

Information Technology Usage and Performance of European Enterprises: An *Empirical & Policy* Analysis

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Education and Culture

Erasmus Mundus

An initiative of the

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It doesn’t matter if you win or lose. The most important thing is a sincere effort (Muhammad Umer Wasim)

Acknowledgement

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Preface

This document is the final version of my Master Thesis Project and marks the conclusion of my MSc education in Engineering and Policy Analysis (EPA) at Delft University of Technology.

The international program Engineering and Policy Analysis (EPA) offers students a challenging interdisciplinary curriculum. The central focus is on analyzing and solving complex problems that involve many parties with conflicting interests. Such problems require solutions that address technological, societal and management issues.

Provided the context of development of this project, the meaningfulness of its topic will be straightforward. The main goals of this study are: (1) which is the underlying success factors that complete the link between information technology and performance at micro level? (2) Which policies (on the basis of these underlying success factors) can be recommended to European Union for improving performance at micro level? The analysis of these main questions is supported both by means of literature review and empirical analysis. The data used for empirical analysis is provided by European commission e-Business Watch Surveys for 2002, 2003, 2005, 2006, and 2007.

This report serves as one of the outcomes of a collaborative project between the University Paris Sud 11, France and Technical University of Delft, Netherlands. Its content was developed under the supervision of university members from the Faculty of Economics (Paris Sud 11) and from the section Economics of Innovation (Technical University of Delft)

Part of the evaluation committee of this project are:

First supervisors:	Dr Dr. Stéphane Saussier (Faculty of Ecnomics - Paris Sud 11) and Dr Cees van Beers (Department Economics of Innovation – Technical University of Delft).
Second supervisor:	Ir. Fardad Zand (Department Economics of Innovation – Technical University of Delft).

Executive Summary

The last decade, researchers have been investigating the contribution of information technology to the performance of economies, at the macro level, industry level, and micro level investigating firm's performances. Empirical analysis of historical research concluded that: information technology fails to increase the economic performance of its users or information technology value fails to appear in statistics. This conclusion is knows as "Productivity Paradox".

Nevertheless, more recent empirical studies performed on micro level, concluded that information technology plays a major role in improving the performance of enterprises. The relationship of information technology with performance of the enterprise appears to be dependent on intermediaries; it is not a direct link. These intermediaries are underlying factors in information technology usage effectiveness. Their identification permits the rejection of the productivity paradox.

The objective of this research project is to identify these intermediaries (underlying factors in information technology usage effectiveness) at micro level and to identify polices (on the basis of these underlying success factors) that can be recommended to European Union for improving performance at micro level.

At the theoretical level, this research has used English literature from scientific journal and books in order to grasp potential impacts in the firm following the use of information technology and explaining the observed gap between the firms of different ICT capabilities.

At the implementation level, System engineering and Policy analysis and Resources Based View literature has been used to develop a new framework to perform empirical analysis and policy analysis. The two major design specifications of the framework are: first, (A Saunders, E Brynjolfsson. 2007) argue that, currently one of the major reasons for success of productivity paradox is an exclusion of intangible

affects of information technology while performing empirical analysis. In order to measure full affects of information technology for its usage, we have performed empirical analysis, which include measurement of tangible as well as intangible affects of information technology. Second, Different IT capabilities can be identified at micro level among the firms (e-Business watch, 2005 & 2006), this make it difficult for researchers to identify the gap between adoption of information technology and impact on firm's efficiency for complete set of surveyed firms. As a remedy for such problem, this research has divided set of surveyed firms in the number of IT capabilities levels. Each level will hold firms according to their IT capabilities and then empirical studies of tangible and intangible affects have been studied at each level.

At the empirical level, our research has following conclusions: First, non-IT based innovations are particularly important for European firms to increase their performance i.e. productivity and revenue growth. Such innovations may turn out to be more efficient if inter-firm collaborations are facilitated under integrated ICT systems of the firms of different capabilities. Second, Investments in ICT system gets lost because of lack of open standards. Solving standardization issues will proceed in improving technical performance of the firm and standardized functioning with external links (supply and demand side) which will lower the probability for IT based failures and thus eventually improving performance of the firm. Third, ICT enabled innovation is dependent on high skill labor. Thus, in order to increase labor demand, the quality of labor should be improved. Therefore, EU should focus on increasing education levels, promoting research and development ventures to improve human capital and create favorable conditions for ICT investment, which in turn would increase innovative potential at micro level. Fourth, while innovation typically adds value, innovation may also have a negative or destructive effect as new developments clear away or change old organizational forms and practices. Organizations that do not innovate may be destroyed by those that do. Fifth, if an organization develops its IT capability over time, uses that capability in all of its organizational layers, and gets support from its management, it can benefit from the

roles played by IT. Network based business application, which includes ERP, CRM, and SCM play a role of integration and transformation for the firm and result in improving performance.

At policy analysis level we recommended that: The EU must take an initiative for establishing a global platform among EU enterprises to facilitate the development and usage of Europe's ICT potential by the creating an environment in which laggards can catch up and grow. Eventually this will result in improvement in digital facet of the European economy. The EU basic adaptive policies resulted from this research can facilitate and support the desired initiative and preserve needed flexibility for the future.

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1. INTRODUCTION TO THE RESEARCH

Motivation: This chapter introduces the subject, objectives, scope, contributions, methodology and dataset of this research. It also clarifies the structure of the document by telling what the reader can expect to find in each following chapter.

1.1 Research Problem, Scope, Objective, and Contribution

Problem: Information technology (IT) is defined as design, implementation, and management of computer based information system that can be used as a stand-alone application for performing specific task or can be used as a online application for communication between units of organization e.g. employees, departments etc or communication with partners outside the organization e.g. clients, suppliers, intermediaries etc. It's a common perception that, *"Information technology is used to enhance performance of the user (an individual, firm, industry etc)"*. Researchers are trying to prove or disprove this perception through empirical studies at level of workers, firms (micro level), industry (meso level), country (macro level), and unions (e.g. European Union). The obvious research question that may arise at this point is: How information technology (IT) affects the performance? And in broader view this is the intention of our research. Figure 1.1 gives a pictorial presentation of research problem.

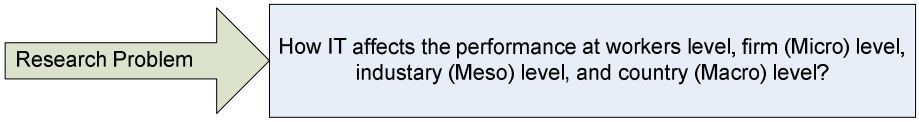


Figure 1.1 Research Problem

Scope: The last decade, researchers have been investigating the contribution of information technology to the performance of economies, at the macro level (Timmer, Ypma, Ark, 2003; Leeuwen & Wiel. 2003), industry level (Bloom, Sadun, Reenen. 2007; Crespi, Criscuolo, Haskel. 2007), and micro level investigating firms'performances (Bardhan, Whitaker, Mithas, 2006; Barua, Kriebel, Mukhopadhyay**.** 1995; Crespi, Criscuolo, Haskel. 2007; Melville, Kraemer, Gurbaxani.

2004; Mooney, Gurbaxani, Kraemer. 1995). Empirical analysis of historical research (Brynjolfsson. 1993) concluded that: information technology fails to increase the economic performance of its users or information technology value fails to appear in statistics. This conclusion is known as "Productivity Paradox" (Brynjolfsson, Hitt. 1998).

Nevertheless, more recent empirical studies (Saunders, Brynjolfsson. 2007; I bardhan, j whitaker, S mithas. 2006; G Crespi, C Criscuolo, J Haskel. 2007) performed at micro level, concluded that information technology plays a major role in improving the performance of enterprises. The relationship of information technology with performance of the enterprise appears to be dependent on intermediaries; it is not a direct link. These intermediaries are underlying factors in information technology usage effectiveness. Their identification permits the rejection of the productivity paradox. The current discussion leads to two research questions: How information technology can improve performance at the micro level? And which are the intermediaries that complete the relationship between information technology and performance at the micro level? These research questions bring us to research scope and problem demarcation, which is: *"rather than looking at information technology and performance relationship at workers, micro, meso and macro level, we restrict our research and empirical analysis to micro level".* Figure 1.2 gives pictorial presentation of research scope.

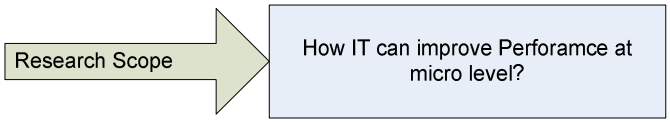


Figure 1.2 Research Scope

Objective: The objective of this research project is to identify these *intermediaries* (underlying factors in information technology usage effectiveness) at micro level and to develop a theoretical framework in order to assess the relationship of these

intermediaries with Information technology usage and performances at micro level. Figure 1.3 gives pictorial presentation of research objective.

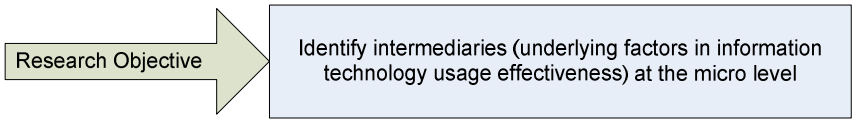


Figure 1.3 Research Objective

Contribution: These intermediaries are indeed the underlying influential factors determining the information technology usage effectiveness and thus shaping the ultimate IT business value. In this research project we aim at answering why some firms are more effective in using IT and how the laggards can catch up the leaders in the race to enhance their performance. The answers to the above two why and how questions lead us to *design robust policy* for the European Union and its member states to performance at micro level. Figure 1.4 gives pictorial presentation of research contribution.



Figure 1.4 Research Contribution

Above discussion and argumentation bring us to the final problem statement, which we will be investigated in this research. Figure 1.5 gives pictorial presentation of problem statement.

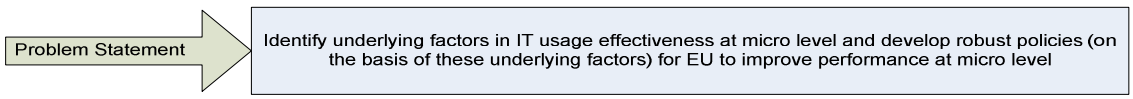


Figure 1.5 Problem Statement

The ultimate goal of this research is to find a solution for the problem statement. Such effort first requires thorough study of the problem domain. For that reason,

problem statement will be divided in a set of research questions which will guide the exploration of the problem and its domain. Next section is dedicated to this task.

1.2 Research Questions

In answering the central question of this research four main areas of knowledge should be understood, these are: Information Technology, Supplements for Information Technology, Information Technology Impacts and Information Technology Policies at micro level. .

Concerning the first theme, Information Technology, the key questions to be answered in pursue of the objectives of this research are:

Q1 What is information technology (IT) in the firm context?

- Q1.1 What does IT mean?
- Q1.2 Which are the different conceptualizations of IT at Micro Level?
- Q1.3 Which are the different drivers of IT at Micro Level?
- Q1.4 Which are the different implementations of IT at Micro Level?
- Q1.5 Which are the different executions of IT at Micro Level?

A second group of questions arises when trying to identify IT impacts. This set of questions has implicit in it also the problem of understanding firm performance since that is one of the levels at which IT impacts can be analyzed.

Q2 What is Information Technology impact?

- Q2.1 What does IT impact mean?
- Q2.3 What is known about IT impacts (academic literature)? Which evidence is there for IT impacts in firm performance literature?

The linkage between these two themes is a third intermediary theme in itself. The questions that will enable the exploration of the third theme are:

Q3 What is supplement in the firm context?

- Q3.1 Which are the externalities at Micro Level?

Q3.2 Which are the intra-firm complementarities at Micro Level?

Adding up together the answers to the first three sets of questions one comes to the last stop in the central themes that is information technology policies.

Q4 What is Information Technology Policy?

Q4.1 Which methodology of policy making for IT infrastructure at micro level is appropriate and why?

It is necessary to understand how the knowledge on the four themes has been integrated in previous studies, for that reason it is recommended to overview preexisting proposed models in the literature.

Q5.1 Which are the models characteristics, advantages and drawbacks in relation to the previously acquired knowledge?

Arrived to a stage where the literature background knowledge that could support the exploration of the research problem in question has been collected, presented and reflected upon, it will be time to deduce and test new knowledge. For that it is necessary to formulate hypotheses and a research framework that can guide the examination of those hypotheses. The next set of questions acts as a bridge between the theoretical and empirical part of the study.

Q6 Which hypotheses can be formulated and which steps should be taken to test them?

Hypothesis and Framework Construction

Q6.1 Which empirical research design and dominant theories will be followed to examine the hypotheses?

Framework Operationalization

Q6.3 Which data sources are used for the analysis?

Q6.4 How can the concepts in the proposed framework be translated into variables in those data sources?

Econometric Models

Q6.5 Which are the econometric models derived from operationalized framework by using scientific literature and intuitions for hypothesis testing?

Econometric Models Validation & Verification

Q6.6 Which methods and tools are used for the econometric models validation and verifications?

Given the results of the analysis a new set of questions arises which seeks to obtain the final answer for those hypotheses. These questions identify which hypotheses have been refuted and which have not and motivate potential reasons for the results obtained.

Q7 Which are possible interpretations, on the light of both statistical and field knowledge, of the results obtained from testing the research hypotheses?

Finally, a last group of questions inquires on the overall conclusions and contributions of the research developed. It also inquires about the limitations of the study and on alternative ways in which it could have been conducted.

Q8 Which are the implications and conclusions that can be made based on the results obtained in the research?

Q8.1 Which are the deliverables and contributions of this study?

Q8.2 Which are the policy implications of this study

Q8.3 Which are the limitations of this study?

Q8.4 Which are the recommendations for future research in the field?

This set of eight main research questions summarizes the path of exploration of the research problem and its domain previously presented. The next step in finding a solution to the problem statement of the research is to construct the research methodology that will be followed in order to find out the answers of above stated research questions and ultimately the solution for the research problem statement. Next section is dedicated to this task.

1.3 Research Methodology

The research methodology runs under three phases. Literature review, statistical analysis, and policy analysis, see figure 1.6.

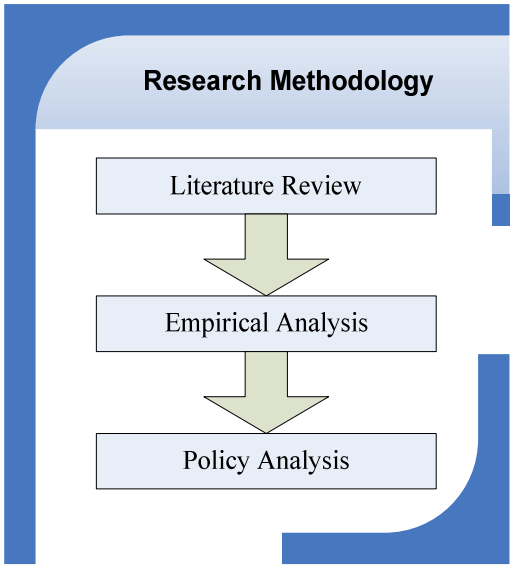


Figure 1.6 Research Methodology

At the *theoretical level*, the research will use organization theories in order to grasp potential learning effect in the firm following the use of information technology (see figure 1.7). A good knowledge of complementarities in firms, that might explain the fact that information technologies leads to higher efficiency only in conjunction with other organization devices will be needed too (Complementarities such as those pointed out by Milgrom-Robert 1990; Holmstrom-Milgrom 1994 and Athey-Stern 2001). The desk research will lead to development of a new analytical framework. This framework will help scholars and practitioners to better assess the IT Value Creation Process and to identify the areas (containing intermediaries - underlying influential factors determining the information technology usage effectiveness), where they have to put more emphasis on to reap higher benefits from IT. The design specification of this framework follows two important considerations. First, as many recent studies (A Saunders, E Brynjolfsson. 2007) pointed to, one of the major reasons why information technology seemingly might not produce the

expected results is the exclusion of intangible effects of IT (such as increased customer satisfaction, product variety, and ease of access) in the empirical studies.

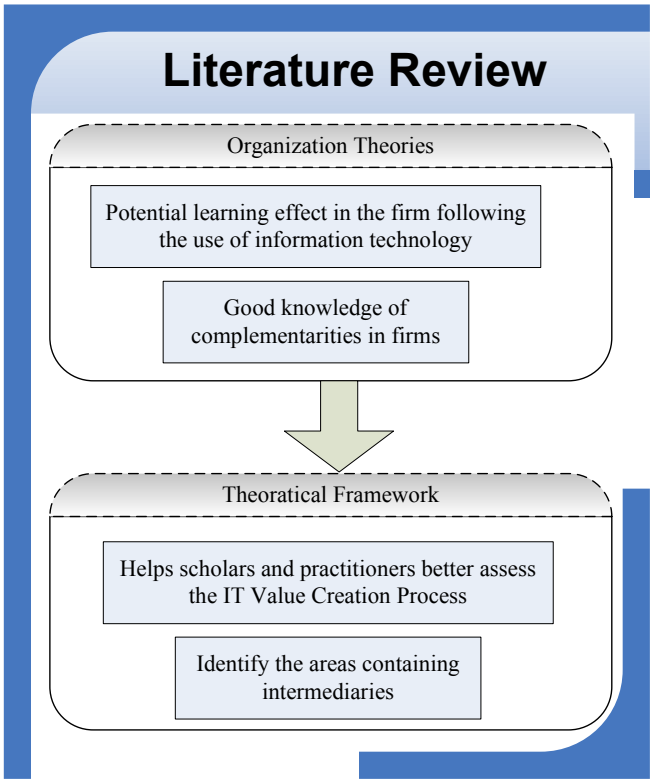


Figure 1.7 Literature Review

In order to portray a more comprehensive picture of the reality, we recommend that *empirical analyses* consider not on only tangible but also intangible effects of information technology at the same time. Second, at the micro level, diverse IT capabilities can be identified (e-Business watch, 2005 & 2006), which are different from one firm to the other. This severe heterogeneity makes it difficult for researchers to clearly identify the gap between adoption of information technology and its impacts on firm performance. As a remedy, we aim at classifying our surveyed firms into a number of categories according to their IT capabilities and competencies. The study of tangible and intangible effects of IT can then be

performed separately for each class of firms. This way, the derived policy recommendations will be much more realistic, practical, and effective, see figure 1.8.

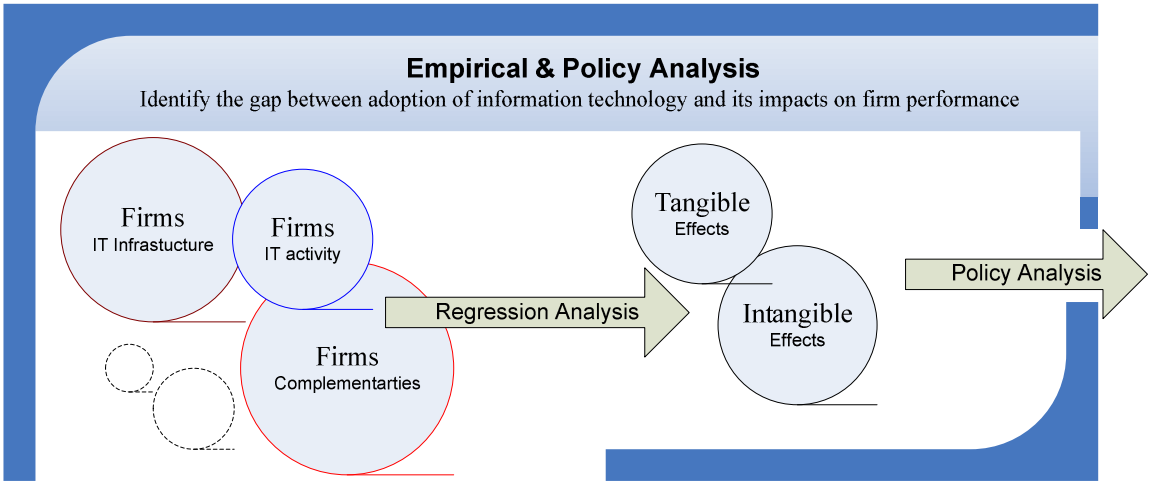


Figure 1.8 Empirical Analysis

Methodology Limitations: At theoretical level, literature surveys will include English based scientific literature that will be identified in journal, concerned books, and marked by experts of the field. Any other literature in other languages will be out of scope for the literature survey of this research. At different stages of research methodology, our research will encounter the research data. The details, source, and limitations of the research data are discussed in next section.

1.4 Research Data

At the empirical level, our starting point is the eBusiness W@tch surveys conducted by the European Commission. Linking the available datasets would provide us with an unbalanced panel serving as the base of the empirical analysis of this research. Although very large in size, this panel, as we expect a priori, would exhibit some major shortcomings for a sound analysis. As examples, we can mention the lack of a longitudinal trend behind the annual surveys and the lack of required supplementary employment, productivity, and innovation statistics. Of course, the identified shortcomings, accompanied by recommendations for a short- as well as a

long-term remedy, will be later communicated to increase the quality and usability of eBusiness W@tch for the next generations.

Data Limitations: In this research we have been using data set that has collected the empirical data through voluntary telephone survey. The problem of refusing or eligible respondent being unavailable results in "non response", which limits the data and its reliability. However, this effect cannot be avoided in any voluntary survey (telephonic or paper based).

After discussing the subject, objectives, scope, contributions, methodology and dataset of this research, the coming section will provide the details of the structure of the document by telling what the reader can expect to find in each following chapter.

1.5 Structure of the Thesis

For the research questions discussed in sections 1.2, the methodologies used for answering these research questions under their parent chapters is listed in table 1.1. Figure 1.9 give brief overview of expected outcomes and methodology of research applied for each chapter.

Research Question	Research design and methodology	Chapter
Q1	Literature review and self-reflection	2 + 3
Q2	Literature review and self-reflection	3
Q3	Literature review and self-reflection	3
Q4	Literature review and self-reflection	3
Q5	Literature review and self-reflection	2
Q6	Literature review and Empirical analysis	2 + 4 + 5
Q7	Literature review and self-reflection	5
Q8	Literature review and self-reflection	6 + 7

Table 1.1 Mapping of Research Questions to Chapters and Methodologies

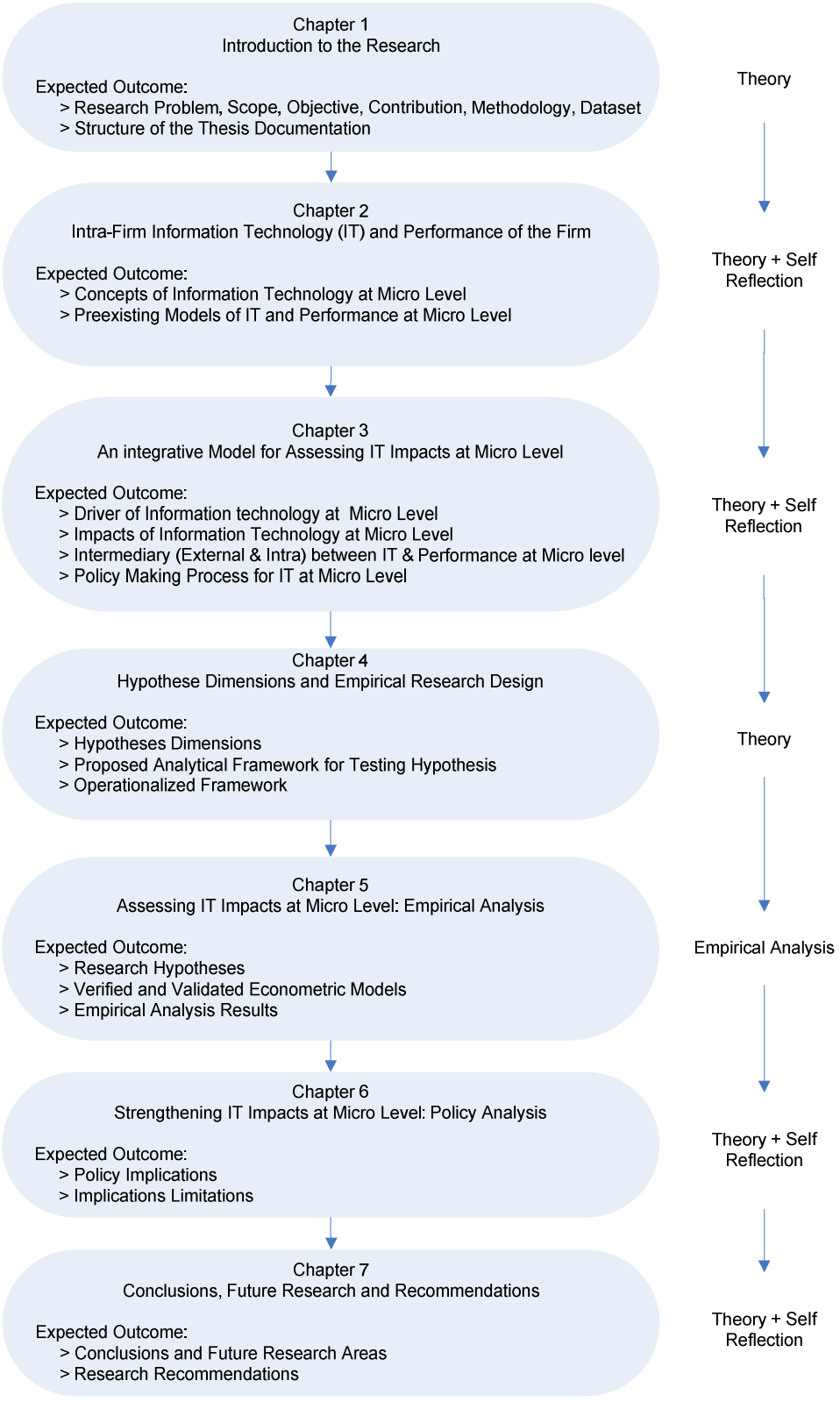


Figure 1.9 Structure of the Thesis

2. IT & PERFORMANCE OF THE FIRM

Motivation: The impacts of information technology (IT) at micro level can not be realized until the link between information technology and the performance of the firm is not investigated, the link between the information technology and its impacts is not a direct link (Verbano C, Venturini K, Petroni G, Nosella A. 2008). This chapter investigates the existence and nature of the factors that either complete this link or support it. Such factors involve: Information Technology Divers (Lin HF, Lin SM. 2008) and Intermediaries (Ramamurthy K, Sen A, Sinha AP. 2008), see figure 2.10.

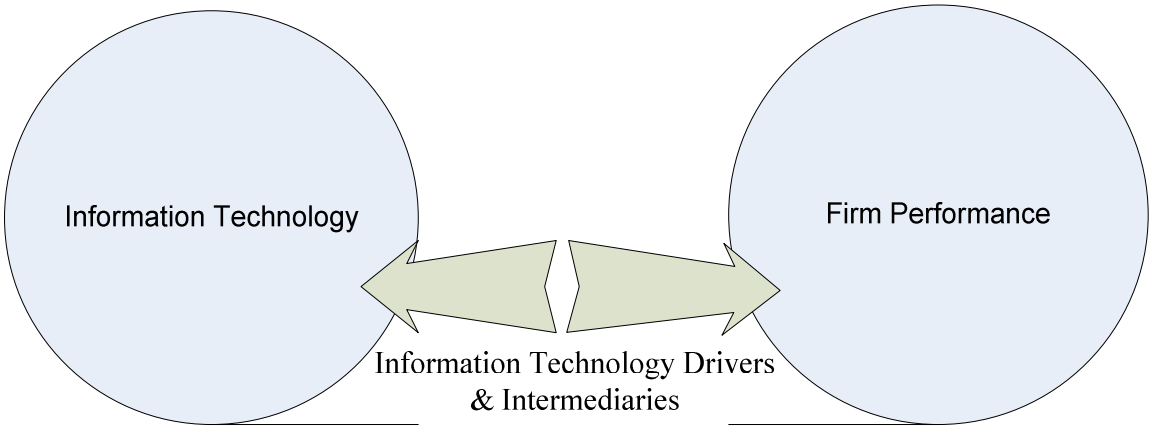


Figure 2.10 Information Technology and Firm Performance

It is obvious that we can not investigate the information technology drivers and intermediaries until *conceptualization* and the *context* of information technology at micro level is discussed. By conceptualization we mean, how academic literature look at information technology at micro level (research question 1.1 and 1.2 in section 1.2). This discussion will help us to develop concrete and research specific conceptualizations of information technology at micro level. Later this conceptualization will be assessed under the context (framework - derived from literature) for the realization of our research objective, which is to investigate the link between the information technology and its impacts on firm performance and design the policies to improve performance at micro level.

2.1 Conceptualization of Information Technology

The research questions 1.1 and 1.2 in section 1.2 are related to conceptualization of information technology. Research questions 1.1 (see below) look upon information technology in general perspective, where as research questions 1.2, looks at information technology under perspective of micro level. Answers to these research questions are actually a discussion of conceptualization of information technology at micro level. Let's investigate the answers of the following questions:

Q1.1 What does Information Technology (IT) mean?
Q1.2 Which are the different conceptualizations of IT at Micro Level?

2.1.1 What is Information Technology?

Information technology has existed and evolved through decades. It will not be fair to the discussion, if we define information technology in the context of recent times. The right definition can be extracted if evolution of information technology (from the 1700's - telegraph Semaphore, until now) is considered. This in-depth analysis of information technology evolution is irrelevant to our research topic. Thus we consider the evolution of information technology from the time when internet was commercialized (i.e. 90's) and information technology is renamed as "*Information and Communication Technology (ICT)*" [Wikipedia-ICT].

In academic literature, different authors have presented conceptualization of information technology in different contexts (micro, meso, and macro level). But our research is focused at micro level and we consider that it will be less descriptive for conceptualizing of information technology, if perspective of different authors at micro level is considered. As a result we have selected an author – Dr Brynjolfsson E, who has been involved in "*micro level analysis of information technology in relation with firm performance"* from 90's until now, see figure 2.11.

In (Brynjolfsson E. 1993) authors define information technology as:

> *"Information technology can be defines in various ways. Among the most common is the category "Office, Computing and Accounting Machinery" of the*

U.S. Bureau of Economic Analysis (BEA), which consist of primarily of computers. Some researchers use definition that also include communications equipment, instruments, photocopiers and related equipment, and software and related services"

In (Brynjolfsson E. Yang S. 1996) authors define information technology as:

"Information technology" can be defined in various ways. Among the most common is the BEA's (U.S. Bureau of Economics Analysis) category "Office, Computing and Accounting Machinery (OCAM) which consists primarily of computers. Some researchers look specifically at computer capital, while others consider the BEA's broader category, "Information Processing Equipment (IPE)." IPE includes communications equipment, scientific and engineering instruments, photocopiers and related equipment. Besides, software and related services are sometimes included in the IT capital. Recent studies often examine the productivity of information systems staff, or of workers who use computers at work.

In (Brynjolfsson E. Hitt L M. 1998) authors define information technology as:

The greatest increase in productivity has historically been associated with a particular class of technologies: "general purpose technologies." What general purpose technology might hold a similar promise in the 1990s? The obvious answer is information technology.

In (Brynjolfsson E. Hitt L M, 2000) authors define information technology as:

"Information technology, defined as computers as well as related digital communication technology, has the broad power to reduce the costs of coordination, communications, and information processing. Thus, it is not surprising that the massive reduction in computing and communications costs has engendered a substantial restructuring of the economy. The majority of modern industries are being significantly affected by computerization. As a result, information technology is best described not as a traditional capital

investment, but as a "general purpose technology".

In (Brynjolfsson E. Hitt L M, 2003) authors define information technology as:

> *"Information technology, defined as computers (general purpose technology) with unmeasured inputs and unmeasured outputs i.e. intangible outputs such as quality, convenience, variety, or timeliness"*

In (Saunders A Brynjolfsson E. 2007) authors have not presented any new definition for information technology, so we assume that same perspective of (Brynjolfsson E. Hitt L M, 2003) for information technology definition is followed in (Saunders A Brynjolfsson E. 2007).

