Cultivating the 'Generic Solution'

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The Emergence of a Chinese Product Data Management (PDM) Software Package

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Declaration

I hereby declare that this thesis has been composed by myself, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institutes of higher learning, except where due acknowledgment has been made in the text.

Mei Wang

Abstract

This is a study of the design and development of an Organisational Software Package (OSP). It particularly focuses on the ambitions and supplier strategy of building a 'generic software solution' (i.e., a software system that in principle can be used by everyone). The study is located in the distinctive context provided by China, with its particular history and in a period of rapid economic reform. The starting point of this research is the apparent empirical and theoretical gap in the social study of Organisational Software Packages, in which the construction of standard solutions and the supply side of the technology's story have been largely overlooked.

Moving beyond conventional information system design perspectives, this thesis draws upon concepts developed within the Social Shaping of Technology (SST) perspective, adopting an interdisciplinary approach to analyse the creation and evolution of OSPs, which enables us to address both the dynamism and continuity of these developments. In order to avoid the shortcomings of snapshot studies, we applied the concepts of 'social learning' and in particular the 'biography' of software package to examine the evolution of the OSP supply as the supplier developed its product and market strategy over a number of product cycles. Lastly, we applied Rip's (Rip and Kemp 1998) technological transitional model to explore the influence of both the broad socio-economic context and institutional arrangements on the OSPs' development, as well as the contribution of these and related changes to changing the setting of technology. Methodologically, an extremely detailed longitudinal and contextual analysis has been undertaken through a qualitative historical case study of the evolution of a Chinese software package from 1998- 2005 in the context of China, triangulating different methods: interviewing, document analysis and participant observation.

The empirical findings of this study *firstly* show that achieving the 'generic' is not an impossible goal but is rather an evolutionary process which is filled with struggles and tensions. OSP suppliers are forced to maintain a strategic balance between a range of contextual factors with technical, financial and social dimensions. *Secondly*, and perhaps the key contribution of this study, is the complex multi-locus and multi-layered account it offers of the OSP innovation process, according to which the supplier learns about the representation of users and use in both 'local' and 'community design' spaces with different approaches and foci through interaction with user organisations and other social players. The findings show that OSP suppliers are required to readjust their relationships with user organisations and establish cycles that move between seeking to achieve the economic imperative through standardisation and seeking to accommodate local user requirements. *Thirdly,* while this empirical study confirms some observations that have been made about packaged OSP production in western countries, it also reveals some specifically Chinese characters. These particular features of the development process which were identified in the Chinese PDM development were framed (using the terminology of Rip's transitional model) by the unstable landscape and socio-technical regimes. *Finally*, this case study also throws light on the applicability of SST in developing countries and on the policy and practice of China's future technology development.

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Abbreviations

3G	Third generation
ANT	Actor network theory
BPR	Business process reengineering
CAPM	Computer aided production management
CAD	Computer aided design
CCCP	Central Committee of the Chinese Communist Party
CCD	Concurrent design
CIM	Computer-integrated manufacture
CInM	Construction inspection management system
CIIIC	Committee of Construction Industry Informatisation Implementation
CM	Construction management
CMO	Chief marketing officer
CPPC	A power planning and consulting firm's name
CPBM	City planning and building management
CTO	Chief technology officer
DCST	Department of Construction Science and Technology
DPMS	Design process management system
DSNC	Department of Standards and Norms for the construction ministry
ERP	Enterprise resources planning
EPCM	Engineering, procurement and construction management
EVD	Enhanced versatile disc
GEPDO	An electrical power design organisation's name
GDP	Gross domestic production
GIS	Geographical information system
IDRC	International development research centre
ICT	Information communication technology
IT	Information technology
LRM	Land resource management
LTS	Large socio-technical system
MISSS	Management information system software standard
MIS	Management information system

MOC	Ministry of Construction
OA	Office automation
OECD	Organisation for Economic Co-operation and Development
OSP	Organisational software package
PDM	Product data management
PPS	Production/design planning system
QCS	Quality control system
QDBD	A company name
R&D	Research and development
RAD	Rapid application development
SAC	Standardisation Association of China
SCCMC	Standardisation Committee of Construction Materials and Components
SCDI	Shanghai Construction Design Institution
SCOT	Social construction of technology
SLIM	Social learning in multimedia
SMEs	Small or medium enterprises
SOE	State-owned enterprises
SSK	Sociology of scientific knowledge
SSD	Software standard department
SST	Social shaping of technology
S&T	Science and technology
TDSCDMA	Time division synchronous code division multiple access
TT	Technology transition
v1	Version one
v2	Version two
v3	Version three
WTO	World Trade Organisation
WRM	Water resource management
XMIAD	An architectural design company's name

To my parents:
Guanxiong Wang
Yingjun Sun

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Chapter one

Building the 'Generic Solution' in Practice

1.1 FOCUS AND SCOPE

Over the last two decades, organisational software packages (OSPs), as largely standardised complex information systems, have increasingly dominated the global business application software market (Huang and Palvia 2001; van Everdingen et al. 2000). The rapid adaptation of this technology has raised a number of design and development issues. The one which has been receiving the most attention from both industry and academia is the dilemma that arises when the standard solution meets the non-standard user, such that a misfit between the generic solutions and the unique local user context occurs (Tierney and Williams 1990). Inside the package, the dilemma, or the 'package paradox', centers upon whether to localise the model to fit into the specific local practice or to maintain it as a generic product. From the perspective of OSP suppliers, the challenge involves dealing with the tension between, on the one hand, the need to build up the product's generic features, and on the other hand, the need to match its technological capabilities to the local user requirements (Tierney and Williams 1990) within time and financial pressures (Carme' and Sawyer 1998; Sawyer 2000).

How did OSP suppliers manage this tension and make the generic system work in different local contexts in practice? Where do the generic features originate? What is the related OSP suppliers' innovation process? How do we understand the deeper relationship between the OSP supplier and local user organisations, as well as its influence on the development of the generic features? These questions are the main concern of this study. This thesis argues that there have been many other studies of OSP development, but these studies have been of either a technological or a generalised nature, such that related issues are only partially addressed. For instance, the relevant technical literature (Jacobson et al. 1997; Reifer 1997) views OSP development as an issue of abstraction such that, by using a range of structured techniques, standard practices can be abstracted and embedded into a single package which is ready to be reused in a range of different user organisations. This perspective is undergirded by the technical belief that 'one size fits all'. Some management studies indicate that OSP suppliers are filled with talent and persons with high intellectual capacities, and therefore the generic package can simply be built upon the basis of their assumptions and experiences (Davenport 1998; O'leary 2000). There is also a small amount of research (Carme' and Sawyer 1998; Salzman and Rosenthal 1994; Sawyer 2000) attempting to identify the features of OSP development, which are contrasted to traditional customised software development. While providing insights into the characteristics of OSP development, for methodological, practical and theoretical reasons, this thesis argues that none of these approaches has systematically attempted to go beyond the conventional information system's life cycle in order to characterise the construction of the generic solution by focusing on the suppliers' strategy, that is, a supplier's approach to managing a vast number of diverse user organisations across a number of product lifecycles.

The primary objective of this study is to provide a detailed account of the OSP building process, in practice. In particular, attention is given to the supplier's strategy for cultivating the 'generic solution'. Drawing upon the social shaping of technology (SST) perspective (MacKenzie and Wajcman 1985; Williams and Edge 1996), our research is carried out through a longitudinal and contextual analysis of a Chinese product data management (PDM) software package. The study is located in the distinctive context of China, with its particular history and its current circumstances of rapid economic reform. The study takes into account both the development context and interactions between OSP suppliers and other social groups, and therefore we also wish to explore the implications for the applicability of SST in developing countries and China's future technology development policies and practices.

This introductory chapter forms the basis for, and explains the rationale and motivation behind, this study. In the next section, the rationale motivating this adoption of the perspective of SST and an outline of its intellectual traditions are presented. This outline is further elaborated in chapter two, in which the primary theoretical concepts and empirical research involved in this study are to be found. Then the chapter continues to reveal the rationale behind the selection of China as the context in which to conduct the research. This discussion is followed by a brief explication of the Chinese PDM innovation process and the research questions. Finally, the chapter ends by introducing the organisation of the thesis as a whole.

1.2 THEORETICAL RESOURCES — AN INTERDISCIPLINARY APPROACH

Literature from science and technology studies, and in particular from the social shaping of technology perspective, throws light on a general understanding of the complexity of OSPs' development. It is only very recently that studies from SST have begun to investigate and analyse OSP development from a broader socio-economic perspective, which is supported by detailed empirical data (Brady et al. 1992; Clausen and Williams 1997; Koch 2003, 2004; Pollock and Cornford 2004; Pollock et al. 2007; Williams 1994, 1997). This study situates itself within this body of work and seeks to understand the process of developing OSPs from a similar theoretical angle.

The SST[1] perspective, which informs this study, emerged through a critique of traditional 'deterministic' approaches, which assume that technology change has its own logic and trajectory, a perspective which limited its investigation to the impacts of this change. As an emerging field, SST has been increasingly used as a powerful conceptual and analytical guide to the study of technology in general, including information communication technology (ICT) (Sørensen and Williams 2002). Over two decades, the social shaping perspective has evolved into a broad theoretical 'church' which includes a loosely defined tradition within the research community,

[1] In response to technological determinism, the social shaping perspective on technology grew out of a critical assessment which was included in the research project, 'Social Shaping of Technology', by Donald Mackenzie and Judy Wajcman in the 1980s, and which was mainly entertained by economists and sociologists. Later on, it was further enhanced by several other researchers in this field, such as Williams, Edge, Russell etc. in the 1980s and 1990s.

with members from several academic disciplines (such as industrial sociology, evolutionary economics, sociology of scientific knowledge, history of technology, innovation studies), and shares concerns about the development of technoscience and its relationship with society (Sørensen and Williams 2002).

From a social shaping perspective, a particular technology is conceptualised as the product of social, political and cultural negotiations between a supplier, users, policymakers and other social groups. SST highlights that every stage in the design and implementation of new technologies involves a set of *choices* between different technical options (MacKenzie and Wajcman 1985). The selections of choices are influenced by a range of broader social and economic factors, alongside technical concerns—thus influencing the content of technologies and related social implications. From an analytical perspective, SST seeks to explore technological change by assessing the decisions made throughout the course of a technology's development, and by taking into account the interplay of social groups, the associated process which eventually achieved an agreement between such groups and the broader socio-economic context.

This perspective is helpful for our study since the OSP suppliers' development strategies take place within a socio-economic context and involve the agency of other social groups, such as user organisations. Although this thesis focuses on design and development, it is essential to consider the nature of such technology and design as a complex social process which is embedded within a range of choices and is influenced by many social groups through negotiation. In this sense, design and development are not carried out in a static manner and isolated from user organisations and society in general. Rather, together they form part of a distributive process which is characterised by dynamism, complexity and contingency and is influenced by its social, economic and political contexts. As a result, supplier decisions on the adoption of a particular development strategy are not just technical choices, but they are rather influenced by a range of other contextual factors.

1.3 CHINA: SHIFTS FROM LOCAL TO GLOBAL

It is necessary to point out the national location of the study, since according to SST the broad social and economic contexts also shape the characteristics and meanings of a technology. The national location of this study is China, a developing country engaged in a process of rapid economic transition and modernisation. There are several reasons and considerations behind this choice.

Firstly, unlike other industries, the software industry represents a unique example of a truly global industry, growing rapidly in both economically advanced and developing countries. From a SST perspective, it is exciting to explore technology development in the context of China, since its socio-economic context is unique, surrounded as it is by extreme uncertainty and contingency. Recent government policy demonstrated China's determination to become a world leader in software development, by utilising China's own intellectual property rights. Hence the study of Chinese OSPs may capture an emerging moment at which a local technology evolves into a global, universal solution. Meanwhile, there is a lack of SST-oriented empirical field research which has been conducted in China, or in any developing countries in general. This study has the potential, therefore, to broaden a SST-based understanding of technology development by testing its concepts and tools in a unique context.

*Secondly***,** there is a need to investigate China's current innovation capabilities**.** On the one hand, as a result of more than two decades of economic reform of a centrally-planned socialist economy, the positive changes have indeed been astonishing. As the largest developing country, China is on its way to evolving into a developed economy, combining advanced scientific and technological development at an unpredictable pace. On the other hand, recent critiques made by SST scholars regarding China's current science and technology policies identify some potential problems for China's future technology development (Shen and Williams 2005). China's 'utilitarian' view of science and technology is perceived to be its fundamental weakness in regards to technology development. Those intellectual findings about China's current science and technology fields explicitly outline the dilemma of China's future economic development. China's recent progress in economic development is undeniable, but major problems remain in both the economic and political realms, as well as social areas (Shen and Williams 2005; Suttmeier 1997). Taking a critical view, this research provides an important opportunity to investigate China's current innovation capability through the study of a particular Chinese domestic software package's development. Hence the results from this study can illuminate valuable implications for China's future substantial technological development strategies.

1.4 OUTLINE OF THE CHINESE PDM DEVELOPMENT PROCESS

The technology examined here, a Chinese PDM software package, is a standard organisational information system software solution technology. It is designed for Chinese construction engineering enterprises to manage the data of each design and its relevant design process, involving data of both current and historical statuses. It is also designed to provide work breakdown structures, and to allow coordination between products, related processes, resource rescheduling and project tracking. This software package includes three main application functionalities; a production/design planning system (PPS), a design process management system (DPMS), a quality control system (QCS), and two client-side programs (data management and process control) with a system management (system administration) function.

This package was conceived by a Chinese domestic software supplier, LZ, during the years 1998-2000. LZ is a software supplier which specialises in the development of construction industry applications and tools. The company was founded in 1995 by seven initial founders and without any financial support from either government or other resources. During the writing-up of this thesis, the firm has grown to a relatively large software enterprise with 400 employees. The LZ PDM is one of their early products that brought the company back from both financial and business crises, and it is the backbone of later technical systems. The package in its development went through a number of distinct and critical phases, which can briefly be characterised as follows:

- Birth: In 2000, they bought a local system from a construction design organisation with the aim of developing a standardised solution.
- Early development: The first version was put into use in 2001. It took LZ almost another three years to build up a relatively mature version of this Chinese PDM package. During this period, LZ started to engage with the national software standard development and successfully drafted the standard with the collaboration of their product development.
- Growth: Until early 2003, the generic features of the LZ PDM gradually matured. By building up user communities and organising related user conferences, LZ managed the diverse local requirements in a collective environment in a systematic way.
- Future: From late 2004, LZ shifted their focus to the development of the future PDM and considered how to extend the life of the PDM. A range of new products were developed and constructed, both in the construction sector and public sector. In order to manage its increasing complexity, LZ also set up a sub–company called Leading.

1.5 RESEARCH QUESTIONS AND METHDOLOGY

Based on the discussions above and through the application of concepts developed within SST, the following research questions have been developed. The first two groups of questions focus on the dynamism and complexity of the development of OSPs, aiming to investigate how the different features of the package emerged from the supplier's struggles and learning, over time. The last question seeks to explore the impacts of China's changing context and related institutional arrangements on the taking up of the technology.

1. Which struggles and tensions did the Chinese supplier face through the development of the generic solution? Which strategies did they use to enable them to deal with these problems?

As mentioned earlier in this chapter, the development of OSPs involves a range of tensions. How the supplier resolved and managed these problems to achieve the goal of constructing the generic solution is the central focus of this thesis. The reality of the OSPs' development seems to be very complex, in that the nature of such a standard system cannot simply be understood as a technical programming issue. In the practice of OSP development, there is a range of choices which are faced by the supplier (this will be further demonstrated in chapter two). It is essential to capture the diverse choices related to the adaptation of development strategies which were made by the Chinese supplier during the shaping of the generic features of the software package.

2. How did the Chinese supplier develop its early assumptions as to users and use? How and where did the Chinese supplier interact with user organisations and other social actors in the development of OSPs? What did the Chinese supplier learn in relation to building the generic solution from those interactions?

These questions are related to the OSP suppliers' innovation process. The existing literature on the study of OSPs largely focuses on the implementation and the deployment of the generic solution. Indeed these scholars point out the gulf between the standard package and non-standard user organisations, as well as the importance of implementation and use to the successful delivery of OSPs and technical innovation. The supplier's side of the generic solution innovation process, however, remains understudied. Our study goes upstream to investigate the process of the suppliers' accumulation of knowledge and hence to close the innovation loop. While the first group of questions aims to explore the dynamics of design and development, this second group of questions investigates the complexity of the supplier learning process and learning dynamics. In particular, attention is given to clarifying the spaces (where) and occasions (when and how) (Clause and Koch 1999) in which learning takes place as the software package evolves.

3. How did the Chinese socio-economic context and institutional arrangements influence the ways in which the generic solution was developed?

Based on SST, OSP suppliers' choices regarding the adaptation of strategies to manage tensions during development may well be influenced by the broader socio-economic context, through both the framing of the play space at the micro level and the setting up of related institutional rules. Thus, this question explores the specifically Chinese features of the development process. This is vitally important since the context of China is vastly different from that of more advanced countries. Hence the software development practices and supplier strategies could be different from those that are conceptualised in western countries.

In order to answer these questions, following the tradition of the SST perspective, we require a qualitative methodology which captures both the dynamism and continuity of the development of OSPs within its specific socio-economic context. Such an approach entails moving beyond a 'pure technological' account and the conventional information system's life cycle, to study the building of the generic software system as a 'distributed' process over several product life cycles. The field work was principally conducted at a leading Chinese PDM software vendor's warehouse. The collection of field data involved interviews, documentation and participative observation.

1.6 THE ORGANISATION OF THIS THESIS

The structure of the thesis is as follows:

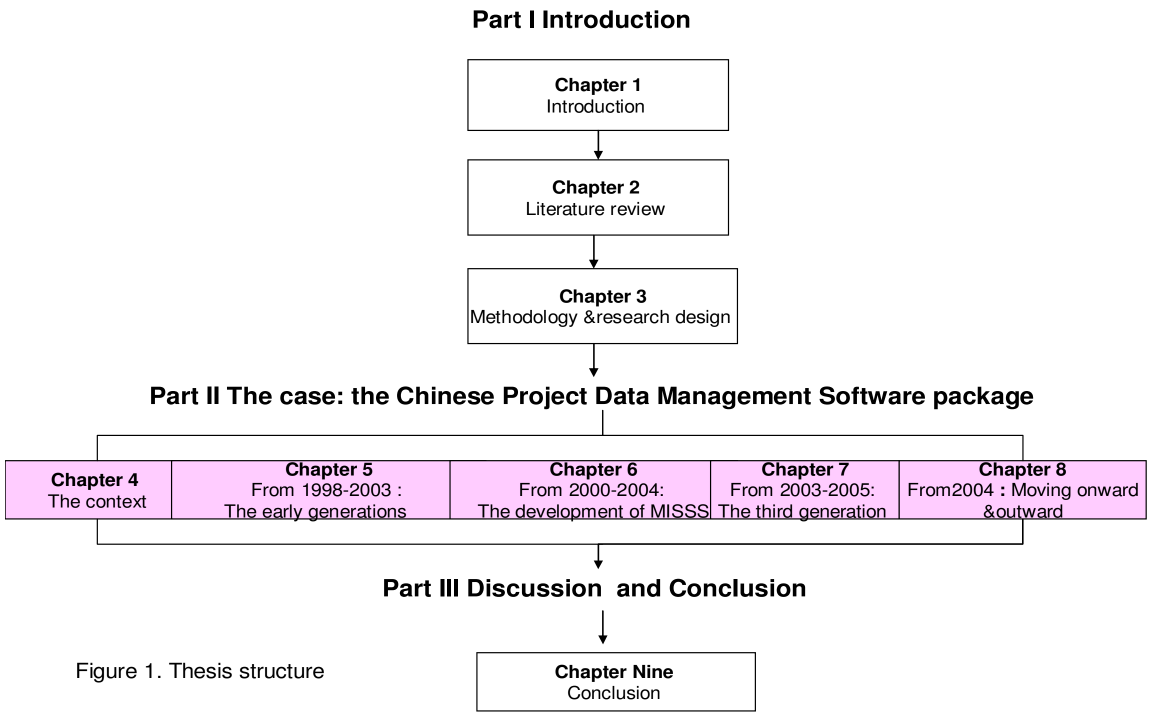

Figure 1. Thesis structure

This thesis is divided into nine chapters. The introduction in chapter one is followed by the following chapters.

Chapter two principally focuses on the literature review, aiming to form the basis on which to build an appropriate framework for this study. The review of the literature is driven by a concern for using concepts and analytical tools developed from the SST perspective to approach the study of building the generic solution. Thus the classification of the literature is based on the bodies of knowledge that directly contribute both to framing our analytical framework and leading to an empirical understanding of the construction of the generic solution.

Chapter three describes the research design and the methodology of this study. Firstly, based on chapter two, an integrated analytical framework is synthesised. Secondly, the recent debates on the design of case studies are discussed. Following this framework, in order to achieve our research objectives, we pursue a combination of longitudinal and ethnographical accounts in the context of actual practice. Later, the chapter ends with a discussion of the data collection methods and data analysis.

Chapters four to eight are devoted to a qualitative case study with regard to the development of a Chinese PDM system. The aim of this part is to demonstrate a detailed account of the complex and dynamic nature of the generic solution development in relation to its supplier's ambition and strategies.

Chapter four, **'The Context of the Chinese LZ PDM Development'**, explores China's recently emerging economy in association with a review of the evolution of the science and technology policy from the 1980s, through the 2000s. It then moves to a discussion of the features of China's current software industry, the construction industry, which is the application domain of the LZ PDM, and the evolutionary history of IT applications in this specific sector. The aim of this chapter is to address the social, economic, political and industrial context in which the development of the LZ PDM occurred.

Chapter five, **'From 1998 to 2003: The Early Generations'**, examines the main characteristics of the early birth of OSPs as well as the related Chinese supplier's strategies for dealing with the tensions and struggles with local user organisations, as well as internal contextual factors such as time and financial constraints. The chapter shows that the emergence of the functionality of the OSPs is experienced as a cumulative process rather than a one-off action, and in relation to innovation, the supplier's main focus is on knowledge acquisition through the implementation of individual projects. The chapter also shows that the choice of strategies and the taking up of the early PDM software development are largely shaped by the development context.

