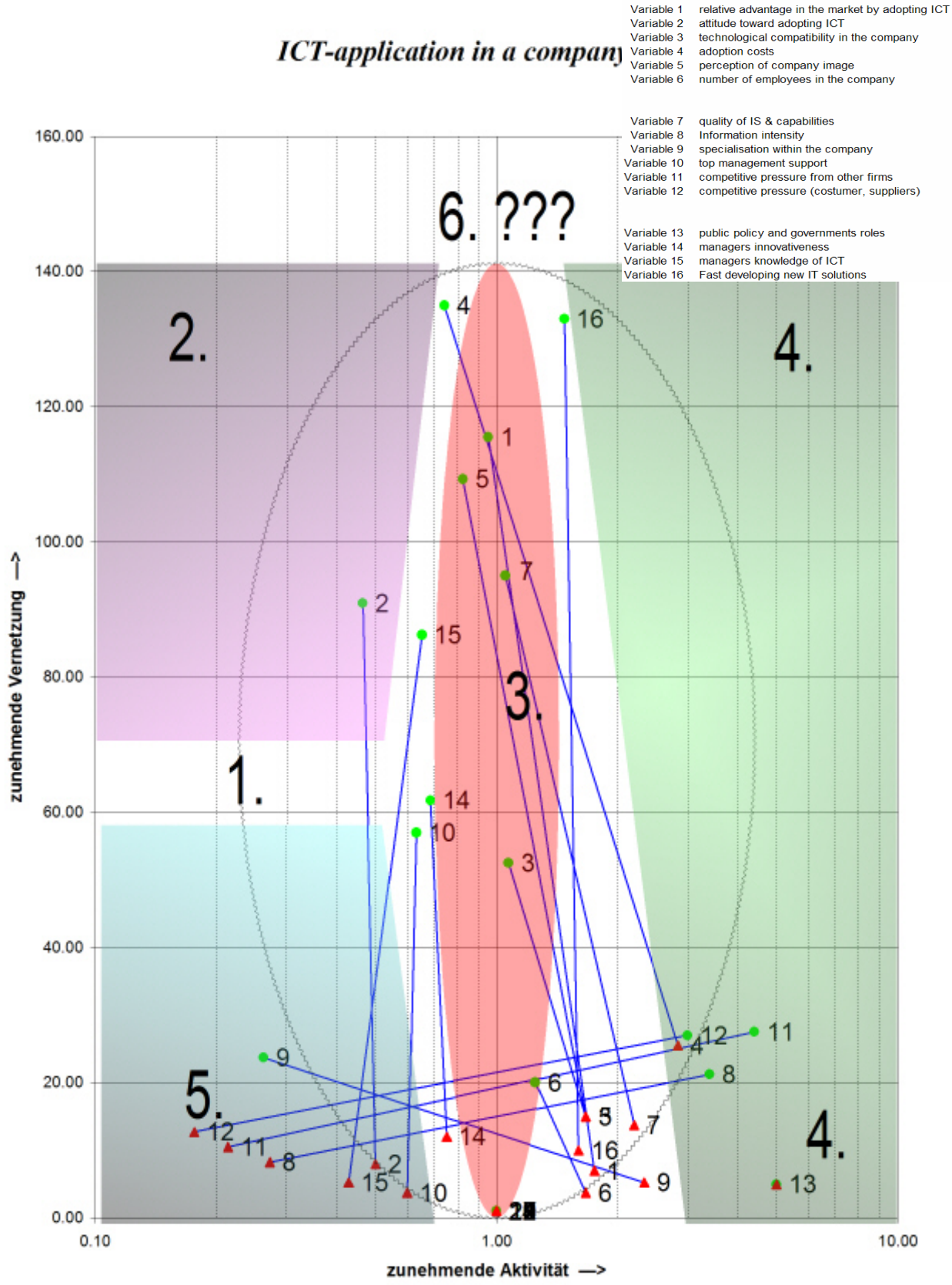

Figure 4: Map of interactions