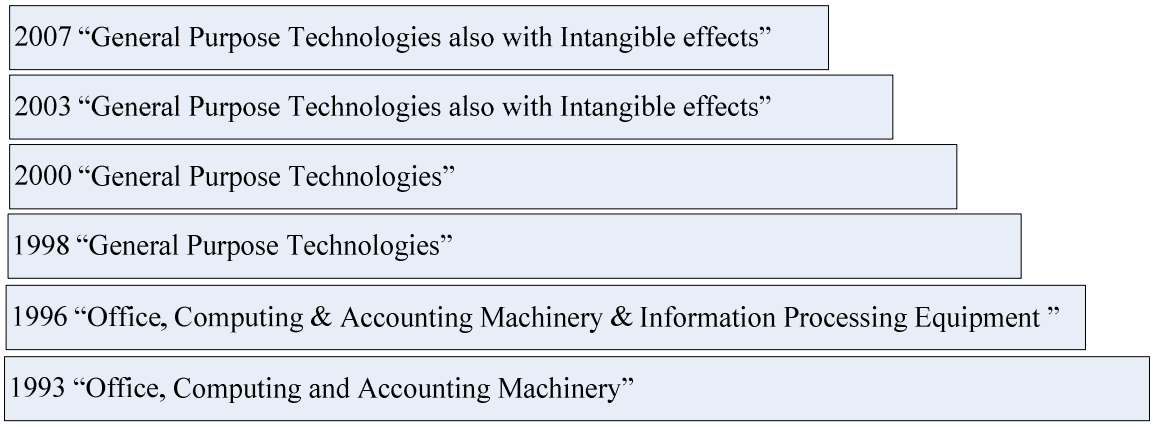


Figure 2.11 Brynjolfsson E Perspective of Information Technology

The discussion of the Dr. Brynjolfsson E. perspectives about information technology has lead to the conclusion that: *information technology is a General Purpose Technology (GPT) with tangible and intangible effects*. In a study by Jovanovic B. Rousseau P L. 2005, authors support Dr. Brynjolfsson E. perspective that information technology is a general purpose technology and has the following three characteristics:

- Pervasiveness: The GPT should spread to most sectors.

- Improvement: The GPT should get better over time and, hence, should keep lowering the costs of its users.
- Innovation spawning: The GPT should make it easier to invent and produce new products or processes.

As a boarder picture for information technology, we agree with the conclusion and arguments provided by (Jovanovic B. Rousseau P L. 2005), but in reference to our research context i.e. at micro level, is this conceptualization true?

We believe that at micro level information technology can not be defined as General Purpose Technology (GPT), because at the firm level it is not the information technology as GPT exist but it is the variants of information technology (specialized in performing specific information technology related tasks) are implemented e.g. Data warehousing (Ramamurthy K, Sen A, Sinha AP. 2008), Electronic-Procurement System (EPSs) (Soares-Aguiar A, Palma-Dos-Reis A. 2008), Application Service Provider (ASP) (Lee H, Kim J, Kim J. 2007), ERP Systems (Law CCH, Ngai EWT. 2007), Supply Chain Management (Subramani M. 2004) etc and none of these variants fully support GPT related three characteristics (Pervasiveness, Improvement, and Innovation spawning). For example patent data security algorithms, which are information technology based innovations, consider to be company specific and private property. This leads to volition of one of the characteristics of GPT – Pervasiveness. Also in literature related to "Resources Based View (Wade M. Hulland J. 2004)" present resources (even information technology variants) of the firm are sources for competitive advantage rather then generalized goods. If information technology is not a General Purpose Technology then how can we conceptualize it? To find the answer for this question we have to investigate different conceptualizations of IT at Micro Level (research question 1.2) in the academic literature.

2.1.2 Which are the different conceptualizations of IT at Micro Level?

In (Albadvi A., Keramati A., Razmi J. 2007) an author discusses the existence of information technology at firm level with respect to the context in which it is used.

"IT in communications IT in communications refers to those directly involved in transaction of information. This criterion includes the following applications: email, fax, cell phone, Internet access, local access networks (LAN) for technical data within the company, LAN for companies, internal networks of the company, company's website for advertisement, intranet, data interaction with suppliers and customers. Assessing the

IT in decision making This decision-making support criterion indicates the application of IT in supporting management of processes. So, it includes IT applications such as decision support systems (DSS), data analysis techniques and prognostic software.

IT in manufacturing and operation This criterion works as an umbrella to delineate a range of computer-assisted technologies for direct or indirect support, control, detecting and monitoring of manufacturing activities.

IT in administrative or office work This criterion refers to the use of IT to help administrative or office work like organizing documents organizing and storing data etc."

From the arguments provided by (Albadvi A., Keramati A., Razmi J. 2007), we can perceive that information technology does not have one solid conceptualization. Rather information technology conceptualization depends upon the context in which it is implemented and used. For example, if we follow the arguments of (Albadvi A., Keramati A., Razmi J. 2007) then we can say that: information technology is "communication medium" for information asserts, when it is used in communication or information technology is the complementary (IT based decision making software) when it is used for supporting management of processes.

At abstract level information technology can be defined as General Purpose Technology, e.g. Steam, electricity, internal combustion, and information technology (IT) (Jovanovic B. Rousseau P L. 2005) but at concrete level (e.g. firm, house, hospital etc), its conceptualization depends upon its context.

Note: By definition, context means "the set of facts or circumstances that surround a situation or event [google.com]". In the literature of (Albadvi A., Keramati A., Razmi J. 2007) discussed above, the context is: communication, decision making, administrative work, and manufacturing and operation, which are actually setups (for achieving some purpose in the firm). In our research project, it is not possible to build these real time setups and implement conceptualization of information technology to evaluate the research objective. Under such research constraint, we will use literature to build a virtual context (framework) that will be used for implementation of the conceptualization and evaluation of our research objective.

2.2 Context of Information Technology (IT)

At firm level information technology is context specific and this context is directly influenced by firm itself. Under the literature of "System Engineering and Policy Analysis (Lempert, R.J., Popper, S. and Bankes, S.E. 2003)" the factors in the system that can be influenced directly are called instruments. Thus we can conclude that at firm level information technology is not General Purpose Technology (GPT) rather it's a *Context Specific General Purpose Instrument*. Still its nature is general because two GPT characteristics which are: improvement and innovation spawning are still followed at firm level.

2.2.1 Context of IT & System Engineering and Policy Analysis

Although we have successfully defined the conceptualization of information technology at firm level as a Context Specific General Purpose Instrument, this definition is still some how vague if we didn't specify the context (framework) and then use that context for realization of our research objective, which is to investigate the link between the information technology and its impacts on firm performance. To define the context we have used the literature of "System Engineering and Policy Analysis (Lempert, R.J., Popper, S. and Bankes, S.E. 2003)" and "Theory of Resources Based View (Wade M. Hulland J. 2004)".

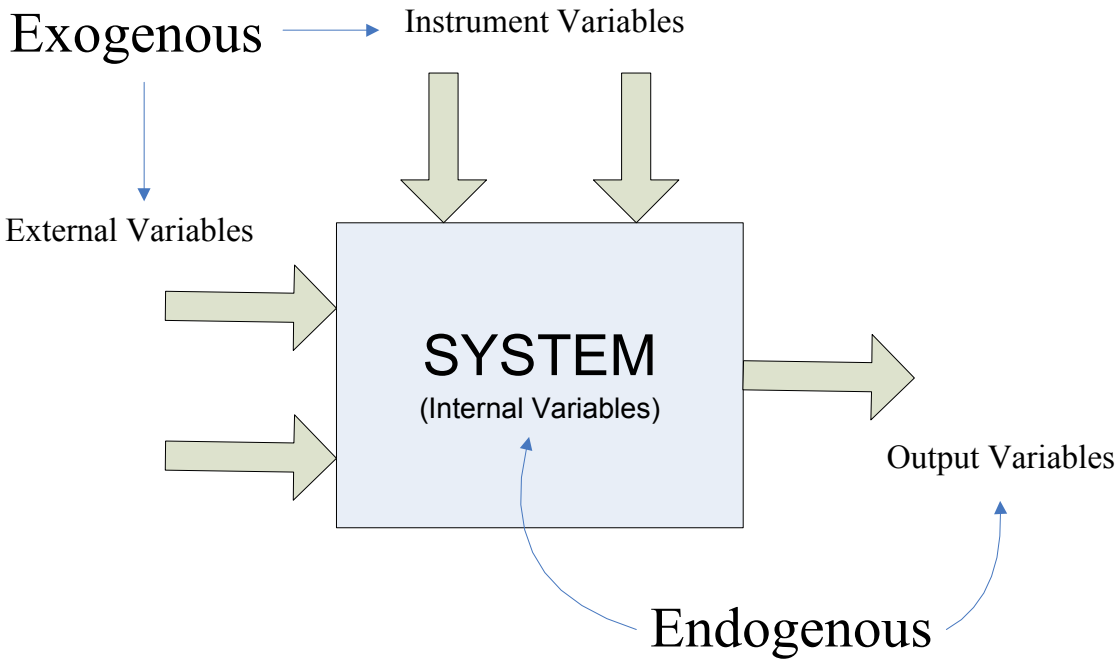


Figure 2.12 Contextual model of System Engineering and Policy Analysis

Figure 2.12 gives a pictorial presentation of "Contextual Model of System Engineering and Policy Analysis". In this model we have different variables which are: instrumental variables, external variables, output variables and internal variables.

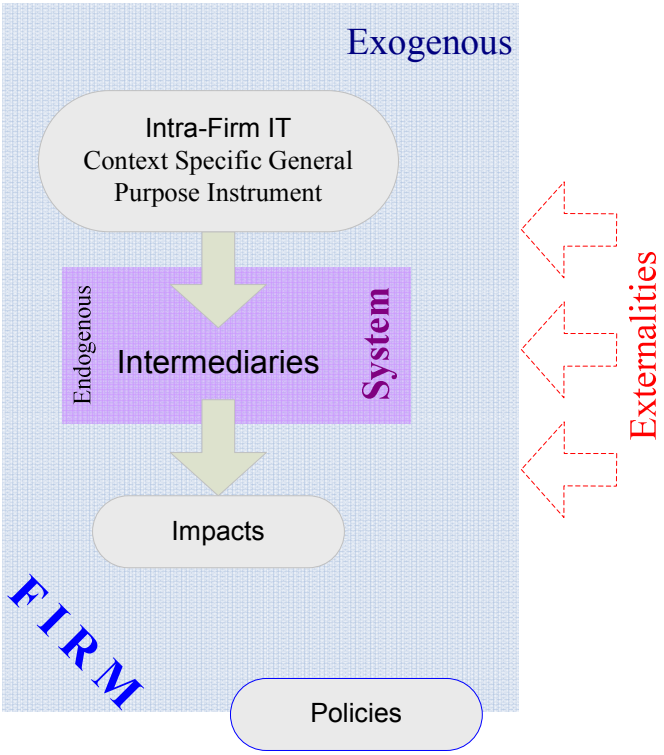


Figure 2.13 Contextual Model based on System Engineering and Policy Analysis

As mentioned earlier, instrumental variables are factors that can be influenced directly e.g. IT investments. External variables are factors that can not be influenced directly e.g. Competition. Output variables are factors on the basis of which state of the system is judged e.g. IT revenue. Internal variables are factors that complete the casual link between instruments and output variables e.g. e-marketing. The values of instrumental and external variables are not determined by the model that's why they are called exogenous. Where as in case of output variables and internal variables, the values are determined by the model itself and that is why they are called endogenous. If we translate "Contextual Model of System Engineering and Policy Analysis" into our research context (framework for our derived conceptualization of information technology) then we get the model shown in figure 2.13.

Although contextual Model of IT and Firm Performance (derived from Contextual model of System Engineering and Policy Analysis) is an implementation of our

define conceptualization of information technology at micro level, but still the model is not providing the concrete level that is needed. The reason is the variables defined in the model (IT, intermediaries, and impacts) have subsets of factors that we need to explore further, but unfortunately we are unable to follow literature of "System Engineering and Policy Analysis" for exploration for these subsets. It is not that literature of "System Engineering and Policy Analysis" which is not enough but rather it is our research scope that differs from literature of "System Engineering and Policy Analysis" from this point forward.

Note: literature of "System Engineering and Policy Analysis" is typically used to evaluate the output variables under current system for analysis of policy options, where as in our research we need to evaluate the link that exists between the information technology and its impacts on firm performance.

2.2.2 Context of IT & Theory of Resource based View

From this point forward we jump from literature of "System Engineering and Policy Analysis" to the "Theory of Resources Based View (Wade M. Hulland J. 2004)". Further construction on the contextual Model of IT and Firm Performance will follow the literature of "Resources Based View". The resource-based view argues:

> *"Firms possess resources, a subset of which enables them to achieve competitive advantage, and a further subset which leads to superior long-term performance. Resources that are valuable and rare and whose benefits can be appropriated by the owning (or controlling) firm provide it with a temporary competitive advantage. That advantage can be sustained over longer time periods to the extent that the firm is able to protect against resource imitation, transfer, or substitution. One of the key challenges RBV theorists have faced is to define what is meant by a resource. Researchers and practitioners interested in the RBV have used a variety of different terms to talk about a firm's resources, including competencies, strategic assets, assets, and stocks" (Wade M. Hulland J. 2004)*

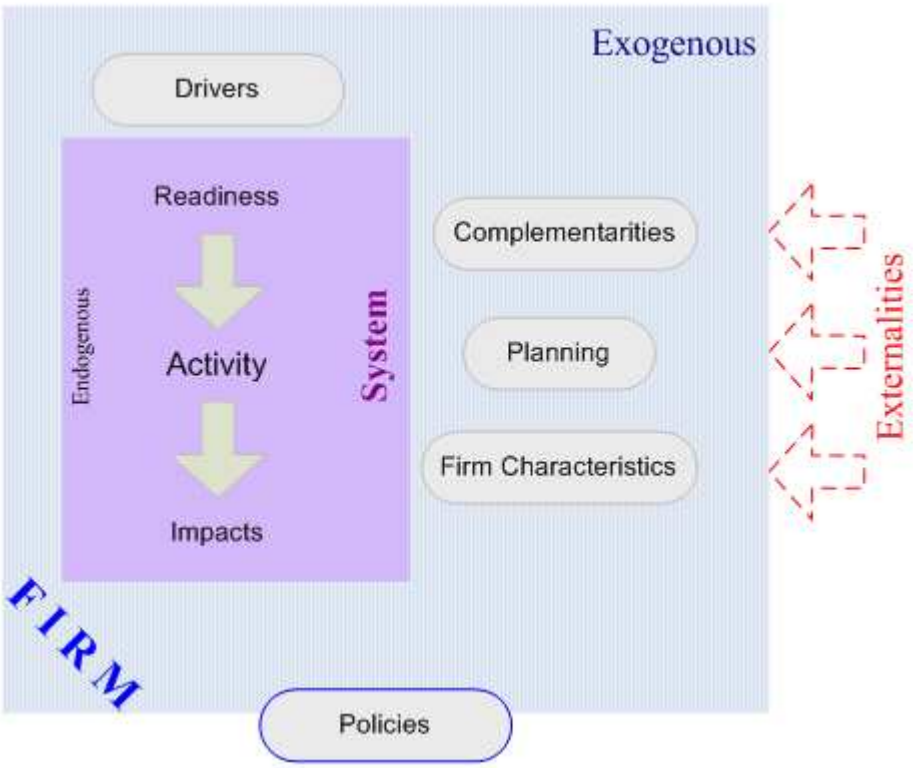


Figure 2.14 Contextual Model based on Resource Based View

2.3 From Context of IT to Framework of IT

Under such argumentation and discussion of "Theory of Resources Based View", we have dissolved the variables (IT, intermediaries, and impacts) in the model to further 2-level-subset of IT based and non IT based concrete factors, which firms implement and use for attaining competitive advantage and improve performance in long run. In figure 2.14, the first level of the subsets of IT based and non IT based concrete factors (drivers, readiness, activity, complementarities, planning, externalities, and impacts) is presented. *This form of structure (figure 2.14) have taken our conceptualization (inventing an idea and formulating it mentally) to the concept of framework (a structure supporting or containing idea).*

2.4 Comparative Analysis of Proposed Framework

The research question that will be answered in this section is: Q5.1 Which are the models characteristics, advantages and drawbacks in relation to the previously acquired knowledge?

Before we jump into details insight of concrete levels of our proposed framework, let's verify the contribution and integrity of this framework, and for that we will perform theoretical comparative study between our framework and frameworks previously existed in literature. There are different frameworks that exist in literature for measuring IT contributions and identifying the intermediate variables that complete the link between IT and its impacts. Some of these frameworks are:

Barua (1995) performed a two stage analysis by using intermediate and higher level output variables for tracing and measuring IT contributions. As Figure 2.15 illustrates the study controls for industry specific and economic wide variables which have been previously mentioned to affect the value creation process. However, this framework misses the firm's specific variables. Furthermore, when one looks at the operationalisation of these components one finds that this model is very much based in the supply chain model.

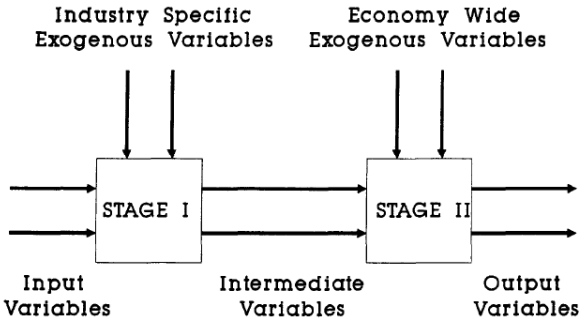


Figure 2.15 Barua (1995) Model for Measuring IT contribution

Intermediate level variables include: capacity utilization, inventory turnover, relative inferior quality, relative price and percentage sales of new products. Final performance variables include: market share and return on assets. In conclusion, the intermediate effects chosen by the authors are too related with flows and

production of physical goods which makes it hard to use the model in the service sector.

Melville (2004), see figure 2.16, considers both exogenous and internal factors to the firm. At the internal level it considers information technology technological and human resources as well as complementarities. It uses IT resources as inputs used in business processes through which business process performance get effected. Business processes are described as activities that underline value generation, such as e.g. inbound logistics, manufacturing, sales and distribution. Business process performance, which is later translated into organizational performance, is defined as operational efficiencies measurable through e.g. customer service, flexibility and information sharing, depending on the business process considered. Organizational performance is defined as overall firm performance measurable through performance indicators like: productivity, efficiency and competitive advantage.

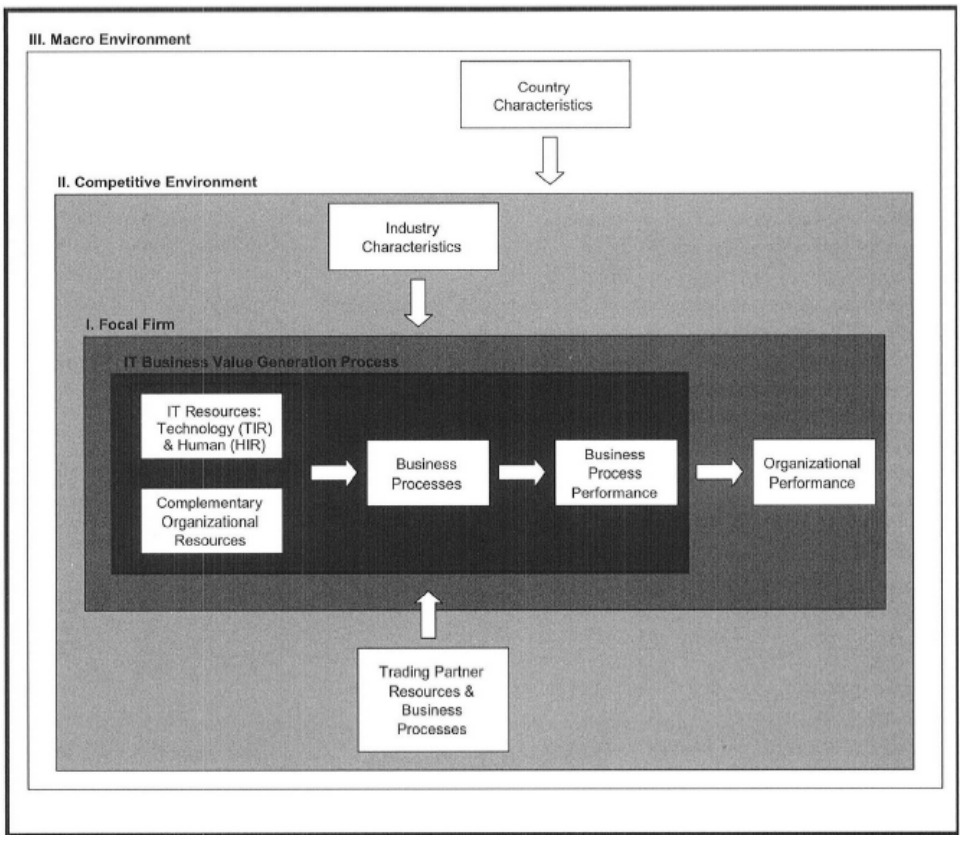


Figure 2.16 Melville (2004) Model for Assessing IT Impacts on Firm Performance

e-Business W@tch (2003) proposed model (see figure 2.17) is based on a widely used conceptual framework for the analysis of electronic business proposed by the OECD[1]. This model is designed to analyze how ICTs are used to support business processes within the enterprise, interaction with business partners, procurement and production processes and finally marketing and sales activities. This model have thee modules: e-Readiness (IT infrastructure), e-Activity (IT based e-Business Activities), and e-Impacts (e-Business based activities Impacts on firm performance). This model is the one that is closest in design and have similar context when compared to our conceptualization of information technology at micro level for European enterprises.

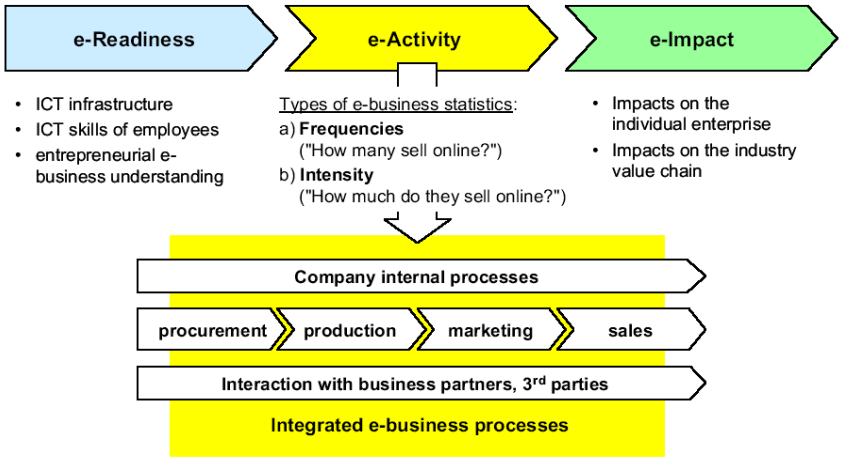


Figure 2.17 e-Business W@tch (2003) Model for Assessing e-Business Impacts on Firm Performance

2.4.1 Conclusion from Comparative Analysis

In form of conclusion it can be said that:

- First in (A Saunders, E Brynjolfsson. 2007) author argues that, currently one of the major reasons for existence of productivity paradox is an exclusion of intangible affects of information technology while performing empirical analysis. In order to measure full affects of information technology for its usage, analysis must also include measurement of tangible as well as intangible effects of information technology. None of the above mentioned

cf. Colecchia, Alessandra / Pattinson, Bill / B. K. Atrostic (2000): Defining and Measuring Electronic Commerce. A discussion paper, OECD, Paris. February.

frameworks makes a distinction between tangible and intangible impacts and measure them separately.

- Second different IT capabilities can be identified at micro level among the firms (e-Business watch, 2005 & 2006), this make it difficult for researchers to identify the gap between adoption of information technology and impact on firms' efficiency for a complete set of surveyed firms. As a remedy for such problem, the research must divide the set of surveyed firms in the number of IT capabilities levels. Each level will hold firms according to their IT capabilities and then empirical studies of tangible and intangible affects will be studied at each level. None of the above mentioned framework considers the IT capability of the firms; they assume that all firms hold same capabilities, which is an odd assumption in reality.
- Third, the ultimate goal for measuring the effect of IT at micro level is to design and propose IT based policies that can improve the performance of the firms. All above mentioned frameworks try to investigate the impacts of IT and identify intermediaries that are responsible for these impacts, but none of them provides a bridge between their proposed framework for assessing IT impacts and policy analysis frameworks for designing IT policies.
- Fourth, although these frameworks (Melville. 2004) (Barua. 1995) consider the external forces that drive information technology, they did not explicitly define the forces that exist inside the firm and drive information technology. Such ambiguity leads to incorrect conceptualization of exogenous variables at the micro level.

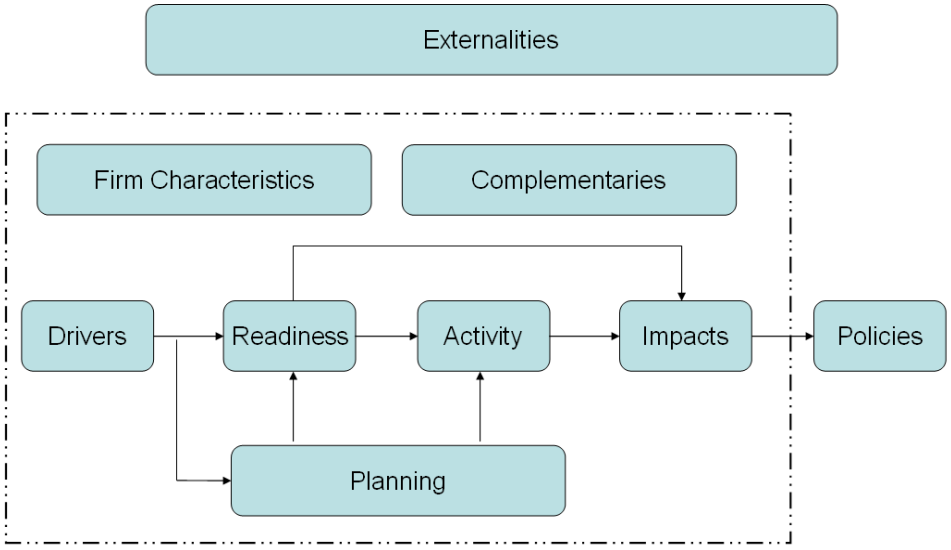
There is an obvious need of a new framework that can identify the intermediaries that support information technology but also provide a bridge between IT assessment framework and Policy Analysis Framework. Framework in figure 2.14 is purposely designed to achieve such objective and provides solutions to the shortcomings identified in previous frameworks (Melville. 2004) (Barua. 1995) (e-

Business W@tch. 2003). The proposed framework is discussed in details in next chapter. Discussion in next chapter shows how our proposed framework has overcome the shortcoming of the previous frameworks.

3. PROPOSED FRAMEWORK & POLICY ANALYSIS

Motivation: Deriving from the previous literature review there is an obvious need of a new framework that can: first, identify the intermediaries that complete the link between information technology and its impacts at micro level; second, provide support for policy analysis; and third provide solution for the shortcomings of previously proposed frameworks.

As mentioned in last chapter, under argumentation and discussion of "Theory of Resources Based View", we have dissolved the variables (IT, intermediaries, and impacts) in the proposed framework to further 2-level-subset of IT based and non IT based concrete factors, which firms implement and use for attaining competitive advantage and improve performance in long run.



** Dotted line represents the boundary of the firm in our research project.*

Figure 3.18 Proposed Framework with Relationships among first level factors

In figure 3.18, the first level of the subsets of IT based and non IT based concrete factors (drivers, readiness, activity, complementarities, planning, externalities, and impacts) is presented. The second level, called operationalization, which even looks inside the first level factors, will be explored in next chapter. Operationalization (chapter 4) and statistical analysis (chapter 5) will help us to fulfill first objective of

our research, which is to *identify the underlying success factors that complete or support the link between IT and firm performance*. Let's explore the first level factors and their relationships. The research questions related to next discussion are:

(See section 3.1 for answer)

Q1.4 Which are the different implementations of IT at Micro Level? (See section 3.2 for answer)

Q1.5 Which are the different executions of IT at Micro Level? (See section 3.3 for answer)

Q2.1 What does IT impact mean at micro level? (See section 3.4 for answer)

Q2.3 What is known about IT impacts (academic literature)? Which evidence is there for IT impacts in firm performance literature? (See section 3.4 for answer)

Q3.1 Which are the externalities at Micro Level? (See section 3.5.2 for answer)

Q3.2 Which are the complementarities at Micro Level? (See section 3.5.1 for answer)

Q4.1 Which methodology of policy making for IT infrastructure at micro level is appropriate and why? (See section 3.6.2 for answer)

3.1 Which are the different drivers of IT at Micro Level?

The research question answered in this section is: Q1.3 Which are the different drivers of IT at Micro Level?

Drivers of Information Technology are the forces that exist inside the firm and drive the firm to invest in information technology (Zhu K, Kraemer KL, Gurbaxani V, Xu SX. 2006). One of the shortcomings of previously proposed frameworks is: "*although these frameworks (Melville. 2004) (Barua. 1995) consider the external forces that drive information technology, but they did not explicitly defined the forces that exist inside the firm and drive information technology. Such ambiguity leads to incorrect conceptualization of exogenous variables at micro level*". The driver module in our proposed framework is a solution of this shortcoming. External forces that exist outside the firm are captured in another module called "Externalities[2]", see figure 3.18, this module will be discussed later in this chapter.

[2] The term externalities is related to literature of System Engineering and Policy Analysis rather then micro economics, in which externalities are benefits or costs that are not included in the market price of goods or services.

The relationship between driving forces and investments in information technology by the firm is depicted in figure 3.18 with an arrow between modules of “Drivers” and “Readiness”. Let us see how academic literature looks upon driver of information technology.

In (Lee H. Kim J. 2007) authors gives an overview of the determinants of success for application service provider for small businesses. They find out that seven information system (IS) factors that drive the success of application service provider: system quality, information quality, service quality, intention to use, user satisfaction, individual benefit, organizational benefit and an additional factor, trust, have good fit with data gathered. These factors, except for system quality, show significant coefficients and explanatory power. Furthermore, it is found that both service quality and information quality are significant for fostering user satisfaction, trust, and intention to use.

In (Lin H F. Lin S M. 2008) authors try to find out determinants of e-business diffusion in reference with theories like “Technology diffusion theory and Technology-organization-environment (TOE) framework”. There research model examines the influence of technological context (IS infrastructure and IS expertise), organizational context (organizational compatibility and expected benefits of e-business) and environmental context (competitive pressure and trading partner readiness) on e-business diffusion. E-business diffusion is characterized by two dimensions: internal integration and external diffusion. The results reveal that expected benefits of e-business is one of the important drivers shaping e-business diffusion. Other factors include IS infrastructure, IS expertise, and competitive pressure.

In (Zhu K, Dong ST, Xu SX, Kraemer KL. 2007) authors study the determinants of post-adoption stages of innovation diffusion, using enterprise digital transformation as an example of technology-enabled innovations under reference of theories like “Diffusion of innovation theory and Technology organization-environment framework”. They find out that among the innovation characteristics, compatibility

is the strongest driver, and security concern outweighs cost as a usage inhibitor and among the contextual variables, technology competence, partner readiness and competitive pressure significantly drive e-business usage, and the structural inertia of large firms tends to slow down its penetration.

In (Wu, CM; Zhao, J; Xia, L. 2006) authors study the information and communication technologies (ICT) adoption choices of Italian manufacturing firms, investigating the factors, both at the firm and at the environmental level, that speed up or slow down the adoption. For firm-specific variables they investigated variables like size, human capital, the composition of the workforce and organizational indicators that the literature on technology adoption cites as potential factors in determining the optimal rate of investment in ICT. Second, given the network aspect of many ICT, particularly internet-based applications, they investigate whether the local industrial structure affects adoption patterns even after controlling for individual characteristics. The results indicate that the most important drivers are size, the human capital of the workforce and the presence of large firms in the local environment.

In (Lal K. 1999) authors try to measures the intensity of adoption of Information Technology (IT) and identify its determinants. Paper argues that the degree of IT adoption is determined by the variables such as entrepreneurship, skill intensity, government policy, openness of economy, competitive environment, and other firm-specific factors. The results suggest that the qualification and information base of entrepreneurs and their attitude towards innovative activities and market share are significant drivers for IT adoption.

3.2 Which are the different implementations of IT at Micro Level?

The research question answered in this section is: Q1.4 Which are the different implementations of IT at Micro Level?

Readiness is the implemented information technology based initiatives to establish new or support older information technology infrastructure that exist inside the

firm. There are three relationships that are identified in our research that exist between:

- Established initiatives (information technology infrastructure inside the firm – module readiness) and information technology induced activities inside the firm (module - activity) (Soares-Aguiar A, Palma-Dos-Reis A. 2008).
- Established initiatives (information technology infrastructure inside the firm – module readiness) and end results of information technology induced activities (module - impacts) (Koh CE, Nam KT, Prybutok VR, Lee S. 2007), (Lin JSC, Hsieh PL. 2006).
- Established initiatives (information technology infrastructure inside the firm – module readiness) and the initiatives which firm have planned to take in future because of the opportunities or lapses firm sees in information technology setup, activities inside the firm and end results of information technology induced activities (module - planning) (Kearns GS. 2007).

First relationship is depicted in figure 3.18 with an arrow between modules of "Readiness" and "Activity". Second relationship is depicted in figure 3.18 with an arrow between modules of "Readiness" and "Impact" and third relationship is depicted in figure 3.18 with an arrow between modules of "Readiness" and "Planning". Let us see how academic literature looks upon readiness of information technology.

Readiness to Impacts Link (see figure 3.18): In (Koh CE, Nam KT, Prybutok VR, Lee S. 2007) authors discuss the readiness factor - internet and its impact on performance of the firm. They compare two countries regarding the pattern of internet utilization, the impact of the internet on organizational performance, and the readiness for the internet from the value chain perspective. The study provides an empirical evidence for the connection between the organization's readiness for the internet and the impact of the internet on organizational performance.