Chapter six, 'From 2000 to 2004: The Development of the MISS Standard', focuses on a critical event, the MISS (management information system software) standard development for the construction sector, which occurred during the early development of the Chinese PDM system. This chapter addresses how the MISS, a Chinese OSP industrial software standard, and its development process, in which LZ played a key role, were used to support the supplier's own product development. On the one hand, the development of the MISS standard established access to the related knowledge and necessary technology; on the other hand, it was used as a political tool to persuade relevant social groups to support the supplier's own interests. The chapter focuses on the ways in which the meanings and related features of the standard were constructed.

Chapter seven, 'From 2003 to 2005: The Third Generation', illustrates how the Chinese supplier LZ managed the development of the generic solution in the phase of third generation development, when the number of users was greater than ever. At this stage, the early development strategies had shifted to a range of new strategies for continuing product development and innovation. We describe another scenario whereby the Chinese supplier actively segments and manages the user community through a range of related but different solutions. This chapter shows that the supplier's community management strategies directly impact the features of OSPs. By deploying a range of strategies, the supplier tries to diminish the value of local practices, aiming to persuade user organisations to perform internal organisational changes rather than change the software. In so doing, the Chinese supplier actively shapes and reconstructs the local requirements.

Chapter eight, '**From 2004: Moving Onward and Outward'**, examines the future of the software package. The chapter explores how the supplier LZ managed to extend the application scope of the PDM to construct its product family tree, as well as the particular strategies LZ used to ensure that the technology remained promising at this particular biographical stage. By demonstrating the extension of the scope of the LZ PDM application, we hope to show how LZ manages to effect both technical and economic advances. Furthermore, through investigation of related future technology development strategies adopted by LZ, we found that in this stage, supplier choices and the features of strategies for the development of future technology are largely influenced by their socio-economic context.

Chapter nine is a concluding and analytical chapter. It presents the main findings and draws out implications for theory, policy and practice, indicating directions for future research. It also explores the further implications of the study for similar research which attempts to use SST in an analogous manner, as well as for Chinese science and technology policy.

Chapter Two

The Social Shaping of Organisational Software Packages (OSPs)

2.1 INTRODUCTION

This chapter is devoted to the review of literature relevant to the study of OSP development. Its primary aim is to explore how theoretical, analytical and empirical developments in SST can be applied to the interdisciplinary study of the building of the generic solution. To this end, in addition to reviewing the relevant literature from SST, it is also necessary to question the conventional perspectives on and analytical approaches toward information system development in order to strengthen our choices and clarify our point of departure. We do not intend to critise the intellectual grounds of convential perspectives. This approach is taken rather to add value to their theoretical realm by suggesting that a better approach may be needed for the studying of OSP development and, furthermore, that employing an SST perspective could provide this alternative path. Although our study focuses on the suppliers' strategy and ambitions for building OSPs, this does not mean that users are neglected. Inspired by SST, we believe that the user organisations also contribute to the technology development process. Thus, literature on empirical understandings of OSPs' material characters and related adaptation issues will be reviewed and utilised as part of the basis to understand our empirical research on suppliers' actions and reactions.

2.2 SOCIAL SHAPING OF TECHNOLOGY

Our research on the construction of the generic solution asks fundamental questions about various views of technological change, including the relationship between technology and organisation. For more than two decades, the social shaping approach has developed a range of valuable conceptual tools and analytical models to improve our understanding of the relationship between technology and society. By taking both the theoretical and analytical traditions with the recent empirical evidences that are provided by SST, we hope to move from the traditional understanding of the design and development of information systems into a perspective with a broader scope, whereby both the advanced material nature of modern ICT and the complexity of development will be taken into account.

2.2.1 The integration of actor-centred and structure-centred approaches

The rest of this section summarises the formation and development of SST in terms of its primary intellectual origins. In particular, attention is given to recent advances in the debate between micro (actor-centred) and macro (structure-centred) analysis by introducing the technology transition (TT) model, which is used as the one of key concepts in our study.

SST emphasises the *uncertainty, complexity and dynamism* of technology development. *Firstly*, SST highlights the fact that innovation does not follow a linear model of design, implementation and use. Rather, it is a multi-cycle process (Fleck 1988: innofusion), such that innovation continues in the hands of the user during the stage of implementation and use. *Secondly*, SST emphasises the dynamics of technology development. Following the tradition of the sociology of scientific knowledge (SSK)[2] (Barnes 1985; Latour 1983, 1987), the social construction of technology (SCOT)[3] (Bijker 1995; Bijker et al. 2001; Pinch and Bijker 1984) and actor network theory (ANT)[4] (Callon 1986, 1991; Law 1991; Law and Callon 1988), a range of concepts such as 'negotiability of technology' and 'interpretive flexibility'

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[2] The development of SSK sought to move beyond previous science studies by scholars from the Edinburgh school, such as Barnes, B., Bloor, D.,and Henry, J., and the Bath school, such as Collins in the 1970s and 1980s and to demonstrate that scientific knowledge itself is embedded in social relations rather than standing alone as acontextual 'truth'.

[3] SCOT was developed by Pinch and Bijker by drawing upon SSK. They argue that technological development is a 'closure' process during which the form of an artefact or system becomes 'stabilised' as consensus emerges among key social groups.

[4] ANT has its origins in the work of Michel Callon, Bruno Latour and John Law (1987, 1992, 1999). It is an approach focusing on the alignment and networking of human actors, such as scientists and engineers, and non-human actors, such as machines and technologies, which together represent the primary actors in development.

are used to demonstrate how technologies may result from negotiation between numbers of social groups/actors. The idea of 'negotiability of technology' is used to show that a technology emerges through a complex process of action and interaction involving a wide range of players. The concept of 'interpretive flexibility' is developed to capture the multiple meanings that may be associated with a technology (Pinch & Bijker 1984), in order to point out that the meaning of a technology can be renegotiated. The socio-technical system approach, emerging from the history of technology and particularly associated with Hughes (1979; 1999; 2001), furthermore, exerts a strong influence on SST. The concepts of 'system builder' and the 'seamless web', which are developed within a socio-technical system, are used to depict the complex relationships involved in technological change. This suggests that technological change is a result of interaction between social, technical and economic factors, as a seamless web with no clear divisions (Hughes 1999). The construction of a new system requires a system builder to conduct strategic management in order to compete with an existing system and eventually replace it. *Thirdly*, SST further seeks to explore the consumption of technology and related impacts on its design and development. Some notions such as 'domestication' (Silverstone and Hirsch 1992) and 'appropriation' (SØrensen 1996; Williams et al. 2005) are used to present how users, as one type of social group, can assign new meanings to technology in order to achieve their own ends, which brings about related impacts on later technology design and implementation. In recognition of those dynamics, SST also seeks to explore how a technology is stabilised. The processes of 'closure' and 'entrenchment' are used to demonstrate how an innovation may become stabilised through alignment and network externalities. During the processes of interaction, actors can employ different strategic manoeuvres to achieve favourable alignments and thus reduce the cost and risk of technology development and change (Disco and Van der Meulen 1998; Molina 1995).

Meanwhile, in contrast to the research focusing on the contingency and dynamics of social groups and organisational networks on technology development, some SST studies also extend into investigation of *continuity and patterning* in technological innovation. This research attempts to capture the regularities and patterns in technological development, including studies of institutional structures and mechanisms that influence the social actors' choices, actions and reactions in specific industries and sectors, as well as micro analysis of R&D within firms. Representing these approaches are the evolutionary economists, who highlight the dynamism of economics. They suggest that technologies' trajectories of progress are associated with particular criteria of assumed improvement (Dosi 1988) that are also termed techno-economic paradigms (see the technology transition model below). The paradigms are framed by the so-called selection environment (Nelson and Winter 1982), which contains a range of rules and institutional arrangements which impact on definitions of social and economic factors such as profit, cost, future technology demand and the market, etc. Distinct from conventional approaches to economics, such as neo-classical economics (Coombs et al. 1987), which treated technology change as a 'black box' in which changes are driven by a supplier's profit maximisation, evolutionary economics gives attention to the complex of cumulative change in technology and economic organisation, giving particular attention to the accumulation of knowledge, acknowledging the presence of uncertainty (Dosi 1988; Freeman 1982; Nelson and Winter 1982).

It is necessary to mention that the roles of social actors and structures (economic factors, genders, class and context) in technological change have been developed in tension, both in terms of the explanatory resources of technology and the relevance of analyses of the contexts in which innovation takes place in the field of science and technology studies (MacKenzie 1988, 1990; Russell 1986; Russell and Williams 1987). The main critiques of early actor-centred approaches such as SCOT and ANT are, firstly, that they neglect the broader context by overlooking the power relations between various actors or social groups in relation to choices concerning technology development; secondly, such studies tend to look only at a particular moment of technological development in a particular space. Evolutionary economists have also been critised as tending to underrate the reflexive creation of technical alternatives, as well as the artificial and social shaping of the selection environment (Rammert 1997). Hence their explanations fail to acknowledge and explain diversity and contingency among innovation processes and firms (Mcloughlin 1999; Russell and

Williams 2002). There is still an ongoing debate, but SST emphasises that we can not understand everything concerning the origins and development of technology solely in terms of local actions; rather this development occurs through a process of co-evolution between action and structure, and actors and institutional arrangements, such that a technology's influences could be embedded in social structures with deep historical roots (Russell and Williams 2002).

To apply SST to this study, therefore, means that we must examine the actors' interactions and the historical evolutionary processes of technology design, as well as the impacts of broader socio-economic contexts on the shaping of technology. Hence determining how to understand the relationships and interactions between actors and structures in relation to the shaping of technology is essential to this research.

Based on earlier studies, some new concepts (Rammert 1997, 2002; Rip and Kemp 1998; Rip and Schot 2002) have been developed to expand conceptions of relevant actors and their terrain of activities within the increasingly complex innovation process, in order to explore the evolution of technological development over multiple cycles with multiple players. One of the most representative approaches is the technology transition model (TT) which was used as the main model for our study.

Technology Transition Model

Originally, the TT model, which takes a multi-level perspective, was developed by Dutch researchers (Geels 2002, 2004, 2005; Kemp et al. 1998; Rip and Kemp 1998; Rip et al. 1995). Its initial purpose was to help the government create policies and promote institutional changes and, in these ways, achieve substantial environmental technology development in the Netherlands. This model was widely used as an analytical tool to explore the interplay between local actors and broader structural conditions over the analysis of the contexts in which innovation takes place. In relation to our study, it is an ideal model which leads us beyond micro- and meso-level agency dynamics to answer questions regarding 'why' particular patterns occurred, by taking the situated context into account. Similar to the Dutch context, in contemporary China, the government takes a critical and active role in the economic development of the country. Thus, another result of using such a multi-level conceptual model is that it could be beneficial to China's government for the building up of future technology strategies.

With a critique of the traditional evolutionary economy (path-dependency and lock in) and social system approaches to understanding technology development (such as the national system of innovation and large socio-technical system (LTS)), the scholars of TT argue that in order to understand technological innovation (since it is a socio-technical system change), it is necessary to explore how a system can be transferred from one context to another, which should be done by focusing on dynamics and change instead of economic performance (like the system of innovation). In other words, if path-dependency literature provide tips on understanding 'lock in', a conceptual model is needed to explain a system 'lock out' through the emergence of a new innovation, and in particular, to give attention to the interaction between technical and social factors, as well as institutions and rules (Geels 2002, 2004, 2005).

By integrating literature from evolutional economic studies such as that related to 'selection environment' (Nelson and Winter 1982), 'technology paradigms' (Nelson and Winter 1982), 'technology trajectory' (Dosi 1988) and 'technology regimes' (Rip and Kemp 1998), as well as literature from the socio-technical systems approach (Hughes 1999), the TT scholars highlight that the key point of the multi-level perspective is that (socio-technical systems) transitions come about through the interplay between processes in different dimensions: systems (landscapes), rules (socio-technical regimes) and social group interplay (niches) (Geels 2002, 2004, 2005; Kemp et al. 1998; Rip and Kemp 1998). As Geels argues:

> *'…… these dimensions and their inter-relations (TT multi-level) will be described. The elements and linkages of socio-technical systems do not exist autonomously, but are created, (re)produced and refined by social groups. Actors in these social groups act in the context of social structures and formal, normative and cognitive rules……'*
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> Geels (2005, p. 449)

While TT affirms that human actions are structured, it leaves much room for intelligent perception and strategic action.

The macro-level: the *ST-landscape* contains a set of heterogeneous factors which cannot be controlled by the actors, being beyond their direct influence and unable to be changed at will. The landscape is an external structure or context for the interactions of actors. The meso-level: *regimes* are dominated by sets of rules which are created by different social groups. By extending Nelson and Winter's 'technological trajectory' and Dosi's 'technological paradigm', the technological regime is used to refer to 'the rule-set or grammar embedded in a complex of engineering practices, production process technologies, production characteristics, skills, procedures, ways of handling relevant artefacts and persons, and ways of defining problems' (Rip and Kemp 1998, p. 339). The technological regime has been extended, furthermore, to socio-technical regimes which include other social groups (Geels 2005). Similar to the technological regime, other regimes, like policy and user organisational regimes, represent the related rules in each of their own social groups. Those social groups have relative autonomy but at the same time interact and form networks. Socio-technical regimes account for the stability of existing socio-technical systems. Due to the presence of the stabilising mechanisms, it is difficult to create radical innovations within a socio-technical system. In reference to the scholars of TT, in the micro-level *niches* there is a protected space (Law and Callon 1988) for radical new innovation, hence fostering the early 'hopeful monsters' (i.e. technologies that could become dominant designs in the future) (Law 1991). As pointed out by Rip and Kemp (Rip and Kemp 1998) the idea of the niches does not refer to market niches but to evolutionary niches in biology, as in the way that yeast cells grow, with developments branching off in different directions, a picture further complicated by cross-connections and interactions. A niche is a place which is rife with uncertainty. The social networks around new technologies are small, and the rules are diffuse and unclear. Actors work in different directions, exploring different trajectories. The niche is important because it provides space for the learning process in several dimensions. Niches also provide a space to build social networks that support innovations, e.g. new industry networks, user associations, etc.

Applying this model to our research, studying OSP development in context means that we must investigate each of these three levels and explore their interactions related to the construction of the generic solution. The detailed analytical implications provided by TT, as well as the means by which we will apply those to our research, will be discussed further in chapter three.

2.2.2 Social shaping of ICT

In the past two decades, the perspective of the social shaping of technology has been advanced and enriched by the extension of empirical work into different technologies and related settings. In particular, research on the social shaping of information and communication technology has been fruitful. As a result, a number of valuable conceptual tools and analytical models have been developed to capture the character of ICT and the complexity of the innovation process. In particular, regarding software technology there is a range of rich studies that have been conducted to investigate the nature of software systems and their related dynamics, as well as contingencies of the development process, including the 1990s' computer-aided production management (CAPM) (Clause and Koch 2002; Clausen and Williams 1997; Williams 1994, 1997), research on the commodification of software packages (Brady et al. 1992; Tierney and Williams 1990), and recent enterprise resources planning (ERP) system studies (Koch 1999, 2001, 2003, 2004; Pollock 2001; Pollock and Cornford 2004; Pollock et al. 2003). Following the key tradition of SST that we had reviewed above and emphasising the impact of actors' interplay and the evolutionary process of technology development, as well as the broad socio-economic context, on explanations of technology, in this section we focus on the review of some notions and related concerns which have been developed in recent SSICT studies and are helpful guides for our study of the construction of OSPs.

‘Social learning’ in ICT development

Our study of the innovation process of OSPs inside the supplier firm is largely underpinned by the concept of social learning. Rather than emphasising power relations among social players and actors, we hope to deploy a more positive perspective which examines learning and knowledge gathering through the interaction of actors.

Following the works of Fleck (Fleck 1988, 1988a, 1992) and drawing insights from the concept of ‘appropriation of technology’ (Pacey 1983), consumption of technology (Silverstone and Hirsch 1992) and the evolutionary economy, SST scholars Williams, Stewart and Slack (2005) further enriched the concept of ‘social learning’. Social learning was originally addressed in Sørensen’s 1996 work (Rip et al. 1995; SØrensen 1996) which drew attention to the active role of various players during technology innovation and adaptation, through the findings of a major European study, Social Learning in Multimedia (SLIM) in the late 1990s. This concept was developed to explore the process by which generic technological capabilities get matched to, applied with, and eventually form a part of, the diverse social settings and activities in a specific national context (Williams et al. 2005).

Following the tradition of SST, the concept of social learning is a critique of the traditional innovation model, whereby technology development has been understood to be a linear process starting from design and development and diffused through later implementation and use in the market. Drawing upon evolutionary economics, SST scholars such as Stewart and Williams highlight that technological innovation, in particular ICT, as described by Freeman (1979), is *a coupling process between the technological supply and the market* in which interactive learning takes place between suppliers, users and other social groups through cooperation and competition (Webster and Williams 1993; Williams and Edge 1996; Williams et al. 2005).

The concept of social learning as clarified by Sørensen is not a narrow cognitive term; rather it is a broad term that points to socio-technical change as a process of negotiation and interaction among different players and social groups who learn from each other, but this process is subject to conflicts and differences of power and interests (SØrensen 1996). The learning process is not, therefore, smooth; it is filled instead with struggles and negotiations.

Fleck developed the concept of 'innofusion' (Fleck 1988). He argues that the implementation stage is also a stage of innovation. This concept is used to show that innovation does not stop when artefacts emerge from suppliers, but rather it continues as these artefacts are implemented. The importance of this concept is that it provides a new way to understand technological development in situations whereby innovation is not restricted in the supply of technology. The implementation and its use also contribute to new product development. User organisations can therefore be seen as a laboratory in which both suppliers and users jointly learn about the functionality of the technology and users' requirements. While these organisations can be understood as laboratories in the implementation phase, the concept of social learning takes the analogy further and suggests that the whole of society can be seen as a laboratory for critical technological innovation (Herbold 1995), in which a range of different social groups are engaged with technology development.

By drawing upon concepts from evolutionary traditions in economics such as 'learning by doing' (Arrow 1962)[5], 'learning by using'[6] (Rosenberg 1982) and 'learning by interacting'[7] (Lundvall 1992), Williams, Stewart and Slack suggest that there are two learning arenas directly involved in technology development, which are

5 Originally, this idea is used by Arrow (1962) to indicate that the most efficient way to use a machine can be improved through experience of use. There is a 'learning curve' that accompanies accumulated experience.

6 Similar to 'learning by doing', 'learning by using' is used by Roserberg to describe a process whereby users gain familiarity with a given technology and develop skills through the use of it.

7 'Learning by interacting' has been addressed by several evolutionary approaches to the study of technology. Freeman has emphasised that innovation is a coupling process between supplier and users. In order to perform such interactive learning between the suppliers and users, a communication channel or a linkage is necessary. This operation of learning has been described as the 'learning economy' by economists such as Andersen Lundvall.

located in both the phase of early design and development, and in the later appropriation of technology (Pacey 1983). The early design arena represents a space in which, through interactions with other actors, suppliers try to learn about users and use and to identify representations of users and use, materialising them into the artefacts; users, on the other hand, learn about the functionality of a new product and its potential utility. The appropriation arena is another space in which users actively and creatively incorporate supplier offerings and adapt them to their specific needs. The accuracy of a supplier's hypotheses about the representation of users is tested in this space, in which the final meaning of the technology will be established.

In relation to the objective of this research, we deploy 'social learning' in a relatively loose way, such that attention is given to the design arena in order to investigate how and what suppliers are trying to learn through interaction with other social groups around the construction of the generic solution. Giving attention to the design and development phase does not imply ignorance of the user and use, and providing snapshots, as argued by Stewart and Williams (Stewart and Williams 2002), to represent episodes of design does not mean that these snapshots should be viewed in isolation, but they should rather be seen as moments of innovation across multiple cycles of design, implementation and consumption. We are also fully aware of the importance of users and use in the shaping of technology. Although this research is not specifically designed to investigate the adaptation of OSPs, we believe that understanding implementation and use-related issues could help us to explore the late supplier's action and reaction. Thus, one of the sections of this chapter is devoted to reviewing the literature on their influences on this development. In other words, rather than conduct an empirical investigation into adaptations, we take users and use into account in the study of the construction of OSPs by 'reading' the related literature.

From an analytical perspective, the design arena is similar to the notion of the 'development arena' developed by Jorgensen and Sørensen (Jorgensen and Sorensen 2002) to denote a particular space in which political, social and technical performances related to a specific technological problem occur. In such a space, a range of heterogeneous elements are brought together, such as players, artefacts etc., which can seem distant in the geographical and conventional cultural space during the development of OSPs. This approach emphasises the cooperation and competition between different networks such that they co-exist and interfere with each other within a certain space. The design arena can be seen as located within the development arena, but a particular focus is given to the supplier and its learning process regarding the shaping of technology through its interactions with other social actors.

- **The representation of users and use in the design arena**

During the early design and development of an artefact, it is impossible to anticipate the user and the way in which the artefact will be used. As demonstrated by van Lieshout in his paper 'Configuring the digital city of Amsterdam' (2001), designers seek a range of conceptual inspirations and metaphors to construct their assumptions about possible users and use. It has been suggested that there are some ways to anticipate representations of users and use, such as market research, consumer testing, information gleaned from other products (Akrich 1995), user expertise participation and user groups (Pollock et al. 2003; Scott, J.E and Kaindl 2000), the influence of the designers' own professional backgrounds and assumptions (Woolgar 1991), and expectations of future technology (Lente 1993).

Indeed to some extent, the representations of user and use are important to the designer's conceptualisation. But such representations can not be collected on a one-time basis. It is noteworthy that early ideas in science and technology studies such as the notion of 'configuring the users' (Grint and Woolgar 1997; Woolgar 1991, 1996)[8] and the concept of 'inscription,' with its associated processes (Akrich 1992; Akrich and Latour 1992),[9] portray a liner procedure within which the related

[8] In his ethnographic research on the development of a personal computer, Woolgar portrays designers as configuring users to describe how designers built computer hardware to enforce the norms and actions that they wanted the users to follow. For Woolgar, the user problems can be managed by design, which embodies preferred user roles and relations.

[9] The notion of '(de)inscription' is used to show that in practice, configuring the users is not something simple and straightforward. Users do not necessarily follow the directions and norms that have been inscripted as texts in the artefacts by the designers. As described by Akrich, inscription is

representation materialised into artefacts by the designers and are thus fixed and only passively accepted by users such that, although users may reproduce scripts in the adaptation stage, they can not influence the features of a technology. The danger of such an understanding, as argued by Williams and his co-authors, is that it privileges the designer and design and downplays the importance of users.