Readiness to Impacts Link (see figure 3.18): In (Lin JSC, Hsieh PL. 2006) authors examine how technology readiness (TR) influences customers perception and adoption of self-service technologies (SSTs). Paper explores the relationships among TR, perceived service quality, satisfaction and behavioral intentions toward self-service technologies. Results indicate technology readiness influences perceived SST service quality and behavioral intentions, while perceived SST service quality has a positive impact on customer satisfaction and behavioral intentions toward SSTs.

Planning to Readiness Link (see figure 3.18): In (Bendoly E, Citurs A, Konsynski B. 2007) authors discusses the readiness factor – radio frequency identification (RFID), and argue that for many firms, RFID suggests not only a new alternative to existing tracking methods but also a means to a range of previously cost-prohibitive internal control and supply chain coordination innovations. In any event, and even in light of possible external pressures to adopt, the full potential of RFID for an individual firm must ultimately be viewed in consideration with the infrastructural capabilities of that firm. Furthermore, because adoption decisions are fundamentally based on managerial perceptions, it is critical to consider how certain forms of infrastructure provide the necessary transparency into other infrastructural characteristics to augment such decisions. Results demonstrate that the complementary effects of these infrastructural capabilities significantly impact both perceptions of and commitments to RFID.

Examining link between Readiness and Activity in Presence of Complementarities (see figure 3.18): In (Haugh HM, Robson PJA, 2005) authors examines the diffusion of Information Communication Technology (ICT) into firms in Scotland and northern England. Data concerning micro-computers, e-mail, the Internet, ISDN, in-house website (readiness), and the automation of business functions (activities) is analyzed by industry, firm size, firm age, rate of growth, export involvement, and innovation activity (complementaries). The results from a sample of 1347 firms found an overall increase in the adoption of ICT in firms between 1998 and 2001. The increase is led by older and larger firms in comparison to younger and smaller firms. In addition, the diffusion of the automation of business functions was found to

be sequential, from generic to specific applications. Further increases in the diffusion of ICT are likely to come from upgrading existing equipment and increases in the range of business functions that can be automated. Finally, although use of the Internet and web-based trading has increased in the sample firms, this has not replaced traditional marketing and sales. The results support the view that more firms are taking up the challenge of using ICT in-house, with older and larger firms leading the way ahead of younger and smaller firms.

3.3 Which are the different executions of IT at Micro Level?

The research question answered in this section is: Q1.5 Which are the different executions of IT at Micro Level?

Activities are the information technology induced activities that exist inside the firm and are currently performed by the firm (Whelan, E. 2007), (Zhu K, Kraemer KL, Xu S. 2006). There are two relationships that are identified in our research that exist between:

- Information technology induced activities inside the firm (module -activity) and end results of information technology induced activities (module - impacts) (Verbano C, Venturini K, Petroni G, Nosella A. 2008).
- Information technology induced activities inside the firm (module -activity) and the initiatives which firm have planned to take in future because of the opportunities or lapses firm sees in information technology setup, activities inside the firm and end results of information technology induced activities (module - planning) (Kearns GS. 2007),.

The first relationship is depicted in figure 3.18 with an arrow between modules of “Activity” and “Impact” and second relationship is depicted in figure 3.18 with an arrow between modules of “Activity” and “Planning”. Let us see how academic literature looks upon activities of information technology.

Examining link between Activity and Impact (see figure 3.18): In (Subramani M. 2004) authors argue that Supply chain management systems (SCMS) championed by network leaders in their supplier networks are now ubiquitous. Rather then examining the benefits for network leaders from these systems, paper exams the benefits for supplier firms. It proposes that two patterns of SCMS use by suppliers-exploitation and exploration-create contexts for suppliers to make relationship-specific investments in business processes and domain knowledge. These, in turn, enable suppliers to both create value and retain a portion of the value created by the use of these systems in inter-firm relationships. In (Mishra AN, Konana P, Barua A. 2007) authors examines the antecedents and consequences of Internet use in the procurement process. The results suggest that while some resources, such as procurement-process digitization, influence Internet use in both the procurement stages, other resources, such as the diversity of organizational procurement knowledge, impact Internet use in only one stage. We also find that Internet use in the OIC stage has a more significant impact on procurement-process performance than use in search.

3.4 What is Information Technology impact at micro level?

The research questions answered in this section are: Q2.1 What does IT impact mean? Q2.3 What is known about IT impacts (academic literature)? Which evidence is there for IT impacts in firm performance literature?

These are the end results of information technology induced activities (Lin HF, Lin SM. 2008), (Zhu K, Kraemer KL, Xu S. 2006). There are two relationships identified in our research that exists between:

- The end results of information technology induced activities (module - impacts) and policy implications (module - polices)
- The end results of information technology induced activities (module - impacts) and the initiatives which firm have planned to take in future because of the opportunities or lapses firm sees in information technology

setup, activities inside the firm and end results of information technology induced activities (module - planning) (Kearns GS. 2007).

The first relationship is depicted in figure 3.18 with an arrow between modules of “Impacts” and “Policies” and second relationship is depicted in figure 3.18 with an arrow between modules of “Impacts” and “Planning”. For the relationship between modules of impacts and policies, the theory of Adaptive policy making will be applied to identify implications that will support the underlying effective factors of information technology in the firm. Let us see how academic literature looks upon impacts of information technology.

In (Yang, L. 2007) authors investigate the impacts of Information Technology on technical efficiency in a firm's production process through a two-stage analytical study and they concluded that IT exerts a significant favorable impact on technical efficiency and in turn, gives rise to the productivity growth.

In (Koh CE, Nam KT, Prybutok VR, Lee S. 2007) examine the extent to which the internet impacts business performance and concluded that Organization readiness for internet and impact of the internet on organization performance is positive in USA and South Korean firms.

In (Stare M, Jaklic A, Kotnik P. 2006) authors examine the effects of ICT use by firm-level analysis and apply production function approach to estimate the impact of ICT on the performance of service firms in Slovenia. The results suggest that service firms are more intensive ICT users than manufacturing firms and that ICT use significantly influences the productivity of service firms. The positive impact of ICT use on productivity applies to all service firms irrespective of their size. The links are stronger for service firms with above average ICT use.

3.5 Supplements in the firm context

The research questions answered in this section are: Q3 What is supplement in the firm context? Q3.1 Which are the externalities at Micro Level? Q3.2 Which are the intra-firm complementarities at Micro Level?

Supplements are the factors which support or oppose the link between information technology and its impacts on the firm performance. They are further sub divided in to two kinds: Intra-firm complementarities and externalities. Let's discuss these two categories one by one.

3.5.1 Which are the intra-firm complementarities at Micro Level?

Intra-firm complementarities include those factors which support or oppose the link between information technology and its impacts on the firm performance while they exist inside the firm. Intra-firm complementarities include following modules, see figure 3.18:

Complementarities: The factors that are either information technology based or non information technology based and exist inside the firm that complements modules of "Readiness" and "Activity" e.g. innovation (Ramamurthy K, Sen A, Sinha AP. 2008), Organizational and Strategic Practices (Bocquet R, Brossard O, Sabatier M, 2007). Note that the complementarities can be supportive or can be unsupportive. Let us see how academic literature looks upon complementarities for information technology.

In (Law CCH, Ngai EWT. 2007) authors examined the relationships between the success of ERP system adoption, extent of business process improvement (BPI), and organizational performance and investigated the associations between the outcomes of these initiatives and such organizational complementarities as strategic intent, senior management support, and the status of the IT function within a company. This empirical evidence reinforced the long-held assumption that organization-level benefits, BPI, and ERP success were closely related; and that these relationships were subject to the influence of the organizational complementarities.

In (Bayo-Moriones A, Lera-Lopez F. 2007) authors examined the role played by five groups of factors in ICT adoption: environment (externalities), firm structural characteristics (firm characteristics), human capital (driver), competitive strategy,

and internal organization (complementarities). Results highlight the need to study the different ICT separately as well as the importance of establishment size, multinational ownership, and high-skilled workforce in ICT adoption. Complementarities like Quality control systems and team-based organization of work also play a relevant role in the diffusion of certain elements of ICT within firms.

Planning: Planning for Information Technology are the initiatives which firm planned to take in future because of the opportunities or lapses firm sees in information technology setup (module - readiness), activities inside the firm (module - activity) and end results of information technology induced activities (module - Impacts) (Bendoly E, Citurs A, Konsynski B. 2007, (Premkumar G, King Wr. 1994), (Premkumar G. 1992). Let us see how academic literature looks upon Planning of information technology.

In (Premkumar G, King Wr. 1994) authors explore the differences in IS planning characteristics among various industry groups. The results indicate that some IS planning characteristics such as IS planning resources, IS resources, role of IS in the organization, extent of business domain analysis, contribution to organization's performance, and implementation success vary significantly among industry groups. Other planning variables such as top management and user involvement, planning effectiveness, information input to planning, and the use of a steering committee do not significantly differ among industry groups. On an overall basis, it was found that firms in insurance, banks, retail, and publishing tend to lay greater emphasis on most IS planning characteristics, and firms in utilities and oil industry do not lay much emphasis on IS planning characteristics.

Firm Characteristics: Firm Characteristics are the firm related factors same as complementarities but with a difference and difference is: complementarities have either supportive or unsupportive relationships with “Readiness” and “Activity” modules but for some of the complementary factors inside the firm it is difficult to define the relationship with any of the modules of the proposed framework, we call

these complementary factors as “Firm characteristics”. Let us see how academic literature looks upon Firm Characteristics

In (Ramamurthy K, Sen A, Sinha AP. 2008) authors concluded that firm characteristics – firm size is one of the key determinants for data warehouse adoption.

In (Lal K. 1999) authors concluded that firm characteristics - market share are significant determinants of the degree of IT adoption. The results also indicate that size of operations and skill intensity of the firms influenced the extent of IT use.

In (Haugh HM, Robson PJA, 2005) authors analyze the diffusion of Information Communication Technology (ICT) into firms in Scotland and northern England under firm characteristics like Firm Size, Firm Age, Rate of Growth, and Export Involvement and readiness factors. One of the conclusions of their study is: the increase in diffusion of Information Communication Technology (ICT) into firms is led by older and larger firms in comparison to younger and smaller firms.

3.5.2 Which are the externalities at Micro Level?

Externalities include those factors which either support or oppose the link between information technology and its impacts on the firm performance while they exist outside the firm.

Externalities are the forces that exist outside the firm and they are beyond the control of the firm. These forces have reasonable affect on the firm (Lin HF, Lin SM. 2008), (Verbano C, Venturini K, Petroni G, Nosella A. 2008). This module proves to of very high importance in our research and regression analysis. In econometrics literature the models that depict the proposed frameworks are a closed system, which means that these models are performing estimations on predefined system (i.e. regression models static in nature) with out taking into consideration the effect of external factors, which means: “not taking into consideration the presence of uncertainly around the system”. According to literature of policy analysis, estimations performed on static system, will lead to may be short term effective

policies but will not produce effective long term policies or effective short term policies for sure. Under influence of policy literature we have included the module of externalities in our proposed framework to cope with uncertainly that exist around the system (proposed framework). Let us see how academic literature looks upon externalities.

In (Lin HF, Lin SM. 2008) authors study the determinants of e-business diffusion and concluded that competitive pressure are important factors shaping e-business diffusion.

In (Zhu K, Kraemer KL, Xu S. 2006) authos assess the Assimilation of Internet-based e-business innovations by firms in an international setting. They argue that there are three assimilation stages: initiation -> adoption -> routinization. They concluded that Competition positively affects initiation and adoption, but negatively impacts routinization, suggesting that too much competition is not necessarily good for technology assimilation because it drives firms to chase the latest technologies without learning how to use.

3.6 What is Policy Analysis?

The research questions answered in this section are: Q4 What is Information Technology Policy? Q4.1 Which methodology of policy making for IT infrastructure at micro level is appropriate and why?

Policy Analysis is aimed at facilitating the policy making process by producing policy-relevant information that can be utilized to resolve problems in the specific political setting (Riet O v d, 2002). Finding solutions to problems is thus the core of policy analysis. This definition by Riet is a systematic way of looking at policy analysis process.

If we dig deeper in the policy analysis literature, we can realize that in reality policy making is all about the future. If we able to predict the future accurately (finding solution to the problem), preferred policies could be identified by simple examining

the future that would follow from implementation of each possible policy and picking the one that produced the most favorable outcomes (Walker W E. Rahman A S. Cave J, 2001).

If we combine the concepts provided by Riet and Walker to define the process of policy analysis under context of micro level and econometric analysis, then we can say that "Policies are the future favored implications that can be derived through process of statistical analysis to improve performance of the firm (King WR, Flor PR. 2008), (Zhu K, Dong ST, Xu SX, Kraemer KL. 2007)".

3.6.1 Methodologies for Executing Policy Analysis

The process of policy analysis can be executed under different models. Such models include: Rational Style, Argumentative Style, Client Advice Style, Participatory Style, Process Style, and Interactive Style (Mayer I S. Daalen C E v. Bots P W G. 2004). The underlying values of these models are:

- Rational style. What is good knowledge?
- Argumentative style. What is good for the debate?
- Client advice style. What is good for the client/problem owner?
- Participatory style. What is good for democratic society?
- Process style. What is good for the process?
- Interactive style. What is good for mutual understanding?

Under the context of our research some of these models can contribute in the phase of policy analysis if and only if future is predictable. Under such conditions these models contribute in following ways:

- Rational style – can be used for identification of intermediaries
- Argumentative style – Not needed for our research.
- Client advice style – Can be used for Identifying EU favored policies
- Participatory style – Not needed for our research.
- Process style – Not needed for our research (for managerial implication)
- Interactive style – Not needed for our research.

Note: These models are only applicable and implementable if and only if future is predictable, because future favored policies are derived by models from the predictions of current system behavior. If prediction is not possible then models will not be able to find the most beneficial policies and thus policy analysis process will fail.

3.6.2 Information Technology & Policy Making at Micro Level

The model selection for the phase of policy analysis in our research is highly dependent on the context of our research, which in our case is information technology usage at firm level. The context of information technology at micro level is highly unpredictable (Dewan S. Shi C. Gurbaxani V. 2007) (Schwartz E S. Gorostiza C Z. 2003). Under such unpredictability is it not possible to employee the models mentioned above. As remedy for the problem of future uncertainty we will employee "Adaptive Policy Making" approach (Walker W E. Rahman A S. Cave J, 2001) in the phase of policy analysis of our research.

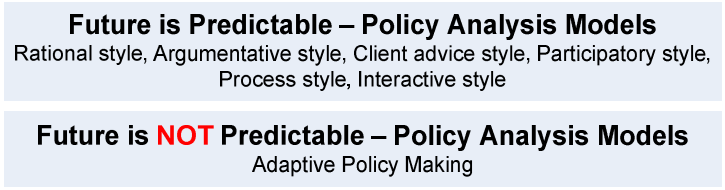


Figure 3.19 Policy Models

The "Adaptive Policy Making" approach is dynamic, thus allowing uncertainties to be resolved over time. It explicitly recognizes the value of additional information at different steps in the process, and the trade-offs in time and money to collect it. Further, it is designed to incorporate the actions and reactions of other players. In sum, it is a systematic method for developing and implementing a policy over time that is based on a clear set of constraints and objectives and that involves monitoring the environment, gathering information, and adjusting and re-adjusting to new circumstances (for further details see: Walker W E. Rahman A S. Cave J, 2001 or coming chapter of policy analysis, where detailed implementation of adaptive policy making will be shown under context of our research), see figure 3.19.

As mentioned in the motivation of the chapter the objective of a new framework is to: "*first, identify the intermediaries that complete the link between information technology and its impacts at micro level; second, provide support for policy analysis; and third provide solution for the shortcomings of previously proposed frameworks*"

We have shown that how our proposed framework can achieve first part of objective i.e. identification of intermediaries. Plus it provides remedy for the short coming of incorrect conceptualization of exogenous factors. Now let us see how proposed framework achieves the second part of objective that is: Providing support for policy analysis. Plus the solutions for shortcoming like:

- First, In (A Saunders, E Brynjolfsson. 2007) author argues that, currently one of the major reasons for success of productivity paradox is an exclusion of intangible affects of information technology while performing empirical analysis. In order to measure full affects of information technology for its usage, analysis must also include measurement of tangible as well as intangible affects of information technology. None of the above mentioned frameworks make distinction between tangible and intangible impacts and measure them separately.
- Second, Different IT capabilities can be identified at micro level among the firms (e-Business watch, 2005 & 2006), this make it difficult for researchers to identify the gap between adoption of information technology and impact on firms' efficiency for complete set of surveyed firms. As a remedy for such problem, the research must divide set of surveyed firms in the number of IT capabilities levels. Each level will hold firms according to their IT capabilities and then empirical studies of tangible and intangible affects will be studied at each level. None of the above mentioned framework considers the IT capability of the firms; they assume that all firms hold same capabilities, which is an odd assumption in reality.

The output of this research will have two products, first is the identified intermediaries that are responsible for completing the link between information technology and its impacts on firm performance, second the polices that will be put forward as recommendation to European Union to improve European enterprise performance. The research performed by e-Business Watch teams (e-Business Watch Report 02, 03, 05, 06, 07) end up in recommending policies to EU for improving European enterprise performance. We believe that, even though these polices are efficiently created but their implementation leading to successful results have some doubts. The doubts are related to different capability levels for information technology of European firms. Some of the firms have amble resources and can implement the policies easily, some have less and some have none. This uneven distribution of firm resources leads to successful implementation of EU policies on very small scale and over all goals of EU policies is not achieved. Under such circumstances, an improved framework is needed, that can be treated as remedy for this problem and provide policies that can be implemented by all European firms. For such reason we have updated the framework in figure 3.18. Figure 3.20 gives pictorial presentation of improved framework and figure 3.21 give the improved version in the presence of externalities. The modifications are as following:

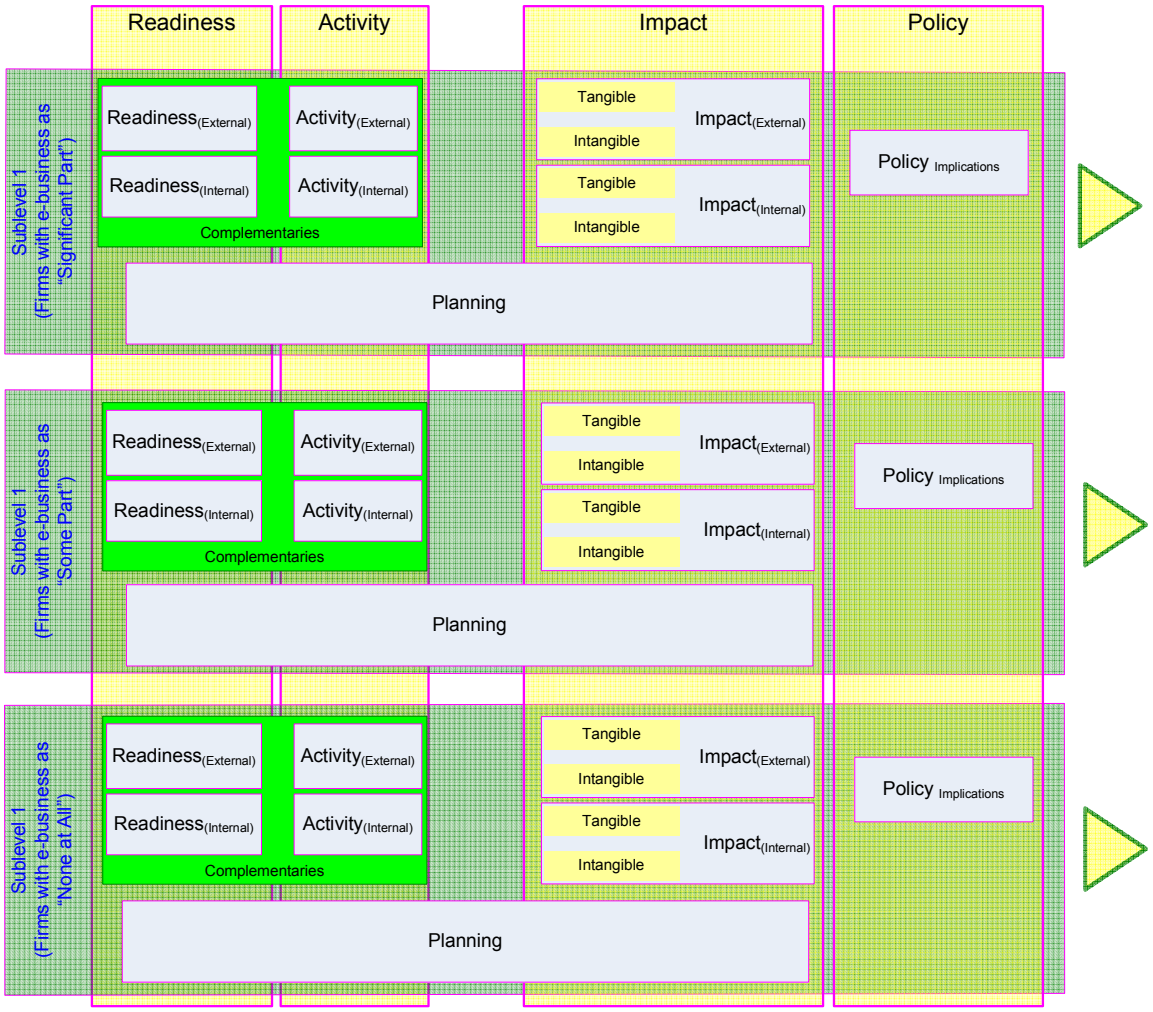


Figure 3.20 Framework based on Firms Categories

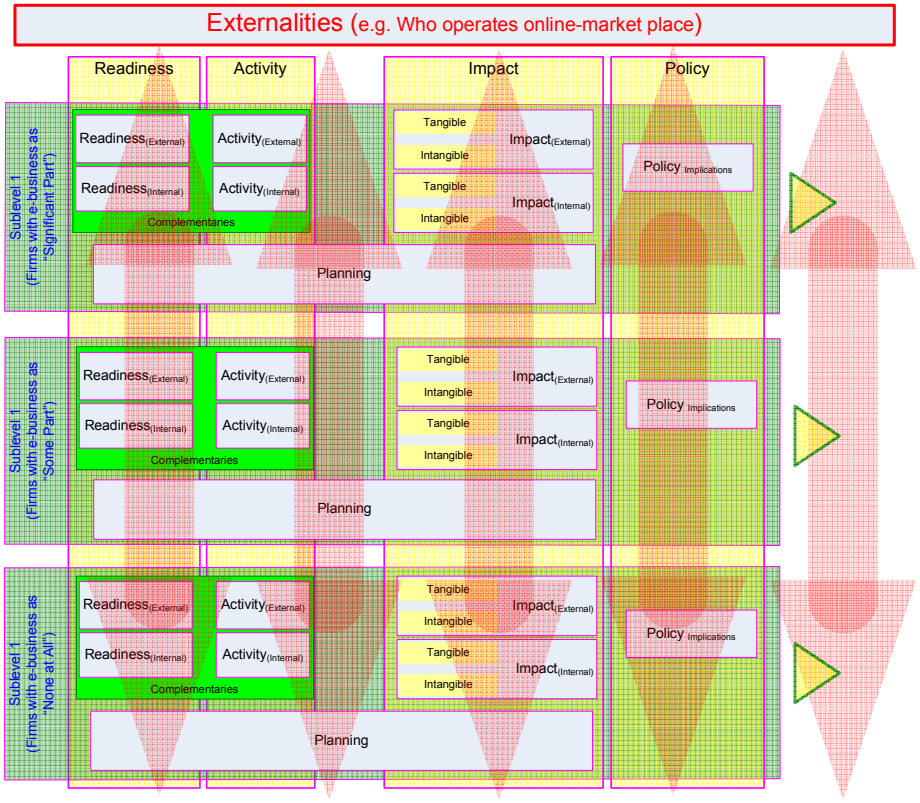


Figure 3.21 Framework based on Firms Categories under Externalities

- Recent research (Wirthmann A. 2008) have accepted that for better monitoring and evaluation of IT based business Impacts, the IT based business processes must be treated separately when executed for external communication and for internal communication. Considering such arguments have lead us to provide more refinement to the second level (operationalization) by dividing module of readiness, activity, and impact in to "Internal readiness and External readiness", "Internal activities and

external activates ", and "Internal impacts and external impacts ". In (A Saunders, E Brynjolfsson. 2007) authors argue that, one of the major reasons for success of productivity paradox is an exclusion of intangible affects of information technology while performing empirical analysis. In order to measure full affects of information technology for its usage, we recommend performing empirical analysis, which include measurement of tangible as well as intangible affects of information technology and that's why the internal and external impacts in the proposed framework are further subdivided into tangible and intangible impacts see figure 3.20.

- Different IT capabilities can be identified at micro level among the firms (e-Business watch, 2005 & 2006), this make it difficult for researchers to identify the gap between adoption of information technology and impact on firms' efficiency for complete set of surveyed firms. As a remedy for such problem, this research have divided the set of surveyed firms in the number of IT capabilities classes. Each class will hold firms according to their IT capabilities and then empirical studies of tangible and intangible affects will be studied at each level. There are three classes defined on the basis of firm's capabilities. These capabilities are derived on the basis of following criteria:

    - **Selection of Criteria:** we have selected the criteria on the basis of our conceptualization of IT as *Context Specific General Purpose Instrument* (see section 2.2). Currently, at micro level, the most implementable context specific general purpose instrument of information technology is e-business. In order to define the classes in proposed framework "e-Business" is used as criteria.
    - **Specification of Criteria:** The literature of policy analysis specifies the criteria on the basis of the stakeholder perception. We have obtained the stakeholder perception about e-business from our research dataset (e-business watch surveys), which is: e-business constitutes a significant part of the way firms operate today, or some part, or none at all.

The three classes derived on the basis of our selected criteria (e-business) and their specifications are:

- *High Tech e-Business based Firms (HTBF)*: e-Business constitutes a significant part of the way firms operate today.
- *Medium Tech e-Business based Firms (MTBF)*: e-Business constitutes a some part of the way firms operate today
- *Low Tech Firms (LTF)*: e-Business does not constitute any part of the way firms operate today.

Note: A fuzzy line exists for the firm to be declared as HTBF, MTBF, and LTF. Under such circumstances it is highly legitimate to use stakeholder perception (IT mangers of the firms) for defining three classes rather then using dataset for definition of the classes.

4. HYPOTHESES DIMENSIONS & EMPIRICAL RESEARCH DESIGN

Motivation: After designing a theoretically based framework, it is time to plan how to evaluate it empirically as well as how to answer the empirically answerable questions of this research.

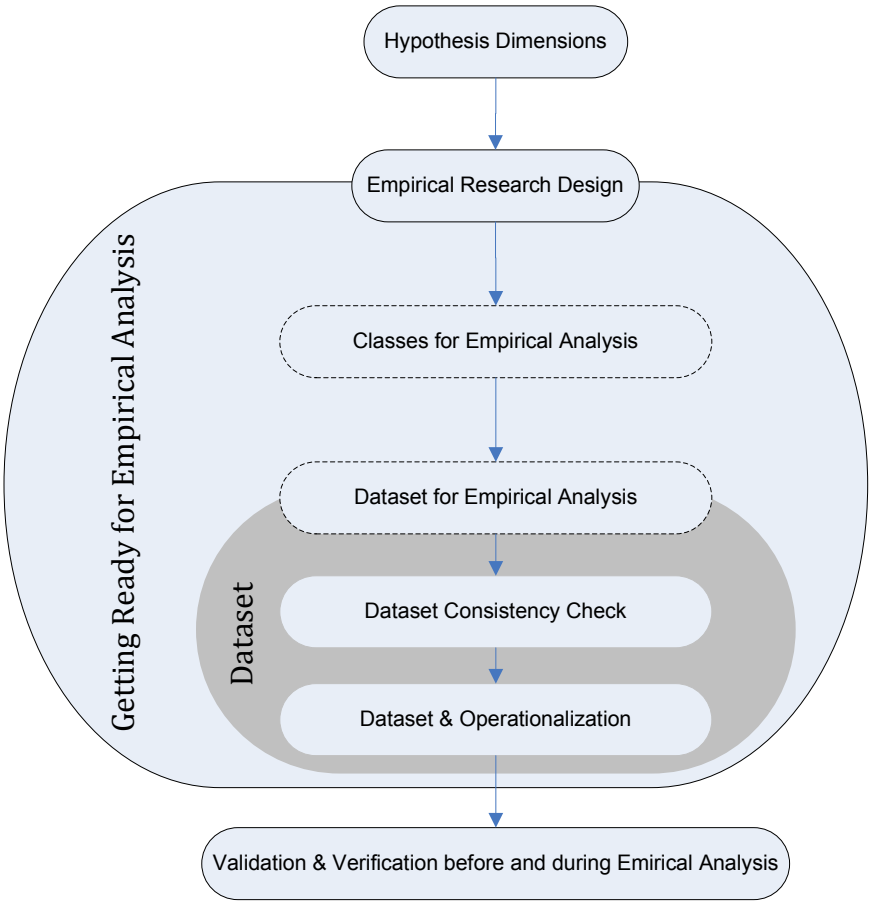


Figure 5.22 Work flow for Empirical Research Design

This chapter establishes the link between the theoretical and empirical part of this research. Figure 5.22 gives an overview of workflow for this section. In first part it presents the hypotheses dimensions. Next it explains the empirical research methodology for the analysis of the hypotheses using given dataset. In the last it gives an overview of the verification and validation methodology used before and during regression analysis (coming in next chapter).

4.1 Hypotheses Dimensions

The research question partially answered in this section is: Q6.1 Which empirical research design and dominant theories will be followed to examine the hypotheses? Rest of the answer is given in section 4.2.

In order to be able to test the proposed framework previously presented a set of hypotheses will be designed and tested though empirical analysis (chapter 5). There are two ways for designing the hypotheses. First, the relationships among the module of the proposed framework can be taken as the basis for designing hypotheses. But in this case we are ignoring the classes that we have created in our proposed framework, which give basis for bridging proposed framework to the policy analysis framework. Under such circumstances we will follow the second approach.

In this approach rather testing the relationships among the module, we will build our hypothesis on the basis of industry dimensions, for example: work force composition, value chain and firm characteristics, market structure, innovation dynamics, market externalities, productivity, and revenue growth as performance indicator (eBusiness Watch - 2008). In next chapter, the hypotheses for each dimension will be designed. Later these designed hypotheses will be tested for different classes of the firms in the proposed framework through empirical analysis. This approach will help in identifying the underlying success factors (intermediaries) per class, which later be given as input to policy analysis framework to design the policies per class to encourage these factors, which will result in improved performance of European enterprises. Let explore the hypotheses dimensions that we have selected for our research.

4.1.1 Productivity

Firm performance is assumed to be the outcome of its conduct (Nanyang W. F. 2003). For example, this would include investments made in ICT, where the availability of resources that can be used for innovative activities depends on the intensity of competition in which a firm operates. Further, ICT readiness and

technical competence influence a firm's ability to gain benefits from ICT investment. Despite extensive research on the use of ICT and its impact, empirical research is unable to state with clarity that ICT use leads to increases in productivity and firm performance (Brynjolfsson. 1993). However, we can say that ICT does have some impact on firm performance (Saunders, Brynjolfsson. 2007) (Bardhan I, Whitaker J, Mithas S. 2006). In this dimension we will explore the influence of ICT on performance indicators like productivity and revenue growth.

4.1.2 Market Externalities

Investment in ICT allows the deployment of more advanced ICT and higher productivity levels (Saunders, Brynjolfsson. 2007) (Bardhan I, Whitaker J, Mithas S. 2006). Such investments are directly driven by strategic decision making process for ICT inside the firm. The firm ICT based decision making process is supplemented by market externalities (competition, customer expectations, supplier expectations, and technology being expansive) and intra-firm issues (IT based incidents, technical issues, and standardization issues). In this dimension we will explore the influence of externalities and intra-firm forces (drivers) at micro level.

4.1.3 Innovation Dynamics

ICT as an enabler of innovation allows for a market based analysis of why different firms exhibit differing payoffs despite similar levels of ICT investment. The differing payoffs are the result of varying adoption patterns and environmental conditions. In this dimension we will explore the influence of varying adoption patterns and environmental conditions at micro level.

4.1.4 Value chain and firm characteristics

The changing relationships of the firms with suppliers and buyers tend to promote the diffusion of ICT. For the firms, ICT has enabled new business structures and redefined B2B interactions through value chain management. These new structures allow the exchange of information and better responses to real-time business conditions. This means that, either its edges of value chain (customer or supplier

relationships) or inside the firm (changing structures) ICT is playing its positive role to improve value chain characteristics and thus structural organization of the firm. In this dimension we will explore the influence of ICT on edges of value chain (customer or supplier relationships) and firm characteristics (organizational structure).