Configuring users is neither simple nor straightforward. By extending Woolgar's argument, through the technocratic study of the rapid application development (RAD) approach, Mackay argues that configuration is not a one-way process; it is rather an interactive process between designers and users, in the sense that designers configure users but are in turn also configured by their own organisations, as well as users (Mackay et al. 2000). He emphasises that within this process, the relations between designers and users are not fixed, but are rather fluid, negotiated, constructed and managed. Likewise, in his forthcoming paper Hyysalo (Hyysalo Forthcoming in Economic use of science and technology) developed the notion of 'figuring' with the associated four modes of shaping technology: pre-, de-, re- and con-figuring to highlight the importance and contribution of user organisations to the construction of representation of users and use.

Williams, Stewart and Slack further argue that acquisition of knowledge related to the representation of users and use is much more complex in practice, since a range of uncertainties around both users and design exist (Williams et al. 2005). By taking the broad view that design is a hypothesis about the user/use (Lobet-Maris and van Bastelaer 1999), they suggest a developmental process with an iterative series of activities (Stewart and Williams 2002; Williams et al. 2005). In this sense, the early hypothesis about the representation of user and use is materialised into actual artefacts but will be subjected to further experimentation and testing through the social leaning process of development, the generation of feedback and the innofusion and appropriation of the technology in real-life contexts. Meanwhile, the learning

followed by pre-scription and de-inscription by user organisations. Indeed, Akrich demonstrates the collision between the inscribed users with the actual users. The pitfall of this notion, however, is rooted in its lack of clarity as to whose scripts are embedded in the artefacts. As addressed by both Williams (2005) and Hyysalo (forthcoming), it seems that for Akrich only designers' scripts can be fixed into the technology.

that occurs in the appropriation of the technology provides one of the resources for the construction of the representation of users and use for the future.

From this perspective, what is useful to our study is the guideline of the design and development of the generic solution embedded in OSPs. With the design and development of the generic solution, the supplier should experience a similar iterative learning process for capturing the representation of users and use through both internal and external learning intermediates. An internal learning intermediate could be represented by the individual design project carried out by designers. External learning intermediates could be any interaction with user organisations and/or other social groups. We know, furthermore, that the OSPs are designed for a group of users instead of one specific user; hence the supplier learning process related to the generic solution is even more complex. On the one hand, the supplier must consider the generic side of the solution since it is designed for a group of users. On the other hand, local uniqueness has to be taken into account during the implementation of the generic solution. This means that suppliers face multiple learning locations at the same time, with the same product.

- **The dynamics of the learning process: alignment and collaboration**

The concept of social learning suggests that knowledge regarding new product development is seldom found within a single organisation; the relevant knowledge is instead distributed among different players located in different geographical places. In order to capture this distributed knowledge, there must be communication intermediaries and mechanisms available to channel the learning activity. Applying this idea to our study indicates that the construction of representation of users and use is also an inter-organisational learning process. Understanding how suppliers build intermediaries and mechanisms, as well as the features of such inter-organisational learning processes is therefore critical to our study.

In developed countries, *alignment* has been recognised as one of the mechanisms for the interactive learning. From the perspective of SST, building a technology is a process of entrenchment whereby the final meaning of the artefacts is finalised through alignment, in which a range of players seek agreement about various issues related to the technology, such as meaning, functionality and expectations, hence striving to reach 'closure' (Bijker et al. 2001; Pinch and Bijker 1984; Russell and Williams 2002; Williams et al. 2005). As described by SST, the technological supplier may be motivated to minimise the risk of failure which could be caused by lack of acceptance from other social groups and/or to achieve the critical economic mass at which leading suppliers benefit from the increasing returns caused by adoption of the technology which becomes dominant. Other social players involved in such a network have their own interests which can be achieved through the alignment, such as obtaining information and influencing the shape of technology, etc. From a 'social learning' perspective, it is most important that such an alignment brings together a range of different players with complementary capabilities and domains of experience and expertise, and that they work together on issues related to technology development (Williams et al. 2005). Through this inter-organisational interactive, the knowledge located in other social groups and geographical locales are acquired and exchanged. Cooperation and coordination, however, is not a smooth process. It is normally characterised by politics and power conflicts, since various social groups have their own interests and expectations regarding the engagement of such a network (one such character has been discussed in ANT and SCOT).

With respect to our study, we should pay attention to how OSP suppliers arrange their inter-organisational learning activities, as well as the particular forms and features of such meso-level learning in the context of China. In the next section, in addition to introducing another analytical concept, related empirical studies conducted in the field of SST will also be reviewed, in order to suggest some potential possibilities that an OSP supplier could face in the real world.

The 'biography' of a software package

This thesis is also strongly inspired by recent research at the University of Edinburgh on the 'biography' of software packages. From a SST perspective, the innovation of ICT is not static and instead is a distributed process which could cross a great period of time and various loci. As Rammert argues, 'the development of technologies should better be conceived as a continuous process of creative variation, taking place in and between various technology projects, enacted by different social actors, closed and re-opened by negotiation in multiple areas of conflict and selected by some institutional filters' (Rammert 2002). 'Social learning' and related concepts such as design and development arenas and alignment contribute to our understanding of the dynamics and contingencies of OSP development that occur at particular times and loci. The concept of the 'biography' of a software package could help us to identify continuities in software package innovation.

Similar to other concepts that are developed in SST, the concept of 'biography' has emerged from a critique of traditional innovation that sees development as a linear process. Departing from this, social shaping points out the problem with traditional information system studies (such as implementation and adaptation studies), which have viewed design and use as separate individual phases, such that their studies only focus on a particular stage of the innovation process (Williams 1997). It argues that those studies only provide a snapshot of the software provision but that the process of innovation should be analysed over time, exploring how a software package may emerge in particular firms and contexts and then become more widely diffused and adopted in other organisations, and in this way creating the biography of a software package (Brady et al. 1992; Pollock et al. 2003; Williams 1997).

From an anthropological perspective, the word 'biography' is used to investigate the possibilities that a society in question offers to individuals and to examine the manner in which these possibilities are realised in the life stories of various people and their wider group contexts (Kopytoff 1986). As claimed by Kopytoff, things/commodities have their own biographies, and a single thing could have various biographies, according to how it is approached, from different angles and with varying foci. Given each age, there is a particular biographical expectation (event) that corresponds to it. For Kopytoff, the study of a 'biography' of a thing requires examination of how the things are moved around, defined and redefined in each new setting, as importance shifts with 'every minor change in context' (Kopytoff 1986) .

Following this, SST scholars like Brady, Tierney, Pollock and Williams have developed several 'biographies' of software package models (Brady et al. 1992; Pollock et al. 2007; Pollock et al. 2003) focusing on the interaction between suppliers and users. The concept as they have described it is developed in an attempt to trace the 'accumulated history' of a software package and also show how it continues to influence the structures and practise of later adopters. In particular, they give attention to the ways in which a software package travels from one place to another, in order to examine how the packages are adopted and redefined according to the needs of each new place (Pollock and Cornford 2004; Pollock et al. 2003).

In their study of the commodification of industry applications software (Brady et al. 1992), Brady and his colleagues have created several biographies of software packages with an emphasis on the profit and cost of OSP development. In relation to the development process of the generic solution from a supplier's strategic management perspective and using Ward's (Ward 1987) life-cycle model, they describe a possible package emergence process. According to this process, an OSP is initially developed as a customised system with a high cost, but in the case that the new application becomes, in time, a sector-standard used by a range of user organisations, the profit is returned to the suppliers. Eventually, the application spreads throughout the sector, having become infrastructural, meaning that both its profit and cost are low.

Pollock and his colleages' very recent research projects related to commercial software package development and implementation, meanwhile, demonstrate more biographical possibilities. Their study of the implementation of a generic solution at the Big Civic university (Pollock and Cornford 2004; Pollock et al. 2003) with the development of the generic 'campus model' illustrates how a generic solution can emerge from local implementations and development.

By analysing two different software packages in different stages of their biographies, both of which are developed by the large European supplier SAP, Pollock and Williams (Pollock et al. 2007) develop the notion of the *process of 'generification'* in which, through struggle and negotiation with user organisations, the supplier employs a range of strategies in the attempt to make their software package work in different local contexts. The concept of 'generification' is used to describe suppliers' strategic management of the development of OSP. They find that in the *birth and early development* stage, the package experiences an accumulated functionality. When the functionality of the software and user bases reaches a certain level, this achievement represents a shift to another biographical stage, the *growth stage*. In this stage, they find that suppliers shift the design to a community space and use other strategies (such as management by community and by content, smoothing strategies and management by social authority) in order to control the influence of specific user organisations on the features of package. The last stage of the 'biography' of software package is *the future,* identified as a range of paths of diversity that have been developed and embedded into the generic software packages and which can give packages additional flexibilities. The development of these paths of diversity is described as a compromise, based on the inability of suppliers to find a single generic template and hence leading to their decision to construct several possible diversity paths.

It seems that such a generification process can also be found in Clausen and Koch's work on Danish IT development (Clause and Koch 1999, 2002). As demonstrated in the design of mass-produced software, they find that in the early development stage, the supplier SAP selected development partners and testers from user organisations and other groups like consultant agencies to form the early version of the package. In this phase, they said: '*As partners and testers of the software a few companies were thus given influence on the software as part of a win-win agreement giving the companies influence and strategic advantage for their skills and competencies within the needed areas of software.'* (1999, p. 477) In the latter stage, once the package is transformed into a black box commodity, the later manufacturing user organisations become the passive buyers of a system and possess less power to shape the product to address their local needs.

The findings of Pollock and William' study on the community practice in the growth stage, meanwhile, are further supported by Koch's 2003 work with the term, *mass-producing community* (Koch 2003), through case studies of Danish IT development and implementation. The community approach as proposed by Koch (2002) is an empirically 'induced' term, which attempts to grasp a vast array of heterogeneous groups who participate in the same technology development. The system and the routines attached to implementation, customisation and development of the systems is described by Koch as the glue of this particular social constellation (2003). Such community practice further indicates the potential form of the inter-organisational interaction regarding the development of OSPs.

Similar development processes and community practices can also be found in Hyysalo and Lehenkari's work on the construction of diabetes management systems (Hyysalo and Lehenkari 2002). They find that in the early development stage, the various users' requirements were accommodated into the package. Once, however, the package became the industry standard, the supplier changed their attitudes towards users' further requirements. As noted in their case study, the supplier preferred to collaborate with leading professionals, and thus the participation of former user partners diminished. Such a shift has been termed 'critical transition' by Hasu (2001). During this transition, suppliers attempt to readjust their relationships, seeking a way to achieve both standardisation and cooperation with user organisations. As pointed out by Hyysalo (Forthcoming), the main challenges for managing this transition lie in recognising and anticipating when and how standardisation must give way to coordinated development with users, as well as in the extent to which a producer company must customise its stabilised products locally to keep its customers interested in the collaboration. In relation to our study, we should pay attention to the ways in which the Chinese supplier manages this transition, in order to examine how the Chinese supplier establishes a cycle between seeking coordinated improvements with user organisations and seeking standardisation.

To summarise, the biography of the software package can be seen as an analytical notion which is used to analyse the dynamics of software package development through the tracing of a package's accumulated history. In relation to our study, the notion of biography avoids the pitfall of traditional studies of design which view it as a one-off job, and instead it looks at design through the evolution of artefacts and its travel across time and space. The detailed process of implementation and adaptation of artefacts in different contexts is not, however, the focus of our study. The potential contributions of the biography of a software package to our study are, firstly, that it identifies specific and significant moments in the life of a software package. Secondly, it identifies the biographical possibilities and expectations relating to the particular features of the package, as well as the suppliers' work that would have to be done in order to realise those expectations. In particular, studying the process of 'generification' contributes to understanding generic solutions development from a supplier angle.

2.3 A CRITICAL REVIEW OF TRADITIONAL SYSTEM DESIGN PERSPECTIVES AND RELATED STUDIES

Although there has been very little empirical or theoretical exploration conducted on the construction of OSPs, there are some texts that discuss various theoretical perspectives and analytical approaches, in particular some in the information system development field, upon which we can draw in this study. The research undertaken for this thesis on Chinese software package design and development, however, is largely informed by the research tradition of the SST perspective, as we demonstrated above. In order to strengthen our line of argumentation, it is necessary to critically assess the conventional understandings and analyses of the development of information systems in general and to flag our points of departure from them.

2.3.1 Conventional life cycle of computer application development and the heroic view of design

Originally, information systems design/development was seen as a form of technological engineering that follows structured sequences. The most well-known example is the waterfall model and its related 'life cycle' process. This model has played multiple roles in guiding the practice of development in the industry, as well as forming a framework to study development in the academic field of information systems (Avgerou 2003).

This life-cycle model has emerged in a context in which there was a need for a better quality of software systems, as well as greater development efficiency. In the late 1960s and early 1970s, while hardware was advancing at a great speed, software development (both operational and early application software) had become notorious for its extremely high cost, unpredictable delivery and poor quality. This 'software crisis' has been blamed upon the combination of an unorganised development process and a shortage of labour (Fincham et al. 1994). Two influential solutions to this problem have been standardisations across a range of areas (such as programming and management processes) and the development of structured methods, aiming to improve the quality of software as well as its productivity (Friedman and Cornford 1989).

Structured system development resulted from these reforms. Unlike the early handcraft style, by which design was viewed as an individualised 'art', this is a software development practice in which a range of different types of expertise are centred around the development of software with strictly defined procedures (Fincham et al. 1994; Friedman and Cornford 1989). According to this practice, design starts from collecting system requirements and specification and then moves to actual design, implementation and testing. This structured system engineering method has been seen as the most serious attempt to transform system development processes into a formalised 'discipline'. It indeed solved the software crisis temporarily by achieving better time management and quality control throughout the individual stages of system development procedures (Friedman and Cornford 1989).

This well-defined, structured process (see Avegerou and Cornford 1998; Avision and Fitzgerald 1996), however, has also led to a range of problems, mainly related to a failure to deliver in the later evolution of software development, at which point matching the technology to user requirements became essential in the 1980s (Friedman and Cornford 1989; Willcocks and Mason 1987). The traditional waterfall design process has been largely critised as paying too little attention to organisational and social factors. The embedded philosophy in the development approach has been viewed as improving the efficiency and productivity of organisations through the reduction of human errors (Willcocks and Mason 1987). More explicitly stated, this philosophy implies that as fewer humans are involved, greater efficiency will be achieved. The system is designed with technical efficiency as the key criterion, and human beings have to fit with, and act as extensions of, the resulting computer system. In other words, once the finished design is in the hands of the designers, the user organisations have to passively receive the technology and follow the routines that have been embedded into the software by the designers. From this perspective, the design of the information system is perceived as a one-off job that is finished by the designers along the system's life-cycle. Following the engineering tradition, the related research is largely designed to investigate the cognitive processes of the designers and software engineers concerning the formulation of functionality at an abstract level (Turner 1987; Winograd and Flores 1989) or the data structures and data processing built into the software (Avgerou 2003).

The problem of this intellectual understanding of the related analytical approaches is embedded in its assumption that the artefact and designers are uniquely privileged to drive the organisational change. In such a context, social and economic life would be located as dependent variables, and technological innovation would be perceived as an independent variable in relation to different ways of living. Societies, organisations and groups with access to more advanced technologies would, from this point of view, work toward more advanced patterns of social organisation. The problem with this position, of course, is that it seeks to simplify the complexity of the relationship between technology and society by reducing it to a linear 'cause and effect' relationship. The naivete of this argument has inspired various counter-positions. In the field of information systems development, there are also similar intellectual trends which aim to reveal the complexity and dynamics of system design and development by emphasising the interactive relationships among designers, end users and user organisations with emphasis on the importance of user requirement capture.

2.3.2 User requirement capture and the 'design fallacy'

Another important line of our critique of the traditional design and development perspective centres upon matching the capabilities offered by information systems and ICT in general to meet the requirements of users. The relationship between software experts and user organisations has become increasingly significant, as the scale and importance of business applications have dramatically increased over the past two decades. In his study of computerisation in the business sector, Friedman (Friedman and Cornford 1989) identifies user relations as being the latest in a succession of development bottlenecks in which the primary challenge is matching technology capacity to meet user business needs.

The traditional structural system's life-cycle of development has been largely critised by most information systems development scholars for the way in which its sequence of stages creates a gap between those who design the technology and those who use it (Jr and Hirschheim 1987). This model failed to develop a sufficiently detailed understanding of users' activities while computers were widely diffused across organisations to support increasingly complex organisational activities (Friedman and Cornford 1989). The increasing recognition of the importance of users and use in the late 1970s and early 1980s has led to the advent of another important perspective on the design practices of information systems, which is centred on how to construct the system to meet the requirements of users. The philosophy related to this perspective perceives human factor considerations and user participation to be essential components of design (Mumford 1979; Noman and Draper 1986; Wood-Harper et al. 1985).

In this body of literature, design has been seen as a matter of collecting the right user requirements from the right users with the right value and contexts. The general motive behind this is to join users, in particular end users, who are experts in their occupational domains, with systems designers, the experts in computer technology, to create new and innovative systems solutions, in order to improve product usability and the overall quality of work experience and environment by promoting work democracy (Mumford 1979).

Collecting and meeting the user requirements is not an easy process. There is a range of related studies that have demonstrated the difficulties and struggles that supplier/designers face (Alvarez 2002; Axtell.C.M et al. 1997; Cavaye 1995; Howcroft and Wilson 2003; Reich et al. 1995), including both technical and organisational political issues. These studies also indicate that information system design is not an abstract thing; instead it involves concrete social and political factors.

In this context, designers are encouraged to learn user requirements through various methods, such as design meetings and formal interviews, with the support of ethnographic techniques (Beynon-Davies 1997; Kyng and Mathiassen 1997; Suchman 1987, 1994), which are generally recognised as being valuable in identifying the expectations, contradictions and contingencies of work activities that do not necessarily figure into formal representations of work. Hence, the major challenge to user participative design has been noted as identifying why, who, and how to participate.[10]

Indeed, the user-centred perspective pays more attention to users in the design of the information system and moves towards positive development. It points to the complexity and diversity of user requirements in the development of information systems. As argued by Williams, Stewart and Slack, however, the fundamental conceptual pitfall is still unresolved (Williams et al. 2005). The problem lies in the

[10] How can the users be identified? Who are they, in which stage should they participate, and how many should be allowed to get involved? Meanwhile, users do not always know what they want, and their requirements are consistently changing. Designers generally suffer these contingencies (users are constantly changing their mind) throughout the collection of user requirements.

related presumption that by promoting user participation and ethnographic observations, designers hope to find the right users with the right representatives with the right value. Thus, the design problems could in theory be solved through application of the suppliers' extensive knowledge of users and use. This view has been termed the 'design fallacy' (Williams et al. 2005), as it still seldom goes beyond the traditional life cycle analysis/design activities, and designs are seen as finished products in the supplier firm such that, once designed, they are largely fixed in their characteristics (Procter and Williams 1996).

Researchers (Alvarez 2002; Axtell.C.M et al. 1997; Cavaye 1995; Heiskanen 2000; Howcroft and Wilson 2003; Land and Hirschheim 1983; Mumford 1979; Olsson 2004; Reich et al. 1995) starting from this perspective have tended to look at the problems that may arise when suppliers collect the requirements in any particular stage of the system life cycle. While they have highlighted the dynamic nature of the process as well as the importance of the user relationship in the design of the information system, they have also over-simplified the design process with snapshots that emphasise only single phases and do not attempt to follow the evolution of the system development.

2.3.3 Local complexity and 'unique adequacy'

The rise of the design fallacy has been understood as being caused by an over-emphasis on the complexity and diversity of local user requirements and contexts, such that information systems must be designed around the uniqueness of culture and working practices of particular users (Stewart and Williams 2002).

The most representative perspective is that of the ethnographically informed information system design. In response to the conventional engineering approach to design, interactional sociologists with a growing body of implementation studies produced a critique of the presumptions that information systems can be designed upon the basis of designers' assumptions or text books.

Scholars such as Suchman, Timmermans and Berg argue that traditional engineering development produced a 'no where' view which claims that the generic features of a information system can be developed without considering the actual context of use and users' local practice. They further argue that such a view is a non-responsible view (Suchman 1994; Timmermans and Berg 1997). They point out that the consequence of such a 'no where' view encourages the designer to ignore and maintain his or her distance from the local setting of technology in-use. They claim that universality can not be designed independently from empirical knowledge of the workplace. In order to develop systems with any integrity one must develop them in relation to the specific settings in which they are to be used. If the universal solution exists, it is also a localised universality (Timmermans and Berg 1997). They argue that without local knowledge, expertise or context, the universality (of standard, generic components) can not survive. By employing Harraway's research on 'situated knowledge' (Harraway 1991), Suchman further suggests that designers should recognise various forms of visible and invisible work that make up the production/use of technical systems. Technology use should be understood as the recontextualisation of technology design in some local site of practice, where it is also a part of design practice, acknowledging and accepting the limited power of actors upon the shaping of the artefacts, etc (Suchman 1994, 1999). Based on this position, a 'co-production' view has been developed to call attention to the contribution of users and use and to rebuild their roles/relations with designers in the design process (Hartswood et al. 2003).

A range of empirical implementation studies have been conducted to demonstrate the importance of local knowledge and practices in the development of generic information systems, such as the implementation of CAMP (Schumm and Kocyba 1994), medical protocols and records (Hartswood et al. 2003; Hartswood et al. 2002; Timmermans and Berg 1997) and system infrastructure (Hanseth and Braa 2001).

Suchman's claims indeed contribute to our understanding of software packages and information system design in general; she suggests that users are also responsible and effectively contribute to the construction of universal technology, both symbolically and literally, in their reading of texts embedded in the generic system and in their articulation work. The localised universality perspective, however, overemphasises the local implementations and gives too little explanation to the construction of generic technology. If we accept this view, how can we explain the existence of generic information systems, and technology in general, which is designed for a range of user organisations, or its diffusion in the software market?

2.3.4 Distributed innovation and multiple cycles

In this section, we argue that the challenges and design dilemmas that are raised by the advancement of modern ICT have broken the conventional system life-cycle sequences and challenged the user requirement- and local uniqueness-centred analysis in general.

Today, the development of ICTs, like OSPs, hardly starts from scratch (Stewart and Williams 2002); instead these technologies are comprised of arrays of standard elements or components, socially and technically mediated relations and informational and physical linkages, loosely coupled with a lack of systematicity within a single framework. In principle, such a nature should increase the flexibility of technology and improve its potential to match technological capabilities and user requirements, since its final shape is formed by the particular requirements of the user organisations.