4.2 Empirical Research Design

This section presents the empirical research design that guides the statistical analysis in the subsequent chapter. First it gives a brief overview of the empirical analysis and introduces the dataset sources that will be used. Later it gives an overview of dataset consistency check and dataset reduction by using factor analysis. Then the resultant dataset is distributed among the modules of proposed framework (called *Operationalization*) for testing of hypotheses through empirical analysis.

4.2.1 Empirical Analysis

In order to give answer to the research questions and aims of this study, an empirical analysis will be run for each hypothesis for two classes of the firms, for example High Tech e-Business based Firms (HTBF) and Medium Tech e-Business based Firms (HTBF). The third class which is Low Tech Firms (LTF) will be taken as reference case during empirical analysis.

4.2.2 Dataset Source

The research question answered in this section is: Q6.3 Which data sources are used for the analysis?

The data used for research in this report are derived from the European e-Business Surveys (2002, 2003, 2005, 2006, 2007), a cornerstone of the monitoring activities of the e-Business W@tch. The fieldwork was carried out by using computer-aided telephone interview (CATI[3]) technology. The decision-maker in the enterprise targeted by the survey was normally the person responsible for ICT within the

[3] Computer-assisted telephone interviewing (CATI) is a telephone surveying technique in which the interviewer follows a script provided by a software application. The software is able to customize the flow of the questionnaire based on the answers provided, as well as information already known about the participant.

company, typically the IT manager. Alternatively, especially in small enterprises without a separate IT unit, the managing director or owner was interviewed.

For organisational and contractual reasons, the e-Business Survey 2003 was split into two parts. The first part consisted of 3,515 telephone interviews with decision-makers in enterprises from five EU countries which were conducted in March 2003. The second part had a scope of 4570 interviews in the EU, 100 interviews in Norway and 2632 interviews in the 10 new EU Member States (NMS) and was conducted in November 2003. We have used both of these surveys for our research dataset.

Year	No. of Firms	Sectors	Countries
2002	9264	15	15
2003 (Survey 1)	3515	7	5
2003 (Survey 2)	7302	10	25
2005	5218	10	7
2006	14065	10	29
2007 – P1 – Sector Survey 1	4200	3	8
2007 – P2 – Sector Survey 2	4369	2	8

Table 4.2 e-Business Watch Datasets

The 'e-Business Survey 2007' is splitted by 4 separate projects; i.e. 2 CATI Sector surveys, 2 CATI Flash surveys (subjected to Radio Frequency Identification technology and Intellectual Property Rights). Eight of these countries (AT, FR, DE, IRE, IT, ES, SE, UK) are 'old' EU Member States (i.e. before 2004), one (PL) is a New Member State (i.e. have joined the EU after May 2004) plus the USA. For our research data set we will use 2 CATI Sector surveys. Table 4.2 give a brief overview of number of firms, sectors and countries per survey per year. For details see appendix – Data Source.

Some definitions (Hsiao, Cheng, 2003): *"A **dataset** containing observations on a single phenomenon observed over multiple time periods is called **time series**. In time series data, both the values and the ordering of the data points have meaning. A data set containing observations on multiple phenomena observed at a single point in time*

*is called **cross-sectional**. In cross-sectional data sets, the values of the data points have meaning, but the ordering of the data points does not. A data set containing observations on multiple phenomena observed over multiple time periods is called **panel data**. **Time series** and **cross-sectional** data are both one-dimensional, panel data sets are two-dimensional".*

The data sets (2002, 2003, 2005, 2006, 2007) used for this research are cross-sectional in nature, which means that our datasets containing observations on multiple phenomena observed at a single point in time. After checking the nature of the data, it is important to execute data consistency checks on surveys in order to have reliable data for empirical analysis.

4.2.3 Dataset Consistency

Data consistency refers to *"verification of gathered data"*. By verification we mean: to check either respondent of the survey have been consistent in this replies during the interviews or not. In case of telephonic interviews there is high probability of inconsistency of responses, this inconsistency is less in questionnaires because respondent have choice to switch back and see his responses and stay consistent. For our research data consistency check was important issues before we go for empirical analysis. In our research we have used an econometric tool called STATA for data consistency. Table 4.3 shows the results of data consistency check for each survey per year. For details of the results for inconsistency found in surveys see Appendix – Inconsistent Data.

Year	Consistent	Inconsistent	Module (Holds Inconsistency)	Fixed or Not Fixable
2002	*			
2003 (Survey 1)	*			
2003 (Survey 2)	*			
2005	*			
2006		*	ICT Expenditure and Investments	Fixed

2007 – P1 – Sector Survey 1	*			
2007 – P2 – Sector Survey 2	*			

Table 4.3 Data Consistency Check Results

After verifying the consistency of the data we can say that our data is reliable and ready to be used for empirical analysis. But if the data constitute of indicators which are measuring the some common phenomenon then it is better to reduce or shrink these indicators into a construct before we use them for empirical analysis.

4.2.4 Dataset Reduction

The methodology that is used for data reduction is Factor Analysis (analysis technique to find common factors called construct from sets of indicator variables). The statistical tool that is used for factor analysis is SPSS. Following measures have been considered while performing factor analysis.

1. Level of Measurement & Correlation: For factor analysis, we have used interval and ration indicator (Note: some dummies may be included) with sufficient correlation that is greater then 0.30.

2. Extraction Method: The extraction method was “Principle Axis Factoring (PAF)”, because we are explaining common variance among the variables. There is another method called “Principle Component Analysis”, this method explains the total variance and only used to summaries the variables in to construct called component rather then generating constructs called factors from indicators. PAF seeks the least number of factors which can account for only the common or shared variance (correlation) of a set of variables. Excluding the unique and error variances of the indicator variables from the analysis results in a more detailed and accurate insight into the measurement model when structural modeling is intended. Under such argumentation we have used PAF as an extraction technique in our research.

3. Determining Number of Factors: To reduce data, a factor should always explain more than the variance of a single indicator. Eigen values are used for this propose. Eigen value of the factor show total variance it explains for indicators. In order to extract those most important factors which explain the highest proportion of the variance of the indicators, we have used a criterion called Kaiser Criterion (known as K1 rule). It is almost the most single commonly used rule (Lance, 2006). Based on this criterion factors with eigen values less than 1.0 are not worth including in the analysis and thus are to be dropped. The underpinning rationale is that every original variable, after standardization, contributes a variance of size 1 to the total variance and applying K1 rule means selecting only those factors that explain the amount of variance of at least one of the original variables (and not less).

4. Communality - Does Each Indicator Share Sufficient Variance with Other Indicators? As mentioned earlier we are using PAF as extraction method, which explains the shared variance among the indicators. This shared variance is called communality (the variance that is explained by factor). The rule of thumb for the value of communality is greater then 0.25, but sometime lower of higher values can be set as threshold value (Heijnen P W, 2005).

5. Interpretation Problem – Factor Rotation: In some cases during the factor analysis more then one factor was generated for one set of indicators and some indicators load was high on both factors. In that case factor rotation was used as solution. There are two kinds of rotations: Orthogonal and Oblique. Orthogonal rotation generate factors which are still independent (correlation = 0), this means no multicollinearity among the generated factors, this may help us in handing multicollinearity problem that arise during empirical analysis (detail explanation for multicollinearity is presented in coming chapters). Oblique rotation generates factors that are no longer independent, which often corresponds to reality. In our research we have used orthogonal rotation (Varimax – type of orthogonal rotation) to

cater interpretation problem. Varimax has the effect of differentiating the original variables by extracted factor in such a way that each factor has either large or small loadings of any particular variable. This method is the most common rotation option to use. After rotation, we needed to choose on a cutoff threshold to decide on which variables to include in calculation of factor scores. As a general guideline, loadings (i.e. factor correlation coefficients) less than 0.3 are termed as "weak", more than 0.6 as "strong" and otherwise as "moderate". We choose a moderate cutoff value of 0.4 that is also more than the minimum value calculated above. As the final step, estimated values of the new factors generated are required. These values, called factor scores, are estimates of values for the unobserved factors. There are several approaches to obtain the factor scores (Heijnen P W, 2005). The method we focused in our research is called Sum score where all variables that belong to the factor group, i.e. have a loading above the cutoff level on the factor, are given the same weight and their values are summed. This is the simplest approach, but it does not take into account the different factor loadings.

6. We group the indicators in to theoretical factors on the basis of literature and intuition. Table 4.4 gives an example of one of the theoretical factor (e-Business Inhibitors – from e-Business Watch 2003 survey) and its concerned indicators. Appendix – Dataset Reduction gives a detailed overview of all the theoretical factors created for e-Business watch survey 2002, 2003, 2005, 2006, and 2007.

		C24a: items - Is this an important reason for e-business NOT playing a role in company? - Company is too small to benefit from any e-business activities.	C24b: items - Is this an important reason for e-business NOT playing a role in company? - E-business technologies are too expensive to implement.	C24c: items - Is this an important reason for e-business NOT playing a role in company? - The technology is too complicated.	C24d: items - Is this an important reason for e-business NOT playing a role in company? - We are too concerned about security issues.
N	**Valid**	3197	3197	3197	3197
	Missing	7118	7118	7118	7118
		e-Business Inhibitors			

Table 4.4 Dataset Reduction

Reliability of theoretical factors is checked though different test, which are: Checking Reliability (Bartlett's test of sphericity, KMO measure of sampling adequacy, and Cronbach's alpha) How Reliable and Appropriate the Achieved Model from Factor Analysis Process is? - Some tests have been suggested. Bartlett's test of sphericity calculates if the correlation matrix deviates significantly from the identity matrix. If it does, a first condition for factor analysis is satisfied. A second condition is given by the KMO measure of sampling adequacy. Kaiser-Meyer-Olkin (Kaiser, 1974) generally indicates whether or not the variables are able to be grouped into a smaller set of underlying factors. High values (close to 1.0) generally indicate that a factor analysis may be useful with your data. If the value is less than .50, the results of the factor analysis probably won't be very useful (see table 4.6 as example). For interpretation of the KMO index (Hutcheson, 1999) see table 4.5.

KMO Value	Degree of Common Variance
0.90 to 1.00	Marvellous
0.80 to 0.89	Meritorious
0.70 to 0.79	Middling
0.60 to 0.69	Mediocre

0.50 to 0.59	Miserable
0.00 to 0.49	Don't Factor

Table 4.5 KMO index

Coefficient of Reliability (Cronbach's alpha) - How Well a Set of Indicators (or variables) Measures a Single Unidimensional Latent Construct? - Using factor analysis, the indicators are divided into different groups measuring one construct. After modeling indictors in the form of factor scores, it might be useful to see to what extent every indicator in the group belongs to the other indicator in the group. Cronbach's alpha (Cronbach, 1951), as a coefficient of reliability or consistency, measures the extent to which indicator responses obtained at the same time correlate highly with each other

Note: A set of items can have a high alpha and still be multidimensional. This happens when there are separate clusters of indicators (separate dimensions) which intercorrelate highly, even though the clusters themselves do not intercorrelate heavily. On the other hand, a set of indicators can have a low alpha even when they are unidimensional if there is high random error.

Alpha coefficient ranges in value from 0 to 1. The higher the score, the more reliable the generated scale is. Nunnaly (1978) has indicated 0.7 to be an acceptable reliability coefficient in natural and applied sciences. However, lower thresholds are sometimes used in the literature. Especially in the case of social and management sciences, measures as low as 0.4 are considered acceptable, see table for example. In our research we have used all three tests for checking reliability.

Table 4.6 is giving brief overview for one of the factors that is generated during our research. The table 4.6 show the communalities (0.345 for both indicators) that are greater then 0.25 (rule of thumb value) and the eigen value for generated factor (1.346) which is greater then 1. Appendix – Factor Analysis Results give detailed

picture of factors (generated during factor analysis). This distribution of factors and variables among the modules of proposed framework is called *Operationalization*.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.500**
Bartlett's Test of Sphericity	Approx. Chi-Square	1,172.327
	Df	1
	Sig.	0.000

Communalities

	Initial	Extraction
A21a: Employee training: Does your company offer - in-house computer or IT training?	0.120	**0.345**
A21b: Employee training: Does your company offer - participation in computer or IT training offered by third parties?	0.120	**0.345**

Extraction Method: Principal Axis Factoring.

	Initial Eigenvalues		
Factor	Total	% of Variance	Cumulative %
1	**1.346**	67.312	67.312
2	0.654	32.688	100.000

Factor Matrix(a)

	Factor
	1
A21a: Employee training: Does your company offer - in-house computer or IT training?	0.588
A21b: Employee training: Does your company offer - participation in computer or IT training offered by third parties?	0.588

Extraction Method: Principal Axis Factoring.

a. 1 factors extracted. 8 iterations required.

Reliability Statistics

Cronbach's Alpha	N of Items
.416	**2**

Table 4.6 Factor Analysis & Cronbach's Alpha Results

4.2.5 Operationalization

The research question answered in this section is: Q6.4 How can the concepts in the proposed framework be translated into variables in those data sources?

The theoretical bases that are used for performing operationalization is to use the definition of the modules in the proposed framework, compare them with the underline concept of the factors and variables of our interest and then place each factor and variable in to relevant module. This approach is based upon the operationalization procedure followed in e-Business W@tch reports for year 2002, 2003, 2005, 2006, and 2007 (e-Business W@tch Report, 02, 03, 05, 06, 07).

Let's take an example; one of the construct in our reduced dataset is called "e-Business Inhibitors", see table 4.4. The underline concept of the factor is to show the items for the firm that opposes e-Business. By comparing the definition of module "Drivers" and underline concept of the variable we can place the variable inside the module of "Drivers". Similar approach has been followed for other factors and variables and details can be viewed in Appendix – Dataset and Operationlization.

4.3 Empirical Models Verification and Validation

The research question answered in this section is: Q6.6 Which methods and tools are used for the econometric models validation and verifications?

In this section, we have used a number of tools in Stata for determining whether our data meets the regression assumptions. Below, we list the major commands we demonstrated organized according to the assumption the command was shown to test.

- Tests for Model Specification
    - *linktest* -- performs a link test for model specification.
    - *ovtest* -- performs regression specification error test (RESET) for omitted variables.

- Tests for Heteroscedasticity
    - *hettest* -- performs Cook and Weisberg test for heteroscedasticity.
    - Detecting Unusual Data
        - *predict* -- used to create predicted values, residuals, and measures of influence.
        - *rvfplot* -- graphs residual-versus-fitted plot.
    - Tests for Normality of Residuals
        - *kdensity* -- produces kernel density plot with normal distribution overlayed.
- Fixing Heteroscedasticity
    - *robust* – perform robust regression
- Tests for Multicollinearity
    - *vif* -- calculates the variance inflation factor for the independent variables in the linear model.
- Fixing Multicollinearity
    - Self assessment

For sake of demonstration we have given taken one regression model from 2002 survey. We are trying to show how we have verified and validate the integrity of our regression models (presented in next chapter).

4.3.1 Model Specification

A model specification error can occur when one or more relevant variables are omitted from the model or when one or more irrelevant variables are included in the model. If relevant variables are omitted from the model then common variance they share with included variables may be wrongly attributed to those variables, and the error term gets inflated. On the other hand, if irrelevant variables are included in the model, the common variance they share with included variables may be wrongly attributed to them. Model specification errors can affect the estimate of regression coefficients.

The methods to detect specification errors are: The *linktest* command performs a model specification link test for single-equation models. *linktest* is based on the idea that if a regression is properly specified, one should not be able to find any additional independent variables that are significant except by chance. *linktest* creates two new variables, the variable of prediction, _hat, and the variable of squared prediction, *_hatsq*. The model is then refit using these two variables as predictors. *_hat* should be significant since it is the predicted value. On the other hand, *_hatsq* shouldn't, because if our model is specified correctly, the squared predictions should not have much explanatory power. That is we wouldn't expect *_hatsq* to be a significant predictor if our model is specified correctly.

```
. linktest

      Source |       SS       df       MS              Number of obs =    1809
-------------+------------------------------           F(  2,  1806) =   84.93
       Model |  98.4823234     2  49.2411617           Prob > F      =  0.0000
    Residual |  1047.04309  1806  .579758077           R-squared     =  0.0860
-------------+------------------------------           Adj R-squared =  0.0850
       Total |  1145.52541  1808  .633587063           Root MSE      =  .76142

------------------------------------------------------------------------------
factorint~us |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        _hat |   1.020978   .0784794    13.01   0.000     .8670586    1.174898
      _hatsq |   .3590452   .2366784     1.52   0.129    -.1051471    .8232375
       _cons |  -.0209972   .0240194    -0.87   0.382    -.0681058    .0261114
------------------------------------------------------------------------------
```

Table 4.7 Linltest Results

Table 4.7 show the results for *linktest*, the test of *_hatsq* is not significant. This is to say that *linktest* has failed to reject the assumption that the model is specified correctly. Therefore, it seems to us that we don't have a specification error. But now, let's look at another test before we jump to the conclusion.

The *ovtest* command performs another test of regression model specification. It performs a regression specification error test (RESET) for omitted variables. The idea behind *ovtest* is very similar to *linktest*. It also creates new variables based on the predictors and refits the model using those new variables to see if any of them would be significant.

```
Ramsey RESET test using powers of the fitted values of factorintrafirmebusinessbasedbus
       Ho:  model has no omitted variables
                 F(3, 1768) =      1.23
                   Prob > F =      0.2975
```

The *ovtest* command indicates that there are omitted variables. So we have tried both the *linktest* and *ovtest*, and one of them (*ovtest*) tells us that we have a specification error. We therefore have to reconsider our model. As remedy we have added new variables to recalculate the model and run tests again but some times, unfortunately, we have data limitation problem i.e. a new relevant variable is not available in dataset or its addition reduces the number of observations to undesirable amount. As a result same old model is used.

4.3.2 Heteroscedasticity

In statistics, a sequence or a vector of random variables is heteroscedastic if the random variables have different variances. The complementary concept is called homoscedasticity. Heteroskedasticity does not cause OLS coefficient estimates to be biased. However, the variance (and, thus, standard errors) of the coefficients tends to be underestimated, inflating t-scores and sometimes making insignificant variables appear to be statistically significant.

Test for Heteroscedasticity: The test on heteroskedasticity given by *hettest* is the Breusch-Pagan test. The null hypothesis is that the variance of the residuals is homogenous. Therefore, if the p-value is very small, we would have to reject the hypothesis and accept the alternative hypothesis that the variance is not homogenous. So in this case, the evidence is against the null hypothesis that the variance is homogeneous. The test is very sensitive to model assumptions, such as the assumption of normality.

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of factorintrafirmebusinessbasedbus

         chi2(1)      =    35.26
         Prob > chi2  =   0.0000
```

Predicting Residuals: In statistics and optimization, the concepts of statistical error and residual are easily confused with each other. A statistical error is the amount by which an observation differs from its expected value; the latter being based on the

whole population from which the statistical unit was chosen randomly. The expected value, being for instance the mean of the entire population, is typically unobservable. If the mean height in a population of 21-year-old men is 1.75 meters, and one randomly chosen man is 1.80 meters tall, then the "error" is 0.05 meters; if the randomly chosen man is 1.70 meters tall, then the "error" is −0.05 meters. The nomenclature arose from random measurement errors in astronomy. It is as if the measurement of the man's height were an attempt to measure the population mean, so that any difference between the man's height and the mean would be a measurement error. A residual (or fitting error), on the other hand, is an observable estimate of the unobservable statistical error. The simplest case involves a random sample of n men whose heights are measured.

```
. predict res, residual
(6915 missing values generated)
```

Checking Normality for Residuals: Many researchers believed that multiple regressions require normality, this is not the case, normality of residuals is only required for valid hypothesis testing, that is, the normality assumption assures that the p-values for the t-tests and F-test will be valid. Normality is not required in order to obtain unbiased estimates of the regression coefficients. OLS regression merely requires that the residuals (errors) be identically and independently distributed. Furthermore, there is no assumption or requirement that the predictor variables be normally distributed, If this were the case than we would not be able to use dummy coded variables in our models. After we run a regression analysis, we can use the predict command to create residuals and then use commands such as *kdensity* to check the normality of the residuals.

```
. kdensity res, normal
```

Figure 4.23 shows the use of the *kdensity* command to produce a kernel density plot with the normal option requesting that a normal density be overlaid on the plot. *kdensity* stands for kernel density estimate.

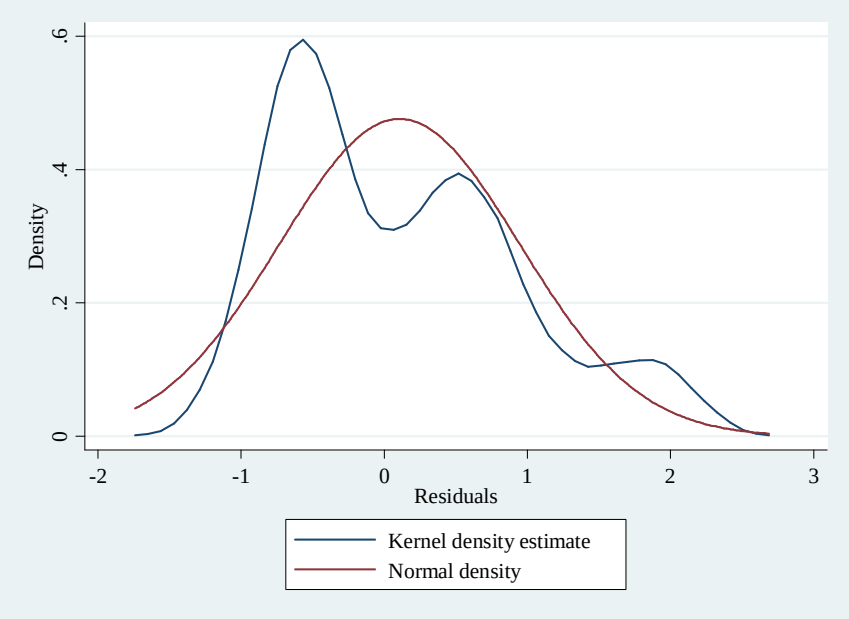


Figure 4.23 Kernel Density Estimate

Checking Homoscedasticity of Residuals: One of the main assumptions for the ordinary least squares regression is the homogeneity of variance of the residuals. If the model is well-fitted, there should be no pattern to the residuals plotted against the fitted values. If the variance of the residuals is non-constant then the residual variance is said to be "heteroscedastic." There are graphical and non-graphical methods for detecting heteroscedasticity. A commonly used graphical method is to plot the residuals versus fitted (predicted) values. We do this by issuing the *rvfplot* command. Figure 4.24 shows the use of the *rvfplot* command with the *yline*(0) option to put a reference line at y=0.

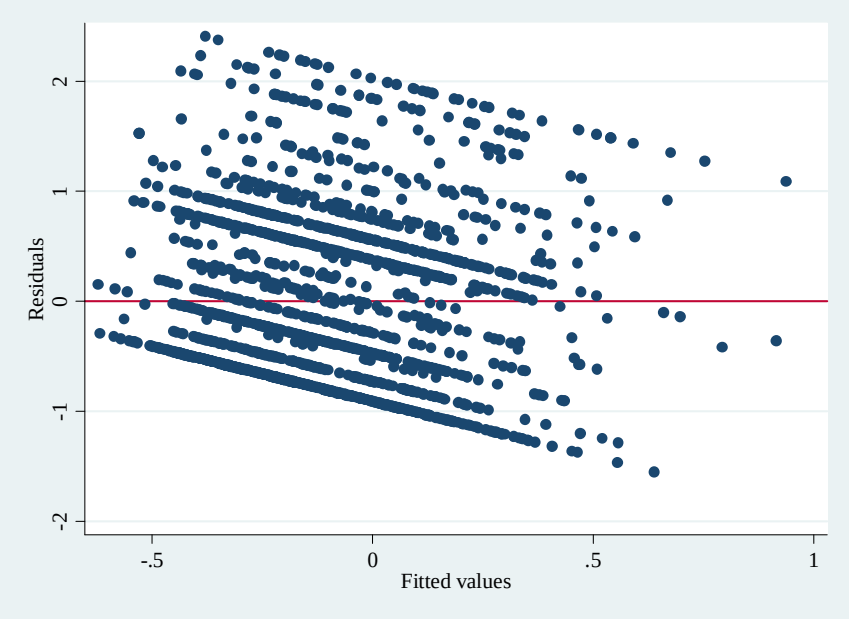


Figure 4.24 Checking Homoscedasticity of Residuals – *rvfplot*

4.3.3 Fixing Heteroscedasticity – Robust Regression

One instance in which robust estimation should be considered is when there is a strong suspicion of heteroskedasticity. In the homoskedastic model, it is assumed that the variance of the error term is constant for all values of x. Heteroscedasticity allows the variance to be dependent on x, which is more accurate for many real scenarios.

```
. reg  factorintrafirmebusinessbasedbus  factorskillsdevelopment, robust
```

4.3.4 Checking for Multicollinearity

When there is a perfect linear relationship among the predictors, the estimates for a regression model cannot be uniquely computed. The term collinearity implies that two variables are near perfect linear combinations of one another. When more than two variables are involved it is often called multicollinearity, although the two terms are often used interchangeably. The primary concern is that as the degree of

multicollinearity increases, the regression model estimates of the coefficients become unstable and the standard errors for the coefficients can get wildly inflated.

We can use the *vif* command after the regression to check for multicollinearity. *vif* stands for variance inflation factor. As a rule of thumb, a variable whose VIF values are greater than 10 may merit further investigation. Tolerance, defined as 1/VIF, is used by many researchers to check on the degree of collinearity. A tolerance value lower than 0.1 is comparable to a VIF of 10. It means that the variable could be considered as a linear combination of other independent variables.

```
. vif

    Variable |       VIF       1/VIF
-------------+----------------------
factornetw~s |      2.18    0.459158
factorintr~l |      2.16    0.463417
I~tBusApplic |      2.13    0.469641
I~aBusApplic |      2.03    0.492208
-------------+----------------------
    Mean VIF |      1.56
```

Table 4.8 VIF Results for Multicollinearity

As we can see in table 4.8 none of the VIF values is greater then 10 or none of tolerance value is lower than 0.1, so we concluded that there is no multicollinearity. In case of multicollinearity exist then by means of self assessment (rather then statistical tests) we have to make tradeoffs between variables that hold multicollinearity.

5. EMPIRICAL ANALYSIS: RESULTS AND DISCUSSION

Motivation: After designing a theoretically based model and planning on how to empirically evaluate it, the statistical analysis planned was run. This chapter presents those statistical results and their interpretation according to the statistical and theoretical knowledge developed along this project.

Figure 5.25 gives an overview of the work flow for this section. Hypotheses for each of the industry dimensions are presented with their casual analysis. Casual analysis provides justification for factors and their relationships used in empirical analysis.

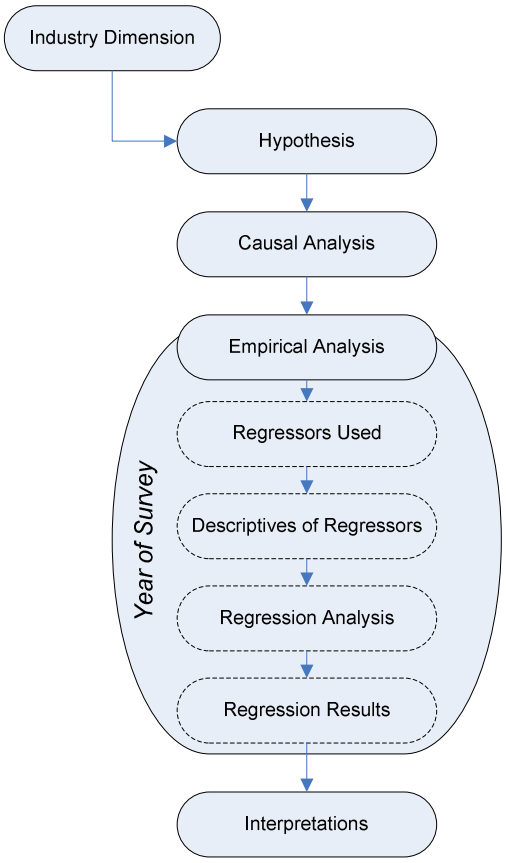


Figure 5.25 Work Flow for Empirical Analysis

Regression analysis[4] is used for modeling the casual relationships and hypothesis testing. Later results from the regression analysis are used to determine validity or fallibility of hypotheses. The interpretation of the results in each industry dimension will help us in achieving the first part of our objective that is: Identification of

[4] Regression can be used for prediction (including forecasting of time-series data), inference, hypothesis testing, and modeling of causal relationships.

underlying success factors (intermediaries) that complete the link between IT and its impacts.

The research questions that will be answered in the following sections are: Q8.2 Which are the policy implications of this study? Q6.5 Which are the econometric models derived from operationalized framework by using scientific literature and intuitions for hypothesis testing? Q7 Which are possible interpretations, on the light of both statistical and field knowledge, of the results obtained from testing the research hypotheses?

5.1 Productivity

Hypothesis: ICT readiness and technical competence influence a firm's ability to extract benefits out of the ICT investment. Despite extensive research on the use of ICT and its impact, empirical research is unable to state with clarity that ICT use leads to increases in productivity and firm performance (Brynjolfsson. 1993). However, recent research concluded that ICT does have some influence on firm's productivity (Saunders, Brynjolfsson. 2007) (Bardhan I, Whitaker J, Mithas S. 2006). In order to realize validity or fallibility of such conclusions, following hypotheses will be empirically tested for the industrial dimension of productivity:

1. ICT positively influence the productivity of the firms.

Casual Analysis: Figure 5.26 present the casual chain that is followed to measure the influence. Although there are many factors in the firm that can influence the productivity, but in this case we are looking in to system interoperability with supply side and demand side. In the chain, the first factor is interoperability importance *(driver)* for management of the firm that leads to the decision of integrating their ICT system with supply and demand side *(readiness-external)*, this result in online activities performed by the firm with its suppliers and buyers *(activities-external)*, which eventually result in influence on productivity of the firm *(impact-internal-intangible)*. Innovation in the firm *(complementary)* may influence the process of interoperability implementation.

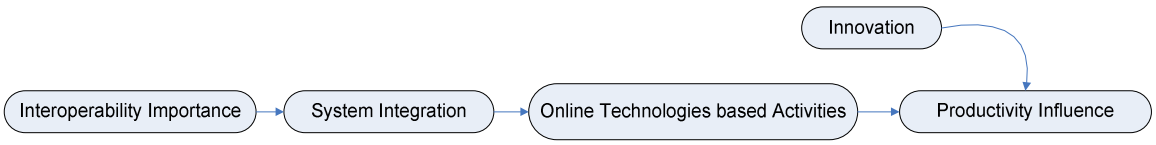


Figure 5.26 Hypothesis 1 – Productivity Influence

Regressors Used: Figure 5.26 shows the casual diagram that includes the factors that we have selected for empirical analysis, which include:

- Interoperability Importance (*Driver*): This regressor represents the firm measure for importance given to interoperability with firms: in firm's own industry, in other industries, and for producing and providing the product and services firm's offer. This may influence the productivity of the firm.
- System Integration (*Readiness External*): This regressor represents firm setup for ICT system to be linked with ICT systems of suppliers and customers. This may influence the productivity of the firm.
- Online Technologies based Activities (*Activity External*): This regerssor represent ICT technologies used with external links outside the firm, this include: Collaboration with business partner in design of new product, Collaboration with business partner to forecast product demand, to manage capacity and inventories, to exchange documents electronically with suppliers, to exchange documents electronically with customers, and to negotiate contracts. This may change processes and structure exists inside the firm. This may influence the productivity of the firm.
- Innovation (*complimentary*): This regressor represents Firm's non IT based innovation activities. This may influence the productivity of the firm.

Regressors Descriptives: Let examine the descriptive statistics of the regressors. This will help us in understanding the basic feature of the gathered data. Table 5.9 gives the summary of the descriptive statistics.