In this context, the related artefact is not a completed product in the supplier firms. In this sense, user involvement during the implementation stage is a critical part of the development. The traditional life-cycle development has thus been broken into at least two visible parts (Fleck 1992). The first part, the prior design, is located in supplier firms and is concerned with constructing the generic functionality that addresses a range of alternative ‘requirements’. The second one is located in the user firms and seeks to configure a purchased generic product to their specific structures and processes. Furthermore, the feedback and local innovation from each individual user organisation contribute to the supplier side of product innovation and are used for new development which could impact on other user organisations. As a result, the design and development of such technology are distributed in terms of both time and location. It is a multiple innovation cycle.

Another problem of the user requirements capture perspective on the development of generic information system centres upon the number of user organisations to which suppliers must cater. Most existing user requirements studies were conducted in a context in which the supplier deals with only a single user organisation's needs by providing a customised solution. The construction of generic functionalities for configurational technology such as OSPs has, however, indicated that a large number of organisations' needs must to be taken into account. The important question regards whose requirements should be added into the generic functionalities and whose requirements should not. The settlement of this dilemma cannot be explained using the system life-cycle approach.

These points highlight the limitations and difficulties of using traditional perspectives in information systems design. The concepts and analytical notions we deployed from SST, as demonstrated in 2.2, however, are better suited to capture the distributed location and related complexity, because from an analytical perspective, they assess a product's accumulated history, with an emphasis on continuity. As highlighted by SST, the adaptation of technology is also a very important stage of technology development. Although the implementation and use of OSPs is not the focus of our study, as noted in each chapter's introduction, we feel it is necessary to acknowledge how OSP user organisations influence the features of OSPs through adaptation, as this influence represents an important part of the knowledge we need to understand the supplier's innovation process, if we perceive that innovation to be achieved through a coupling process. Thus, the next section is devoted to reviewing this part of the literature.

2.4 ORGANISATIONAL SOFTWARE PACKAGES

2.4.1 The features, origins and embedded philosophy of OSPs

OSPs are a type of large, complex, integrated generic information system that is designed to meet a group of user organisations' needs. The origin of OSPs can be traced back to the 1980s' development of computer-aided production management (CAPM) in the manufacturing industry for the purpose of integrating disparate business activities, which was introduced for production planning by the Americans during the 1960s and later extended into other industries (Clausen and Williams 1997; Fleck 1992). Similar to the characteristics of contemporary ICT, OSPs are made up of a number of complementary generic or semi-generic applications/software solutions that are based on the same architecture and share the same development platform, loosely coupled together (D'Adderio 2004; Kallinikos 2004; Koch 2001; Pollock et al. 2007; Sportt 2000). Each application supports specific tasks and functions of a business. The OSP is specifically designed to facilitate the integration of the discrete activities of firms which normally operate individually, by providing integrated transaction processing models (D'Adderio 2004; Davenport 1998; Fleck 1992; Kumar and Hillegersberg 2000; O'leary 2000). A certain amount of generic choices are also embedded in each function. Among these widely known applications are enterprise resource planning (ERP) and product data management (PDM) software. The latter, PDM, is the core subject of this study.

The demand for those large generic information system applications showed extensive growth in the 1980s due to a range of reasons, for instance, financial factors (a cheaper price), and operative concerns, such as a lack of the IT expertise and knowledge resources inside business organisations which are required in order to develop customised information systems. More importantly, however, this demand was also caused by the views of the adoptive user organisations on the use of OSPs for the implementation of the business process reengineering (BPR) strategy, as well as their interest in the opportunity to update their working routines according to their industry's best practice (Avgerou 2003; D'Adderio 2004). These perspectives can be seen as results of the push from business consultants for the adaptation of the BRR, as well as that from software vendors promoting their products as the 'best practice'.

The BPR is a management concept that was originally developed in the USA (Davenport 1993, 1998; Davenport and Short 1990; Davenport and Stoddard 1994;

Hammer 1990; Hammer and Champy 1993; Hammer and Stanton 1995) with the aim of achieving the integration of business functionalities through radical change. It is generally promoted with alignment of the use of IT (information technology). The assumption is that IT with cross-cutting functionality, such as OSPs, could facilitate organisations' achievement of the goals of the BPR (Koch 2001).

The generic solution that is embedded in OSPs has also been portrayed as the best practice of the application industry by the software vendors. As explained by suppliers, the rationale behind the embedded routines is the integration of a range of local user organisations' best working practices, and as a product, it had been tested in different user organisations through implementation. Hence, compared with the customised solution, it in principle provides broader functionality with better related working practices and should also reduce the risk of failure. Parallel to the promotion of OSPs in industry, in some of the literature on management change, OSPs were promoted as the best tool/enabler to improve organisational productivity through the use of the 'best practice' business models (Davenport 1998; Davenport and Short 1990; O'leary 2000) in the management and organisational change literature from the 1990s through today. As O'Leary claims:

> *'……Thus ERP can be used to help firms create value. In particular, ERP facilitates value creation by changing the basic nature of organisations in a number of different ways. ERP integrates firm Activities…… ERP employs use of 'best practices'…… ERP enables organisations standardisation…… '*
>
> O'Leary (2000; p.7)

2.4.2 The adaptation of OSPs

There are several ways to adapt OSPs. Firstly, as claimed by most OSP supplier vendors, user organisations can tailor the system by choosing the ones they want from the given generic functionality. The exercise of choices is known as configuration or customisation, and in theory this allows OSP features to be maximally configured in order to meet local user requirements (Kallinikos 2004; Koch 2001; O'leary 2000) by choosing modularised functions and working routine templates. Alternatively, user organisations can change their working practices to fit into the generic solutions that are provided by the suppliers. Having said this, in practice, as stated by some scholars (Avgerou 2003; D'Adderio 2004; Davenport 1998), the OSPs are so complex that major modifications subject to the particular needs of the user companies are impractical. There are also other reasons for this impracticality, such as the fact that large-scale customisation of the generic solution could lead to the danger of losing technical support from the supplier (Tierney and Williams 1990). As a result, rather than reconfigure every aspect of the standardised system, organisations simply accept those 'default' features. This quality has been named 'the power of default' (Koch 1999). To this end, most user organisations carry out internal organisational changes based on the 'best practice' that is provided by the standard software package. As a result of its perceived superiority as the 'best practice', the implementation of such an integrated system is generally followed by a substantial push towards 're-engineering' the organisations (Koch 2001).

In the 1980s, the increasing pace of the diffusion of OSPs revealed a range of problems. A large amount of empirical evidence which was obtained from the industry around the 1980s and 1990s has shown that a large number of companies experienced disastrous or nearly disastrous experiences in the implementation stage. This indicates that the adaptation of OSPs is problematic and that the delivery of such a generic system to achieve business success is not always satisfactory.

The related explanations of such failures have been well documented. In principle, as claimed by Hobday, the large complex information system, due to its sophistication, requires a depth and breadth of knowledge and skills from the local experts and thus normally tends to be produced in one-off projects (Hobday 1998, 2000). OSPs, however, are designed for a mass market, rather than any specific user. From the knowledge perspective, therefore, some scholars claim that the standard package contains codified knowledge and is for this reason difficult to use, lacking familiarity with the tacit knowledge that is only embedded in the local context and comes from local expertise and daily practice (Hobday 1998, 2000; Newell et al. 2000). A great body of management studies also emerged to investigate the failure of this implementation. In summary, the failure of OSPs has been seen as the mis-fit between the generic functionality that is provided by a software vender and the locally specific user organisations' context and working practices (Davenport 1998;

Lucas et al. 1988; Soh 2000). Generally, mis-fits arise either from company-specific or country-specific requirements that do not match the generic 'best practice' that is provided by the standard software package.

In additional to the mis-fit, the management and organisational change literature highlight the crucial importance of organisations' internal implementation and change management to the OSPs' successful delivery. As a solution, they suggest that before the implementation of these systems, organisations should first have a clear understanding of the system's full implications for their business (Davenport 1998). A range of success factors and implementation strategies for OSPs projects have been investigated and identified. The studies have drawn on different sets of strategies throughout the several stages of the implementation process, such as pre-implementation, implementation, and post-implementation (Aladwani 2001; Davenport 1993; Davenport and Short 1990; Leonard-B and Kraus 1985; Lucas et al. 1988; O'leary 2000; Swanson 1988; Zhang et al. 2002).

We argue that regarding the adaptation of OSPs, the views of management and organisational change literature created an image of suppliers as simply clever, such that the generic solution could easily be developed on the basis of their assumptions and beliefs. From their point of view, the generic solution has been taken for granted, and user organisations have had to adapt themselves to fit the standard solutions without having a real choice on the matter.

The embedded assumptions and beliefs about users and use inside the package could indeed impact on the shaping of organisations and their related operational processes by providing a pre-defined framework. There is enough evidence, however, which can be used to demonstrate that not all users will follow the orders and rules that are provided by OSPs. In contrast to management and organisational change literature, there is another body of research that has been conducted to investigate the sociology of OSPs' implementation and adaptation. The notion of 'work around' has been used in several studies to show how user organisations are able to adjust a computer to meet their particular needs, even after the acceptance of the script of designers, aiming to regain the control from the technology (Gassder 1986; Pollock 2001; Pollock and Cornford 2004). As demonstrated in their study, technologies have to be 'tamed' or 'domesticated' to fit into a concrete local routine and context. Such activity involves a range of symbolic and practical work in which users integrate the artefact into their user practices and cognitive processes (Lie and Sørensen 1996). It will also impact on the shaping of designers' assumptions and, as a result, on the influencing of the development of the generic solution. By emphasising the co-evolution between technology and organisation, D'Addero's (2004) study provides substantial empirical detail as to how the introduction process of a software package changes the user organisation's capability. This occurs by knowledge acquisition, cognitive problem solving, learning and innovating, and in turn influences the features of software packages by providing feedback to software firms. These empirical evidences demonstrate that OSP development indeed is a coupling and mutually shaping process in which there is an interaction between supplier and user organisations across different locations.

2.5 SUMMARY

It is clear that there is a gulf between the generic solution and the locally specific user organisations' practice, as pointed out by implementation studies. This gap then begs the question, how do the suppliers construct a universal package in the first place? How do the suppliers manage the tensions between the need for standardisation, in order to achieve the economic imperative, and the need to meet local organisations' requirements? How do they decide which user organisations' needs should be catered for? And how do they make the solution work in different organisations? The answers to these questions are beyond the explanatory capacity of a traditional system design perspective in the sense that to answer them requires an ability to move between the low level of designers' and users' relations and a strategic level and finally to explore OSP suppliers' strategies regarding the management of their dynamic relationships with a range of user organisations.

In contrast to customised system development, the practice of OSP development is located in at least two spaces; one is in a supplier firm; another is in the user organisations' space during the local configuring and implementation phase. As demonstrated in sociological accounts of OSP implementation and domestication studies, user organisations also engage the development of the generic solution in their own way. Therefore there is a complex interaction between suppliers and user organisations that shapes the generic solution, even after sales and implementation. This interaction indicates that a study of the construction of the generic solution which focuses on suppliers must also take into account the impacts of users' organisations, as well as perceive design and development as an evolutionary process, thus avoiding a narrow and static view of design.

From an analytical perspective, rather than assuming the simplicity of design and development, we need a broader view that problematises the development process of OSPs, in order to capture the multiple locations of the generic solution development, as well as suppliers' approaches to dealing with vast user organisational requirements. By drawing upon SST, we hope to reveal and unfold the complex process of the software package's evolution. In the body of this chapter, we have reviewed the intellectual tradition of SST, several concepts and studies that are related to our research on the development of a generic solution. We chose to use the TT model to provide the main frame for our research, in order to explain the interrelations and interactions between actors and embedded structures over time, and we will discuss this in detail in chapter three. This model enables us to understand the specific features of the Chinese development process, and furthermore, by deploying the concept of 'social learning', we can see the development of OSPs as one arena of a complex technology innovation process, as well as an interactive learning process characterised by dynamic negotiations and subject to conflict and interest. The concept of the 'biography of the software package' helps us to identify the continuity of the OSPs' design and development by tracing their 'accumulated history'. Equally important, the associated empirical evidences that have been yielded from past SST research have raised potential concerns and considerations to which this study should pay attention.

Part two of the thesis is a case study, in which we shall explore the story of the construction of a Chinese software package, in China, to reveal a different development narrative of a generic information system. Before moving into this narrative, in the next chapter, the methodology and methods adopted for the purposes of this research will be discussed.

Chapter Three

Methodology and Research Design

3.1 INTRODUCTION

… Many arrows, loosed several ways,
Fly to one mark …

(William Shakespeare, Henry V)

There is no definitive construction of the social research process, but merely a framework (Crotty 1998). Research design provides a framework for achieving research objectives. It can be characterised as a process of making choices about how to achieve the research aims, and each choice represents the researcher's particular interests, beliefs and purposes.

Our research on the construction of OSPs is largely inspired by the tradition of SST. The SST's detailed examination of the contents of a technology and its context has well served the research objectives undergirding it, namely, the opening up of the black box of technology. The distinctive combination of a reconstruction of social processes around particular technologies with sociological actor-based analyses marks the case study method of the social shaping approach which has informed our study. The purpose of this chapter is to justify our choices regarding the conducting of this research and to explain how these choices have been applied.

This chapter is divided into four sections. It starts by explaining the choice of research strategy, as well as the related framework, methodology and design. In the second section, we shall discuss the data collection methods that have been adopted and the process of collection. This is followed by the data analysis section, in which we present both the techniques and process of analysis that are deployed in this study. The conclusion draws the chapter to a close.

3.2 RESEARCH STRATEGY AND DESIGN

3.2.1 Framework and methodology

In this research, we use a deductive strategy which uses as a starting point some regularity which has been discovered, following this with formulations of possible theoretical explanations and/or frameworks, and aims to explain some social phenomenon that researchers are trying to understand (Blaikie 2000; Gilbert 2003). The theoretical framework, or what Remenyi et al. (2000) calls the 'theoretical conjecture', serves as a guideline for empirical study, and it is gradually refined as the empirical research develops.

We share with many other SST scholars the desire to systematically link detailed explorations in the social shaping of software packages with the socio-historical development of practices. From an epistemological angle, SST follows the traditions of constructionism, according to which human knowledge and related meanings are not simply objective truths waiting to be discovered, but rather they are constructed socially. In this sense, the world is a subjectively-based reality that takes account of the meanings people give to their activities, meanings which are, in turn, influenced by their contexts and environments. As discussed in chapter two, SST addresses technological development as a heterogeneous and dispersed process. The action, reaction and interaction are dispersed over time and space and are framed by different cultures and the constraints of economic and political structures. This belief and philosophical understanding has been characterised as interpretative social science, which stands as the opposite of positivist social science perspectives, which view reality as comprised of purely objective and tangible facts and seeks to explain those 'facts' by testing the correlations between them (Silverman 1993).

By drawing upon the concepts and related literature of the SST perspective, we adopt a double methodological framework. On one hand, this methodology addresses the influence of the broader structural and contextual factors upon a pattern of innovation. On the other hand, it seeks to explain the detailed content of the technological development process, through an approach made possible by actor-centred approaches at the micro-level. As indicated in chapter two, the features of such a framework are guided by the technology transition (TT) model (Geels 2002, 2004, 2005; Kemp et al. 1998; Rip and Kemp 1998; Rip et al. 1995).

As indicated in the following picture, the technological transition model developed three analytical levels to demonstrate how a technological system changes through the interaction of actors, structures and rules. The different levels are not ontological descriptions of reality; rather they are analytical tools to help us understand the complex dynamics of socio-technical change (Geels 2005). The relationship between these three conceptual levels can be understood as a nested hierarchy.

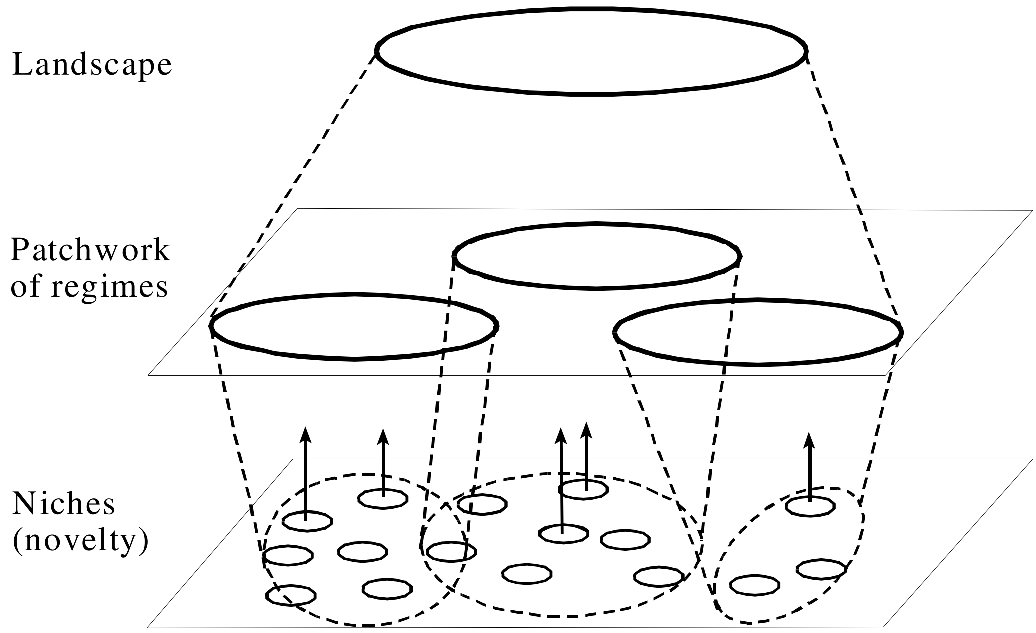

Figure 2: Technology transition model (Rip and Kemp 1998)

Several phases are distinguished within the technological change process by the interaction among these three levels (Rip and Kemp 1998): *The first stage*, the TT, includes niches that were created under pressure from the landscape and regime levels. Radical innovation is created in niches, often outside the existing regime. This level is characterised by instability and fragility. The emergence of niches is strongly influenced by existing regimes and landscapes. In this stage, early innovation does not have a strong impact on regimes. In *the second stage*, new innovations and related development rules begin to be created and stabilised (dominant design). TT emphasises that there is neither a critical challenge nor threat to the existing regime as long as it is stable. In *the third stage*, the accumulated new technological capabilities created at the niches level bring the breakthrough of the new technology, as well as competition with the established regime. Additionally, TT stresses that the breakthrough from a niche to a regime level does not take place immediately, but rather through a sequence of steps. Finally, as a result of regimes changing, the landscape will be influenced and transformed.

With respect to the study of the construction of a generic solution in China, this model indicates that the recent landscape changes in China, such as socio-economic reform and other large institutional shifts, could impact on the innovation patterns which emerge from niches, such as the forms of learning mechanisms and intermediaries. The Chinese landscape is deeply marked by uncertainty, as the nation is in the middle of transition from a centrally controlled system to a social market economy, while facing the multiple opportunities and challenges brought by accession to the WTO. Furthermore, the Chinese socio-technical regimes are also weak in the sense that a range of general rules and guidelines are still under construction. Similar to the state of China's economic system, the old socio-technical regimes were not completely destroyed, and the new regimes are still uncompleted. The old and new co-exist at the same time. In such a context, at the niche level, the software supplier, user organisations and other social groups involved in development, as well as their choices, interests, and expectations regarding the shaping of the generic solution, could differ from those that are conceptualised in developed countries, since the selection environment of the niches could have strongly Chinese characteristics.

Applying the framework of the TT model, in order to capture the dynamics and continuity of a software package's development, we use a combination of *longitudinal and contextual* analysis. In his work on longitudinal field research on change, Pettigrew calls such an approach 'the contextualist analysis of change' process (Pettigrew 1990). He says,

> ‘A contextualist analysis of a process, such as change, draws on phenomena at vertical and horizontal levels of analysis and the interconnections between those levels through time. The vertical level refers to interdependences between higher or lower levels of analysis upon phenomena to explain at some further level; for example, the impact of a changing socioeconomic context on features of intra-organisational context and interest-group behaviour. The horizontal level refers to the sequential interconnectedness among phenomena in historical, present, and future time…’ (p. 269)

Vertically, following the approach of ‘social learning’, we are concerned with the design arena of OSPs at a particular time. Inside such a space, we focus on the suppliers’ interests, development strategies and approaches, in connection with the features of the artefact, through interactions with other social groups, such as user organisations. *Horizontally*, following the notion of biography, we trace and reconstruct the ‘accumulated history’ of the software package, noticing the changes of suppliers’ and other actors’ actions and interactions inside an arena and over time, as the package evolves.

3.2.2 Case study with multi-time dimension

Our longitudinal and contextual investigation of the construction of OSPs was designed and carried out in the rich tradition of case studies, through the social shaping approach and with a multi-time dimension. The method of the case study has been characterised by intensive examination of subject matter in its context (Yin 1994), and it is believed to be particularly appropriate for exploratory work and answering ‘why’ and ‘how’ questions. This method allows others to see the world through the researcher’s eyes, and in the process, to reveal things we otherwise might not have seen (Donmoyer 2000).

Generalisability and time scale

Traditionally, there are two key debates centring upon the deployment of the case study: its generalisability and its time scale. How to deal with the tension between the number of the cases and the depth of each case is always seen as a challenge for social researchers who chose to use the case study approach.

In relation to quantity of data, the case study has often been criticised on the grounds that it is not useful for generalisation of the findings, especially in comparison with those of survey research (Blaikie 2000; Gomm et al. 2000; Yin 1994). Many social scientists have written about case studies as if, intrinsically, the study of a particular case is not as important as studies that obtain generalisations pertaining to a wider population of cases (Stake 1998). From this perspective, some criticisms assert that, unlike surveys, case studies can not draw inferences about features of a large but finite population of cases from the study of a sample drawn from that population (Gomm(1) et al. 2000). In response to these criticisms, some case study researchers argue that their work is not designed to produce scientific generalisations of narrow statistical meaning; instead, case studies should enable 'logical inference' or 'analytic generalisation' such that the uniqueness of situations and cases should be valued (Donmoyer 2000; Gomm et al. 2000; Lincoln and Guba 2000; Stake 1998; Yin 1994).

Initially, in the conducting of this research, acknowledging the issue of the scope of the case study approach led to the creation of a conventional case design, which was carried out in such a way as to allow explicit comparisons. Two alternative solutions were initialised, in order to examine two different packages' development in the same countries, or even to conduct national comparisons between, for instance, the UK and China. For the latter case, four software packages had to be selected. During early pilot studies that were conducted in China, the strategy of comparison between case studies was shifted towards that of the in-depth single case study. This shift was mainly caused by the great availability of access to one of the Chinese suppliers and relatively poor access to another supplier. Still following the original plan, in order to maintain the validity of comparison, conducting two case studies meant that less detailed investigations were required. Furthermore, due to a lack of access in the UK, making an in-depth cross-country comparison was less practical.