```
  Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
factorinte~s |      5777   -.0326134    .9298561  -.7488473   2.032779
Interoperability Importance
factorsyst~n |     13619   -.0019428    .7540492  -.3278368   2.490103
```

```
System Integration
factoronli~t |     13012   -.0091277    .9074074  -.6146216   2.659019
Online Technologies based Activities
factorinno~n |     13542   -.0037375    .7428579  -.6973264   1.152751
Innovation
```

Table 5.9 Descriptive Statistics for Hypothesis 1 – Productivity Influence

Regression Analysis: The dataset survey used for this regression is e-Business Watch survey 2006. We have used multinomial logit model[5] in Stata for statistical analysis of this hypothesis. In this model we are measuring the influence (increased, decreased, or no influence) on productivity of the firm. Ordinal logit model is another method that can be used for this regression analysis. If we compare the two modeling methods, we find multinomial logit model more clear and explainable for our regressors. Let examine how?

In current regression we are analyzing the influence on productivity of the firm. This influence has three categories: increased, decreased, or no influence. For sake of simplicity we are taking innovation as a regressor to explain the difference and skipping other regressors. Let suppose the result of regression analysis for ordinal logit is as follows:

```
Innovation      0.607***     (0.0510)
```

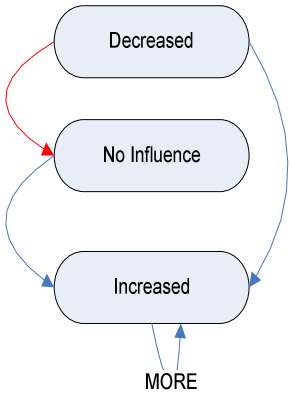


Figure 5.27 Regressor Movements

Figure 5.27 shows these positive movements. Although results for beta coefficient of innovation shows that there is a positive movement but for which path, is it from "increased to more increased", or "no influence to increased", or "from decreased to

[5] Multinomial logit model reports coefficients for the effect of each independent variable on each category relative to the base category.

no influence or increased". In case of "increased to more increased", or "no influence to increased", or "from decreased to or increased" we can interpret that firm's productivity is increasing but for "decreased to no influence" (red line in figure 5.27) although we are moving in positive direction but still we can not say for sure that this lead to more productivity in the firm because the end status is "no influence". This leads to ambiguity for interpretation of results and later for acceptance or rejection of the hypothesis. As a result we have used multinomial logit model. This model reports coefficients for the effect of each independent variable on each category relative to the base category. This help in clear understanding of movements of regressors for dependent variables categories.

	MTBF		HTBF	
	Productivity Influence		Productivity Influence	
Decrease				
factorinte~e Interoperability Importance	-0.190	(0.137)	**-0.480***	(0.205)
factorsyst~n System Integration	-0.178	(0.162)	0.176	(0.217)
factoronli~t Online Technologies based Activities	0.0392	(0.122)	-0.251	(0.210)
factorinno~n Innovation	-0.226	(0.160)	-0.155	(0.277)
_cons	-3.702***	(0.538)	-4.467***	(0.993)
No influence				
factorinte~e Interoperability Importance	**-0.265*** **	(0.0408)	**-0.357*** **	(0.0767)
factorsyst~n System Integration	-0.0957	(0.0494)	0.123	(0.0724)
factoronli~t Online Technologies based Activities	**-0.124** **	(0.0413)	-0.133	(0.0690)
factorinno~n Innovation	**-0.607*** **	(0.0510)	**-0.575*** **	(0.0890)
_cons	-1.287***	(0.160)	-1.782***	(0.326)
N	4797		2290	
pseudo R-sq	0.100		0.129	

Table 5.10 Hypothesis 1 – Productivity Influence Results

Regression Results and Interpretations: In the results given above – table 5.10, the base category is "increase in firm productivity". As we can see in the results the factors of the regression in both categories (decreased and no influence) are

negative (highlighted in results), which means the base category (increase in firm productivity) is better and we can reject the other categories. This lead to our interpretations of the results:

- *ICT is positively influencing the productivity (impact-internal-intangible) of the firm*, this result in acceptance of our hypothesis. For Medium Tech e-Business based Firms (MTBF), the ICT factors are: Interoperability Importance, Online Technologies based Activities, and Innovation. For High Tech e-Business based Firms (HTBF), the ICT factors are: Interoperability Importance and Innovation.
- As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). From the results we have identify following underlying success factors that give significant results, see figure 5.28.

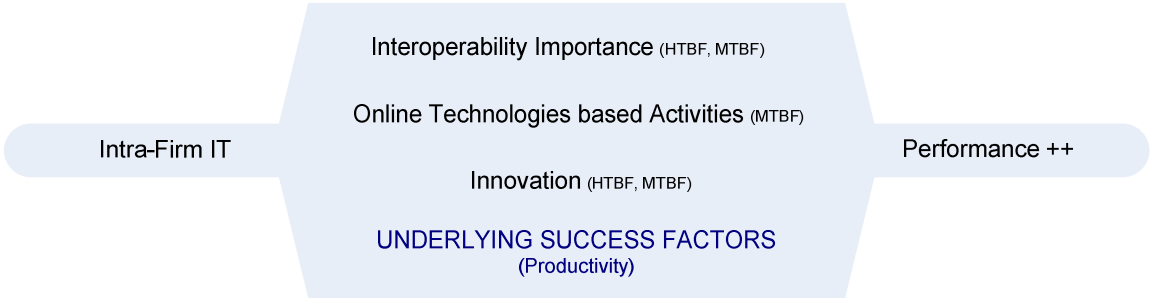


Figure 5.28 Hypothesis 1 – Productivity Influence – Underlying Success Factors

Hypothesis: Recent research (Saunders, Brynjolfsson. 2007) (Bardhan I, Whitaker J, Mithas S. 2006) and previous empirical test results concluded that ICT does have some influence on firm's productivity (an indicator of firm performance). Another measure for the firm performance is revenue growth. Realizing the influence of ICT on firm's revenue growth will help us in strengthens the results obtained from previous regression and conclusion of the recent research (Saunders, Brynjolfsson. 2007) (Bardhan I, Whitaker J, Mithas S. 2006).

2. ICT positively influence the revenue growth of the firm.

For this hypothesis testing we are performing the empirical analysis following the same empirical model and dataset survey (e-Business Watch 2006) that were used in previous hypothesis.

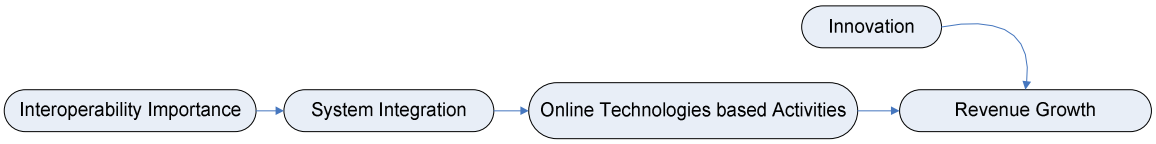


Figure 5.29 Hypothesis 2 – Revenue Growth Influence

Figure 5.29 present the casual chain that is followed to measure the influence. The factors in the chain are same as we have for measuring the influence on productivity.

	MTBF Revenue Growth Influence		HTBF Revenue Growth Influence	
decrease				
factorinte~e Interoperability Importance	-0.209	(0.158)	-0.0766	(0.270)
factorsyst~n System Integration	**-0.516***	(0.246)	0.124	(0.225)
factoronli~t Online Technologies based Activities	0.0440	(0.140)	0.0352	(0.237)
factorinno~n Innovation	-0.165	(0.181)	**-1.123****	(0.371)
_cons	-3.582***	(0.552)	-3.905***	(0.991)
no influence				
factorinte~e Interoperability Importance	**-0.303*****	(0.0389)	**-0.306*****	(0.0681)
factorsyst~n System Integration	-0.0897	(0.0470)	0.0136	(0.0684)
factoronli~t Online Technologies based Activities	**-0.0987***	(0.0387)	-0.0294	(0.0595)
factorinno~n Innovation	**-0.427*****	(0.0479)	**-0.394*****	(0.0801)
_cons	-0.698***	(0.152)	-1.928***	(0.292)
N	4733		2261	
pseudo R-sq	0.116		0.151	

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 5.11 Hypothesis 2 – Revenue Growth Influence Results

Regression Results and Interpretations: As we can see in the results – table 5.11, the factors of the regression in both categories (decreased and no influence) are negative (highlighted in results), which means the base category (increase in firm

revenue growth) is better and we can reject the other categories. This lead to our interpretations of the results:

- *ICT is positively influencing the revenue growth (impact-external-intangible) of the firm*, which is our hypothesis. For Medium Tech e-Business based Firms (MTBF), the ICT factors are: Interoperability Importance, System Integration, Online Technologies based Activities, and Innovation. For High Tech e-Business based Firms (HTBF), the ICT factors are: Interoperability Importance and Innovation.
- As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). From the results we have identify following underlying success factors that give significant results, see figure 5.30.

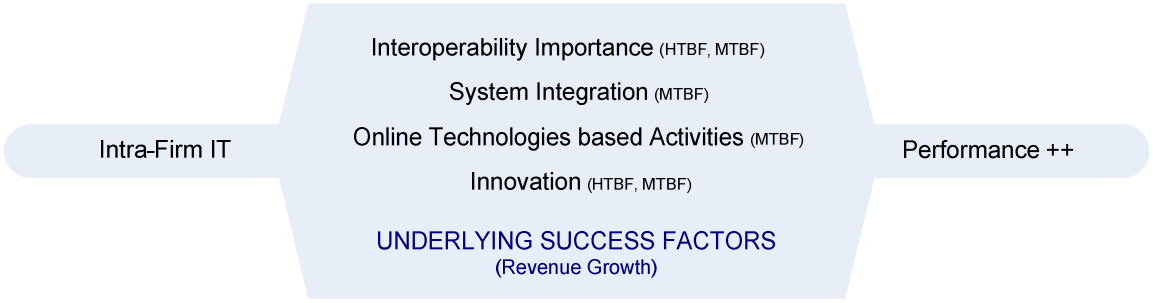


Figure 5.30 Hypothesis 2 – Revenue Growth Influence – Underlying Success Factors

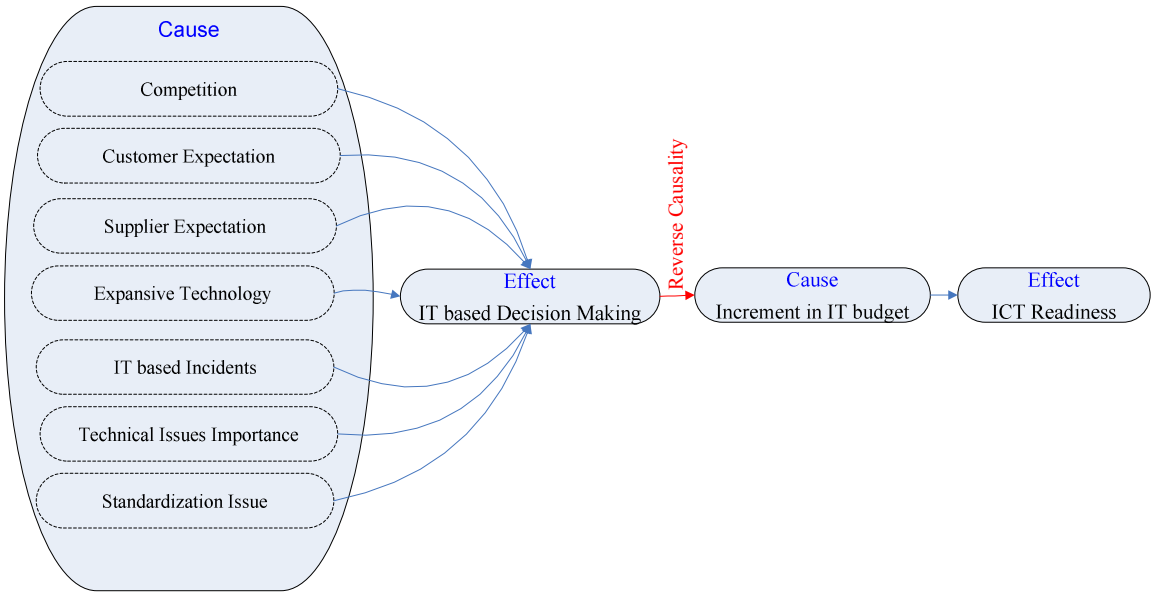
5.2 Market Externalities

Hypothesis: In previous empirical analysis we realize that ICT have positive influence on the performance of the firm. Readiness of the firms for ICT is dependent upon investments made by the firm in ICT and such investment decision is influenced by the intra-firm forces (drivers) and externalities. Externalities are the forces that can not be influenced by firm as compared to forces (drivers) that exist inside the firm. Thus we can investigate that: Is it externalities that influence the decision making process more as compared to intra-firm forces (drivers). In order to realize the validity or fallibility of such argumentation, following

hypotheses will be empirically tested for the industrial dimension of market externalities:

1. Strategic decision making process for ICT in the firms is more influenced by market externalities as compared to firm's issues.
2. Increments in IT budget are positively correlated with decision making process on ICT in the firms

Casual Analysis: In figure 5.31, we have two sets of cause[6] and effect[7], first one exists between forces (externalities and drivers) and IT based decisions making, and second one exists between increments in IT budget and Readiness for ICT (Saunders, Brynjolfsson. 2007) (Bardhan I, Whitaker J, Mithas S. 2006). If we consider a complete casual chain then we will see a third casual link (red color link) exists between IT based decisions making (*Effect*) and increments in IT budget (*Cause*). The casual link that exists between effect and cause is called reverse causality[8].



$$\text{IT based Decision Making} = \beta 1 + \beta 2\,\text{Competition} + \beta 3\,\text{Supplier Expectation} + \beta 4\,\text{Customer Expectation} + \beta 5\,\text{IT based Incidents} + \beta 6\,\text{Technical Issues Importance} + \beta 7\,\text{Expansive Technology} + \beta 8\,\text{Standardization Issue} + E_1$$

$$\text{Increment in IT budget} = \alpha 1 + \alpha 2\,\text{IT based Decision Making}^{*} + E_2$$

Figure 5.31 Hypothesis 1 & 2 – IT decision making & Increment in IT Budget

[6] A *cause* is something that makes something else happen
[7] An *effect* is what happens as a result of the cause
[8] Cause is predated by an effect

Regressors Used: Figure 5.31 shows the casual diagram that includes the factors that we have selected for regression analysis, which include:

- Competition (*Externality*): The regressor measure the importance given by the firm to the competition.
- Customer Expectation (*Externality*): The regressor measure the importance given by the firm to the Customer Expectation.
- Supplier Expectation (*Externality*): The regressor measure the importance given by the firm to the Supplier Expectation.
- Expansive Technology (*Externality*): The regressor measure the importance given by the firm to the expansive attribute of the technology.
- IT based Incidents (*Driver*): This regressor represent the IT based items impacts on the firm business for last year. These incidents include: Security hacks, New legislation related to information technology, Failure of internet, Inadequate confidentiality of information (for instance for customers), unauthorized access to systems, spasm, virus or Trojan attacks, lack of security awareness, software failures or malfunctioning, and hardware failures.
- Technical Issues Importance (*Driver*): This regressor measure the importance given by the firm to the technical issues like: Integration of IT components by means of web services and RFID to trace and track mobile assert.
- Standardization Issues (*Drivers*): This regressor represent firms need to fix standardization issues like: information and information system security, data protection, product cataloguing and classification, transaction process, and authentication.

Regressors Descriptives: Let examine the descriptive statistics of the regressors. This will help us in understanding the basic feature of the gathered data. Table 5.12 gives the summary of the descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
DUMitdecis~g IT Decision Making	5218	.3852051	.4866904	0	1
DUMstandar~s Standardization Issues	5218	.3162131	.4650417	0	1
factoruitb~s IT based Incidents	4797	-.0310526	.8697252	-.830818	6.395064
factortech~e Technical Issues Importance	4470	-.0146123	.6902717	-.5840311	1.363726
DUMcomp~NIMP Competition Rather Unimportant	5218	.1536987	.3606943	0	1
DUMcomp~RIMP Competition Rather Important	5218	.1950939	.396311	0	1
DUMcomp~VIMP Competition Very Important	5218	.1117286	.3150625	0	1
DUMsupp~NIMP Supplier Expectations not Important	5218	.1809122	.3849823	0	1
DUMsupp~RIMP Supplier Expectations Rather Important	5218	.1556152	.3625249	0	1
DUMsupp~pIMP Supplier Expectations Important	5218	.0919893	.2890385	0	1
DUMcust~NIMP Customer Expectations not Important	5218	.1025297	.3033727	0	1
DUMcust~RIMP Customer Expectations Rather Important	5218	.208509	.4062815	0	1
DUMcust~pIMP Customer Expectations Important	5218	.191261	.3933318	0	1

Table 5.12 Descriptive Statistics for Hypothesis 1 & 2 – Market Externalities

Regression Analysis: The basic assumption for regrssion analysis is that the independent (exogenous) variable actually causes the dependent (or endogenous) variable. Endogeneity occurs when the dependent variable (IT based decision making) may actually be a cause of the independent variable (increment in IT Budget). Sometimes this is referred to as reverse causality (already explained in casual analysis). In regression analysis issue of endogeneity is tackled by using two-stage least squares regression. We have used Probit model with endogenous regressors[9] (Two-stage least squares regression - 2SLS) in Stata for statistical analysis of both hypotheses. The equations in figure 5.31 give demonstration of two-stage least squares regression. The dataset survey used for this regression is e-Business Watch survey 2005.

[9] Probit model with endogenous regressors (ivprobit) fits probit models where one or more of the regressors are endogenously determined. By default, ivprobit uses maximum likelihood estimation

	MTBF		HTBF	
	Change in IT Budget INC		Change in IT Budget INC	
Increment in IT Budget				
DUMitdecis~g	**0.294*** **	(0.0796)	0.207	(0.134)
IT Decision Making				
_cons	-0.438***	(0.130)	-0.167	(0.201)
IT Decision Making				
DUMstandar~s	**0.846*** **	(0.0133)	**0.800*** **	(0.0256)
Standardization Issues				
factoruitb~s	**-0.0119***	(0.00522)	0.00356	(0.00893)
IT based Incidents				
factortech~e	0.0144	(0.00862)	0.00659	(0.0138)
Technical Issues Importance				
DUMcomp~NIMP	-0.0271	(0.0188)	0.0406	(0.0381)
Competition Rather Unimportant				
DUMcomp~RIMP	**-0.0519** **	(0.0172)	0.0199	(0.0337)
Competition Rather Important				
DUMcomp~VIMP	-0.0404	(0.0225)	0.0283	(0.0344)
Competition Very Important				
DUMsupp~NIMP	-0.0119	(0.0161)	-0.0427	(0.0316)
Supplier Expectations not Important				
DUMsupp~RIMP	0.00729	(0.0176)	-0.0478	(0.0330)
Supplier Expectations Rather Important				
DUMsupp~pIMP	**-0.0511***	(0.0200)	-0.0406	(0.0323)
Supplier Expectations Important				
DUMcust~NIMP	-0.0164	(0.0211)	-0.0744	(0.0504)
Customer Expectations not Important				
DUMcust~RIMP	0.0121	(0.0192)	-0.00459	(0.0493)
Customer Expectations Rather Important				
DUMcust~pIMP	**0.0566***	(0.0227)	0.000653	(0.0478)
Customer Expectations Important				
_cons	0.259***	(0.0329)	0.291***	(0.0590)
N	1749		716	

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 5.13 Hypothesis 1 & 2 – IT decision making & Increment in IT Budget Results

Regression Results and Interpretations: We can see in the results – table 5.13, the for Medium Tech e-Business based Firms (MTBF) standardization issues (driver 0.846***) and customer expectation (externality 0.0566*) are factors that support IT decision making process (complimentary), where as IT based Incidents (driver -0.0119*), competition (externality -0.0519**), and Supplier expectation (externality -0.0511*) are opposing IT decision making process (complimentary). For High Tech e-Business based Firms (HTBF) standardization issues (driver 0.800***) is a factors

that support IT decision making process (complimentary). These results shows that neither externalities nor firm issues are playing more influential role for supporting or opposing IT decision making process. This lead to our interpretations of the results:

- *Strategic decision making process for ICT in the firms is influenced by market externalities and firm's issues, none of them is playing more influential role*. This result in rejection of out hypothesis 1.

We can see in the results, IT decision making process (complimentary 0.294***) for Medium Tech e-Business based Firms (MTBF) is positively correlated with increments in IT budget (Impact-Internal-Intangible). This lead to our interpretations of the results:

- *Increments in IT budget are positively correlated with decision making process on ICT in the firms*. This result in acceptance of the hypothesis 2.

As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). From the results we have identify following underlying success factors that give significant results, see figure 5.32.



Figure 5.32 Hypothesis 1 & 2 – IT decision making & Increment in IT Budget - Underlying Success Factors

From the results we have identify following underlying opposing factors that gives significant results, see figure 5.33.



Figure 5.33 Hypothesis 1 & 2 – IT decision making & Increment in IT Budget - Underlying Opposing Factors

5.3 Innovation Dynamics

Hypothesis: The conceptualisation of ICT as an enabler of innovation allows for a market based analysis of why different firms exhibit differing payoffs despite similar levels of ICT investment. The differing payoffs are the result of varying adoption patterns and environmental conditions. One of such environmental conditions are employee qualification e.g. is he a holder of certification or university degree? Following are the hypotheses that look upon employee qualification and there impact on non-IT based innovation in the firm:

1. Firms characterized by a higher share of employees with a university degree are more likely to conduct innovations.
2. Firms characterized by a higher share of employees with certifications are more likely to conduct innovations.

For innovation it is not just one ICT factor that play vital role but rather it's a number of ICT factors implemented together in the firm that leads to the innovation. These combinations of ICT factors are varying adoption patterns. Firms vary in these factors when compared with each other and they keep adopting different factors (which represent different patterns). There are different ICT factors included in these varying adoption patterns, the once we used in our analysis are: IT based process innovations, Open sources software, ICT applications, Increase in firm turnover, non IT based process and product innovations, Technological externalities. Let examine these factors and their related hypothesis:

IT based process innovations: The output of firm processes is the product which can be input to other processes or it can be a final product of a value chain. Similarly non IT based innovation is an output of IT based process innovations and it can be input to other processes in the firm. Following hypothesis looks upon how IT based process innovation affect non IT based innovations for the firms:

3. IT based process innovations are positively correlated with general innovations of the firm.

Open sources software: Investments in ICT system gets lost because of lack of open standards (Jan Julianus - Ministry of Economic Affairs, The Netherlands) [10], which leads to less readiness of ICT in the firms and thus eventually affect IT based innovations. By using open sources software as a solution we can sort out this issue. Following hypothesis examine the correlation between open sources software and IT based process innovations, if this correlation proves to be positive then our argument "By using open sources software as a solution we can sort out this issue" can work out and performance of the firm can be improved:

4. Open sources software usage leads to IT based Innovations.

ICT Applications: In previous hypothesis we are looking at open sources software. There are other ICT applications that contribute in IT based innovation. To examine impact of these ICT applications we have designed following hypothesis:

5. ICT applications are positively correlated with IT based Innovations.

Increase in Firm Turnover: Investment in ICT allows the deployment of more advanced ICT (Saunders, Brynjolfsson. 2007) (Bardhan I, Whitaker J, Mithas S. 2006) and this may lead to IT based innovation. Investments in ICT are possible when firms are improving its financial standings (e.g. improved turnover). In order to realize the validity of this argument, we try to find correlation between increase in firm turnover and IT based innovations. Following hypothesis is designed for this purpose:

[10] Proceedings from the Sectoral eBusiness Watch Conference 2008 "Understanding the eEconomy", 19-20 May in Brussels

6. IT based innovation is positively correlated with process innovations of the firm.

Product innovation: As said earlier the output of firm processes is the product which can be input to other processes or it can be a final product of a value chain. Under such argumentation we ca say that IT based process innovations in the firms may lead to product innovation. In order to realize validity of this statement we have designed following hypothesis:

7. IT based Innovation is positively correlated with Product innovation of the firm.

Technological externalities: Presence of externalities is not only driving decision in the firms (section 5.2) but also influences the processes going on inside the firms and thus the output of the process (IT based innovations). In order to realize the validity of this statement we have designed following hypothesis:

8. Technological externalities drive IT based innovations

Casual Analysis: In figure 5.34, we have two sets of cause and effect; first one exists between factors (turnover, IT skill development, intra-firm network infrastructure, network infrastructure, intra firm online technologies based applications, and online technologies based applications) and IT based Process Innovations, and second one exists between non IT based innovations and Firm's Productivity. If we consider a complete casual chain then we will see a third casual link (red color link) exists between IT based Process Innovations (*Effect*) and non IT based innovations (*Cause*). The casual link that exists between effect and cause is called reverse causality.

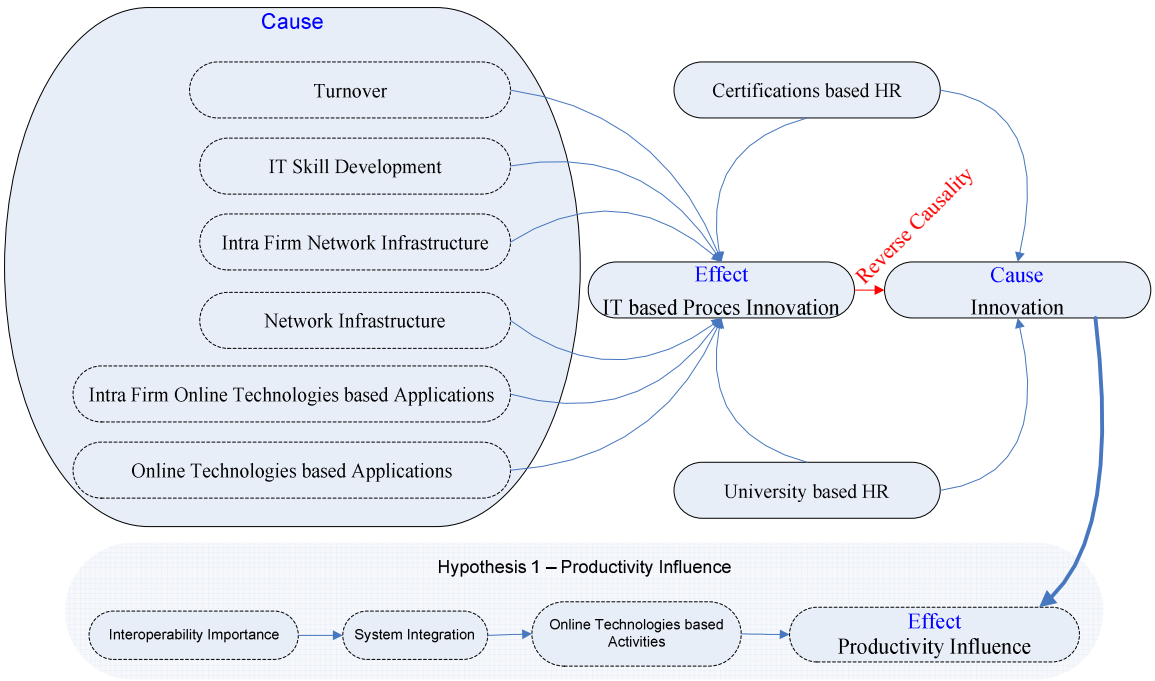


Figure 5.34 Hypothesis 1 & 2 – University Degree & Certification for Innovation

Regressors Used: Figure 5.34 shows casual diagram which includes factors that have been selected for empirical analysis, which are:

Note: some of the factors are reparative e.g. Online Technologies based Applications is already have been defined as Online Technologies based Activities in previous regressions (productivity – Hypothesis 1). It was mentioned in previous chapter that we are using cross sectional databases, even though factors name are same but the indicators used to construct these factors may change and that is the reason we have to explain the factors every time for each model.

- Turnover (Driver): The regressor reflects the turnover comparison between current and last financial year.
- IT Skill Development (Driver): This regressor is representing firms IT employee hiring for last year. This may change processes and structure exists inside the firm.
- Intra Firm Network Infrastructure (Readiness Internal): This regressor represent intra Firm ICT infrastructure: Intranet, LAN, wireless LAN.

- Network Infrastructure (Readiness External): This regressor represent network infrastructure that connect the firm with outside world, this include: Extranet and Wide area network.
- Intra Firm Online Technologies based Applications (Activity Internal): This regerssor represent intra-firm ICT technologies used for: collaboration between employees, automated reimbursement of employee, tracking working hours and production times, supporting human resources management, and e-learning.
- Online Technologies based Applications (Activity External): This regerssor represent ICT technologies used with external links outside the firm, this include: Collaboration with business partner in design of new product, Collaboration with business partner to forecast product demand, to manage capacity and inventories, to exchange documents electronically with suppliers, to exchange documents electronically with customers, and to negotiate contracts.
- University based Human Resource (Driver): This regressor represents firm's intentions to hire employees with academic degree e.g. masters or PhD in computer science.
- Certification based Human Resource (Driver): This regressor represents firm's intentions to hire employees with IT industry certifications and at least a few year of experience.

Regressors Descriptives: Let examine the descriptive statistics of the regressors. This will help us in understanding the basic feature of the gathered data. Table 5.14 gives the summary of the descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
RVitbasedp~n IT based Process Innovation	3002	.4893404	.4999696	0	1
factorinno~n Innovation	6925	-.0034953	.7100085	-.8294966	.9162796
DUMturnov~NC Turnover Increased	10315	.3772176	.4847136	0	1
DUMturnov~EC	10315	.1780902	.3826072	0	1

Turnover Decreased					
DUMskillsd~S	10315	.1762482	.3810497	0	1
IT Skill Development					
factorintr~c	6644	-.0477579	.7867032	-.9304389	1.322536
Intra Firm Network Infrastructure					
factornetw~e	9398	-.0027523	.7389769	-.4260127	1.876754
Network Infrastructure					
factorintr~p	9465	-.0095904	.8465091	-.5621504	2.47429
Intra Firm Online Technologies based Applications					
factoronli~t	8777	-.0186113	.8982181	-.8198358	2.366086
Online Technologies based Applications					
DUMunivers~S	10315	.0325739	.1775272	0	1
University based Human Resource					
DUMcertifi~S	10315	.0767814	.2662572	0	1
Certification based Human Resource					

Table 5.14 Descriptive Statistics for Hypothesis 1 & 2 – Innovation Dynamics

Regression Analysis: Our model suffers from endogeneity. Endogeneity occurs when the dependent variable (IT based Process Innovations) may actually be a cause of the independent variable (non IT based Innovations). Sometimes this is referred to as reverse causality (already explained in casual analysis). In regression analysis issue of endogeneity is tackled by using two-stage least squares regression. We have used Probit model with endogenous regressors (Two-stage least squares regression - 2SLS) in Stata for statistical analysis of the hypotheses. The dataset survey used for this regression is e-Business Watch survey 2003.

	MTBF Innovation		HTBF Innovation	
RVitbasedp~n	**0.265***	(0.126)	**0.872***	(0.350)
IT based Process Innovations				
DUMunivers~S	**0.0884***	(0.0438)	0.0575	(0.0586)
University based Human Resource				
DUMcertifi~S	-0.00872	(0.0354)	-0.106	(0.0826)
Certification based Human Resource				
_cons	0.617***	(0.114)	-0.0763	(0.368)
N	1106		474	

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 5.15 Hypothesis 1 & 2 – University Degree & Certification for Innovation Results

Regression Results and Interpretations: We can see in the results – table 5.15, for Medium Tech e-Business based Firms (MTBF) and High Tech e-Business based Firms (HTBF) the IT based process innovation (Impact-Internal-Intangible 0.265*, 0.872*) is positively correlated with non IT based Innovation (complementary). This lead to our interpretations of the results:

- *IT based process innovation is positively correlated with general innovations of the firm*. This means our hypothesis is accepted.

We can see in the results – table 5.15, for Medium Tech e-Business based Firms (MTBF), university based human resources (driver 0.0884*) is having positive correlation with non IT based innovation (complementary). For High Tech e-Business based Firms (HTBF) results are not significant. This lead to our interpretations of the results:

- *Firms characterized by a higher share of employees with a university degree are more likely to conduct innovations*. This means our hypothesis is accepted.

We can see in the results – table 5.15, the results for certification based human resources (driver - not significant) is not significant. As a result we can't test the third hypothesis. As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). From the results we have identify following underlying success factors that give significant results, see 5.35.



Figure 5.35Hypothesis 1 & 2 – Innovation Dynamics - Underlying Success Factors

In previous regression we try to analyze ICT contribution toward non-ICT based innovations of the firm. In the following regression we are trying to analyze ICT and

non IT based innovation contribution toward ICT based innovations (process or product).

Casual Analysis: Figure 5.36 show casual diagram of the factors. The turnover increase in the firm may lead to more ICT implementation and thus more activities (intra-firm network based application). Open sources software may help in solving compatibility issue (if exist) and allow smooth running of firm network based application, in turn the use of these specialized application may lead to product or process innovations. Non IT based innovation (managerial, structural, conceptual, strategic, product, process) and technological development relevance may act as supplement (supporting or opposing) for product or process innovations. In order to examine validity if above argumentations following hypotheses have been designed:

3. Open sources software usage leads to IT based Innovations.
4. ICT applications are positively correlated with IT based Innovations.
5. Increase in firm turnover is an opportunity for firm to perform IT based Innovation.

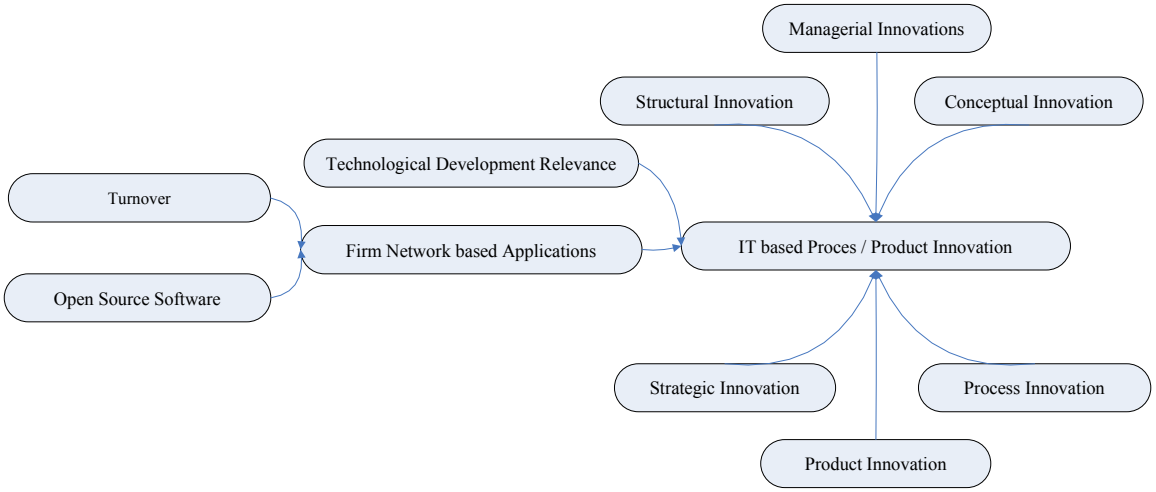


Figure 5.36 Casual analysis - IT based Innovation

6. IT based Innovation is positively correlated with Process innovation.
7. IT based Innovation is positively correlated with Product innovation.

8. Technological externalities drive IT based innovations

Regressors Used: Figure 5.36 shows casual diagram which includes factors that have been selected for empirical analysis, which are:

- Firm Turnover (*Driver*): This regressor shows firm turnover increase, decrease, or stability when compared to last financial year.
- Open Source Software (*Readiness Internal*): This regressor shows firm's usage of open source software. The softwares are: Linux, mySQL, Mozila Firefox.
- Firm Network based Applications (*Activity Internal – Activity External*): This regressor shows firm's usage of: software application to manage the placing and receipt of the orders, enterprise resources planning, document management system for string and archiving electronic documents, software for product lifecycle management, material requirement planning software, manufacturing resources planning software, and RFID technology.
- Product Innovation (*Complementary*): This regressor represents firm's product innovations.
- Process Innovation (*Complementary*): This regressor represents firm's implementation of new internal process e.g. for producing or supplying goods and services.
- Strategic Innovation (*Complementary*): This regressor represents firm's innovative changes in cooperate strategy.
- Managerial Innovations (*Complementary*): This regressor represents firm's innovative changes in management techniques.
- Structural Innovation (*Complementary*): This regressor represents firm's innovative changes in organizational structure.
- Conceptual Innovation (*Complementary*): This regressor represents firm's innovative changes in its marketing concepts.

- Technological Development Relevance (*Externality*): This regressor represents importance firm give to technological developments like: VoIP, data communication though mobile devices, blogs and social networking technologies.

Regressors Descriptives: Let examine the descriptive statistics of the regressors. This will help us in understanding the basic feature of the gathered data. Table 5.16 gives the summary of the descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
RVitbasedp.. IT based Process Innovation	817	.376989	.484929	0	1
DUMfirmtu~EC Firm Turnover Decrease	2121	.0622348	.2416385	0	1
DUMfirmtu~NC Firm Turnover Increase	2121	.5219236	.4996369	0	1
factoropen~e Open Sources Software	2022	-.0035462	.7834558	-.5705149	1.921974
factorintr~i Firm Network based Applications	1956	-.0157104	.869616	-.7286717	2.647676
DUMproduct~s Product Innovation	2121	.3899104	.4878447	0	1
DUMprocess~s Process Innovation	2121	.4120698	.4923236	0	1
DUMstrateg~s Strategic Innovation	2121	.2220651	.4157327	0	1
DUMmanager~s Managerial Innovations	2121	.2182933	.4131849	0	1
DUMstructu~s Structural Innovation	2121	.3253182	.4686041	0	1
DUMconcept~s Conceptual Innovation	2121	.2578972	.4375803	0	1

Table 5.16 Descriptive Statistics for Hypothesis 3 to 6 – Innovation Dynamics

Regression Analysis: The dataset survey used for this regression is e-Business Watch survey 2007. Following regressions (see table 5.17 to table 5.24) are performed by using Logistic[11] regression in Stata.

```
Logistic regression                                     Number of obs   =        226
                                                        Wald chi2(18)   =      37.19
                                                        Prob > chi2     =     0.0049
Log pseudolikelihood = -112.55581                       Pseudo R2       =     0.1643

------------------------------------------------------------------------------
             |               Robust
R~cessinno~n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
```

[11] *Logistic regression* is a form of regression which is used when the dependent is a dichotomy and the independents are of any type.

DUMfirmtu~EC	-.7523776	1.021193	-0.74	0.461	-2.753879	1.249124
Firm Turnover Decrease						
DUMfirmtu~NC	**.6453459**	**.3642061**	**1.77**	**0.076**	**-.068485**	**1.359177**
Firm Turnover Increase						
factoropen~e	**.3557528**	**.1997563**	**1.78**	**0.075**	**-.0357623**	**.7472679**
Open Source Software						
factorintr~i	**.4463984**	**.1899258**	**2.35**	**0.019**	**.0741507**	**.818646**
Firm Network based Applications						
DUMproduct~s	.6008235	.3855974	1.56	0.119	-.1549336	1.356581
Product Innovation						
DUMstrateg~s	-.360575	.4682976	-0.77	0.441	-1.278421	.5572713
Strategic Innovation						
DUMmanager~s	.5310382	.4274525	1.24	0.214	-.3067533	1.36883
Managerial Innovations						
DUMstructu~s	.3492816	.3884465	0.90	0.369	-.4120596	1.110623
Structural Innovation						
DUMconcept~s	.4655701	.4223186	1.10	0.270	-.3621591	1.293299
Conceptual Innovation						
_cons	-.3326316	1.092469	-0.30	0.761	-2.473832	1.808569

Table 5.17 HTBF - IT based Process Innovation – Results

Logistic regression — Number of obs = 351

Wald chi2(19) = 59.48

Prob > chi2 = 0.0000

Log pseudolikelihood = -206.50503 — **Pseudo R2 = 0.1391**

R~cessinno~n	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
DUMfirmtu~EC	.7360506	.5280178	1.39	0.163	-.2988452	1.770946
Firm Turnover Decrease						
DUMfirmtu~NC	.4721645	.286961	1.65	0.100	-.0902688	1.034598
Firm Turnover Increase						
factoropen~e	.182849	.1631065	1.12	0.262	-.1368339	.5025319
Open Source Software						
factorintr~i	**.341602**	**.1660279**	**2.06**	**0.040**	**.0161933**	**.6670108**
Firm Network based Applications						
DUMproduct~s	.2625128	.2572256	1.02	0.307	-.2416402	.7666658
Product Innovation						
DUMstrateg~s	-.452045	.3337359	-1.35	0.176	-1.106155	.2020653
Strategic Innovation						
DUMmanager~s	.1537307	.3091452	0.50	0.619	-.4521827	.7596441
Managerial Innovations						
DUMstructu~s	-.0623624	.2965883	-0.21	0.833	-.6436649	.51894
Structural Innovation						
DUMconcept~s	-.2509889	.3236358	-0.78	0.438	-.8853034	.3833256
Conceptual Innovation						
_cons	-1.535919	.6960738	-2.21	0.027	-2.900199	-.17164

Table 5.18 MTBF - IT based Process Innovation – Results

Regression Results and Interpretations: The table 5.17 results shows that IT based Process Innovation (Impact-Internal-Intangible) in High Tech e-Business based

Firms (HTBF) is positively correlated with firm turnover (driver .6453459), open sources software (Readiness Internal .3557528), firm network based applications (Activity Internal, Activity External .4463984). This lead to out interpretation:

- *Open sources software usage leads to IT based Innovations*. This means our hypothesis is accepted.
- *ICT applications are positively correlated with IT based Innovations*. This means our hypothesis is accepted.
- *Increase in firm turnover is an opportunity for firm to perform IT based Innovation*. This means our hypothesis is accepted.

Regression Results and Interpretations: The table 5.18 results shows that IT based Process Innovation (Impact-Internal-Intangible) in Medium Tech e-Business based Firms (MTBF) is positively correlated with firm network based applications (Activity Internal, Activity External .341602). This lead to out interpretation:

- *ICT applications are positively correlated with IT based Innovations*. This hypothesis is already accepted for High Tech e-Business based Firms (HTBF) but these results have reconfirmed for Medium Tech e-Business based Firms (MTBF) also.

```
Logistic regression                                     Number of obs   =        204
                                                        Wald chi2(20)   =      44.97
                                                        Prob > chi2     =     0.0011
Log pseudolikelihood = -101.68579                       Pseudo R2       =     0.2758

------------------------------------------------------------------------------
             |               Robust
RVitbasedp~n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
DUMfirmtu~EC |   .8702539    1.69681     0.51   0.608    -2.455433     4.19594
Firm Turnover Decrease
DUMfirmtu~NC |   .5200662   .3724663     1.40   0.163    -.2099543    1.250087
Firm Turnover Increase
factoropen~e |   .4930771   .2409837     2.05   0.041     .0207578    .9653964
Open Source Software
factorintr~i |  -.0747635   .1904381    -0.39   0.695    -.4480154    .2984884
Firm Network based Applications
DUMprocess~s |   1.237314   .5098823     2.43   0.015     .2379629    2.236665
Product Innovation
DUMstrateg~s |  -.2812095   .4549031    -0.62   0.536    -1.172803    .6103842
Strategic Innovation
DUMmanager~s |   .1543978   .4624191     0.33   0.738     -.751927    1.060723
Managerial Innovations
```

DUMstructu~s	-.0261949	.3968973	-0.07	0.947	-.8040993	.7517096
Structural Innovation						
DUMconcept~s	**.8485445**	**.4056012**	**2.09**	**0.036**	**.0535808**	**1.643508**
Conceptual Innovation						
factortech~e	.2858479	.2313938	1.24	0.217	-.1676756	.7393713
Technological Development Relevance						
_cons	-1.918689	1.141809	-1.68	0.093	-4.156593	.3192161

Table 5.19 HTBF - IT based Product Innovation – Results

Logistic regression — Number of obs = 329

Wald chi2(20) = 51.70

Prob > chi2 = 0.0001

Log pseudolikelihood = -183.07441 — **Pseudo R2 = 0.1323**

RVitbasedp~n	Coef.	Rb Std. Err.	z	P>|z|	[95% Conf.	Interval]
DUMfirmtu~EC	.4152774	.5057655	0.82	0.412	-.5760047	1.40656
Firm Turnover Decrease						
DUMfirmtu~NC	.0229312	.3075901	0.07	0.941	-.5799343	.6257966
Firm Turnover Increase						
factoropen~e	.1177328	.1599802	0.74	0.462	-.1958226	.4312881
Open Source Software						
factorintr~i	**.2905997**	**.1697668**	**1.71**	**0.087**	**-.0421371**	**.6233365**
Firm Network based Applications						
DUMprocess~s	**.9230295**	**.2777513**	**3.32**	**0.001**	**.378647**	**1.467412**
Product Innovation						
DUMstrateg~s	-.2237437	.3961049	-0.56	0.572	-1.000095	.5526077
Strategic Innovation						
DUMmanager~s	-.0647597	.3904531	-0.17	0.868	-.8300337	.7005144
Managerial Innovations						
DUMstructu~s	-.0107224	.35163	-0.03	0.976	-.6999045	.6784598
Structural Innovation						
DUMconcept~s	.1328081	.3545657	0.37	0.708	-.562128	.8277442
Conceptual Innovation						
factortech~e	.2581392	.1693672	1.52	0.127	-.0738143	.5900928
Technological Development Relevance						
_cons	-.939431	.673681	-1.39	0.163	-2.259821	.3809595

Table 5.20 MTBF - IT based Product Innovation – Results

Regression Results and Interpretations: The table 5.19 results shows that IT based Product Innovation (Impact-External-Intangible) in High Tech e-Business based Firms (HTBF) is positively correlated with open sources software (Readiness Internal .4930771), process innovation (Complementary 1.237314), and conceptual innovation (Complementary .8485445). This lead to out interpretation:

- *Open sources software usage leads to IT based Innovations*. Acceptance reconfirmed.

- *IT based Innovation is positively correlated with Process innovation*. This means our hypothesis is accepted.

Regression Results and Interpretations: The table 5.20 results shows that IT based Product Innovation (Impact-External-Intangible) in Medium Tech e-Business based Firms (MTBF) is positively correlated with firm network based applications (Activity Internal, Activity External .2905997) and process innovation (Complementary .9230295). This lead to out interpretation:

- *ICT applications are positively correlated with IT based Innovations*. Acceptance reconfirmed.
- *IT based Innovation is positively correlated with Process innovation*. This hypothesis is already accepted for High Tech e-Business based Firms (HTBF) but these results have reconfirmed for Medium Tech e-Business based Firms (MTBF) also.

Externalities can effects the behavior of the firm and its related attributes. To realize these effects we have performed previous regression (5.17 to 5.20) in presence of externalities.

```
Logistic regression                                     Number of obs   =        219
                                                        Wald chi2(19)   =      41.03
                                                        Prob > chi2     =     0.0024
Log pseudolikelihood = -106.62364                       Pseudo R2       =     0.1886

------------------------------------------------------------------------------
R~cessinno~n |      Coef.  Rb Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
DUMfirmtu~EC |  -.7333394   1.064279    -0.69   0.491    -2.819287    1.352609
Firm Turnover Decrease
DUMfirmtu~NC |    .458207   .3747239     1.22   0.221    -.2762384    1.192652
Firm Turnover Increase
factoropen~e |   .3474863   .2116027     1.64   0.101    -.0672474    .7622199
Open Source Software
factorintr~i |   .5030517   .2091782     2.40   0.016     .0930699    .9130334
Firm Network based Applications
DUMproduct~s |   .7249924   .3923105     1.85   0.065    -.0439221    1.493907
Product Innovation
DUMstrateg~s |  -.5109585   .4758259    -1.07   0.283     -1.44356     .421643
Strategic Innovation
DUMmanager~s |   .5024735   .4348228     1.16   0.248    -.3497636    1.354711
Managerial Innovations
DUMstructu~s |    .444497   .3868045     1.15   0.250    -.3136259     1.20262
Structural Innovation
```

```
DUMconcept~s |   .3579929   .4332102     0.83   0.409    -.4910835    1.207069
Conceptual Innovation
factortech~e |   .2946955   .2177995     1.35   0.176    -.1321837    .7215746
Technological Development Relevance
       _cons |  -.4483326   1.129575    -0.40   0.691    -2.662259    1.765593
------------------------------------------------------------------------------
```

Table 5.21 HTBF - IT based Process Innovation under Externality of Technological development Relevance

```
Logistic regression                               Number of obs   =        340
                                                  Wald chi2(20)   =      53.58
                                                  Prob > chi2     =     0.0001
Log pseudolikelihood = -194.63657                 Pseudo R2       =     0.1587

------------------------------------------------------------------------------
R~cessinno~n |      Coef.  Rob Sd. Err.    z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
DUMfirmtu~EC |   .7619548   .5340862     1.43   0.154    -.2848349    1.808744
Firm Turnover Decrease
DUMfirmtu~NC |    .585195   .3063311     1.91   0.056    -.0152028    1.185593
Firm Turnover Increase
factoropen~e |   .1783308   .1645602     1.08   0.279    -.1442014    .5008629
Open Source Software
factorintr~i |   .3146245   .1674144     1.88   0.060    -.0135016    .6427507
Firm Network based Applications
DUMproduct~s |   .2463176   .2659061     0.93   0.354    -.2748488     .767484
Product Innovation
DUMstrateg~s |  -.5535801   .3483138    -1.59   0.112    -1.236262    .1291023
Strategic Innovation
DUMmanager~s |   .1604914   .3202939     0.50   0.616    -.4672731    .7882559
Managerial Innovations
DUMstructu~s |  -.0317736   .3097706    -0.10   0.918    -.6389128    .5753656
Structural Innovation
DUMconcept~s |  -.2880114    .336417    -0.86   0.392    -.9473766    .3713538
Conceptual Innovation
factortech~e |   .5869853   .1688228     3.48   0.001     .2560987    .9178719
Technological Development Relevance

       _cons |  -1.227804   .6973095    -1.76   0.078    -2.594505    .1388979
------------------------------------------------------------------------------
```

Table 5.22 MTBF - IT based Process Innovation under Externality of Technological development Relevance

Regression Results and Interpretations: Tables 5.21 results shows that IT based Process Innovation (Impact-Internal-Intangible) under externality of technological development relevance in High Tech e-Business based Firms (HTBF) is positively correlated with firm network based applications (Activity Internal, Activity External .5030517) and product innovation (Complementary .7249924). This lead to out interpretation:

- *ICT applications are positively correlated with IT based Innovations*. Acceptance reconfirmed.

- *IT based Innovation is positively correlated with Product innovation*. This result in acceptance of our hypothesis.

Comparison: Results are different as compared to the regression model in which externality was not present (table 5.17).

Regression Results and Interpretations: Tables 5.22 results shows that IT based Process Innovation (Impact-Internal-Intangible) under externality of technological development relevance in Medium Tech e-Business based Firms (MTBF) is positively correlated with increase in firm turnover (Driver .585195), Firm Network based Application (Activity Internal, Activity External .3146245), and technological development relevance (Externality .5869853) This lead to our interpretations:

- *Increase in firm turnover is an opportunity for firm to perform IT based Innovation*. Acceptance reconfirmed.
- *ICT applications are positively correlated with IT based Innovations*. Acceptance reconfirmed.
- *Technological externalities drive IT based innovations*. This result in acceptance of our hypothesis.

Comparison: Results are different as compared to the regression model in which externality was not present (table 5.18).

```
Logistic regression                               Number of obs   =        204
                                                  Wald chi2(20)   =      44.97
                                                  Prob > chi2     =     0.0011
Log pseudolikelihood = -101.68579                 Pseudo R2       =     0.2758