In respect to the objective of extending the existing SST concepts generalised from 'thick description' (Russell and Williams 2002, p. 88), the great access that was gained to the single supplier and our own preferences and beliefs, the choice was made to conduct in-depth 'thick description' through a single case study. We believe that even a single study, if well analysed, can provide rich insights toward understanding similar cases and conditions. Such a study could provide an explanation about why a choice is made at a particular time and place and thus why it leads to particular result. In this respect, this research approach will be more useful to achieve the research objective of understanding how a particular package has been created.

The second issue specific to the case study approach is the time scale. Our single case study includes both historical and contemporary perspectives, such that we enter an ongoing process and work in both directions: to rebuild the past and to explore the current life context. As Yin (Yin 1994) notes, a case study is generally used to investigate a contemporary phenomenon in its real-life context, and it is frequently compared with the subject matter of history (p. 13). Social shaping studies, however, have developed as an interdisciplinary field in which history is an integral part. For example, contextual historians of technology have pioneered the documentation of specific instances of technologies in close relation to their social contexts (Geels 2005; Hughes 1999, 2001), while SSK, as a major inspiration for the perspective of SST, was itself founded on the accumulation of historical case studies. It seems that the time scale of the case study reflects the researcher's judgment on the adequacy of factors to be included and the appropriate time span needed to understand them. By exploring both past and current events, we hope to gain a greater depth of understanding about the construction of OSPs. In relation to time scale, a case study that examines, as ours does, both the past and the contemporary context is not new. In his study of uses of innovation, Hyysalo (2004) used a similar case study approach, in which longitudinal analysis and ethnography were deployed together, in order to explore a lengthy innovation process which lasted from 1980 to 2003. He argues that the aim of such a study is not to examine the development of a particular technology as such, but to elaborate the more general dynamics and historical developments which are present in it.

The selection of the case

In our research, the methodological approach of a single case study with multiple units of analysis has been selected. But what is a case? A case may be an individual, an event or an entity (Yin 1994). In the research on the development of OSPs, the primary meaning of a single case is the all-encompassing story of the development of the generic solution, situated in its context and history. Following notions of 'social learning' (Williams et al. 2005) and the 'development arena' (Jorgensen and Sorensen 2002), the unit of analysis is the design arena, which includes a number of elements such as artefacts, suppliers, users and other social groups, and is located in various places and spaces with related interests. Due to our research interests, we give particular attention to the supplier's interests.

We selected a Chinese PDM software package which is designed for the Chinese construction industry by a domestic supplier in China. The selection of such a bundle of elements and objects is influenced by the extremely dynamic complexity and uniqueness of this arena. Furthermore, as we had discussed in chapter one, in order to contribute to SST, which lacks empirical research conducted in developing countries, the location of our research has been selected as China, a fascinating country experiencing a range of transitions, from local to global, from social to market economy, from passive receiver of technology to technological leader in some fields.

We believe that such an in-depth case study will not only enhance our understanding of the design and development of OSPs, but also broaden the field of SST by extending its study location into a totally different place: China. To summarise, the entire single case study, with time scale and unit analysis, is demonstrated in the following diagram:

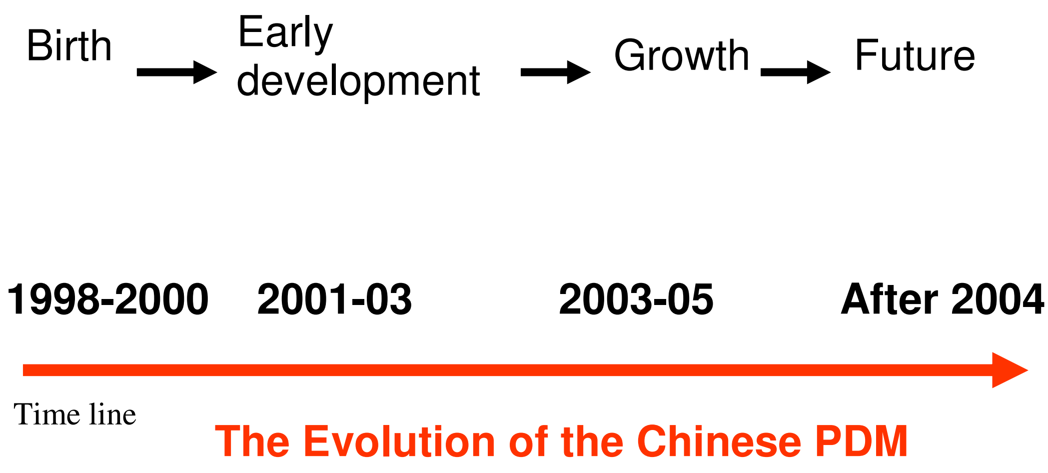

Figure 3: The evolution of the Chinese PDM

3.3 SOURCES OF DATA

For a case study, there are several data collection methods that can be used, such as documentation, interviews, archival records, direct observation, participative observation and physical artefacts (Blaikie 2000; Yin 1994). Following the recommendation of Yin on the use of multiple sources of evidence, we use a triangulation approach, whereby the primary sources are interviews, complemented with documentation and observation (Blaikie 2000; Yin 1994). We believe such a combination helps us to gain a greater depth of understanding of the construction of OSPs. As stated in Hyysalo's work (Hyysalo 2004), longitudinal analysis' focus on the very recent past allows the creation, through interviews, of new detail-rich historical data, and ethnographic observations offer a good data gathering method, as well as a way to gain a better contextual understanding of both the past and current situations. Furthermore, being physically present on many occasions allows one to gather related documents and ask specific questions. In the following part, we justify our choices of these methods.

3.3.1 Semi-structured interviews – The primary source

As Rubin and Rubin say:

‘*Qualitative interviewing is both an academic and practical tool. It allows us to share the world of others to find out what is going on, why people do what they do, and how they understand their worlds*.’

(Rubin and Rubin 2004)

The decision to use semi-structured interviews as the main data collection method is based on the specific characteristics of this research. This choice primarily relates to the nature of the questions which needed be asked in order to address our research objectives; such questions involve some highly sensitive and in some cases confidential aspects, including, for example, the company’s technical, marketing and price strategies. In such a situation, Easterby (Easterby et al. 1991) recommends semi-structured interviews, as they allow the researcher to build a rapport with the respondents, thereby reducing their reluctance to respond openly. Semi-structured interviews also allow the researcher to manage the interview more easily. It provides a structure that researchers can follow and, at the same time, gives researchers enough flexibility to expand interview content.

Interview design

In total, twenty-five formal interviews were conducted during two field research trips between 2004 and 2005. This number does not include the early pilot interviews, daily conversations with the LZ employees nor informal chats (unstructured interviews). These are presented in more detail in the following table:

Interviewed people	**Related questions**	**Interviewees**	**Interviews**	**Length (per interview)**
CTO (Chief technical officer /founder of LZ)	Strategies and development style	1	4	40 mins
CMO (Chief marketing officer / founder of LZ	Strategies and development style	1	3	1 hr
CSO (Chief solutions officer) / founder of LZ	Configuring users and use	1	1	40 mins
Business solutions manager	Standard development and the CEEDI case	1	3	1 hr

Standard development team members	Standard development and the CEEDI case	2	5	30 mins
Current technical manager / former design team members	The detailed development stories	4	5	1 and a half hrs
Others from outside the firms (university, government, user organisations)	OSPs and standard development	3	4	1 and a half hrs
Total		**13**	**25**	

Table 1: Interviews conducted for the study

On the basis of the literature review and our theoretical framework, the interviews are organised in four phases with different topic themes and question guides throughout the evolution of a software package. The interview topic themes and guides were defined in terms of an exciting scenario which could develop at each stage. The detailed content is presented below:

Table 2: Interview content

Biography of OSPs	**Interview themes**	**Question guide**
Pre-birth and birth	Background and initial concept	What has motivated them to develop such software? Why? Where did they gain the insights about users and use that allow them to formulate early concepts of the generic solution?
Early development	The development strategies and approaches	How did they develop the features of the early OSPs? What were their strategies and approaches? How did designers construct the representation of users and use? Do any networks exist? What is the role of the supplier inside such networks? And the supplier's influences on the features of package?
Growth	The development strategies and the related changes	What was the development style, in relation to the construction of the representation of users and use at this stage? In particular, how did the suppliers deal with customising requirements from user organisations at this stage? Have the development style and strategies changed? If so, what are those changes?
Future	The direction of future development	How did the supplier make the package work in other domains?

All interviews were tape-recorded, except for some informal interviews which were not planned. The content in these cases was written down immediately afterwards. To ensure the validity of the interview, the transcripts were sent to respondents within three days of the interview. Meanwhile, the information obtained from the interviews was checked, when possible, with the data gathered through documentation and with the data provided by other interviewees.

The process -- An iterative learning

The whole interviewing process is an iterative one. The interview guide and detailed questions were progressively refined during the research process.

- **Pilot interviews**

Before embarking upon my trip to China, four pilot telephone interviews were conducted with each case supplier company in July of 2004. These interviews were intended, firstly, to identify the companies' suitability for the study and the possibilities of conducting the planned data collection methods. Secondly, the interviews tested the usability of the sequence and the scope of the interview guide which was identified in the early research proposal. Thirdly, this process offered a good opportunity to practice interview skills.

The pilot interview questions were developed based upon the early literature review. The questions were split into two main sections. The first part included questions about the nature of a company's product and then followed with questions about the design process. The second part of the interview mainly related to the identification of possible people and organisations which could be accessed, as well as other data collection methods (in addition to the interview).

- **Formal interview process**

The interviewing process was not a smooth one. While a structured interview approach was adopted initially, during the data collection phase it was felt that a more flexible approach was necessary, because a flexible approach could allow the researcher to capture the meanings that interviewees associate with the concepts involved, such as generic designs, configurations, standards, etc. For instance, in the PDM case, it is far more complicated to use structured interview questions and apply them to all respondents, due to their different areas of activities.

This problem appeared during the first attempt at data collection in the field, rather than during the testing stage/pilot interview, due to two reasons, the first being that the researcher's own experience in interviewing techniques and confidence in her abilities to conduct the interviews grew. The second reason relates to knowledge building; as data was gathered and analysis proceeded, the researcher's understanding of the phenomenon increased. The initial interview questions, for instance, were developed according to a preconceived clear path of development of an artefact (moving from concept to generic model and then to implementation). The feedback from one of the respondents was: '*In practice there is no clear division between each stage. I don't understand what you mean by the design of the generic model in the first user context. This software was not built in a night; instead the functions of this software were gradually developed each time important users influenced our product.*' In this case, the researcher began to obtain important information which challenged her initial assumptions. She accordingly refined her next interview questions.

For these reasons, and following the recommendations of Hussey and Hussey (1997) as to situations in which a step-by-step logic of the situation is not clear, the relevant interview was changed to a more loosely structured format, with only a few topical questions, so that it followed an open-ended format. Additionally, some of the questions that had been asked to all respondents were subsequently filtered according to the individual's background and his or her role in the PDM development project.

The PDM case interviews were conducted first on 15 October 2004, the second day after arrival in Beijing. In the first few days, three top management members from the technical development and marketing departments were interviewed regarding their work and responsibilities in the company. These early interviews can be characterised as interviews about the general history of this company and the general background of the PDM system development (what motivated them to develop such a system, and why, as well as the general PDM innovation process, etc).

The next round of interviews started on 20 October 2004. Four interviews with individual designers were conducted, mainly with the core system developers who were directly involved in the PDM design. These interviews addressed the general topic of their roles and experiences in the history of the PDM project, and more specifically, the detailed development process of the generic features of the PDM and its implementation in the user context. The interview responses have thus provided a detailed picture of the evolution of the PDM, from a supplier perspective.

Interviews regarding interactions with users and general implementation problems, as well as their approaches to these issues, were asked to LZ top management members, four system developers and a staff member from the implementation department who was in charge of several implementation projects. These interviews yielded data on the supplier's problems which were caused by local user organisations' requirements, as well as the supplier's approaches to dealing with them. Another round of interviews, meanwhile, was conducted in order to collect data on the development of standardisation and its impact on the shaping of the package. The CTO, the standard development manager, and two team members involved in this process were interviewed. Furthermore, in order to fully understand the phenomenon of standard development, external groups such as university and government administrators, who were part of the standardising team, were also interviewed.

The first field interview schedule was finished within one month. Some of the collected data were translated into English, and a research report was produced as the summary of the first trip. Several intensive meetings were conducted to discuss the findings and future direction of the research project. The second field research trip began in early 2005. In this trip, the main focus was to explore the supplier's present development strategies and future product development directions, as well as the birth stage, for which the researcher did not collect enough data in the first trip. Three interviews with top management personnel were conducted in order to gather data on the birth of the package, as well as their own strategies for new product developments and related issues regarding the representation of users and use. Additionally, another three formal interviews with a technical team leader and a manager from solutions development were conducted in order to collect specific data related to a particular development project (CEEDI) that was ongoing and which the researcher herself experienced as part of the process alongside local employees.

3.3.2 Documentation

Following Remenyi (2000), documentation was used to set the context for the interviews. At the same time, documentation served to increase interview reliability by triangulating the data sources (Yin 1994). Document collection in the project included both a systematic inquiry to locate and obtain documents regarding the past, as well as the careful filing of all the documentation that was related to current affairs and the researcher's own field notes. In this case, the company product description, business plan, technical development strategy report, project documentation, and any published conference paper, etc., were collected and studied. The primary types of documents include the following:

- **Functional descriptions of the PDM package, 2002-2004**

There are three distinct documents, in total more than 100 pages, that systematically present the features and functionality of the PDM at each of its developmental stages. The first one was produced in early 2001, and the second was drafted in early 2004 for the third version of the PDM. The last document was produced for the government's evaluation of the result of national construction research and development projects, since the development of the PDM was also identified by the Chinese government as one of the national technology development projects in 2003. The third document was produced on 2 April 2004 and consists of sixty pages. It provides detailed descriptions of the version and features of the LZ PDM version three as well as comparisons with other similar software packages both in and outside of China.

- **Software demo**

In order to fully understand the functionality of PDM, the software demo was required, so that researchers could use the package directly.

- **Design report**

This is a twenty-five page design report with a technical focus which was produced on 30 December 2002. It outlines the technical principles behind the building of the PDM and provides data resources on the architecture, package design logics and references which were deployed by the supplier LZ to provide generic choices to user organisations.

- **User requirement analyses and reports**

More than ten user requirement analyses and reports were collected from user organisations. Some of them directly relate to later individual development projects. These analyses and reports record the problems of user organisations that the supplier identified, as well as related solutions that were based on the configuring of the supplier software. In particular, in response to the case of the CEEDI (Chinese Electrical and Engineering Design Institute), the detailed analyses and solutions were well documented.

- **Standards, related meeting records and conference proceedings**

Six versions of the industrial software standard were collected according to its time sequences. Conference proceedings related to the standardisation of the construction software package were published by the Chinese Architecture & Building Press. The evolution of the content and the related meeting records indicate the supplier's struggles and its strategies for generalising the generic features of the PDM software package itself. The conference proceedings were used to better understand the building of the technological regime.

- **The company achievement articles**

One company publicity handbook and a range of articles on product development and new R&D (research and development) in the public sectors were collected from both external newspapers and company websites. The handbook was used as a time line on which to trace the exciting moments of company growth. Other articles were limited to addressing how the company had sought and manipulated publicity in order to construct concepts of the new technology.

- **The company website**

The company website provided information on the description of products, the implementation story and related new product development directions.

- **The government official policies**

Three related official policies were gathered. They are *'Decision to accelerate the development of science and technology'* which was announced by the Chinese Communist Party Central Committee and the State Council in May 1995*, 'The development plan for the informatization of the construction engineering investigation and design sector for 2000-2005*' and '*Decision on the reform of the state owned enterprises (SOEs).* These documents were used to explore the motivations behind, and the early conceptual stages of, the PDM.

3.3.3 Direct observation

Ethnographic observation varies according to the extent of the researcher's involvement. It ranges between two extremes: on one hand, the researcher adopts a functional role and participates in the events being studied; on the other, the researcher adopts the role of spectator, uninvolved with the surrounding environment (Yin 1994). The latter approach is adopted in this study.

Ethnographic observation

It was impossible, however, to be completely uninvolved, since the researcher was placed in the company, alongside the solution department employees on a daily basis, from 9am to 5pm, for more than three months. This observation was mainly used to collect data related to the case of the CEEDI during the growth stage of the PDM, on the second field trip. The department in which the researcher was located is a space in which top management, development teams and the solutions department interact. In this context, the important internal strategies regarding response to user organisations' requirements at a particular developmental stage were captured through the researcher's participation in development meetings, solution trainings and project discussions, as well as daily conversations. Inside this space, the researcher felt the tensions and struggles of the supplier, through observation of employees' daily work and life. Furthermore, being Chinese and having grown up in China enabled the researcher to perceive the broader context and related issues from a privileged angle.

- **Three development meetings**

Three development meetings were attended. The first meeting related to the latest version of the PDM and its related technical advancements. The second and third meetings addressed the construction the CEEDI user requirement analysis and the drafting of user solutions in general. These meetings enhanced our understanding of the supplier's development strategies during the growth stage, which was further supported by the early interviews and discussions with top management personnel and the employees from the implementation and solutions departments.

- **Dialogue data**

Dialogue was produced from recordings of employee conversations. This data was used to document the supplier's frustrations, which were caused by the generic requirements of the CEEDI.

Great attention was paid to the issues of privacy and ethics for all informants, as well as the data collected from these interviews. Permission was obtained for recording each interview and using the resulting data for the construction of the research thesis. In some management meetings, recordings were not allowed, but in these cases, it was permitted to take notes.

As a measure of protecting interviewees' privacy, confidentiality was guaranteed. Bailey (1996) clarifies the distinction between confidentiality and anonymity as follows: when anonymity is guaranteed to participants, this means the reader is not able to identify such individuals, while a confidential study allows the researcher access to identity of the participants but does not reveal these identities to others. In this particular case study, the *names* of the participants are confidential, but their positions within departments and/or units are revealed, and thus strict confidentiality of their *identities* is not possible.'

3.4 DATA ANALYSIS

3.4.1 The process

As suggested by Blaikie, data analysis normally follows three steps (Blaikie 2000):
(1) Description: This first step mainly addresses the context and thus produces descriptions of the facts, activities, actors and processes being studied.
(2) Classification (coding/analysis): During this second step, the data is assigned to categories and sub-categories.
(3) Connection: Finally, relationships are established between these categories and sub-categories, and connections are created upon the basis of the relevant theoretical framework and the questions developed by the researchers. The aim of this process is to discover regularities, variations and singularities in the data and thus to begin to develop some conclusions.

In this case study of the Chinese PDM, we loosely follow this process, such that there is no clear divide between description and coding. A major concern of qualitative data analysis, as stated by Blaikie (Blaikie 2000), is the extent to which the researcher attempts to 'retain the integrity of the phenomenon'. In other words, qualitative data analysts have attached great significance to the extent to which the researcher remains close to the language, concepts and meanings of the social actors themselves, rather than imposing her own concepts and categories upon lay accounts. The researcher is faced with a choice between taking a high stance, in which she imposes concepts and meanings onto data collected, and a low stance, in which she derives concepts and meanings from lay language. In this research, a relatively high stance toward data analysis is taken, and data is presented through a combination of description and analysis. Current literature on the study of OSPs from the SST perspective provides instructive guidelines for understanding this case. The ways in which we describe the social world of OSP development are guided by existing SST concepts, as a means to examine the relevance of these concepts in the Chinese context. Thus, we gradually test these concepts in an extensive and rich case study, following our adopted framework for driving and analysing the findings. In the conclusion of chapter nine (the final chapter), we connect the biographical stages and identify related patterns in order to answer the research questions.

All of the interviews were transcribed, and all observations were recorded as handwritten field notes. Important conversations which occurred during observations were also recorded. All the data that were collected from different resources were presented in the biographical sequences. For most of the data gathered in interviews, we tried to capture the interviewees' understandings, concerns and problems, which are reflected in their own interests. We did not merely accept what interviewees told us, in relation to some issues, as objective truths; instead we were also concerned with the interviewees' backgrounds, roles and interests in the world that they described (Silverman 1993). The interview data were therefore interpreted against the contexts in which they were produced. The documents used in this study were employed in two major roles, as resources and as topics (Scott, J 1990). The MISS standard, and the CEEDI user requirement analysis and reports were used as topics and in this way regarded as social products, to be treated as objects of sociological analysis. The aim of this approach is to illustrate the social processes through which these data were produced, in order to explain their form and content, as well as their authors (LZ) and the circumstances in which they were situated. The documents, such as organisational handbooks and newspaper articles relating to the supplier and products, as well as meeting records and ethnographic field notes, are used as informational resources. In general, for all documents, we used a technique consisting of a combination of content and ethnographic analysis (Silverman 1993), by which we explored the content of the documents, as well as a range of questions related to each category of documents, regarding for instance how the documents were written, how they were read, who generally read them, and for which purposes, etc. For those conversational data that were collected through observation, we used an ethnographic approach similar to that by which we analysed document data, whereby we studied the relationship between the content of conversation and its context, rather than using other complex language analysis techniques.[11] Those data were substituted for others which could be gained from behavioural observation.

Chapter	**Data collection**
4. From 1979 to 1995 : Chinese socio-economic context	Documents and interviews Secondary data resources
5. From 1995- 2003: Birth and early development	Documents and interviews
6. The MISS standard development	Documents and interviews
7. From 2003-2005 : Growth	Observations and documents, complemented by interviews
8. From 2004 to the future	Documents and interviews

Table 3: Outline of case chapters and associated data collection methods

The above table, which is based on the content of the early interviews, gives an overview of the interrelationship between the chapters and data collection methods.

Combining interviews with the use of documents and secondary data resources, we reconstruct the birth and early development process of the Chinese PDM. Furthermore, by adding observation to our methods of research, we present two episodes of the biography of a ‘software package’, in order to review the tensions

[11] More details about how to analyse transcripts can be found in Silverman’s book, Interpreting Qualitative Data (1993).

faced by the supplier and its related strategies during the stages of growth and the future of the software package. This process is described, in large part, in chapters four through eight.