------------------------------------------------------------------------------
RVitbasedp.. |      Coef.  Rob Std. Err.   z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
DUMfirmtu~EC |   .8702539    1.69681     0.51   0.608    -2.455433     4.19594
Firm Turnover Decrease
DUMfirmtu~NC |   .5200662   .3724663     1.40   0.163    -.2099543    1.250087
Firm Turnover Increase
factoropen~e |   .4930771   .2409837     2.05   0.041     .0207578    .9653964
Open Source Software
factorintr~i |  -.0747635   .1904381    -0.39   0.695    -.4480154    .2984884
Firm Network based Applications
DUMprocess~s |   1.237314   .5098823     2.43   0.015     .2379629    2.236665
Product Innovation
DUMstrateg~s |  -.2812095   .4549031    -0.62   0.536    -1.172803    .6103842
Strategic Innovation
```

DUMmanager~s	.1543978	.4624191	0.33	0.738	-.751927	1.060723
Managerial Innovations						
DUMstructu~s	-.0261949	.3968973	-0.07	0.947	-.8040993	.7517096
Structural Innovation						
DUMconcept~s	**.8485445**	**.4056012**	**2.09**	**0.036**	**.0535808**	**1.643508**
Conceptual Innovation						
factortech~e	.2858479	.2313938	1.24	0.217	-.1676756	.7393713
Technological Development Relevance						
_cons	-1.918689	1.141809	-1.68	0.093	-4.156593	.3192161

Table 5.23 HTBF - IT based Product Innovation under Externality of Technological development Relevance

Logistic regression — Number of obs = 329; Wald chi2(20) = 51.70; Prob > chi2 = 0.0001; Log pseudolikelihood = -183.07441; **Pseudo R2 = 0.1323**

RVitbasedp..	Coef.	Rob Std. Err.	z	P>|z|	[95% Conf.	Interval]
DUMfirmtu~EC	.4152774	.5057655	0.82	0.412	-.5760047	1.40656
Firm Turnover Decrease						
DUMfirmtu~NC	.0229312	.3075901	0.07	0.941	-.5799343	.6257966
Firm Turnover Increase						
factoropen~e	.1177328	.1599802	0.74	0.462	-.1958226	.4312881
Open Source Software						
factorintr~i	**.2905997**	**.1697668**	**1.71**	**0.087**	**-.0421371**	**.6233365**
Firm Network based Applications						
DUMprocess~s	**.9230295**	**.2777513**	**3.32**	**0.001**	**.378647**	**1.467412**
Product Innovation						
DUMstrateg~s	-.2237437	.3961049	-0.56	0.572	-1.000095	.5526077
Strategic Innovation						
DUMmanager~s	-.0647597	.3904531	-0.17	0.868	-.8300337	.7005144
Managerial Innovations						
DUMstructu~s	-.0107224	.35163	-0.03	0.976	-.6999045	.6784598
Structural Innovation						
DUMconcept~s	.1328081	.3545657	0.37	0.708	-.562128	.8277442
Conceptual Innovation						
factortech~e	.2581392	.1693672	1.52	0.127	-.0738143	.5900928
Technological Development Relevance						
_cons	-.939431	.673681	-1.39	0.163	-2.259821	.3809595

Table 5.24 MTBF - IT based Product Innovation under Externality of Technological development Relevance

Regression Results and Interpretations: Tables 5.23 results shows that IT based Product Innovation (Impact-External-Intangible) under externality of technological development relevance in High Tech e-Business based Firms (HTBF) is positively correlated with open source software (Readiness Internal .4930771), process innovation (Complementary 1.23731) and conceptual innovation (Complementary .8485445). This lead to out interpretation:

- *Open sources software usage leads to IT based Innovations*. Acceptance reconfirmed.
- *IT based Innovation is positively correlated with Process innovation*. Acceptance reconfirmed.

Comparison: Significant variables are same as for the regression model in which externality was not present (table 5.19).

Regression Results and Interpretations: Tables 5.24 results shows that IT based Product Innovation (Impact-External-Intangible) under externality of technological development relevance in Medium Tech e-Business based Firms (MTBF) is positively correlated with Firm Network based Application (Activity Internal, Activity External .2905997), and process innovation (Complementary .9230295). This lead to our interpretations:

- *ICT applications are positively correlated with IT based Innovations*. Acceptance reconfirmed.
- *IT based Innovation is positively correlated with Process innovation*. Acceptance reconfirmed.

Comparison: Significant variables are same as for the regression model in which externality was not present (table 5.20). This means for IT based Process Innovation externality (technology development relevance) have their influence but for IT based Product innovation this externality presences doesn't make any difference.

As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). From the results we have identify following underlying success factors that give significant results, see figure 5.37.



Figure 5.37, IT based Innovation – Underlying Success Factors

5.4 Value chain and firm characteristics

Hypothesis: For the firms, ICT has enabled new business structures and redefined B2B interactions through value chain management. These new structures allow the exchange of information and better responses to real-time business conditions. This means that, either its edges of value chain (customer or supplier relationships) or inside the firm (changing structures) ICT is playing its positive role to improve value chain characteristics and organizational structure. In order to realize validity of the argument we have designed following hypothesis:

1. Intra-firm processes and structural changes are positively correlated with ICT applications.

Casual Analysis: Figure 5.38 gives an overview of casual relationships. Firm may develop its IT skills to perform ICT based activities, and this may lead to changes for the processes and organizational structure inside the firm or at the edges of value chain. IT training can complement these changes.

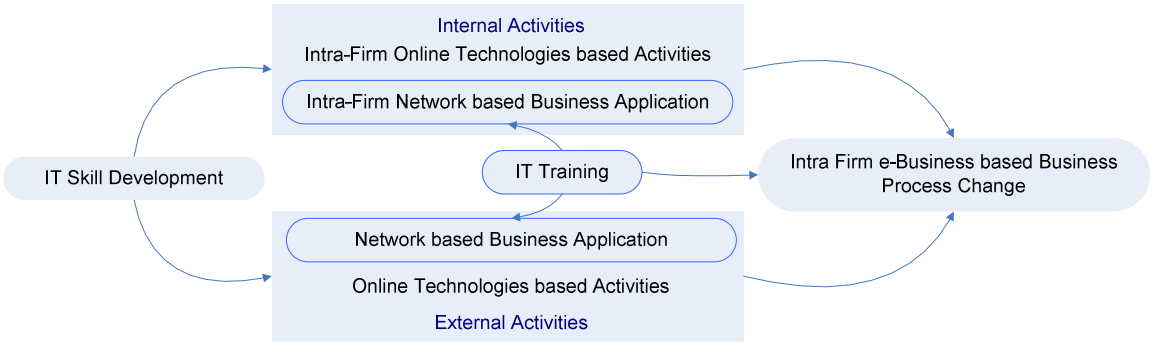


Figure 5.38 Hypothesis 1 – Intra-Firm e-Business based Business Process Changes

Regressors Used: Figure 5.38 shows the casual diagram that includes the factors that we have selected for empirical analysis, which include:

- IT Skill Development (*driver*): This regressor is representing firms IT employee hiring for last year. This may change processes and structure exists inside the firm.
- Intra Firm Online Technologies based Activities (*Activity Internal*): This regerssor represent intra-firm ICT technologies used for: collaboration between employees, automated reimbursement of employee, tracking working hours and production times, supporting human resources management, and e-learning. This may change processes and structure exists inside the firm.
- Intra Firm Network based Business Applications (*Activity Internal*): This regressor represents intra-firm ICT applications like: content management system, knowledge management system, and enterprise resources planning system used inside the firm. This may change processes and structure exists inside the firm.
- Online Technologies based Activities (*Activity External*): This regerssor represent ICT technologies used with external links outside the firm, this include: Collaboration with business partner in design of new product, Collaboration with business partner to forecast product demand, to manage capacity and inventories, to exchange documents electronically with

suppliers, to exchange documents electronically with customers, and to negotiate contracts. This may change processes and structure exists inside the firm.

- Network based Business Applications (*Activity External*): This regerssor represent ICT applications used with external links outside the firm, this include: supply chain management system, customer relationship management system, and services of application service provider. This may change processes and structure exists inside the firm.
- IT Training (complimentary): This regressor by name shows IT training opportunities created in the firm for employees. This may change processes and structure exists inside the firm.
- Interaction Terms: There are two interaction terms that represent IT training given to employee for Intra Firm Network based Business Applications and Network based Business Applications.

Regressors Descriptives: Let examine the descriptive statistics of the regressors. This will help us in understanding the basic feature of the gathered data. Table 5.25 gives the summary of the descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
factorebus~c Business Based Business Process Changes	4557	-.0058264	.8383862	-.8512809	1.928191
factorint~us Intra-Firm Business Based Business Process Changes	4558	-.0039175	.8823161	-.9100535	2.0248
DUMskillsd~W IT Skill Development	9264	.2197755	.4141168	0	1
factorintr~p Intra Firm Online Technologies based Activities	8609	-.0097508	.8573332	-.6375702	2.488726
factorintr~l Intra Firm Network based Business Applications	5317	.0496002	.7048773	-.385736	2.456762
factornetw~s Online Technologies based Activities	7541	-.0032997	.7394214	-.3450294	3.069401
factoronli~t Network based Business Applications	8108	-.0187964	.8947368	-.8669167	2.348053
factorittr~g IT Training	9183	-.0004517	.7162185	-.875891	.8770972

Table 5.25 Descriptive Statistics Hypothesis 1 – Value Chain and Firm Characteristics

Regression Analysis: The dataset survey used for this regression is e-Business Watch survey 2002. We have used Linear Regression model in Stata for statistical analysis of this hypothesis. In this model we are analyzing the affects of e-Business for processes and organizational structure exists inside the firm. The factor represent such effect is called Intra-Firm e-Business based Business Process Change.

	MTBF Intra Process Change		HTBF Intra Process Change	
DUMskillsd~W IT Skill Development	0.0193	(0.0444)	0.130	(0.101)
factorintr~l Intra Firm Network based Business Applications	0.0402	(0.0385)	0.0510	(0.0851)
factorintr~p Intra Firm Online Technologies based Activities	0.0436	(0.0242)	0.0865	(0.0514)
factornetw~s Network based Business Applications	**0.0645***	(0.0313)	**0.231*****	(0.0575)
factoronli~t Online Technologies based Activities	**0.0856*****	(0.0212)	-0.0114	(0.0483)
I~aBusApplic Intra Firm Network based Business Applications* IT Training	-0.0129	(0.0528)	-0.0331	(0.109)
I~tBusApplic Network based Business Applications* IT Training	-0.0287	(0.0447)	-0.0587	(0.0811)
factorittr~g IT Training	-0.0504	(0.0326)	0.0104	(0.0695)
_cons	-0.358***	(0.0752)	0.00391	(0.171)
N	1809		510	
R-sq	0.085		0.155	

Standard errors in parentheses

- p<0.05, ** p<0.01, *** p<0.001

Table 5.26 Hypothesis 1 – Intra-Firm e-Business based Business Process Change results

Regression Results and Interpretations: The result in table 5.26 show that Intra-Firm e-Business based Business Process Changes (Impact-Internal-Intangible) for Medium Tech e-Business based Firms (MTBF) is positively correlated with Network based Business Applications (Activity External 0.0645*) and Online Technologies based Activities (Activity External 0.0856***). For High Tech e-Business based Firms (HTBF) it is positively correlated with Network based Business Applications (Activity External 0.231***). This lead to our interpretations of the results:

- *Intra-firm processes and structural changes are positively correlated with ICT applications*. This result in acceptance of our hypothesis.

As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). From the results we have identify following underlying success factors that give significant results, see figure 5.39.



Figure 5.39 Hypothesis 1 – Intra-Firm Business Process Changes – Underlying Success Factors

Hypothesis: As mentioned earlier, tor the firms ICT has enabled new business structures and redefined B2B interactions through value chain management. In previous empirical test we have tested the ICT affects on firm's processes and organizational structure. The following hypothesis tries to analyze correlation between ICT and firm's B2B interactions with an empirical model and dataset survey (e-Business watch 2002) used for previous empirical model:

2. ICT diffusion is a positive influence for the edges of the value chain (customer and supplier relationships).

Regression Analysis: We have used Linear Regression model in Stata for statistical analysis of this hypothesis. In this model we are analyzing the effects of e-Business on edges of the value chain (customer and supplier relationships). The factor represent such effect is called e-Business based Business Process Change. The regressor of this model are the once that were used for measuring the effect of intra-firm e-Business based Business Process Change (hypothesis 1) under same relationship that are shown in casual diagram – figure 5.38.

	MTBF Process Change		HTBF Process Change	
DUMskillsd~W IT Skill Development	0.0548	(0.0422)	-0.0869	(0.0982)
factorintr~l Intra Firm Network based Business Applications	0.00651	(0.0359)	0.0554	(0.0743)

factorintr~p	**0.0650****	(0.0233)	**0.113***	(0.0495)
Intra Firm Online Technologies based Activities				
factornetw~s	0.0561	(0.0310)	0.0833	(0.0589)
Network based Business Applications				
factoronli~t	**0.144*****	(0.0210)	0.0693	(0.0452)
Online Technologies based Activities				
I~aBusApplic	0.0495	(0.0501)	0.0779	(0.0970)
Intra Firm Network based Business Applications* IT Training				
I~tBusApplic	-0.0467	(0.0413)	-0.0425	(0.0804)
Network based Business Applications* IT Training				
factorittr~g	0.00767	(0.0304)	0.0285	(0.0695)
IT Training				
_cons	-0.323***	(0.0722)	0.174	(0.166)
N	1805		506	
R-sq	0.117		0.165	

Standard errors in parentheses

- p<0.05, ** p<0.01, *** p<0.001

Table 5.27 Hypothesis 2 – Value chain edges results

Regression Results and Interpretations: The result in table 5.27 show that e-Business based Business Process Changes (Impact-External-Intangible) for Medium Tech e-Business based Firms (MTBF) is positively correlated with Intra Firm Online Technologies based Activities (Activity Internal 0.0650**) and Online Technologies based Activities (Activity External 0.144***). For High Tech e-Business based Firms (HTBF) it is positively correlated with Intra Firm Online Technologies based Activities (Activity Internal 0.113*). This lead to our interpretations of the results:

- *ICT diffusion is a positive influence for the edges of the value chain (customer and supplier relationships)*. This result in acceptance of our hypothesis.

As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). From the results we have identify following underlying success factors that give significant results, see figure 5.40.



Figure 5.40Hypothesis 2 – Value Chain Edges – Underlying Success Factors

Hypothesis: Previous result show that redefined B2B interactions through ICT has lead firms to improve their value chain edges (customer and supplier relationship). Such e-trading may result in increased number of suppliers. To analyze validity of this argument we have developed following hypothesis:

3. Numbers of suppliers are positively influenced by ICT based trading.

Casual Analysis: Firms try to implement data exchange tools and then take part in B2B trading, and this may result in increase of decrease of number of suppliers. Figure 5.41 give pictorial representation of casual relationships.



Figure 5.41 Hypothesis 3 – Number of Suppliers

Regressors Used: Figure 5.41 shows the casual diagram that includes the factors that we have selected for empirical analysis, which include:

- Data Exchange Tools (*Readiness External*): This regressor is representing firm's usage of EDI – electronic data interchange. This may increase or decrease the number of suppliers for the firm.
- B2B Trading (*Activity External*): This regerssor represent firm's ability to trade through e-marketplace[12].

Regressors Descriptives: Let examine the descriptive statistics of the regressors. This will help us in understanding the basic feature of the gathered data. Table 5.28 gives the summary of the descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
variablen~rs Number of Suppliers	3584	.2307478	.4213701	0	1
DUMdataexc~S Data Exchnage Tools	9264	.1846934	.3880696	0	1
DUMB2Btrad~S B2Btrading	9264	.0536485	.225335	0	1

Table 5.28 Descriptive Statistics Hypothesis 3 – Value Chain and Firm Characteristics

[12] B2B e-Market Place: Electronic trading platforms on the internet, where companies can sell and/or buy goods or services to/from other companies. These platforms can be operated by a single buyer / seller or by a third party. Many marketplaces are industry-specific. Some marketplaces require registration and membership fees from companies that want to conduct trade on them.

Regression Analysis: The dataset survey used for this regression is e-Business Watch survey 2002. We have used Multinomial Logistic Regression model in Stata for statistical analysis of this hypothesis. In this model we are analyzing the effects of ICT based trading on number of suppliers of the firm.

	MTBF Number of Suppliers		HTBF Number of Suppliers	
Decreased				
DUMdataexc~S Data Exchange Tools	**0.363***	(0.180)	0.503	(0.327)
DUMB2Btrad~S B2B Trading	**0.492***	(0.227)	**0.700***	(0.334)
_cons	-1.792***	(0.278)	-1.196**	(0.436)
Increased				
DUMdataexc~S Data Exchange Tools	-0.0831	(0.128)	0.301	(0.237)
DUMB2Btrad~S B2B Trading	0.286	(0.173)	0.338	(0.238)
_cons	-0.750***	(0.193)	-0.777*	(0.343)
N	2148		586	
pseudo R-sq	0.035		0.105	

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 5.29 Hypothesis 3 – Number of Suppliers Results

Regression Results and Interpretations: In the results given above the base category is "Remained about the same". As we can see in the results – table 5.29, the factors of the regression in the category (decreased) are positive (highlighted in results), which means the base category (Remained about the same) is running behind and we can reject the base category. This lead to our interpretations of the results:

- *Numbers of suppliers are negatively influenced by ICT based trading*, this result in rejection of our hypothesis. For Medium Tech e-Business based Firms (MTBF), the opposing factors are: Data exchange tools and B2B trading. For High Tech e-Business based Firms (HTBF), the opposing factor is: B2B trading. One of the explanations for such decrease in suppliers can be: *The demand or supply side for MTBF's and HTBF's is not ready for this change or*

may be in the process of change and facilities are not functional yet. This argument can be supported by descriptive statistics taken from the dataset of 2002 e-Business Watch survey (same dataset used for this regression), see table 5.30. In case of MTBF's out of total 2,984 firms only 648 firms are sure that their supplier compatibility is OK, other firms have their doubts. *If these firms implement Data Exchange Tools and B2B trading then they may suffer from loss of suppliers*. We can put the same arguments for HTBF's by looking at the descriptive statistics in the table 5.30.

MTBF's: items - purchasing online - suppliers technical systems are not compatible

	Freq.	Percent	Cum.
disagree completely	648	21.72	21.72
disagree somewhat	980	32.84	54.56
agree somewhat	934	31.30	85.86
agree completely	422	14.14	100.00
Total	2,984	100.00	

HTBF's: items - purchasing online - suppliers technical systems are not compatible

	Freq.	Percent	Cum.
disagree completely	270	33.21	33.21
disagree somewhat	273	33.58	66.79
agree somewhat	163	20.05	86.84
agree completely	107	13.16	100.00
Total	813	100.00	

Table 5.30 Suppliers Compatibility

As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). Although we didn't find any success

factor but we have factors that may result in loss of performance of the firm, see figure 5.42.



Figure 5.42 Hypothesis 3 – Number of Supplier – Underlying Opposing Factors

So far we have designed hypotheses that highlight the correlation of ICT with value chain and firm characteristics. As a result of ICT implementation or diffusion in these dimensions, for some firms, ICT have become a reasonable part of the business in the form of e-business. To measure this effect we will also test the following hypothesis:

4. ICT positively contribute to e-business growth of the firm.

Casual Analysis: The casual links in figure 5.43 are individual links rather then long chain of interactions, the obvious intention is to measure the contribution of each regressor independently for "Net e-Business Effects (Impact-External-Intangible)"

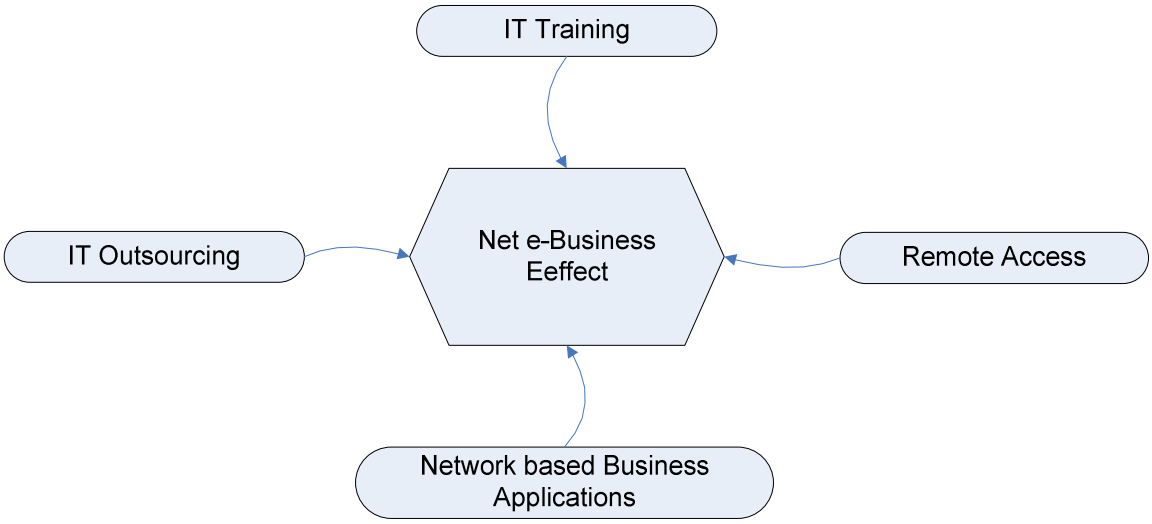


Figure 5.43 Hypothesis 4 – Net e-Business Effects

Regressors Used: Figure 5.43 shows the casual diagram that includes the factors that we have selected for empirical analysis, which include:

- Remote Access (*Readiness External*): This regressor is representing firm's ability to have remote access facility. This may change the way in which company operate its business.
- Network based Business Applications (*Activity External*): This regerssor represent ICT applications used with external links outside the firm, this include: supply chain management system, customer relationship management system, and services of application service provider. This may change the way in which company operate its business.
- IT Training (*complimentary*): This regressor by name shows IT training opportunities created in the firm for employees. This may change the way in which company operate its business.
- IT Outsourcing (*complimentary*): This regressor represent Firm's ability to contract external service providers for: web hosting, web design, and updating website. This may change the way in which company operate its business.
- Interaction term: This interaction term represent IT training given to employee for Network based Business Applications. This may change the way in which company operate its business.

Regressors Descriptives: Let examine the descriptive statistics of the regressors. This will help us in understanding the basic feature of the gathered data. Table 5.31 gives the summary of the descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
variablene~s Net e-Business Effects	4682	.8109782	.6503275	0	2
factorremo~s Remote Access	8646	-.0018799	.6511094	-.542158	1.241007
factornetw~s Network based Business Applications	7541	-.0032997	.7394214	-.3450294	3.069401
factorittr~g	9183	-.0004517	.7162185	-.875891	.8770972

IT Training					
factoritou~g	5897	-.0040591	.9276764	-1.216278	.8845873
IT Outsourcing					

Table 5.31 Descriptive Statistics Hypothesis 4 – Value Chain and Firm Characteristics

Regression Analysis: The dataset survey used for this regression is e-Business Watch survey 2002. We have used Multinomial Logistic Regression model in Stata for statistical analysis of this hypothesis. The reason for preferring multinomial logit model against ordinal logit model is already explained previously. In this model we are try to measure the extent to which e-Business has changed the way in which firm conduct business. This measure is represented by factor called "Net e-business Effects".

	MTBF Net e-Business Effects		HTBF Net e-Business Effects	
has not ch~d				
Has not changed				
factorremo~s	-0.0435	(0.0810)	-0.386	(0.215)
Remote Access				
factornetw~s	-0.255**	(0.0878)	-0.0600	(0.166)
Network based Business Applications				
factorittr~g	0.195*	(0.0837)	-0.150	(0.223)
IT Training				
factoritou~g	-0.0676	(0.0564)	0.0974	(0.156)
IT Outsourcing				
INTERittra~l	-0.00592	(0.117)	-0.0627	(0.222)
_cons	-0.740***	(0.214)	-0.413	(0.518)
has change~y				
Has Changed Significantly				
factorremo~s	0.117	(0.145)	-0.199	(0.162)
Remote Access				
factornetw~s	-0.0132	(0.126)	0.232	(0.132)
Network based Business Applications				
factorittr~g	-0.183	(0.173)	-0.281	(0.166)
IT Training				
factoritou~g	0.126	(0.112)	-0.0372	(0.114)
IT Outsourcing				
INTERittra~l	0.204	(0.180)	-0.0239	(0.163)
_cons	-2.335***	(0.420)	0.598	(0.390)
N	1978		562	
pseudo R-sq	0.044		0.095	

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 5.32 Hypothesis 4 – Net e-Business Effects Results

Regression Results and Interpretations: In the results given above the base category is "has changed somewhat". As we can see in the results – table 5.32, the regressor Network based Business Applications in the category (has not changed) is negitive (-0.255** highlighted in results), which means the base category (has changed somewhat) is better, so we can reject other categories. This lead to our interpretations of the results:

- *ICT positively contribute to e-business growth of the firm*, this result in acceptance of our hypothesis. For Medium Tech e-Business based Firms (MTBF) the underlying success factor is: Network based Business Applications. For High Tech e-Business based Firms (HTBF) the results are not significant.
- IT Training as complementary is another factor that shows significant results for Medium Tech e-Business based Firms (MTBF) and positive results for category (has not changed). This mean for MTBF's in which e-Business is not taking over the usual business process are more prone to conduct IT training for employees.

As mentioned earlier, the main objective of the regressions is to identify the underlying success factors (intermediaries). From the results we have identify following underlying success factors that give significant results, see figure 5.44.



Figure 5.44 Hypothesis 4 – Net e-Business Effects – Underlying Success Factors

5.5 General Conclusions

Table 5.33 gives an overview of the hypotheses methodology, results of regression and dataset survey used for their testing.

PRODUCTIVITY

ICT positively influence the productivity of the firms.

Results Accepted
Methodology Multinomial logit model
Survey e-Business Watch 2006

ICT positively influence the revenue growth of the firm

Results Accepted
Methodology Multinomial logit model
Survey e-Business Watch 2006

MARKET EXTERNALITIES

Strategic decision making process for ICT in the firms is more influenced by market externalities as compared to firm's issues

Results Rejected
Methodology Probit model with endogenous regressors (Two-stage least squares regression - 2SLS)
Survey e-Business Watch 2005

Increments in IT budget are positively correlated with decision making process on ICT in the firms

Results Accepted
Methodology Probit model with endogenous regressors (Two-stage least squares regression - 2SLS)
Survey e-Business Watch 2005

INNOVATION DYNAMICS

IT based process innovation is positively correlated with general innovations of the firm.

Results Accepted
Methodology Probit model with endogenous regressors (Two-stage least squares regression - 2SLS)
Survey e-Business Watch 2003

Firms characterized by a higher share of employees with a university degree are more likely to conduct innovations

Results Accepted
Methodology Probit model with endogenous regressors (2SLS)
Survey e-Business Watch 2003

Firms characterized by a higher share of employees with certifications are more likely to conduct innovations.

Results Results not Significant – Undecided
Methodology Probit model with endogenous regressors (2SLS)
Survey e-Business Watch 2003

Open sources software usage leads to IT based Innovations

Results Accepted
Methodology Logistic regression
Survey e-Business Watch 2007

ICT applications are positively correlated with IT based Innovations.

Results Accepted
Methodology Logistic regression
Survey e-Business Watch 2007

Increase in firm turnover is an opportunity for firm to perform IT based Innovation

Results Accepted
Methodology Logistic regression
Survey e-Business Watch 2007

IT based Innovation is positively correlated with Process innovation

Results Accepted
Methodology Logistic regression
Survey e-Business Watch 2007

IT based Innovation is positively correlated with Product innovation

Results Accepted
Methodology Logistic regression
Survey e-Business Watch 2007

Technological externalities drive IT based innovations

Results Accepted
Methodology Logistic regression
Survey e-Business Watch 2007

VALUE CHAIN AND FIRM CHARACTERISTICS

Intra-firm processes and structural changes are positively correlated with ICT applications

Results Accepted
Methodology Linear Regression
Survey e-Business Watch 2002

ICT diffusion is a positive influence for the edges of the value chain (customer and supplier relationships)	
Results	Accepted
Methodology	Linear Regression
Survey	e-Business Watch 2002
Numbers of suppliers are positively influenced by ICT based trading	
Results	Rejection
Methodology	Multinomial Logistic Regression
Survey	e-Business Watch 2002
ICT positively contribute to e-business growth of the firm	
Results	Accepted
Methodology	Multinomial Logistic Regression
Survey	e-Business Watch 2002

Table 5.33 Hypotheses Methodology and Results

As mentioned earlier that our objective through regression analyses is to find underlying success factors (intermediaries) that complete the link between intra-firm IT and firm performance. Figure 5.45 give an overview of the underlying success factor and opposing factor for High Tech e-Business Based Firms (HTBF). Figure 5.46 give an overview of the underlying success factor and opposing factors for Medium Tech e-Business Based Firms (MTBF).



Figure 5.45 – High Tech e-Business Based Firms – Underlying Success / Opposing Factors

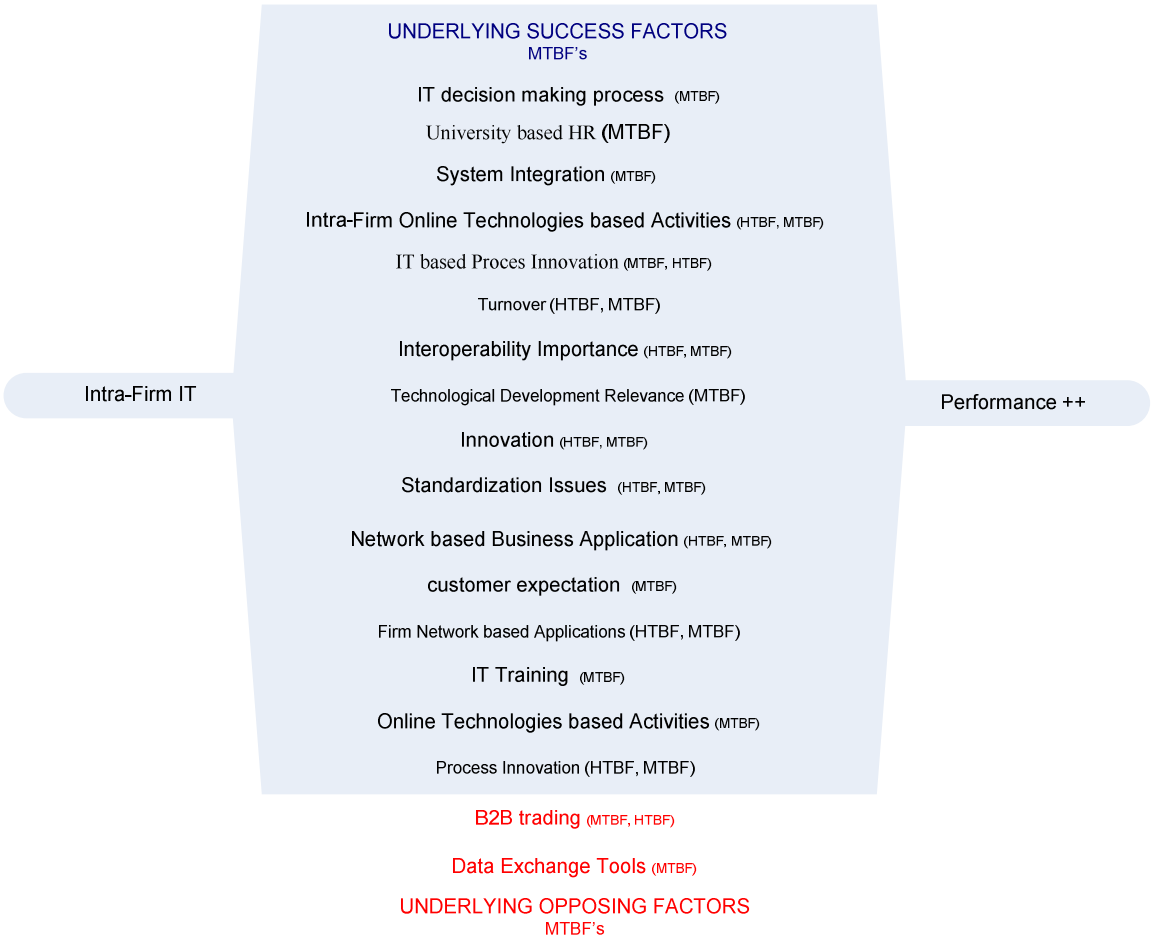


Figure 5.46 – Medium Tech e-Business Based Firms – Underlying Success / Opposing Factors

The results in figure 5.45 and 5.46 shows that High Tech e-Business based Firms (HTBF) and Medium Tech e-Business based Firms (MTBF) are not so much different at all when considering ICT diffusion in both categories.

e-busines contribution	Freq.	Percent	Cum.
none at all	4,348	48.32	48.32
some part	3,680	40.89	89.21
significant part	971	10.79	100.00
Total	8,999	100.00	

Table 5.34 Firms Classes Frequencies – 2002 Dataset

e-business contribution	Freq.	Percent	Cum.
none at all	4,402	43.55	43.55
some part	4,162	41.17	84.72
significant part	1,545	15.28	100.00
Total	10,109	100.00	

Table 5.35 Firms Classes Frequencies – 2003 Dataset

e-business contribution	Freq.	Percent	Cum.
none at all	2,103	40.87	40.87
some part	2,171	42.19	83.05
significant part	872	16.95	100.00
Total	5,146	100.00	

Table 5.36 Firms Classes Frequencies – 2005 Dataset

e-business contribution	Freq.	Percent	Cum.
none at all	4,775	34.59	34.59
some part	6,109	44.26	78.85
significant part	2,920	21.15	100.00
Total	13,804	100.00	

Table 5.37 Firms Classes Frequencies – 2006 Dataset

e-business contribution	Freq.	Percent	Cum.
none	660	31.87	31.87
some	977	47.18	79.04
a good deal	304	14.68	93.72
most	130	6.28	100.00
Total	2,071	100.00	

Table 5.38 Firms Classes Frequencies – 2007 Dataset

Tables 5.34 to 5.38 show the population of the firms for three categories per survey year. From these numbers we can judge that the Low Tech Firms (firms for whom e-busines constitutes a part of the way firms operate today: none at all) is reasonable in the number (almost 35 to 50 % of total firms).

Figure 5.47 shows the industrial dimensions that are influence positively (showed by regression results – table 5.46) by ICT for both High Tech e-Business based Firms (HTBF) and Medium Tech e-Business based Firms (MTBF). This means both HTBF's and MTBF's are progressing in right direction and have sufficient ICT diffusion that

is improving their performance. But then question is: Why European Union is still lagging behind in performance at micro level when compared with other countries?

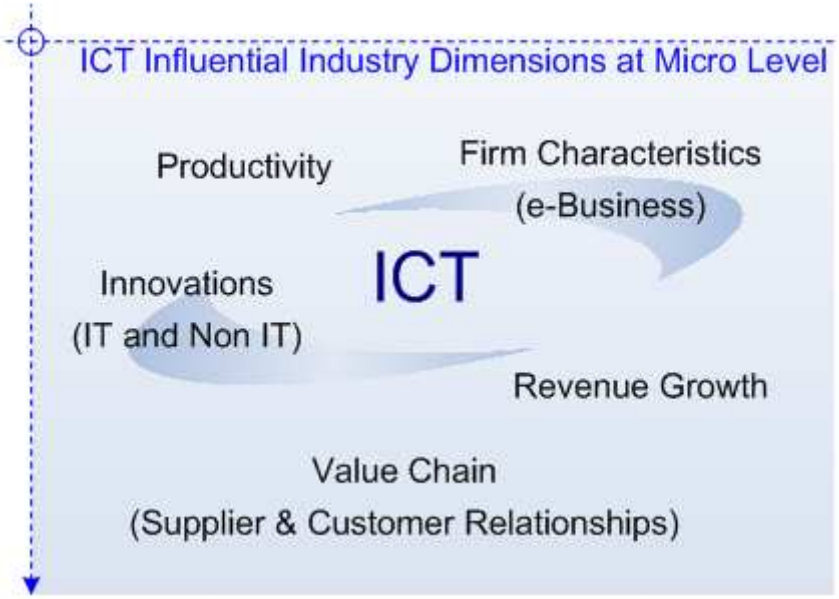


Figure 5.47 ICT Influential Industry Dimensions

The answer is related with population of LTF's, which is (as mentioned before and show by tables 5.34 to 5.38) is almost 35 to 50 % of total firms. This leads to the conclusion that:

***It is not HTBF's or MTBF's that need European Union policies attention but it is LTF's that need to be looked at*.**

6. POLICY ANALYSIS AT MICRO LEVEL

Motivation: Public policies must be devised in spite of uncertainties about the future. When there are different plausible scenarios for the future, it may be impossible to construct any single static policy that will perform well in all of them. The uncertainties that confront planners will be resolved over the course of time by new information. Thus, policies should be adaptive and devised not to be optimal for a best estimate future, but robust across a range of plausible futures. Such policies should combine actions that are time urgent with those that make important commitments to shape the future and those that preserve needed flexibility for the future. This chapter is going to demonstrate the methodology employed for policy analysis framework to identify policies that will help European Union (EU) to improve performance at micro level.

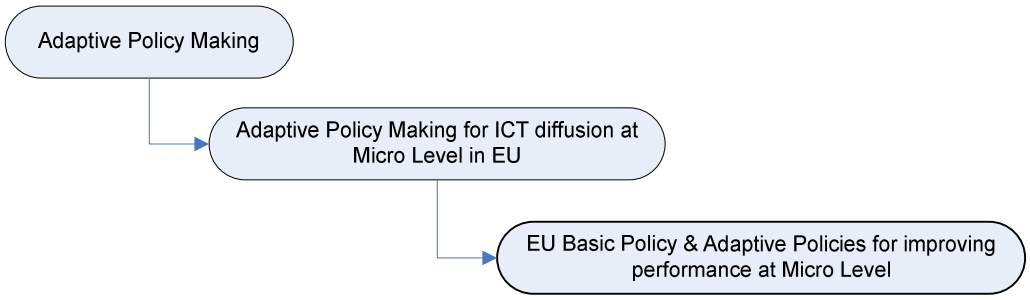


Figure 7. 48 Policy Making Work Flow

Figure 7.48 gives an overview of the work flow that will be followed in this chapter. Initially we will look into adaptive policy making approach. Later we will execute this approach for identification of polices that will be recommend to EU for improving performance at micro level. Adaptive approach is used to identify one basic policy with adaptations that deal with uncertainty. In this way we have more then one policy, they are: “basic policy” and “basic policies with adaptations”.

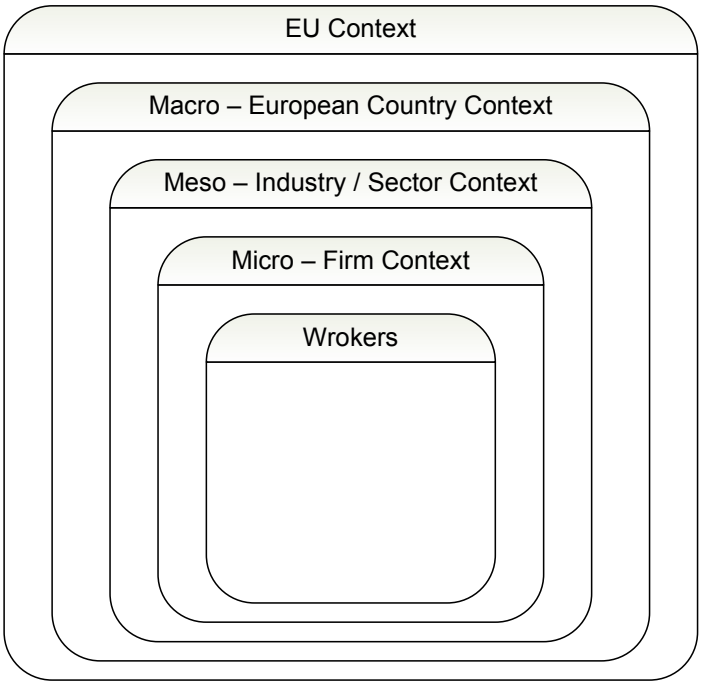


Figure 6.49 Level of Context

Like every system of interest for researchers there is a context of the system, which actually defines the boundaries of their research and limitation of proposed solution. If we follow the same argument and draw the context of our policy analysis research then we will end up in figure 6.49.

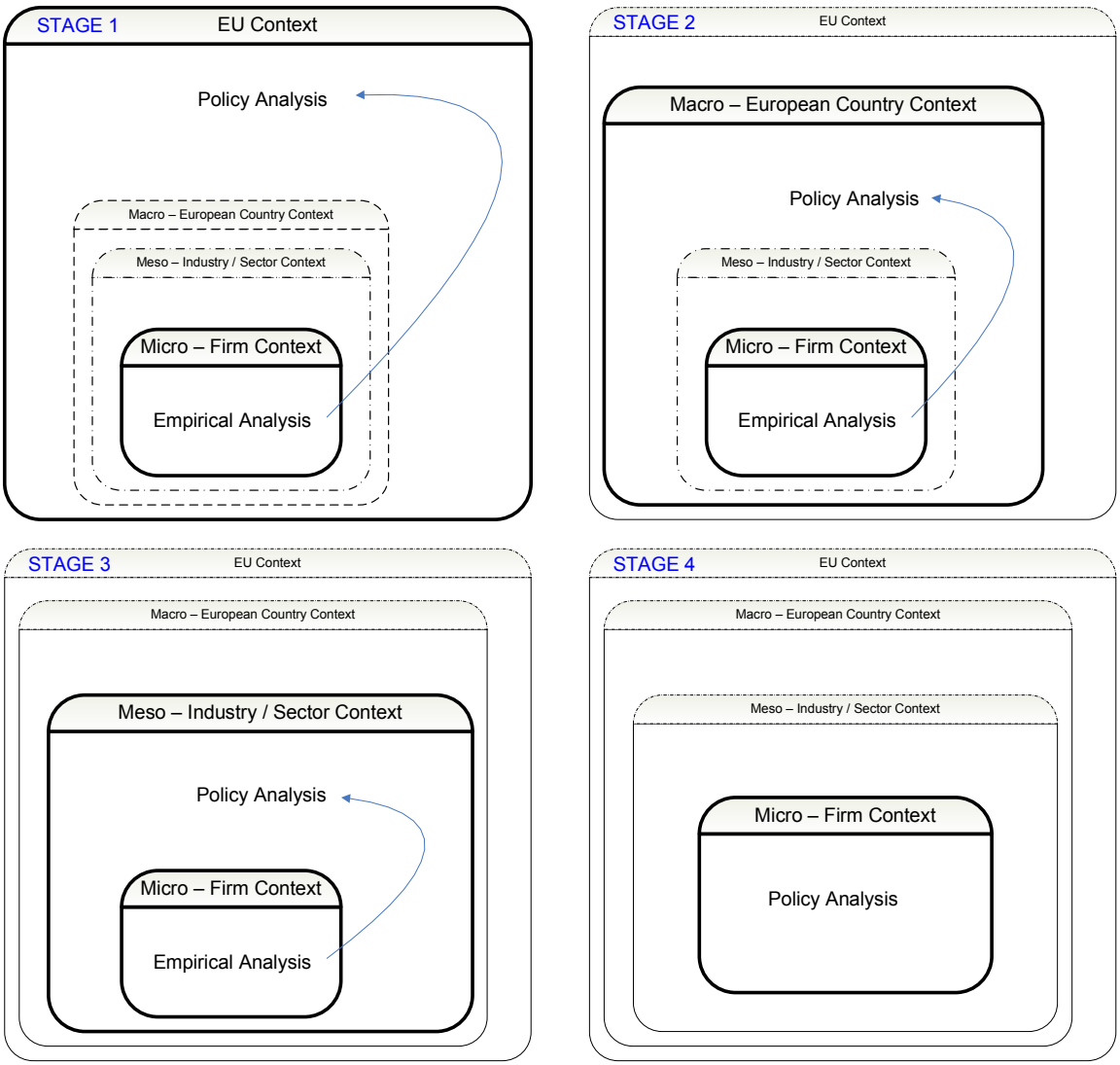


Figure 6.50 Policy Analysis Stages

There are four contexts, EU level, Macro, Meso, and Micro. In our current research we are performing empirical analysis at micro level and policy analysis at EU level. The objective of empirical analysis at micro level is to identify underlying success factors that complete the link between intra-firm IT and performance of the firm; where as the objective of policy analysis phase to identify policies that can be recommended to EU for supporting or enhancing identified underlying success factors for improving performance at micro level.

Even though our objective statement is straightforward and realistic but still it misses a very important link. After recommending the policies to EU, another phase of policy analysis is needed at macro, meso, and micro level. The reason is logical, EU can't implement its policies if countries, industries, and firms are not defining or updating there policies under influence of EU polices. The four stages of policy analysis are pictorially shown in figure 6.50. As mentioned before, scope of this research is to perform empirical analysis and policy analysis of STAGE 1 (see figure 6.48). Rest of the stages for policy analysis will be executed in the future research. Empirical analysis performed in chapter 5 is already contain result for sectors and countries, so there is not need to jump back to empirical analysis. We can continue our hunt for policies from stage 2 in future.

In chapter 3 (section 3.5.2) one of the conclusions we made were: *"The model selection for the phase of policy analysis in our research is highly dependent on the context of our research, which in our case is information technology usage at firm level. The context of information technology at micro level is highly unpredictable (Dewan S. Shi C. Gurbaxani V. 2007) (Schwartz E S. Gorostiza C Z. 2003). Under such unpredictability is it not possible to employee the models like: Rational style, Argumentative style, Client advice style, Participatory style, Process style, and Interactive style. As remedy for the problem of future uncertainty we will employee "Adaptive Policy Making" approach (Walker W E. Rahman A S. Cave J, 2001) in the phase of policy analysis of our research".* Let exam this approach.

6.1 Adaptive Policy Making

Figure 6.51; give pictorial presentation of adaptive policy making framework. The framework is composed of four stages. Let discuss these stages one by one.

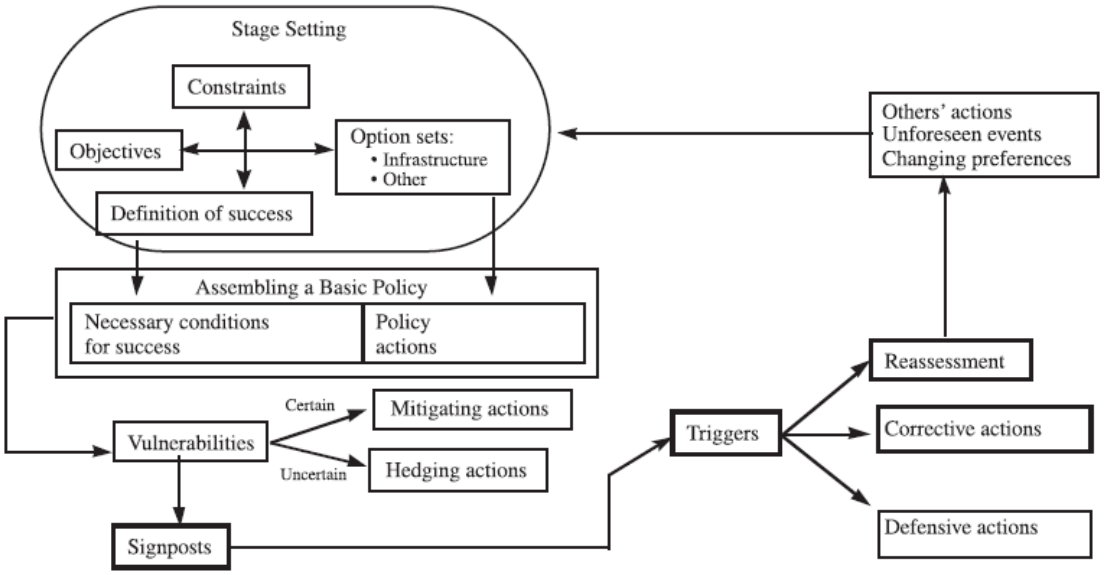


Figure 6.51 Adaptive Policy Making Framework

Step 1 - Setting the stage: In this step, the important objectives, constraints, and available policy options are specified or discussed. Out of this discussion comes a definition of success, which is a specification of the outcomes in terms of the stated objectives and constraints that the participants in the policy-making process would find acceptable.

Some Definitions (*Walker W E. Rahman A S. Cave J, 2001****) "Basic policy*** *is an infrastructure option and one or more additional policy actions, together with a plan for their implementation.* ***Vulnerabilities*** *are potential adverse consequences of the policy associated with key uncertainties regarding the assumptions of the basic policy or ``side effects'' of that policy.* ***Signpost*** *is the information that should be tracked in order to determine whether defensive or corrective actions or a policy reassessment is needed.* ***Triggers*** *are critical values of the signpost variables that lead to implementation of defensive or corrective actions or to a policy reassessment.* ***Mitigating actions*** *are actions taken in advance to reduce the certain adverse effects of a policy.* ***Hedging actions*** *are actions taken in advance to spread or reduce the risk of possible adverse effects of a policy.* ***Defensive actions*** *are actions taken after the*

fact to clarify the policy, preserve its benefits, or meet outside challenges. ***Corrective actions*** *are adjustments to the basic policy in response to specific triggers.* ***Reassessment*** *is a process to be initiated or restarted when the analysis and assumptions critical to the policy's success have clearly lost validity"*

Step 2 - Assembling the basic policy: The next step is assembly of the basic policy. This involves two related activities: (1) specification of a promising policy, and (2) identification of the conditions that must be met in order for it to succeed. These conditions complement the definition of success by providing an advance warning of failure.

Step 3 - Specifying the rest of the policy: In the third step of the adaptive policy-making process, the necessary conditions for success and the details of the basic policy are combined in two sorts of forward-looking analyses, which result in a specification of the remaining pieces of the policy. One analysis is the identification of vulnerabilities ± potential adverse consequences of the basic policy. These vulnerabilities can reduce acceptance of the policy to the point where its success is jeopardized. Associated with certain vulnerabilities are mitigating actions to be put in place immediately. In anticipation of uncertain vulnerabilities hedging actions can be developed to diversify or reduce exposure or cushion the consequences. The important analysis is the translation of the necessary conditions for success into signposts that should be monitored in order to be certain that the underlying analysis remains valid, that implementation is proceeding on schedule and according to expectations, and that necessary policy corrections or additional actions are taken in a timely and effective manner. The identification of signposts does not call for immediate implementation of any direct policy actions. But once signposts are identified, efforts must be initiated to collect and monitor the necessary information. The critical levels and appropriate contingency plans that make up the triggers should also be specified in this step.



Figure 6.52 Contexts and Signposts

Figure 6.52 show the context and its related signposts. At EU level, signposts are stakeholder related because we are focusing at multi-cultural and multi-actor settings (Riet O v d, 2002). At macro level we can use industry dimensions like productivity, revenue growth, innovation – patents etc (see section 4.1). Also at industry level same dimensions can be used. But at micro level the underlying success factor identifies in section 5.5 can be used as signposts.

Step 4 - Implementation phase: Once the above policy is agreed upon, we are in the implementation phase. In this phase, events unfold, signpost information is collected, policy actions may be altered, started, or phased out, etc. The adaptive policy-making process (as distinct from the adaptive policy itself) is suspended until a trigger event is reached. The response to a trigger event depends on the nature of the alarm. Many contingencies will have been foreseen in the original plan, or can be handled within the discretion of those charged with implementing the plan. They will decide whether to defend a policy that is in jeopardy or to pursue the objectives of the policy by other means. As long as the basic policy, objectives, and constraints remain in place, these responses can be characterized as defensive actions or corrective actions.

6.2 Adaptive Policy Making for ICT diffusion at Micro Level in EU

This section will show how adaptive policy making is employed for achieving second objective of our research, which is, identify and recommend policies to EU that enhances the performance of European Enterprise.

6.2.1 Step 1 - Setting the stage

In the conclusions of the chapter 5 (section 5.5) we realize that ICT is almost equally diffused in High Tech e-Business based Firms (HTBF) and Medium Tech e-Business based Firms (MTBF) and they are progressing well under influences of ICT. It is Low Tech Firms (LTF) that need attention of EU policies for improving their performance. Under such argumentation and results, we have formulated the objective of our adaptive policy making for improving performance at micro level in EU as: *Improve and facilitate diffusion of ICT in European Union Low Tech Firms (LTF)*. The constraints that keep EU achieving this objective are:

- Constraints at micro level:
  - *Size of LTF's (small, medium, or large):* For the small LTF's (or may be medium LTF's) it may become difficult to implement ICT solutions, for example financial resources are not sufficient.
  - *Lacking Resources to Grow:* Not every firm able to grow nationally (or even globally) because their resources are not sufficient, for example firms may lacks technical and managerial resources.
  - *Preferring profits over performance:* Mostly private firms are profit oriented and for achieving high profit they apply performance measures. This behavior result in considering performance as second objective and may lead to minimum application of performance measures to met required standards.
  - *Different level of Firms even among LTF's*: Inside LTF's category there are firms with different capabilities and that may results in insufficient contribution from LTF's.

- Constraints at Government level:
  - *Lacking commitment to become long term partner:* In most cases, the government life time is less then the life of ICT project. This uncertainty results in less commitment to ICT based projects and partnerships.

- Constraints at EU level [EU, 2007][12]:
    - *Hesitation to step out side of boarders (cultural difference, language barriers)*: Because of different cultures, government regulations, and language barriers, firms are reluctant to jump in the pool of European market.

Lets exam the policy options which European Union can employee to overcome the constraints and achieve the objective; we have divided the options in two categories:

- Traditional
    - *Tax free ICT equipment:* This is the most common approach used around the globe to improve ICT infrastructure.
    - *Subsidize Technology*: Another common approach used by government is to buy and donate the technology to firms to improve their condition, which will result in better economical standards of the country.

- Innovative, radical
    - *Global Platform:* The collaborations between firms at EU level, which means that EU have to establish a common platform where European enterprises from different origin can come together to share the expertise and knowledge. This pool of firms will also include LTF's. These LTF's will be benefited by expertise, resources, and knowledge of MTBF's and HTBF's. In this way LTF's can improve there ICT diffusion level under shared resources.

Above abstract discussion can be interpreted into to concrete definition of success which is: *Presence of More medium and high tech firms, fewer low tech firms under context of EU.*

[12] video documentary "The Key to Innovation"(May 2007) by DG Enterprise and Industry, EC http://ec.europa.eu/enterprise/innovation/index_en.htm

6.2.2 Step 2 - Assembling the Basic Policy

As mentioned earlier, basic policy is an infrastructure option and one or more additional policy actions, together with a plan for their implementation. We have defined the basic policy for EU as: *Implement Innovation Platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and facilitate the process of collaboration.*

The conditions that must be met in order for basic policy to be successful are:

- *High commitment of the firms:* Even though cultural difference and language barriers are keeping firms away from becoming active member of the platform. EU has to facilitate the firms with environment that is convenient, supportive and motivating.
- *Financial support for implementation:* keeping the platform alive and working efficiently require sufficient financial resources. These resources must be well planned a head of time to cater uncertainties of the future.
- *Basic support from crucial actors (government, firms):* The process of involving multiple stakeholders in policy making process is one of the basic success factors for policies to be accepted by all (Riet O v d, 2002). EU has to keep all stakeholders in contacts and act as liaison and facilitate negotiations.
- *Policy Tracking:* There is a need to follow the implemented policies and track their performance.

6.2.3 Step 3: Specifying the rest of the policy

This phase of Adaptive Policy making requires analysis to identify vulnerabilities. These vulnerabilities can reduce acceptance of the basic policy to the point where its success is jeopardized. Table 6.32 present the Vulnerabilities which are identified at this stage. These vulnerabilities may grow or shrink with time.

Vulnerabilities	Mitigating/Hedging Actions	Possible Signposts/ Triggers/Actions
Certain - Privacy Economics (Hui K L, Png	*Mitigating actions* Make sure to guarantee	

I.P.L. 2005)	the privacy of data by means of EU regulation e.g. European Union adopted Directive 95/46/EC on data protection (Hui K L, Png I.P.L. 2005).	
Uncertain - Commitment of firms. Lose commitment may lead to free rider problem (Sanghavi S. Hajek B. 2005)	*Hedging actions* Intensive use of game theory (Rasmussen. E. (2006) by EU researchers to show incentives to the actors. Such incentive exposure may result in loss of free rider behavior.	
Uncertain - Sufficient funding	*Hedging actions* Enable EU funding for implementation and operation	*Signpost/Trigger* Monitor expenditures; in case of cost overruns, implement defensive (e.g. explain cause to the actors) or corrective (e.g. subsidize the losers) actions
Uncertain - Price of Technology	*Hedging actions* > Start with simple technology > Negotiate with firms on making more advanced technology (GPS) less	*Signpost/Trigger* Monitor price levels of advanced technologies; in case of affordable price level (trigger), implement corrective action (change

	expensive EU enterprises; this is possible by EU firms only.	to more advanced technology)
Certain - Win Win Dream , losers are always there	*Hedging actions* Loser must be dealt strategically and must be compensated. In (Bruijn H. Heuvelhof E. 2008) authors provide range of strategies to compensate losers.	
The following vulnerabilities and mitigating actions are taken from video presentation[13] of Iordana Eleftheriadou (eBSN Coordinator, DG Enterprise and Industry, European Commission), Jan Julianus (Ministry of Economic Affairs, The Netherlands), and Marc Moreau (Ministry of the Economy, Finance and Industry, France)		
Certain – Loss of Investments in ICT system is because of lack of open standards	*Mitigating actions* Use of opens sources standards and software's	
Certain – lack of transparency of ICT products and services and companies lead to difficulties for customer to choose		
Certain – Issues of alignment because of	*Mitigating actions* EU and member states	

[13] video documentary "The Key to Innovation"(May 2007) by DG Enterprise and Industry, EC http://ec.europa.eu/enterprise/innovation/index_en.htm

miscommunication between actors because they don't speak each other language	must facilitate the means to establish trust and safely in digital environment	
Certain – Investment decisions are mostly taken on the basis of instincts and emotions	*Mitigating actions* Awareness about ICT investments for LTF's by tailor made advices given by EU and government of member states	
Certain – Lack of e-Business skills *Note: e-skills are related to employees of firm but e-business skills are needed for management of the firms*	*Mitigating actions* EU and member states must establish means to train the cooperate leaders to develop or improve their e-business skills	

Table 6.39 Identifying and Handling Vulnerabilities

In adaptive policy making the initial vulnerabilities are identified on the basis of literature study and initial perceptions of stakeholders (can be gathered through interviews). In our research we have considered literature study and presentation (video) of DG enterprise and industry[14] to formulate the initial vulnerabilities. At this stage interviews can play very important role to identify more vulnerabilities, which lead to reliable and robust adaptive policy. Because of the time and resource constraint, it is not possible to conduct interviews at this stage of research but in future we have plan for such actions.

[14] Proceedings from the Sectoral eBusiness Watch Conference 2008 "Understanding the eEconomy", 19-20 May in Brussels

6.2.4 Step 4: Implementation

The adaptive policymaking process is now suspended until a trigger event is reached.

6.3 Adaptive Policies for improving performance at Micro Level

The research question that will be answered in this section is: Q8.2 Which are the policy implications of this study?

The core basic policy recommended to European Union for improving performance at micro level is: "Implement platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and facilitate the process of collaboration". As mentioned earlier in section 3.6.2, the context of information technology at micro level is highly unpredictable (Dewan S. Shi C. Gurbaxani V. 2007) (Schwartz E S. Gorostiza C Z. 2003). To cope with such uncertainty the basic policy need adaptations. Following are the adaptive policies which are recommended to European Union to handle vulnerabilities that lead to uncertainty while improving performance at micro level.

- Vulnerability: *Certain* - Privacy Economics (Hui K L, Png I.P.L. 2005)
    - Adaptive Policy: Implement platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge under the guarantee of providing full protection for privacy data of the firms through EU regulation and facilitate the process of collaboration

- Vulnerability: *Uncertain* - Commitment of firms. Lose commitment may lead to free rider problem (Sanghavi S. Hajek B. 2005)
    - Adaptive Policy: Implement incentive based platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and facilitate the process of collaboration

- Vulnerability: *Uncertain* - Sufficient funding

- Adaptive Policy: Implement and subsidize platforms with ample resources that can help in creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and facilitate the process of collaboration

- Vulnerability: *Uncertain* - Price of Technology
  - Adaptive Policy: Implement platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and update underlying technological base of platforms by monitoring price levels of advanced technologies; in case of affordable price level change it to more advanced technology.

- Vulnerability: *Certain* - Win Win Dream , losers are always there
  - Adaptive Policy: Implement platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and facilitate the process of collaboration by compensating the losers strategically (Bruijn H. Heuvelhof E. 2008).

- Vulnerability: *Certain* – Loss of Investments in ICT system is because of lack of open standards
  - Adaptive Policy: Implement platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and facilitate the process of technical collaboration using opens sources standards and software.

- Vulnerability: *Certain* – Issues of alignment because of miscommunication between actors because they do not speak each other language
  - Adaptive Policy: Implement platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and facilitate the process of collaboration with the means to establish trust and safely in digital environment

- Vulnerability: *Certain* – Investment decisions are mostly taken on the basis of instincts and emotions
    - Adaptive Policy: Implement platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and educate the firms by creating awareness about ICT investments through tailor made advices given by EU and government of member states

- Vulnerability: *Certain* – Lack of e-Business skills
    - Adaptive Policy: Implement platforms for creating a pool of European enterprises from all across Europe to share their expertise, resources and knowledge with LTF's and establish means to train the cooperate leaders of the firms to develop or improve their e-business skills

7. CONCLUSIONS & RECOMMENDATION

Motivation: Marking the end of this project, this last chapter summarizes and adds together the findings and contributions of this thesis. It opens with the conclusion from empirical research and later presents the conclusion from policy analysis. The limitations of the study are discussed and finally, it concludes with a set of recommendations for future research.

The research questions that will be answered in the following sections are: Q8 Which are the implications and conclusions that can be made based on the results obtained in the research? Q8.3 Which are the limitations of this study? Q8.4 Which are the recommendations for future research in the field?

7.1 Empirical Analysis Conclusions

As mentioned earlier there are two classes of firms that have been included in the empirical analysis. They are High Tech e-Business based Firms (HTBF) and Medium Tech e-Business based Firms (MTBF). In chapter 5, empirical analysis results are obtained for both classes depending upon significance and insignificance of the results. On the basis of these results interpretations for each class have been presented already in chapter 5. For overall conclusions made for European enterprises, we have to consider the results which show significance for both classes otherwise these conclusions will be biased. Following are the overall conclusions:

From the empirical results for industry dimension "Productivity", we concluded that: Non-IT based innovations are particularly important for European firms to increase their performance i.e. productivity and revenue growth. Such innovations may turn out to be more efficient if inter-firm collaborations are facilitated under *integrated ICT systems* of the firms of different capabilities (e.g. HTBF, MTBF, and LTF). But such facilitation may suffer a flaw. The collaboration will result in knowledge spillovers and knowledge spillover arises from public good character of the knowledge [Beer. C. v. 2007][15], which leads to fewer incentives for being

[15] Cees van Beer, Economics of Innovation presentations, 2007, Technical University of Delft

innovative. Remedy for such issue are patents. But question is how patents can be defined for innovation that results from collaboration?

From the empirical results for industry dimension "Market Externalities", we concluded that: Non IT based Innovations are particularly important factors for European firms to increase their performance i.e. productivity and revenue growth. Such innovations may turn out to be more efficient if inter-firm collaborations are executed under ICT system integrated among the firms of different capabilities because of knowledge spillovers see figure 5.53.

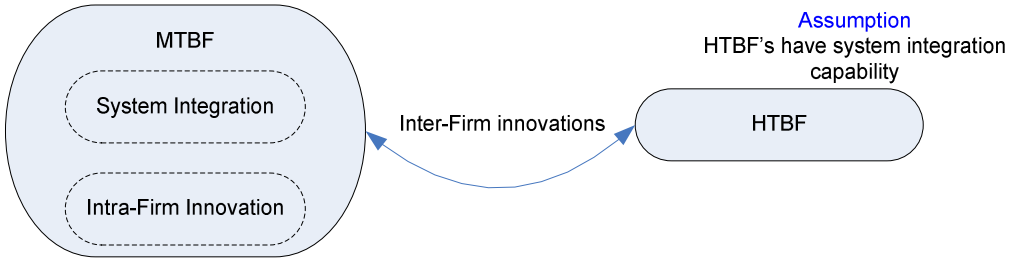


Figure 5.53 Inter-Firm Innovations and ICT

Even though our industry dimension is market externalities but our conclusion refers to drivers (forces which exist inside the firms and they can be influenced) to improve performance of the firm. Externalities can not be influenced; they are exogenous factors and are highly unpredictable. Such attributes lead to biased conclusions (if made about externalities) for improving performance of the firms.

From the empirical results for industry dimension "Market Externalities", we concluded that: Investments in ICT system gets lost because of lack of open standards (Jan Julianus - Ministry of Economic Affairs, The Netherlands)[16]. Solving standardization issues will proceed in improving technical performance of the firm and standardized functioning with external links (supply and demand side) which will lower the probability for IT based failures and thus eventually improving performance of the firm.

[16] Proceedings from the Sectoral eBusiness Watch Conference 2008 "Understanding the eEconomy", 19-20 May in Brussels

From the empirical results for industry dimension "Innovation Dynamics", we concluded that: ICT enabled innovation is dependent on high skill labour. Thus, in order to increase labour demand, the quality of labour should be improved. Therefore, EU and national government policy should focus on increasing education levels, promoting research and development ventures to improve human capital and create favorable conditions for ICT investment, which in turn would increase innovative potential.

While innovation typically adds value, innovation may also have a negative or destructive effect as new developments clear away or change old organizational forms and practices. Organizations that do not innovate effectively may be destroyed by those that do. Hence innovation typically involves risk. A key challenge in innovation is maintaining a balance between process and product innovations where process innovations tend to involve a business model which may develop shareholder satisfaction through improved efficiencies while product innovations develop customer support however at the risk of costly R&D that can erode shareholder return. From the empirical results for industry dimension "Innovation Dynamics", we concluded that: *IT based process innovations and non-IT based process innovations* are playing positive role in improving performance of the firms and the reason for such improvement is improved business model which may develop shareholder satisfaction.

If an organization develops its IT capability over time, uses that capability in all of its organizational layers, and gets support from its management, it can benefit from the roles played by IT [Zand F. 2007][16]. Such roles have three levels. Level one include following roles: Information and Communication. Level two include following roles: Automation and Coordination. Level three include following roles: Integration and transformation. Level three includes combination, assimilation and real-time (synchronous) organization of different processes and domains into new processes and domains and result in innovation and changes in status quo. Real time examples include: ERP, CRM, and SCM systems, integrating procurement, production, and

[16] Fardad Zand, IT does it really matter? Economics of Innovation presentations, 2007, Technical University of Delft

sales functions. From the empirical results for industry dimension "Innovation Dynamics", we concluded that: Network based business application, which includes ERP, CRM, and SCM play positive role in improving performance of the firm or we can say that *Inter-Firm specialized IT based business applications* are proved to be beneficial for improving business performance.

Note: As mentioned earlier the above stated conclusions stand for all type of firms. In order to dig deeper and see which kind of ICT factors play supportive or opposing role for improving firm performance according to firms classes (HTBF and MTBF) we have to jump back to section 5.5 (General Conclusions).

7.2 Policy Analysis Conclusion

IT as a *Context Specific General Purpose Instrument* is influencing the performance of European enterprises in a positive way. It influences on the firm's performance varies according to firm's ability. Such variation may result in a negative influence to the European economy. For such circumstances European Union initiatives and policies can play a vital role to the realization of effective ICT usage at the micro level.

The EU initiative of establishing a global platform for collaboration among EU enterprises will facilitate the development and usage of Europe's ICT potential by the creation of an environment in which laggards can catch up and grow. Eventually this will result in improvement in digital facet of the European economy. The EU basic adaptive policies resulted from this research can facilitate and support the desired initiative and preserve needed flexibility for the future.

7.2 Limitations of the Research

The research limitations that this study dealt with, deliberately imposed by decisions or not, are of various qualities and may have had different impacts in the overall research and particularly in its results. An explanation of these limitations, their sources and their implications is provided here.

7.2.1 Scope limitations

The ultimate goal of the research is to improve performance of European enterprise. In current research we have targeted EU for policy recommendations. Where as the macro (EU countries), meso (European sectors), and (European firms) micro level are still needed to be addressed to achieve the ultimate goal.

7.2.2 Data limitations

First, the data used in this study is cross-sectional in nature, and this prevents the modeling of lagged effects. Second, consistent with earlier studies, an assumption of linearity has also been made. It is recommended that non-linear models be explored in future IT value research.

7.2.3 Measurement limitations

First, a considerable portion of the variables used were based on the opinions of professionals inside the firms. This may strongly compromise the research results since firms, in their opinion about internal aspects, generally do not have the ability or capability to compare themselves to other firms. As such, it may be that the data used was not truly representative of the effective reality. Second, vulnerabilities for adaptive policy making were identified on the basis of literature and video presentations, where as interviews are most beneficial and effective way to identify the realistic vulnerabilities. Unfortunately because of limited time and resources this exercise of interviews was not possible.

7.2.4 Methodology limitations

First, during model specification checks (test for omitted variables by *ovtest*), some times, unfortunately, we have data limitation problem i.e. either desired variable is not available in dataset or its addition reduces the number of observations to undesirable amount. As a result same old model with specification errors is used for empirical analysis. Second, adaptive policy making is an incremental approach. In order to evaluate the increments toward long term objective, we need a performance indicator that reflect the long term objective and evaluate the increments for that objective. Unfortunately, incremental approaches by their methodology fail to provide the indicators that reflect long term objectives. As a

result Adaptive policy making may suffer deviations and unable to reach the long term objective.

7.3 Future Research

First, as mentioned earlier still we have to execute the process of policy analysis at macro (EU countries), meso (European sectors), and (European firms) micro level to achieve the ultimate goal of improving performance of European enterprises. This process requires intensive time and resources. Second, we will look deeper into LTF's categorization. According to descriptive statistics for LTF's, small and medium firms – SME's (0 to 250 employees) constitute large portion of LTF's in EU, see figure 7.54 to 7.58. This means that LTF-SME's can play vital role in improving digital facet of the European economy. We will pay special attention to LTF-SME's in our future research.

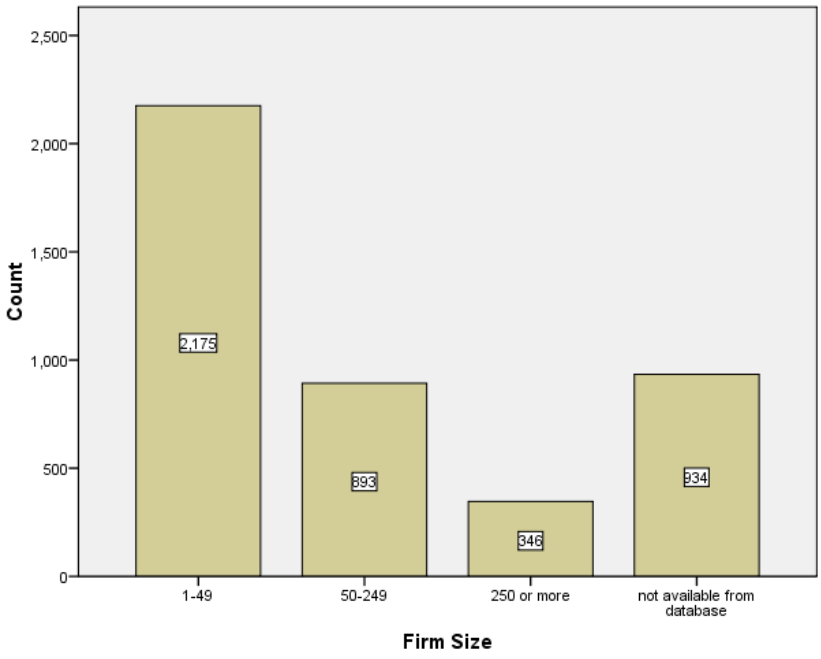


Figure 7.54 2002 LTF's and their Size

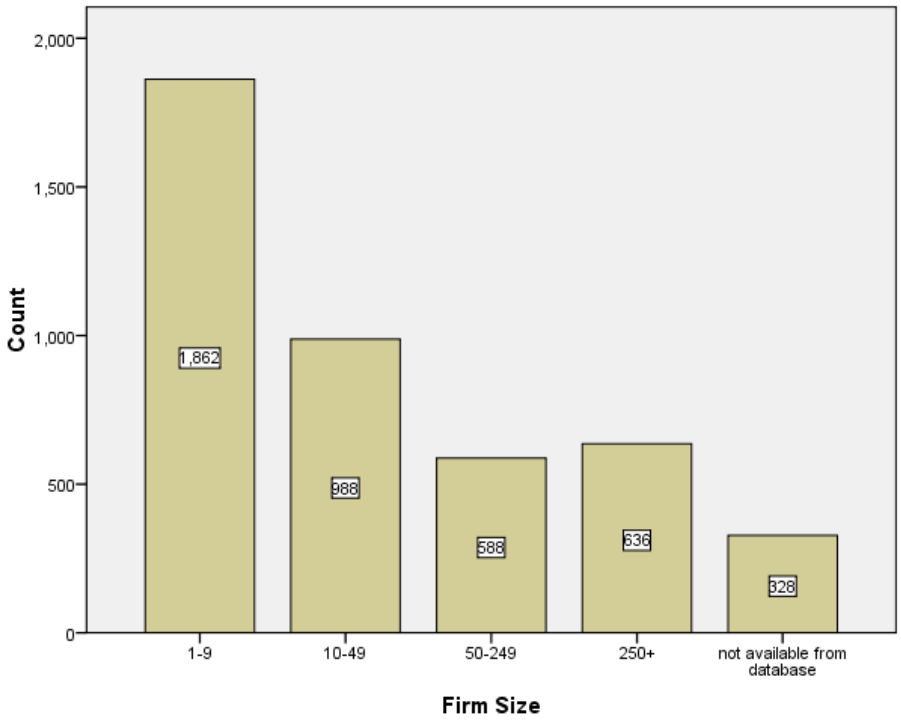


Figure 7.55 2003 LTF's and their Size

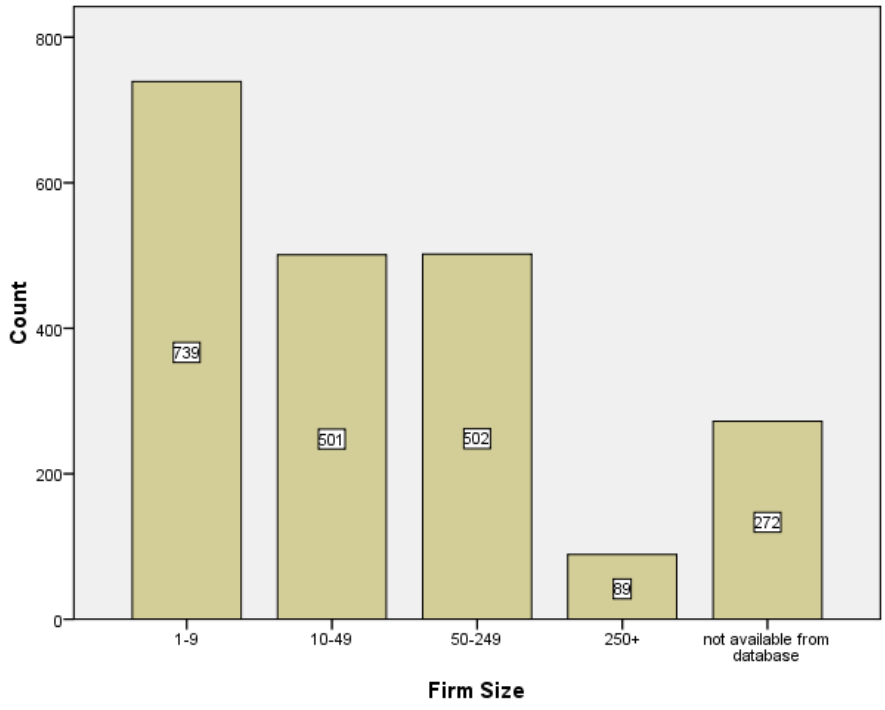


Figure 7.56 2005 LTF's and their Size

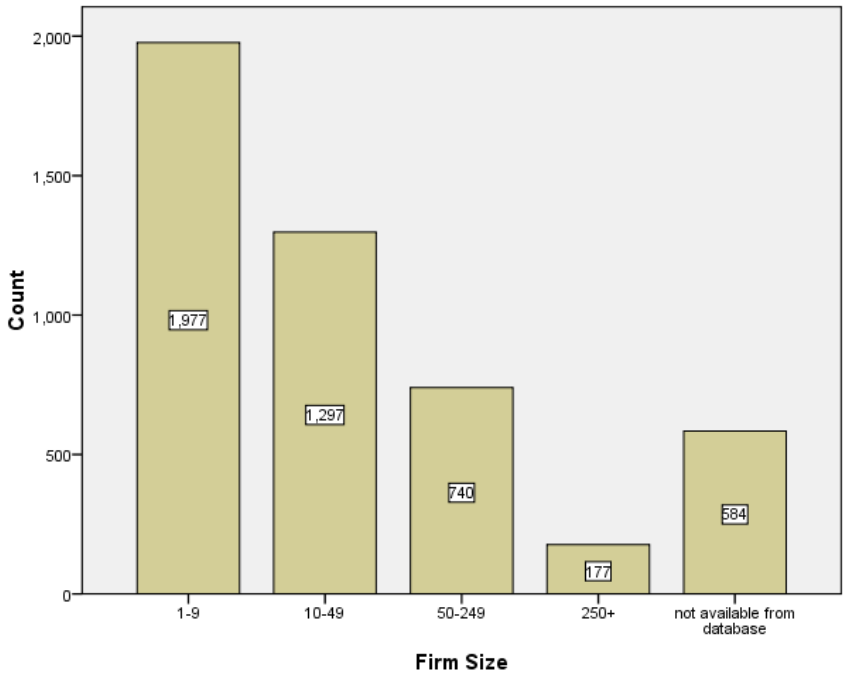


Figure 7.57 2006 LTF's and their Size

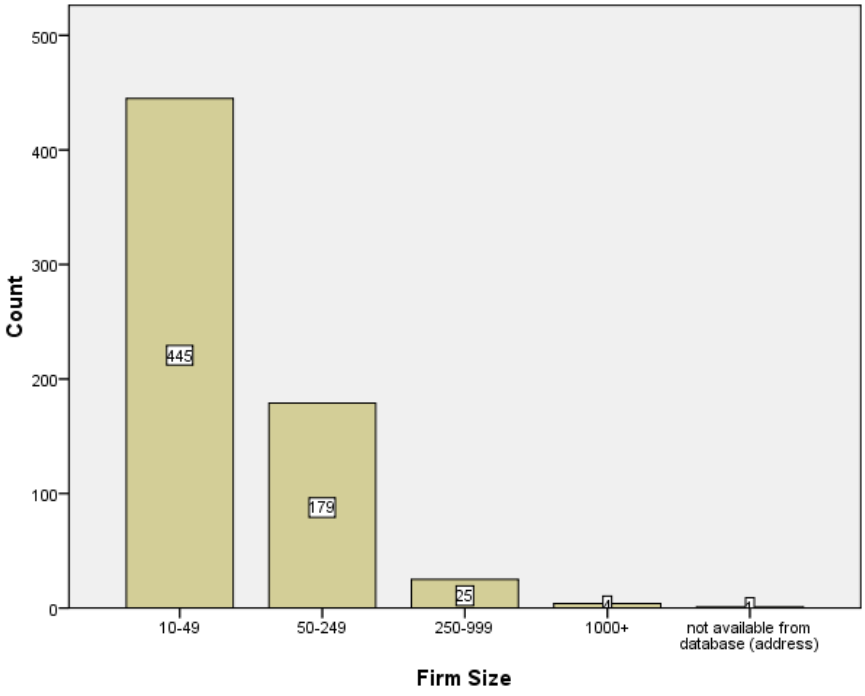


Figure 7.58 2007 LTF's and their Size

7. 4 Recommendations

We suggest e-Business watch survey team to add modules of policy analysis in their surveys. This module must reflect the current policy measures taken by firm, sectors or even governments and their process. In this way, the policy analyst working on e-business watch data don't have to interview official in EU member states and they can start their research from the point where current policies are progressing otherwise with out the knowledge of current policies progress they may reinvent the wheel.

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