3.4.2 Managing the difficulties

It is necessary to mention the difficulties that were encountered during the data analysis stage. The most common challenge during data analysis is the maintenance of distance between the researcher and the fieldwork reality. This can be quite difficult when a strong relationship is built between the researcher and the related practitioners, such that there is a danger of losing objectivity, due to the researcher having shared the managers' and software engineers' stories and concerns and hence possibly failing to see certain elements informing the studied subjects and their behaviours. In conducting this case study, the researcher experienced such a problem in the early stage of data analysis. This problem was overcome by the researcher detaching herself from the fieldwork and avoiding contact with the studied organisations for several months after the data collection stage, as well as revisiting the relevant literature and presenting the collected data to senior lecturers.

3.5 SUMMARY

There is not a single best research methodology nor design. Conducting research is a process of making decisions about a range of alternative approaches, in an attempt to address particular research interests. There are neither wholly good nor wholly bad methods, but only methods which are more or less effective in particular circumstances, for the attainment of certain objectives, en route to a distant goal. In this chapter, we have demonstrated our choices related to the conducting of this study and the process through which these choices were made.

Our research has been largely informed by the tradition of SST. The selection of a methodology and research design, therefore, has also been strongly influenced by this tradition, and the intent of the research is to contribute to the field of SST studies. It is our conviction that a single case study, including multiple units and combined with a longitudinal and contextual analysis approach, can yield some exciting and informative data for the understanding of OSP development. While this approach certainly has its own limits, it derives logically from the concerns of its object of study.

Chapter Four

The Context of the Chinese LZ PDM development

4.1 INTRODUCTION

At the end of the 1990s, in accordance with the '*Decision to accelerate the development of science and technology'* which was announced by the Chinese Communist Party Central Committee and the State Council in May 1995*,* the Chinese Ministry of Construction (MOC) launched *'The development plan for the informatisation of the construction, engineering, investigation and design sectors for 2000-2005'*. In the same year, *the 'Decision for the reform of the SOE design institutes in the construction industry'* was launched. These new policies represented the Chinese government's early determination to rebuild its industrial production and management practices through the deployment of information technology. This modernising motivation was deeply rooted in the past thirty years of Chinese reforms; the period since 1978 has been characterised by major economic reforms, combined with the reforms of enterprise, institutional and industrial structure, as well as related policies such as science and technology policy, for example.

The high-tech industry, in particular the software industry, represents a unique example of a truly global industry, growing rapidly in both developed and developing countries. As an emerging global market, the Chinese government tended to foster its own technological development capacity in order to maintain its competitive edge in this sector. The threats from foreign multinational companies following the Chinese accession to the WTO, as well as trends related to globalisation, have prompted further attention from the Chinese government towards the building-up of the domestic high-tech industry and the technological capabilities of related enterprises, with an emphasis on the Chinese' own intellectual property rights. As a result, a range of related policies were set up in the late 1990s and early 2000s to support and protect domestic enterprises, such as the standard–oriented policy. Meanwhile, according to some observers (Suttmeier 2005; Suttmeier and Yao 2004; Wilsdon 2007) the so-called 'technical-nationalism' continues to grow, and this has directly affected China's local software industry and patterns of development.

An understanding of China's general and changing social and economical environment is an essential precursor to later explanations of the particular shape and trajectory taken by the Chinese software package's innovation and development process. This chapter examines the broad context of the LZ PDM technology development and in particular, it explores the role of the Chinese socio–economic context in the shaping of the software package. The chapter begins with a study of the recent socio-economic structure changes, giving particular attention to the policy development regarding Chinese science and technology. Exploration of Chinese science and technology reforms and related policy shifts helps us to gain an insight into the root of China's modernising reforms. Followed by the related industries study, the next section sets out firstly to investigate the characteristics of the Chinese software industry and secondly to review the evolution of IT applications in the construction industry, in order to provide a foundation for understanding a later investigation of the development and implementation of the Chinese PDM technology in the construction sector.

4.2 CHINA IN TRANSITION

The 1980s and 1990s were not only a period in which many developing countries adopted a series of major economic policy reforms, but they were also an era in which all socialist and former socialist countries, with the apparent exception of Cuba and North Korea, undertook varying degrees of radical reforms in their Soviet-style, centrally-planned economic management systems. Emerging from nearly three decades of largely self-imposed isolation, China, as both a developing and a socialist country, has positioned itself firmly at the forefront of the reform movement since 1979.

4.2.1 The general background

The Third Plenum of the 11^{th} Congress of the Central Committee of the Chinese Communist Party (CCCP), held in December 1978, is widely regarded as the 'turning point' in the history of China's economic development. At the plenum, it was decided that a programme of 'readjustment and reform' should be carried out in order to resolve serious imbalances in the national economy (Ma, H 1990; Naughton 1995). Since then China has embarked upon the course of what is now known as the 'second revolution', Reform and Open Door (Gai Ge Kai Fang). At the head of the reform lies an industrialisation strategy that has combined the introduction of market forces, the gradual reduction of mandatory planning, decentralisation and autonomy in economic management, along with the opening of the economy to international trade and foreign investment (Naughton 1995; Tisdell 1993). In general, this reform is intended, at the macro-level, to replace the government's direct control with indirect control, through the introduction of market mechanisms and, at the micro-level, to increase enterprise autonomy through decentralisation.

China's economic reforms can be seen as taking place in three phases (Naughton 1995; Qian 1999; Shen 1999). The first phase, from December 1978 to September 1984, mainly concentrated on the agricultural sector, with attention given to the reform of SOE. The intention behind this approach was to introduce a more market-oriented system and to give enterprise greater scope for private initiatives by introducing a responsibility system. From October 1984 to December 1991, the second phase of reform shifted its central focus to the industrial sector. Government policies sought to stimulate the dynamism of the industry sector by introducing market forces to the entire system and giving much more autonomy to enterprise. Great attention was paid to the reform of state-owned enterprises, as they occupied more than 90% of the industry. In the third phase, the sphere of economic reform has broadened in many aspects since 1992. Reform acceleration continued in 1993, and at an important party meeting in November, a programmatic document was ratified, which broadly outlined the areas in which reform was needed (CCCP 1993). The aim of the third phase was to enable the construction of a new socio-economic mechanism for the country. The 1993 decision opened China to further contemporary reforms, and since then, a broad range of reforms has been carried out in different 'areas', to accelerate continued economic growth and to accumulate domestic technological capabilities by promoting technological innovation and transformation.

In a relatively short period China has become distinguished as a country with one of the fastest growing economies in the world. The purpose of this section is not to critically assess how successful China's reforms have been, since these economic achievements are related to a range of new social and political problems which largely co-exist with the benefits of reform. Instead, this part demonstrates China's broad socio-economic changes, focusing on the evolution of science and technology policy which has directly influenced the later development of ICT and industrial modernisation.

4.2.2 The Chinese science and technology policy

The slogan which was initially stated by Deng Xiaopin in 1979, '*Science and technology are primary productive forces'*, has strongly influenced the Chinese economic reforms of today. This perception has gained the status of a general consensus among the entire nation. By the 1990s, as a result of this strong emphasis upon science and technology by the Chinese government, Chinese culture became permeated with this belief in the significance of science and technology. Since 1999, the expenditure of the Chinese government on R&D has increased by more than 20% per year and reached 1.3% of gross domestic production (GDP) in 2005 (OECD 2006). In December 2006, the Organisation for Economic Cooperation and Development (OECD) surprised policy makers by announcing that China had moved ahead of Japan for the first time, to become the world's second highest R&D investor after the US (OECD 2006).

The continuity of S&T reform, aggressive investment from government and in particular the recent standard–oriented technology policy have demonstrated the Chinese government's determination to become the technological development leader in the context of globalisation, rather than being the 'workshop' of developed countries. This determination has, however, also created a range of new problems and dilemmas.

S&T reform

The starting point of China's modern science and technology reforms can be traced back to 1949 (Wang 1993). When the Chinese Communist Party came to power in 1949, one of its major goals was to modernise China's science and technology sectors. The Party regarded the development of science and technology as a means to achieve wealth, power and status in the international community (Wang 1993). With the exception of the cultural revolution, from 1966-1976, and despite the twists and turns of the party's policies, this goal has remained consistent (for more details see Ma (1990) and Simon (1989)). The main objective of early S&T reform, however, strongly favoured the advancement of industry, and in particular, heavy industry technologies, in an effort to build a country-wide industrial infrastructure. A large number of technologies had been acquired as a whole from the Soviet Union. The R&D system was identical to the Soviet system, which was centralised, highly structured and firmly controlled and funded by the government. This system did provide instruments for massive resource mobilisation and thus enabled China to build its own S&T system, from the 1950s to the 1970s (Simon 1989; Suttmeier 1997; Wang 1993). The limitations of this S&T system had been recognised as a lack of incentive for innovation and a lack of horizontal communication between universities, institutions and enterprises[12] (International development research centre and the State science and technology commission 1997; Shen 1999; Simon and Goldman 1989; Wang 1993)

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[12] More crucially, according to Mr. Song's paper, the Minister of the State for Science and Technology, this model produced a system which financed research and development with guaranteed funding through annual appropriations that were based on the economic or scientific value of the work being performed. (For more detail, see Saich (1989)) This led to an unbalance between different research subjects, both in funding and human resources. Furthermore, it also disconnected the processes of research and production. Insufficient innovation takes place in an industry in order to bring about the necessary technological advancements, and it is difficult to transfer to the production sector the innovation that takes place in the research laboratories.

The drawbacks of such a centralised R&D system were explicitly identified by Deng Xiaopin when he started to take power in the late 1970s. In 1978, during the first National Conference on Science and Technology, Deng confirmed that S&T were productive forces, giving them pride of place in the whole of economic reform. This event was widely seen as a new beginning for the S&T reform which continues today. In 1982, government guidelines were announced which stated that '*Economic growth must rely on science and technology, while science and technology must be oriented to economic growth*'. This further indicated the determination of the Chinese government that economic growth must rely on intensive increases in productivity, driven by science and technology (Song 1997). Since then, the Chinese government has encouraged experimentation in its science and technology development as a means of reform. A major aspect of reforms preceding the mid-1990s, however, was the decision to gradually reduce the guaranteed annual state funding for most research institutes. Efforts were made to encourage the flow of funds through interactions between research institutes, enterprise and local governments (International development research centre and the State science and technology commission 1997; Song 1997; Suttmeier 1997), in order to build up China's 'technology market'[13] (also called the commercialisation of technology) in which R&D would be funded by the users of technologies, as well as to increase the technical transformation of the Chinese industrial infrastructure[14] by aggressively acquisitioning foreign technologies.

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[13] The idea of the 'technology market' was first mentioned in *Decision on the reform of the Science and Technology Management system, March 1985.* This decision has been characterised as a result of learning and summarising for the past (early 1980s) experiments and sought to push the Chinese S&T reform further (IDRC 1997).

[14] Historically, Chinese enterprises have been inclined to utilise capital for expanding construction or for purchasing foreign equipment in complete packages, ignoring the significance of depreciating equipment and the upgrading of existing technology. These were typical characteristics of Soviet-style extensive development strategies. The 1985 decisions gave attention to the soft side of technology (Simon 1989; Wang 1993 p112-113). This means that they emphasised the importance of renovation and technological upgrading rather than additional capital investment and plant expansion, in the belief that the acquisition vehicle did not provide adequate levels of technology transfer. Since then (the late 1980s), vast amounts of foreign technology have flowed into China via the technological renovation process and foreign investment (Suttmeier 1997, Shen 1999).

In May of 1995, the People's Republic of China convened its first major national science and technology conference since 1978, and the Chinese Communist Party's Central Committee and State Council announced the *'Decision to accelerate the development of science and technology'*. This decision (for detailed content see IDRC 1997, box 2) had been seen as a summary of the past reform experiences and the beginning of a new decade of reform (1995-2005). The 1995 decision further enhanced the strategic role of science and technology in improving the quality and efficiency of economic growth, by promoting the deployment of advanced science and technology in all fields and the development of high technology and related industries. High-tech, in particular ICT became the top priority industry. As pointed out by some scholars, the May 1995 '*Decision*' can be understood as occurring at the convergence of several factors: the past ten-plus years of successes and failures with S&T reforms; important streams of new thinking on reforms, based on the idea of a socialist market economy which was launched in 1993; the overall improvement of China's technologies; and finally the impending competitive challenges China would face with its eventual admission into the WTO. These would include the domestic industries' introduction to more competitors than they had yet experienced in the past twenty years of increasing competition and the emergence of new ICT technology, which would provide China with the potential to catch up with the advanced countries in a relatively short period of time (Chen, C.H and Shih 2005; International development research centre and the State science and technology commission 1997; Suttmeier 1997).

Standard-based technology policy

By the mid-1990s, it was becoming increasingly clear that China was approaching the point at which it would need to intensify its domestic capabilities, in order to match its increasing reliance on foreign technology and answer to any threats arising from its entry into the WTO (Suttmeier 2005; Suttmeier and Yao 2004). China was seeking to reorganise its industrial structure and insure that local firms would have the size, technology and managerial skill needed to compete in the global economy by upgrading production technologies as well as promoting China's own technological innovations.

Since then, a range of government technology policies and strategies were developed in ways which promoted Chinese domestic industry growth. 'Standard–based technology policy' in the information, communication and high-tech industries could be seen as examples of such strategies which have the potential to dramatically influence China's high-tech development.

Over the past few years, there has been a growing interest among Chinese technology policy leaders in both promoting China's own technical standards, broadly understood, and in establishing property rights over Chinese technical achievements (Suttmeier and Yao 2004), for instance, third–generation (3G) mobile telephones and the Time Division Synchronous Code Division Multiple Access (TDSCDMA) standard, as well as the Enhanced Versatile Disc (EVD) standard.

In the past, within the domestic industries, China experienced a range of frustrating experiences which limited Chinese industry growth on the international stage, such as the 'patent trap'[15] set by industry leaders from developed countries. As a result, the Chinese government and industrial enterprises grew alarmed that, in the context of international business, the cheap labour advantage for Chinese domestic producers was starting to be shaken as foreign countries increased import tariffs and/or taxes, in order to protect their own countries' domestic industries. Those experiences reminded China of the importance of the core of technology: patents and intellectual property rights.[16] In the global ICT industry, it has been accepted by most organisations, industries, and academics that the technological winner is now the one who manages to exert de facto control over market standards, while at the same time protecting intellectual property rights.

[15] The patent holders demanded $20 per DVD machine, although these machines had a per-unit sales price of only $90.

[16] For more cases, read 'China's high-tech technological standard strategy research report', China Labs, July 2004

In response to this, the importance of standards in twenty-first century Chinese technology policy, particularly after the country's entry into the WTO, were explicitly stated on the website of the Standardisation Association of China (SAC). In 2003, Shu ZhongMing, the vice director of the SAC, further emphasised the importance of standard development and called attention to the need for ongoing research on, and enforcement of, China's own technical standard development.[17] It seems that the Chinese government gradually came to believe that without its own standards and intellectual property rights, China's high-tech industry, and in fact all industries, are vulnerable and can not compete in an environment of globalisation (Lab 2004).

Apart from protecting the local industry from international competition, some observers also argues that there is another initiative behind the standard-based technology policy which is to accelerate China's own technology capability and promote the leadership of Chinese technology in the global market. As argued by Suttmeier there is little double that China's market size, increasing technological capabilities, cultural preferences, and sense of growing international importance do ensure that the country will become an increasingly active promoter of technical standards including their own national standards in the centre of the international technology development stage (Suttmeier 2005).

Along the development and promotion of standard-related technology policy, the Chinese standard system itself has experienced substantial changes. The reform of the Chinese standard development process started at the end of the 1980s. In a tradition which was strongly influenced by the former Soviet Union, the development of a standard in China was seen as a job for government administration. All standards were planned, identified, drafted and edited by the relevant government departments, and the power of all standards was equal to that of laws**.** In 1988 and 1989, the advent of *'the standard law of the Republic of China'* and *'the application and implementation of the standard law of the Republic of China*'

[17] Chen Zhigang, 'China Starts Standardisation Strategy: WLAN standard is the touch-stone; 27 Dec 2003 (http:// tech, sina.com.cn/it/t/2003-12-27/1054274244,shtml.)

redefined the types of standards and created the non-regulative standard. This latter type is a guideline standard that is also accepted by the Chinese government but which does not have the same effects as a law. It is up to organisations to decide whether or not to follow it and furthermore, how to follow it. It could also be used as a reference by the user organisations. The main objective of this type of standard is to provide a guideline to industries or organisations.

In response to accession to the WTO, the Chinese government further reformed the standard development process (Weeks and chen 2003). In contrast to the traditional development process, the new standard law stated that organisations, individuals and industry associations are allowed to participate throughout the process of development. Moreover, a new standard could be proposed, drafted and edited by those non-government groups, under the supervision of the government or a public institution. There are few texts available, for an investigation of the implementation of this process, thus it is still hard to judge the efficiency of this reformed standard development.

What is clear is that for developed countries, the Chinese standard policy commitment had been interpreted by some international scholars as trying to increase the use of Chinese innovation worldwide by promoting local standards in its own large domestic market, in order to help speed their adoption (Suttmeier and Yao 2004). This policy had been critised as favouring domestic industry, as well as taking advantages of the size of the Chinese market in order to force foreign companies to adopt the local standard. Foreign companies were also concerned with the lack of democracy during the standard development process, since these companies are generally not informed nor invited to develop a local standard.

In general, contemporary Chinese S&T policies tend to put effort into building up domestic industry and enterprise capabilities. What China could achieve by developing their S&T capability in the future is still under debate. What is clear, is that the Chinese government harbours ambitions of becoming the technological innovation leader in a high–tech industry such as ICT, rather than simply catching up with developed countries.

4.3 INDUSTRIES STUDY

By the late 1990s, the whole industry structure had been readjusted. In China's tenth five-year plan, the Chinese government called for efforts to be made to accelerate the use of information technology and to promote the construction of infrastructure, as well as to strengthen the agricultural and energy sectors (PeopleDaily 2000).

In this move, informatisation was officially identified as key to the promoting of industrial advancement and modernisation.[18] As a result, the information industry was recognised as the primary strategic industry of the national economy to help China achieve the status of 'information society'. This point is supported by early studies on S&T policies. There is a strong emphasis on raising productivity levels and promoting a more efficient allocation and use of resources, with the help of such informational technologies in state-owned enterprises. The Premier, Zhu RongJi, said in the draft of the tenth five-year plan:

> '*It is a difficult and historic task for China to continue the process of modernisation and industrialisation, and this is a strategic measure to promote the use of information technology in economic and social development…… Industrialisation is the basis by which developed countries enter the information technology–based stage, and this new opportunity provides China the chance to integrate industrialisation with information technology, to use information technology to upgrade the industrial sector, and to promote the advancement of the productive forces……* '
>
> (Tenth Five-Year Plan Draft from People Daily 2000)

These commitments indicate that the major task of the first decade of the twenty-first century will be utilising information technology in social and economic development, in the new century in China.

[18] In the early 1980s, China's government had already recognised the important impact of information technologies upon economical development. In the early 1990s, several 'government on-line' projects had been developed, such as 'golden card', etc. For greater detail see Zhao Xiaofeng 's presentation in 1999.

Meanwhile, the construction of infrastructure has been perceived to be one of the most important tasks of the next ten years. Both Premier Zhu and the Central Committee of the Communist Party of China (CCPC) demand that in the coming five to ten years, the construction of water conservation, transportation, energy and other infrastructure projects should be further reinforced (PeopleDaily 2000). As a result of this mandate, a great development opportunity arose for the domestic Chinese construction industry.

The aim of this section is to elucidate the features of China's software industry and the evolution of the usage of ICT inside the construction industry, and in particular the construction design sectors, thereby opening doors for the next chapter, a detailed story of the development of a software package for a Chinese construction enterprise.

4.3.1 The Chinese software industry

Compared with PC manufacturing in China, now ranked number one in the world, the Chinese software industry is still very small and immature (Saxenian and Quan 2005). Being part of the information industry, the tenth five-year plan identified software as a critical pillar of industry which is essential to economic growth and national security, and hence deserving of government promotion, along with more established sectors such as computer manufacturing and telecommunications, lasers, etc (Saxenian and Quan 2005). The major shift in policy attention enabled the local software industry to receive significant government support.

Market player and the supply of software

China's software market is still at a stage in which foreign products dominate, particularly among operating systems, databases, and network-related software. Foreign corporations, including Microsoft, IBM and Oracle, accounted for over 65% of packaged software sales, due in large part to the established quality of these brands (Saxenian and Quan 2005). There are also exceptions. For instance, the

Chinese enterprise resources planning market is occupied by local suppliers with 51.7% of the market share, as foreign suppliers like SAP and Oracle only hold 25% of the market share since 2002 (Xue et al. 2005). The reason why western vendors don't dominate China's ERP market has been identified as a mis-fit between the Chinese local practices, including rapidly changing business practices, and the embedded generic models provided by western ERP suppliers, as well as the lack of flexibility or a consideration of local culture (Liang, H et al. 2004; Liang, H.G and Xue 2004; Xue et al. 2005). It seems that the necessity of understanding the specifically Chinese characteristics of the development of Chinese business application software privileges the domestic firms (Saxenian and Quan 2005). It is not surprising that most domestic firms typically focus on developing niche applications tailored to unique needs of the domestic market; such as Chinese character platforms, Chinese localisations of foreign software, Chinese accounting and finance systems and other management information systems for specific sectors, etc.

In recent years, the government market has become another niche which offers great potential for growth in Chinese domestic software suppliers' market shares. The government procurement law clarified that local domestic software will be given priority. Recently, the government funded a range of informatisation projects, such as the 'golden project' and the 'government on the internet', which were initialised during promotion of the use of IT in all fields. The government procurement policy created great demand for all sorts of software applications in different application domains, which was projected to endure for ten years (2001-10) (Suttmeier and Yao 2004)

The Chinese domestic software industry is fragmented, however, with thousands of very small enterprises, most of which employ less than fifty people and undercapitalise, holding few competitive advantages in contrast to the foreign corporations who dominate the Chinese software market. In a few of these companies, however, there may be as many as 200 employees (APIP 1997; Ju 2001; Saxenian and Quan 2005).

Regarding the Chinese software industry as a whole, some personnel within this industry argue that it does not actually exist, since there are very few local suppliers with their own product and brand (Li, M and Gao 2003; Saxenian and Quan 2005; Tschang and Xue 2003). More than half of China's total software output comes from providing customised software services (such as developing a system for individual customers' needs), integration or post-sale service (tailored software development) (Tschang and Xue 2003). There are, in fact, very few specialised Chinese software providers. These critics also argue that it is very difficult to be a specialised, western-standard software producer in China since there is great pressure from the users to provide an integrated service.

The consumption of the software

In Saxenian and Quan's paper, they point out that, in contrast to western countries, Chinese users expect the software technology producer not only to be a product provider, but also to become the service provider and systems integrator for the same customer (Saxenian and Quan 2005).

Such expectations on the users' side indicate the immaturity of the user market. The domestic users are unwilling to pay for the professional software service which is supposed to be provided by the third party, instead of the software product suppliers. They prefer to buy the software service, such as pre-consulting and maintenance, bundled with the software purchase, rather than as an individual purchase. Such consumption behaviour can also be found in the purchasing of hardware systems (Li, M and Gao 2003).

Most industry participants agree that few domestic users, whether governments, local organisations or individuals, fully appreciate the value of investing in and/or paying for software. Primary reasons for this could be the widespread phenomenon of software piracy and associated perceptions of the value of software (Li, M and Gao 2003). It is well known that China has one of the highest piracy rates in the world. The price of an operation system, in Chinese consumers' minds, should be free or less than 10 RMB (less than £1). Although complex organisational software like the ERP and PDM can not be copied, the perception of the Chinese consumers that software is merely an attachment to hardware has influenced the willingness of organisations to invest in OSPs.

Another constraint limiting the business application software market has been recognised as the lack of related knowledge on the part of user organisations and government support as to what kind of systems they need and how to chose the right software suppliers (Liu and Purchase 2002; Saxenian and Quan 2005). Those who do purchase software products remain unsophisticated, unsure of what they want, and thus unable to provide the feedback that might help domestic producers develop innovative products. Most organisations, particularly SOEs, are still working on their internal management systems reform. The demand for management application software has not yet fully emerged.

On the one hand, Chinese consumption of software remains immature. As has been pointed out earlier, on the other hand, an increasing amount of Chinese software package users are choosing to use software made in China, rather than a 'western' product (Liang, H.G and Xue 2004). Apart from a recognition of the potential mis-fit between local practices and the models provided by foreign software suppliers, the local consumption of software is also influenced by the government. The Chinese government has strongly pushed the use of Chinese-produced software in government development, and this has created a huge demand for domestically-produced Chinese e-government and management software of all sorts. As some scholars have predicted (Tschang and Xue 2003), domestic firms will eventually dominate 60% of the Chinese software market.

Labour supply

‘People’ have been recognised as the Chinese software companies’ competitive advantage and exploitable asset, in competition with other developed countries’ software suppliers (Ju 2001; Li, M and Gao 2003). An enormous body (around 470,000) of well-educated software professionals can be steadily replenished and expanded. The labour cost is extremely low by international standards. For instance, a yearly salary for an undergraduate degree–holder in computing science could be only £2500. For a highly experienced programmer, this figure could be only £10,000.

Some scholars, however, believe that although China does not suffer from shortages of low-level programmers, it does lack high-level systems analysts, designers and architects, as well as professional project management and technical talents who bring long-term perspectives to strategic decision-making.

Source of Capital

The immaturity of the Chinese financial system has set up barriers for self-financed or other private enterprises in China. The great majority of software enterprises, like all other private enterprises in China, are self–financed, because they lack access to bank loans or capital markets. There is a strong bias among bankers in China against lending to private enterprises, largely because this has been considered extremely risky. According to Central Bank data, in 1999 less than 1% of all working capital loans went to private companies, and these were most likely not made to local private firms but rather to joint ventures with foreign private companies (Saxenian and Quan 2005). This problem is particularly acute in software because the banks have virtually no credit analysis capabilities, and in any case they prefer to invest in businesses with physical assets. As a result, software enterprises usually start with very small amounts of both human and financial capital. Such small firms are perceived by the Chinese banks as having low credit, and these banks are therefore not willing to invest.

As indicated by studies of a range of large Chinese IT companies, such as Neusoft, Founder and Legend, the software enterprises with close government ties, as well as those that were state-owned before the reform, by contrast, have little trouble gaining access to funding from the state-owned banks. Lack of access to financing has constrained most of the domestic private software organisations.

4.3.2 The Chinese construction industry and IT

Under the central government initiatives regarding the deployment of information technology in all fields under the tenth five-year plan, the ministry of construction in China has drawn up its own five-year plan for the informatisation of the construction industry, which aims at transforming and advancing the traditional construction industry through the energetic generalisation of the application of information technology (for detailed content see Ma (2001), Appendix 1).

In this section, the evolution of the Chinese construction industry is described, to demonstrate the characteristics of the current construction industry, and this description is followed by a review of evolution of IT applications in the Chinese construction industry and recent application trends. It aims to identify the origins of Chinese PDM technology.

The evolution of the Chinese construction industry

The Chinese contemporary construction industry is defined as the national economic sector which engages in the production and operation of buildings and civil engineering works, according to the Chinese Standard Industrial Classification (1993). This is a very broad and fuzzy definition, which could include vastly diverse sectors such as design, building construction, earth investigation and surveys, construction supervision, property management and related construction material and components, etc. So far, there has been no clear official delineation made between these forms.

There was a long period of time in which the construction industry was not recognised officially as a separate economic sector that contributed to the GDP, an acknowledgment which was finally made in 1983 (Li, S.R 2001; Luo and Gale 2000). Before 1980 the construction industry was viewed as merely a subordinate work force which affected the state's fixed capital investment programme. Many people, including certain top government officials, believed that construction activities involved simply assembling the materials, and other items made by other economic sectors, to form buildings and civil engineering works, and therefore adding no value to the total social product (for more detail, read Luo and Gale (2000)).

Construction is a unique industry because of its long productive cycle, nomad-like sites, and the complexity and diversity of its products (Gann and Salter 2000). Construction enterprises' business processes are intra-organisational activities, in which a large number of outside enterprises such as builders, contractors, quality control, and third party and customer organisations are involved. The project team is a short-term grouping of selected enterprises that commit themselves by contract to work together towards the completion of a particular construction project. Inside each enterprise, a number of projects could be going on at the same time. Each project again consists of a short-term grouping of selected people from different departments, who join together to work on a particular project. The context of the individual project is characterised by the resulting unique features and situations. This working process represents an operational and organisational trend in the modern western construction industry (Gann and Salter 2000). It requires organisational flexibility, well-structured communication and coordination channels, as well as industry stability.

The lack of clear labour division, flexibility, and a stable industry structure are seen as the main obstacles, in China, to meeting the needs of both the modern construction industry and organisational management (Sha and Lin 2001). Historically, China's domestic construction enterprises have been largely owned by the Chinese government. Chinese construction SOEs, similar to all other domestic SOEs, are not flexible in terms of operation, are weak in technical innovation, and are heavily in financial debt. The materials, projects and management are centrally controlled by the government. All these factors have resulted in the unreasonable industry structure and the rigid structure of construction SOEs with large permanent staffs. Furthermore, there is no clear division of labour between various construction enterprises, since government acts as the main coordinator in the centralised economic environment. Although in the early 1980s, the government's policies on SOE reforms resulted in an increase in the SOEs' autonomy and improved their incentives, a considerable number of construction SOEs have not yet adapted to the demands of the market economy, due to the persisting, long-term influence of the traditional system (Sha and Lin 2001).

Despite the common problems of the SOEs in most industries, the contemporary Chinese construction industry has become an emerging fast-growth industry as a result of China's economic reform. The GDP's average annual growth was more than 10% between 1978 and 1995 and 8% in 2000 (Li, S.R 2001). The rapid growth in construction has meant that the industry is now a major driver of the economy, as well as a major economic tool. Some decline occurred in the construction industry in the early 1990s, due mainly to the 'austerity program' launched by the government to control the inflation rate (Chen, J.J 1998).[19] The government tried, through this program, to cut back on construction projects and reduce government spending on the construction of infrastructures.

By now, China's construction industry is huge and widespread. The increase in economic activity has created huge demands for infrastructure improvement in the

[19] The economic woes of inflation and corruption in 1988 and the political backlash following the Tiananmen Square incident in 1989 put Chinese economic reform on hold. An austerity program was implemented in 1989 and 1990, to cool down the 'over-heated economy' (Qian 1999, Naughton 1995) by carrying out a program re-establishing governmental control of the economy, a program which would reverse many of the achievements of the previous decade of economic reform. Based on Naughton's book (1995), a special party meeting in November 1989 produced a manifesto for these policies, the 'Thirty-Nine Points', which called for a period of economic rectification lasting at least three years, from 1989 through 1991. This programme had three main goals: macroeconomic austerity, recentralisation and strengthened planning, and preferential policies for state-owned industry. Macroeconomic austerity was given the highest priority. Government largely reduced the expenditures on and investments in production. The growth of bank credit was sharply decelerated. Tight controls were put on fixed investment. With these controls in place, demand for both investment and consumption dropped. During this period of time, there was a dramatic collapse of state-sector profitability. The most immediate cause was described as the tension between decreased sales and increased state-mandated costs. After 1989, losses in the state industrial sector surpassed 2% of the GDP in the 1990s, compared to less than 1% of the GDP before 1989. This period had negative effects on industry growth despite some positive aspects, such as a lowered inflation rate.

power supply, water supply and water treatment, telecommunications and transportation. Meanwhile, the industry itself is increasingly competitive, as a growing number of foreign engineering enterprises have started to take a stake in this market. For local construction firms to survive in such an environment, some scholars insist that deepened domestic reforms are urgently needed.

On 18 December 1999, the launch of '*the decisions about construction design SOE reform'* led to the deepening of construction industry reform as it initiated construction SOEs' property rights into more market-oriented types. After 2000, the main tasks of the Chinese construction industry were identified as establishing a more standardised market, with a rational market economy-based price-management system, and building a reasonable project-oriented organisational framework and modern enterprise system (in the majority of state-owned key enterprises) (daily 2002).

The evolution of IT applications in the Chinese construction industry

Within the construction industry, the earliest sector to use ICT to facilitate production was the engineering design sector. It is necessary to point out that even up to today in comparison to the design sector in Chinese construction industry, other sectors within the construction industry, such as the construction engineering sector, which is responsible for completing the actual building process, and the construction supervision sector, which provides third-party quality control services, are still under-developed in deployment of IT applications, both in terms of the production process and in enterprise management (Ma, Z.L et al. 2001).

The construction industry's history of computerisation can be traced back to the 1970s, at which point the Chinese construction design enterprises were starting to deal with construction calculations by using computers. Each design enterprise set up an individual department which provided computer calculating services to all engineers. In the 1980s, the spread of commercial computing increased the use of the computers in construction design enterprises. Three major IT application developments have been made in this sector.

The first of these was the introduction of CAD (computer aided design). In the 1980s, computers were introduced to engineering designers in order to automate their drawing production by replacing the traditional, and extremely time–consuming, hand drawing process. The application of Auto CAD in construction design represented a new starting point for the 'modernising construction industry'. The CAD technology dramatically increased the productivity and accuracy of the design drawing production by providing extremely fast mathematical calculations and efficient drawing duplications management (Ma, Z.L et al. 2001). In the ninth five-year plan, the updating of industrial technology was set at the top of the agenda of national development strategies. The 'throw away the design board' (Shuai Tuban Gong Cheng) project was initialised to increase both intricacy and speed of deploying CAD applications in all manufacturing industry and construction designs. Accordingly, printing technology was gradually upgraded. By the mid-1990s, most construction design works had been carried out using CAD, instead of hand drawing. The final drawings can be printed by relatively highly advanced printers. The current Chinese CAD technologies are starting to evolve towards co-current design development (Ma, Z.L et al. 2001).

In addition to the CAD development, another important development is GIS (geographical information system). GIS is a tool that is used to gather and analyse data about the surface of the earth. The data can be used to create charts, maps, and three-dimensional models of the earth's surface (Ma, Z.L et al. 2001). This could include hills, mountains, trees, buildings, streets, rivers, and virtually anything else. Civil engineering design institutions/enterprises can use the data gathered by GIS, combined with the use of CAD, to analyse the structure of the earth in order to design the structures of civil facilities. In China, the current GIS applications remain in the early stages, in which most of the GIS databases are separated; there is no integration between databases. This has created a difficulty in drawing well-defined pictures/maps/models, which normally build upon integrated analyses from different databases.

Through the early 1990s, most construction computing applications in the Chinese design sector were mainly developed for design automation purposes. In the late 1990s, a management software application was developed to manage the design process, related human resources and project data. This application is called PDM (product data management).

The PDM[20] system is a software system developed to manage engineering data and engineering activities as well as related product process development. It was originally developed for the manufacturing industry during the 1980s, according to trends of automating manufacturing in the USA and Europe, and following the emergence of computer integrated manufacture (CIM) (Amann 2004). In the west, it has since then been largely moved during the last ten years to the engineering domain and updated with different features (Brant and Halpern 2002). In China, however, particularly in the construction industry, it was still rare to see any advanced PDM applications until the early 2000s. We shall come back to the Chinese construction PDM market in the next chapter to explore the emergence of the LZ PDM.

[20] In the 1970s and 1980s, the wave of technology automation brought a tremendous revolution in the western countries' manufacturing industries. The CIM, as a leading concept, was deployed in western countries (Webster and Williams 1993). At that moment, computer systems in these industries were becoming increasingly concerned with the management of information associated with a range of functions, and computer networks had evolved to integrate previously separate activities. As part of this trend, the early discrete or stand-alone technologies, for example, machine tools and administration systems used in the back office and which were developed in the early 1970s, were integrated and connected (Clausen and Williams 1997). The whole manufacturing process, for instance, could be atomised by the integration of CAD (computer aided design) and CAM (computer aided manufacturing), and those programs by which information is used to coordinate the production and distribution processes, as in MRP (manufacturing resource planning). At the design stage of a product in manufacturing, CAD and CAM technologies have enabled manufacturing businesses to reach higher levels of efficiency and productivity in the manufacturing process. The management of recorded data related to each product, however, remained a problem, as most product data was still kept in a paper-based system. During the early 1980s, the big manufacturing companies in western countries which had already deployed CAD/CAE/CAM realised that their respective development was limited by the large, paper-based, complicated product data system. At the end of the 1980s, some western software companies recognised multiple opportunities latent in the PDM technology and launched the first generation of the PDM. This PDM technology has evolved in step with the rising wave of ICT technology in general. From a simple data management application to a product life-cycle project management system, the changing definition of the PDM illustrates that new functions and expectations of PDM have been added as the product evolved (Brant and Halpern 2002).

4.4 SUMMARY

This chapter has reviewed China's S&T reforms and recent standard-oriented policies, and it has identified the general characteristics of the Chinese software industry, as well as construction industries, maintaining a focus on the evolution of IT applications. The broad context of Chinese economic reform was also discussed in the first pages of the chapter. The range of reforms discussed in this chapter has indicated the determination of the Chinese government to not only catch up with the developed countries but, beyond this, to become the leader in some emerging field.
The primary task of S&T reform in the past two decades has been to develop national S&T resources that can enable China to innovate in production. Throughout the economic transition process, the Chinese government has been highly proactive in putting into place an institutional and organisational infrastructure which can ensure that S&T activities support the process of industrial development, coupled with efforts on behalf of the commercialisation of technology.

The result of these reforms has been identified by some scholars as the emergence of a new 'national innovation system' which integrates government S&T efforts with the business activities of industrial enterprises and related research institutions (Chen, C.H and Shih 2005; Lu and William 2001). There are, however, some critiques that suggest current government technology policies are being used much like the tools of the older, planned economy, to foster entrepreneurship with few changes and an overall lack of democracy (Saxenian and Quan 2005).

Undeniably, the past twenty-five years of experiences and learning in S&T reforms, related in particular to foreign technologies, have resulted in the accumulation of certain domestic technological capabilities, especially in high-tech fields such as the information communication industry. Meanwhile, Chinese national protectionism remains strong in this period, while pressures from the country's entry into the WTO and the weakness of large Chinese domestic industries and enterprises (particularly SOEs) co-exist. These circumstances have resulted in a range of policies, formulated by the Chinese government in order to protect and promote local and, in particular, high-tech industry development, with the intention of gradually building up Chinese industries' competitive advantages and pushing the adoption of Chinese technological innovations throughout the world.

In this context, from the Chinese government's perspective, standard–oriented technology policies can be understood as part of a strategic response to the global economy in which China will participate more fully, following its entry into the WTO. The standard strategy, however, has been criticised by some international organisations as a form of national protectionism, which is counter to the regulations of the WTO. This could make the politics of standardisation more complex then they have previously been.

Such local protectionism is also deeply embedded in software industry development. Given the importance of high technology in China's long-term modernising plan, the software industry began to emerge as the primary strategic sector and thus became the exclusive focus of attention. The Chinese government was determined to promote the Chinese domestic software industry and ensure that China would become one of the largest software export countries, thereby catching up with India. Some aspects of the Chinese economy are expected to positively influence the growth of China's domestic industries, for instance, the proportion of the population with personal computers and the massive Chinese e-government projects. Compared to developed countries' software industries, the entire Chinese software industry is still in an early and emergent stage, and from both the supply and consumption perspectives, it is still immature. This immaturity can be understood to be the result of China's as-yet incomplete economic transition. Although government policy has pushed the deployment of ICT technology in industrial production, most user organisations are not educated enough on the development and use of complicated software systems. As a result, consumption behaviour and demand have constrained Chinese software development. The industry-labour division is not clearly defined.

Since 1978, the construction industry has gradually become one of the key economic support industries in twenty-first century China, and it has become the largest construction market in the world. Facing the same challenge presented to the software industry, that which was raised by China's entry into the WTO, Chinese domestic construction enterprises must catch up with international construction's standards of both production and management, in order to survive in an increasingly competitive market. The policies on modernising and informatising construction organisations which were initialised by the Chinese government can be understood as a policy push towards this end. Today, however, the traditional SOE problems persist in the Chinese construction industry. The deployment of the highly advanced integrated management systems in the construction industry is not a simple or straight-forward task. Construction organisations must address issues of survival without government support, as well as explore the development of advanced management systems with established IT infrastructure.

In summary, the overall economic environment of China strongly supports local industrial development and aims to advance China's own technological capabilities and innovations. Given government policy support, both supply and demand for domestic products are dramatically increasing. Clearly, the government continues to play a critical role in promoting, developing and deploying technologies. Furthermore, a range of problems persist. Contradictory polices are promoted by China's government, such that, on the one hand, the Chinese government seeks to further open the door to the outside world. On the other hand, some policies reflect strong 'nationalism', indicating an unclear future for China's economic reform. The Chinese government, industrial organisations and related actors are still in the learning process of exploring their roles, interests and complex interrelationships, at this juncture in China's economic transition, as well as within the new environment of globalisation. In this socio-economic context, in the following chapters, we shall demonstrate how the generic LZ PDM solution has been cultivated and developed across several biographic stages.

Chapter Five

From 1998-2003 - The Early Generations

5.1 INTRODUCTION

According to the literature (Hyysalo and Lehenkari 2002; Pollock et al. 2003), the *birth and early development* of a software package are some of the most exciting moments, each of which is filled with dynamism and contingency. At these two particular stages of the biography of a software package, the features and functions of the software package are not yet established. The package still awaits further development, shaping and experimentation.

This chapter is structured to examine how the functions of the LZ PDM emerged and evolved in early stages of development, within the context of China. The focus of the chapter is to understand the Chinese supplier, LZ, and its related strategies and sources of knowledge and skills for building up the package's generic features, as well as ways to deal with the diverse Chinese user organisations' requirements during this formative stage in the life of a Chinese software package, the PDM. The chapter seeks to answer the following questions: whence did the original assumptions regarding the PDM come? How did LZ identify commonality of use within the construction industry? Furthermore, how did they know, or based on which understandings did LZ judge, a function to be generic or unique? How did they manage to build up the generic functions from studies of diverse user organisations?

The chapter begins by demonstrating the ways by which the LZ PDM package was born, and it moves into the early development stage, at which generic functions were gradually added into the PDM technology. The chapter concludes with a summary and discussion.

5.2 THE ORIGINS OF THE CHINESE LZ PDM

5.2.1 The influence of government policy

The birth of the LZ PDM occurred in a context in which there was a large potential market, constructed by the Chinese government through related policies. Following the announcement of central policy regarding the acceleration of the deployment of ICT in production, and as part of the speech given on 24 November 1999 by the head of the Ministry of Construction, Mr. Yue, during a seminar on computer applications for the civil engineering design sector, the third wave of informatisation was initiated. This third wave consisted in the automation of management in the construction industry. On 28 December 1999, 'The Development Plan for the Informatisation of the Construction, Engineering, Investigation and Design Sectors for 2000-2005' (1999 no. 314) was published. It is a detailed five-year plan on computing applications development in the construction design sector. For the first time, the importance of an integrated computing system for construction development was identified. The five-year development target was formulated to create,

> '*……a modern construction enterprise with a system which integrated traditional CAD development and enterprise management information systems, based on project-oriented organisational structure, hence to achieve the integration of production and management systems……*'
>
> (1999 no.314, p. 2)

Several important issues and development directions were identified in the plan. For instance, computer applications development in design enterprises aimed to build a multi-integrated network environment application system which combined both design and management applications. The plan suggested that such an integrated system should take project data management as the core issue, following the project management functions and based on the use of the traditional professional CAD design tool (p. 2). A condensed range of functionalities within the multi-integrated system was specified in order to automate the construction design and management process. In general, five systems were identified and recommended to all of the design institutions/enterprises in this government document. They include 'business planning/CRM', 'project management', 'con-current design systems', 'office automation' and 'documentation and drawing output management'. Furthermore, the plan clarified the importance of the implementation of such an integrated system inside the construction design enterprise. The scope of applied system applications for productions and management and the speed of implementations were identified as the key factors in evaluating each design institution/enterprise's working capacity and certified level.[21] Another two important issues were attributed a high priority in the plan, the promotion and support of the development of software with China's own intellectual property rights and the need to develop Chinese computer and software application standards.

Later, on 8 February 2001, the Ministry of Construction published 'The Key Working Points on the Informatisation of the Chinese Construction Industry' (2001 no. 31 MOC; for detailed content, see appendix 1 in Ma 2002). The main working tasks were firstly, developing relevant technological applications and applying technological standards to guide and regulate the construction information market. Secondly, a need was identified to push government agencies and institutions to implement related informatisation work. Thirdly, the industry required guiding and regulating of construction enterprises for the deployment of ICT towards the improvement of industrial growth.

These government policies created a huge potential market for software suppliers in the field of construction, as well as those which were on the outside of this field but willing to enter. LZ, a Chinese domestic software firm that specialised in developing niche applications for the construction industry, was one of these latter suppliers.

LZ is one of a growing number of high-tech innovative enterprises that are nationally competitive within the Chinese computer and information technology industry and which work in the niche market of the construction industry. The company is a

[21] Certified level is a kind of standard that the government grants to civil construction enterprises, to enable them to take projects with different complexity and quality requirements. Each certified level represents a construction engineering capability. For instance, concerning nuclear power stations, only L1 institutions are qualified to bid and make an offer.

wholly independent commercial software enterprise which was set up in 1995 with only ten founders and a single product.

5.2.2 LZ business in transition

At the end of the 1990s, as a small domestic firm, LZ faced declining demand in traditional construction software design tools such as CAD. Due to the lack of business, the demand for CAD and GIS software from this sector was experiencing a downturn. LZ was dependent on selling this technical design software and tools and thus faced a hard time. In order to survive, the company was searching for new business opportunities. Given the saturated CAD market, and combined with their own limited financial support, the primary concern centred upon how LZ could maximise the utilisation of existing customer resources and relevant knowledge to develop new products. This imperative was at the heart of their agenda during the late 1990s.

In the mid-1990s, before the formation of policy on the deployment of integrated information system in the construction field, and based on feedback from users of CAD and GIS, they found that there was a potential need for management application software. As the CTO (Chief Technology Officer) of LZ explained:

> *'During the development of GIS, we found that GIS is only a database with a visual presentation function. However in order to use this data, we need to create some management application software above (GIS system), to achieve a data application in the future.'*
>
> LZ CTO, October 2005

In the same year, the reform of the whole construction design sector, from state-owned to private enterprises, further indicated the needs for management software. As mentioned in the last chapter, under the centrally planned economies, the Chinese civil construction design institutions were largely state-owned enterprises. Like state-owned enterprises in other sectors, they were in a transition period and faced organisational change. The shift from state-ownership to private enterprise presented a big challenge to companies' top management. Without financial support from the government the only way to survive for those enterprises was to increase their sales and reduce costs. How could this be achieved effectively and productively? Management software was starting to gain recognition as a central component of success by the top construction management team. Meanwhile, the 1999 governmental decision on the informatisation of construction design enterprises further enhanced the needs for management software applications, in particular the needs for integrated management system applications.

By the middle of 2000, as one of a few domestic construction software application suppliers, LZ started to develop just such an integrated management system. LZ named it 'MIS'[22] (management information system), and it was a system explicitly suited to the needs of a construction design institution/enterprise.

The first MIS application developed by LZ was office automation (OA), specifically intended for design organisations and launched at the end of 2001. Like most of the OA software, the functionality of LZ's OA is mainly focused on office administration/operation management.[23] It is not involved in the core business (design) of the design organisations. The advantage of developing OA in the first place was explained as the easiest and most low-cost way to build up the foundations (low-level functions) of a complex integrated system from a technical perspective, as well as to familiarise LZ with the design organisation business as a whole. As explained by the CTO of LZ, low-level functions, such as role management, rights management, system management and forms management, should normally be shared by other advanced systems. The principle of system development theory is that the higher-level application should be built on top of the lower-level applications. OA is not a software application that involves the core business of the design institution, but it is rather an office administration system. The ambition of LZ was to enter the business production and management of the construction industry's software territory, starting with the design organisation sector. As a design institution/enterprise, the core business of this sector is to provide design solutions.

[22] Management Information System is a very broad concept. In general it is identified as an integrated reporting system specifically designed to help managers plan, execute, and control an organisation's activities.

[23] For more detailed information, see the company website: www.leading.net.cn)

As a software application supplier, LZ immediately involved itself in the development of the automation of the design production process, based on system architecture and general functions such as *system management* and *configuration management*, which were built upon the OA.

In the construction design sector which sells designs, its 'production process' is the design process. Most popular software that can provide design process control and management is PDM software. It was difficult to find any PDM products in the Chinese construction industry at the end of 2000. Easier entrance into the market was commonly viewed as a great advantage for LZ by top management personnel. Although the PDM is a different product from CAD, GIS and OA, they share the same organisational customers' base; they are different applications but are utilised by the same group of user organisations. The customer base and knowledge gained from past development experience in the same sector represented valuable capital to a software company which lacked strong financial resources, like LZ. Given such intangible assets, and combined with a potential boost in demand stemming from the national plans for modernising construction design, LZ foresaw a promising future in the development of construction-related management system applications. In late 2000, a strategic business shift occurred within LZ, from traditional CAD design to integrated management system development. The vision motivating this shift described by LZ as starting from the development of OA with a shared technical system platform for construction design enterprises, and working towards developing a range of different application products for all enterprises within the construction industry, moving eventually towards a universal solution.

5.3 BIRTH

5.3.1 Building on an existing local system

Entering the PDM market was not an easy or smooth transition for LZ, since they lacked knowledge of the detailed management process, as well as practical experience of working in this setting. This could have been a barrier to developing this system, even though they had gained some implicit understandings from past CAD product development.

Coincidentally, as recorded by the LZ CTO, they discovered a system that was developed by an expert who was familiar with both the design management process and system development in Shanghai. This system was the first Chinese construction PDM system which was tailored by Mr. Luo, and it was introduced at the end of 2000. He was a construction design engineer who worked in the Shanghai Construction Design Institution (SCDI) and later relocated to the IT department within the same company. Based on his construction design knowledge and software development experience, Mr. Luo developed a basic design process management system for his own company in early 2001.

The SCDI is a small enterprise which possessed a widely known and relatively advanced information system in the early 1990s. Ten years ago, when most design institutions were still working on using the CAD design tool, they had already begun to conceive a management information system. For LZ, purchasing this system was perceived as a better and more economical solution than starting from scratch. As claimed by LZ, time pressure and financial limitations were the main concerns; LZ did not have the required time and could not afford the cost of conducting a comprehensive study on users and use, and they were desperately generating revenues to help the company survive. Given the cheapness of labour in China, the latter implementation cost was small, in comparison to the initial R&D cost. More importantly, the lack of attention paid to intellectual property rights made the price of purchase even cheaper. The entire purchasing negotiation process was relatively straight-forward. As recorded by the marketing director of LZ:

> ‘*It was a pretty quick deal. Intellectual property was not such a big thing in China. Mr.Luo, the system designer, thought this system belonged to him. The Shanghai design institution did take it seriously, as well. It was just a deal between LZ and the system designer*’.
>
> LZ marketing director, October 2004

Technically, the Shanghai design institution's system was the only one that LZ could purchase with both relatively high quality and a low price tag. By the end of the same year, LZ bought the design management system from Mr. Luo.

5.3.2 Reverse engineering

Although this system was just a simple one, the fundamental design management process was 'particularised'. In other words, the system was built for a specific user, and thus it was recognised as not easily transferable to other contexts. As recorded by one of the original team members, they were not sure about the relevance of the design process and working details that were embedded in such a particularised system. Later, the CTO further confirmed this early concern.

> *'This system was just a study tool for LZ to get to know the key design operation process, which LZ hardly got from the user organisations at that stage. We felt we needed to understand the design concept behind the system and had to investigate the representation of its details, for instance the work flow, standards, even the users, in order to decide which parts we should change or keep, and how'.*
>
> LZ CTO, November 2005

Treating the system as a 'study example', the first Chinese domestic PDM system was reverse-engineered by LZ. This intensive study, combined with the redesigning task, took LZ almost three months. As indicated by the CTO, the high-level business operation concepts which were embedded in the system were the focus of their study. The key information that LZ was trying to gain from this system was how each function had been put together to support the design process. As mentioned earlier in this chapter, LZ did have some limited knowledge of the design organisations and operational processes from previous product development of CAD and GIS (geographical information system). The knowledge in hand was enough to enable LZ to understand this design operation system. Technically, there was not much to take from this system. As claimed by the LZ CTO, his prediction at the time was that the individual client-based software of the purchased system would be replaced by the network-based software package. Shifting from client-based to web-based systems meant that a significant data and system structure change would be required. This structure change was combined with LZ's knowledge and some of their assumptions about the design management process.

Based on the purchased system and LZ's study of how each function was put together, an abstract picture of the design operation process gradually emerged. By now, the PDM system had been marked as v1, following the modifications by LZ. As recorded by the LZ marketing director, the v1 PDM still could not be used as a prototype for user organisations because of LZ's concern about the lack of the representation of use and users. The features of the software were still rife with the supplier's own assumptions, as well as the specific features of SCDI. Disassembling this specific PDM system, however, provided valuable insights that assisted LZ's understanding of the interior processes of design organisations and, more specifically, the design management process and related system model.

5.4 THE EARLY INTERNAL TENSIONS

5.4.1 The trade-off: The difficulty of adaptation

Thus far the system was still at the stage of internal development, with no direct involvement of user organisations. This lack of domain knowledge and its own time limitations forced LZ to accept the fact that they could not afford to build up the generic solution in a relatively short period of time. Instead, an alternative solution was sought.

> '*By this time, you could not say that we didn't know anything about the design organisation operation system. Either gathered from the system that we bought or from previous systems, we had some ideas about design organisation requirements. However, those ideas only scratched the surface and were not detailed enough. In order to test and fill in new functionality, we need to get closer to the user organisations.* '
>
> LZ CTO, October 2004

Purchasing an existing system accelerated the PDM package's market launching time. It also, however, led to an implementation difficulty, because the early generic solution lacked the ability to fit into local user organisations' contexts, due to its limited functionality. For LZ, the issue became how to increase the functionality of the PDM after the market launch. Lack of understanding about user requirements was seen as the key barrier to further enhancement of the early PDM product. It was clear that there was tension between LZ's financial needs and its need to develop the technical capacity of the product.

5.4.2 A solution: Getting closer to user organisations

As recalled by one of the early development team leaders, the only way to get the detailed user requirements to enlarge the PDM functions was to get close to the user organisations; achieving a degree of closeness was necessary in order to collect and compile a catalogue of their needs and understand the logic behind them. Completing marketing surveys or organising user community conferences was viewed as unrealistic since, firstly, there was no financial support to conduct a study; and secondly, LZ did not have the ability to organise a conference. One of the main problems was LZ was not very well-known in the construction industry, and with its financial difficulties in that particular time, they were not able to exercise much choice over the contracts and customers they acquired. LZ's strategy for addressing these difficulties was to take any single contract every time one presented itself. This strategy was employed, on the one hand, to build LZ's reputation and capabilities, and above all to develop an understanding of user requirements. On the other hand, the strategy would bring cash in to help solve the financial problems which had risen from income loss on their existing CAD products. LZ accomplished this task by taking on the existing re-built system, the PDM v1, as an early internal prototype for the company and amassing as many contracts for the development of business applications from the market as they could. They intended to develop applications for famous and large user organisations so the company could be seen as a future 'reference site' in the application domain, which would therefore build up the product image and their own reputation.

Rather than providing a generic solution, LZ provided a semi-customised solution, in which some parts of the system were largely tailored according to local requirements. Each individual contract was unique in some way. For instance, some companies required the development of a financial management system, whereas others would only request a quality control system. In the initial period, tailored development occupied most of the contracts. It is necessary to understand that providing tailored solutions was not a task the company initially planned to undertake. This decision was due instead to the lack of representation of users and use in their early version of the PDM, as well as their inability to persuade users that the ‘best practice’ was represented in this package. Given their lack of financial support and the pressures of time, the provision of customised solutions was a compromise between their need to develop a generic solution and their need to meet local user organisations’ requirements. LZ believed they could get the detailed and rich user organisations’ requirements during the development and implementation of each individual organisation’s contract, meanwhile obtaining the revenues to reduce LZ’s financial pressures.

5.5 ACCUMULATION OF FUNCTIONALITY

As new functions were extensively added to the early version of the PDM through the provision of the mass-customisation service, LZ also experienced a rapid and extensive learning curve, through a cycle in which a range of different user organisations’ requirements were studied, analysed, abstracted, tested and fed back to the ‘generic solution development’. It is noteworthy that this learning process was not smooth; rather it was a struggle through which LZ learned to face and manage the challenges from local diversity, each time that user organisations tried to diminish the value of the practices embedded in standard package. LZ’s relationship with user organisations was sensitive, as on the one hand, LZ passively accommodated all local user organisations’ requirements, and while on the other hand, it attempted to avoid getting too close to a specific local context. Local implementation projects were the key knowledge resources for LZ to build up their early understanding of the representation of users and use.

The process of learning from local contexts and feeding back to standard solution development can be understood as a process of ‘lumping’, a term Zerubavel uses to describe how certain groups tend to be interpreted as 'similar things' (1996). As he argues, the definition of 'similar things' is influenced by the technological regimes of engineering. He further points out that user organisations have the tendency to bring about the reverse, that is, to split from the universal standard in order to define their own unique identities and challenge the universal assumptions constructed by suppliers. Similar explanations can also be found in Berg's work on the constitution of universalities in medical work (Berg 2000). As claimed by Berg, achieving universality is done through the erasure of local varieties, the gradual growing and transforming of what used to be dissimilar under the same category (p. 33). This further indicates that learning from diverse local practices is critical to supplier knowledge resources, in order to cultivate their assumptions about the representation of users and use.

Indeed, in our case study we found that learning from the local organisations' specific requirements and particularities had strategic impacts on the early development of the LZ PDM. In the following sections we evidence the ways in which LZ managed to learn from each implementation project, as well as the ways in which the three key functionalities of the LZ PDM gradually emerged in the stage of early development.

5.5.1 The architecture design organisations

Lumping and splitting

The first customer that signed a contract with LZ to develop a design management system was XiaMen Institute of Architectural Design Co., Ltd (XMIAD). It is one of the largest architectural design companies located in the south of China. As recorded by one of the LZ engineers, once the top management of XMIAD saw this package, they immediately claimed that their management practices were far removed from the one that was embedded in the PDM v1. There seemed to be a mis-fit between the local requirements from XMIAD and the practices which were provided by the LZ software. XMIAD, one of the largest design institutions, argued that their management process was more practical and easier to use than the system that LZ proposed, and they insisted upon the development of a more particularised system. LZ's development team seemed clearly aware that the current system that they were proposing was developed on the basis of their assumptions, and this meant a lack of flexibility and reasonable functionality for XMIAD. If LZ changed the whole system to meet XMIAD's requirements and expectations, this would mean starting from scratch. Particularising the system was rejected by LZ. The entire project was thus postponed. As explained later, by one of the design team members,

> '*The main goal at that moment was to get as many users as we could in a short time. XMIAD was asking too much. If we designed a system to meet their specific needs, it would take most of our people and time, plus their representation of use was doubtful. Meanwhile, we thought XMIAD did not know what they wanted, either. They expected a system to match their practice. But this is not the 'right' reason to implement such a system.*'
>
> Former team member of XMIAD project

What is interesting from the above-described interaction between LZ and XMIAD is that user organisations tend to emphasis the uniqueness of their local practice in 'contrast' to the standard solution. They separate their local practices from standard solutions. Suppliers such as LZ, as indicated in the above interview, generally try to diminish the value of local practice and emphasise the generality of business operation. What LZ means by 'the right purpose to implement such a system' in this conversation, is organisational change. From LZ's perspective, software implementation should be used as a tool to help the user organisation achieve greater efficiency and effectiveness by pushing the organisation to reform their management practices (this interpretation is confirmed in later studies of software standard development, as well as development studies in the growth stage). Convincing users that package solutions are the 'better practice' is always critical for OSP suppliers. Successfully accomplishing this task means that less manipulation is required of the standard software package (hence less cost is accrued). This was not easy for LZ to achieve. As one of ex- implementation team members, a current software development manager, stated,

> *'It is always a battle in which users are trying to convince the supplier that the software practice does not match the local operation; and the supplier tries hard to prove that the solution provided by the software is the best and*

represents most other organisations' practice by providing evidence and cases from other implementation projects.'

Software development manager, November 2004

In this stage, due to their lack of implementation experience and related evidence, LZ failed to convince their first customer, one of the largest architecture design institutions. Put differently, LZ, in the early stage of PDM development, did not have the legitimacy nor authority to persuade XMIAD that their management process and practices were not efficient. As indicated by the CTO, LZ itself felt that it was not quite ready to receive contracts from such large enterprises.

Generification principle

After XMIAD, LZ continued to experiment with the implementation of the PDM system in several other architecture design organisations. Compared to XMIAD, those organisations were much smaller and the internal working processes simpler. These experiments could be one of the main reasons that the related development processes were relatively smooth, such that the projects were carried out and completed in a relatively short period of time. The feedback obtained from these projects was seen as the result of early learning, which thus enhanced LZ's knowledge of design process management.

Originally, LZ's past experiences with CAD and GIS implementation had fed their assumption that there are basic similarities between each design organisation. Dealing with the generic design process and diverse local differences was thus seen as an extremely easy task undertaken by the supplier. Indeed, LZ was surprised by the author's research questions regarding how to design the generic solution for a diverse group of users. Concerning similarities among diverse design organisations, the marketing director claimed:

> *'It is very simple. Indeed there are some differences between each design organisation. From a design process perspective, they should share one main characteristic. For instance, no matter what kind of design companies, nor what kind of products they design, the design process is identical. There are three steps: design, editing and auditing. Those main procedures are inevitable for all construction design organisations……'*

LZ marketing director, October 2004

For LZ, things remain the same, unless there is evidence that can prove that they are different. This evidential approach represents typical engineering logic. If everything happened exactly the way in which the marketing director explained, the PDM software should be simple to develop and implement. After several implementation experiences in architecture design organisations, however, LZ discovered that things were not that simple. There were great differences between the design organisations. For example, the design process, as described by the CTO, should generally consist of design, editing and auditing. There is, however, a large difference between organisations, for instance, the number of times that editing and auditing are performed, and the way in which audit is conducted. These factors could vary in their occurrence, appearing one time to five times, or even more depending on the complexity of the design. Even the name 'auditing' can be given a different name, such as 'checking', 'monitoring', etc. The early version of LZ's PDM was still inflexible, in that those diversities would not be accommodated by the package. LZ's initial design assumptions were challenged. As pointed out by one of the XMIAD team members,

> '*In the early version of the system, some of the functions were designed as fixed. The contradictions that emerged were from the implementations in user organisations. We had to modify some parts of the system to be active and configurable to meet different users' needs.*'
>
> Former team member of XMIAD project, October 2004

After several experiments in the architecture design organisations, the flexibility of the system was increased by incorporating a certain amount of the differences which were abstracted from each local organisational practice. By the end of 2002 and into early 2003, the second generation of the LZ PDM software package was produced and, more importantly, was ready to be presented to users. Until this time, LZ did not even have a software demo which could be used to demonstrate the package's features to users.

'In 2002, we did not take a lot of contracts. The early version of the system was not presentable as a demo to the user organisations. When the PDM v2 was ok to be used as a demo, it was almost 2003. It was, however, still a concept product; there were not a lot of real generic practical functions in it……'

Former team member of XMIAD project, October 2004

Thus far, the contracts that LZ had taken were mainly from architecture design organisations. The architecture design process and related management system were not perceived as a standard process, due to the fact that the sector itself was fragmented and immature. This made it even more difficult to identify the generic features, though LZ did manage to isolate and produce some of these. In order to produce a more comprehensive understanding of the working practices in the construction design sector as a whole (which, apart from architecture design, also includes other types of design institutions such as electrical power design, post and power design institutions), LZ continued to expand its PDM application domains to extend the diversity of their customer base.

5.5.2 The electrical power design organisations

In April of 2003, the GEPDO (Guangdong Electrical Power Design Organisation) project further shaped the LZ PDM's functionality by extending the scope of applications of the PDM software package, from building architecture design to the electrical power station design sector. GEPDO is one of the top three large design institutions in China and was founded in 1958; it was state-owned and became a private enterprise after China's economic reforms.

It is necessary to mention that LZ was delegated to be a key member in a national industry software standard development committee, drafted in 2002. The positive image and credibility of LZ were raised in both the construction and software domains through this opportunity. It is not, therefore, surprising that LZ began to develop systems for big user organisations. This standard development and its impacts on generic solution development will be examined in detail in the next chapter.

The unique local context and practices

In comparison to the architecture design organisations, the practices in the electrical power design process are more standardised, due to its project size, the breadth and complexity of the design process and the characteristically life-critical nature of these projects. The electrical power design projects are all safety-critical and valued at millions or even billions of U.S. dollars (an example being a nuclear power station project). The operational and quality standards in this sector mainly came from the former Soviet Union. As claimed by the LZ CTO:

> '*The design standards in the electrical power sector were mainly copied from the old Soviet Union; [the Soviet Union was] the planning economy. They did not care about efficiency; instead the quality was the most important thing. The requirements for nuclear power buildings are extremely high and strict. The architecture of nuclear power stations is similar. No matter that the station is built in 'A' place or 'B' place, the architecture of the building can normally be reused. The code of the drawing, the number of the drawing, content, table serial numbers, etc., all those detailed things are standardised in the electrical and power sector. In this case, it is easier to abstract some generic functions.*'
>
> LZ CTO, April 2005

GEPDO had undertaken comprehensive design and survey work in Guangdong province for fossil-fuelled power projects, substation projects, transmission line projects, power system dispatching, communication projects and Guangdong electric power planning. GEPDO had the capability to plan and design 500 KV electric power systems, 500 KV transmission and substation projects, conventional coal-fired power plants with unit capacity up to 600 MW, and nuclear power stations with a unit capacity up to 1000 MW. This enterprise, valued at multiple billions of U.S. dollars, had a well-defined organisational structure, particularised management practices, and clear organisational policies and rules. It is plainly evident that electrical power engineering organisations, in contrast to building design organisations, which are normally relatively small in size and characterised by less regulatory control, have much more complicated working structures and specific local requirements. As recalled by a former GEPDO team member, *'When GEPDO initially saw our PDM demo, they immediately said that some of the models of the PDM could not be used in GEPDO since they did not follow the standards in power construction design and practice.'*

Former team member of GEPDO project, October 2004

It was clear that there was a mismatch between the uniqueness of electrical power design organisations and the business functionalities embedded in the LZ PDM. In order to accommodate the specific features of electrical design organisations to second version of the LZ PDM, at a distance from GEPDO's local practices, LZ experienced a difficult learning curve.

As a result of this mis-fit, LZ met several critical challenges related to the transmission of the design management processes used in the electrical and power sector to the PDM v2. Commonly recognised by the GEPDO team members, these challenges are identified below.

First among them was the structure of GEPDO's electrical and power project design process. In small projects, each design is generally carried out by a few people from different technical divisions, such as structural or electrical engineering. In GEPDO, due to the large size of the projects, a unique concept was utilised, that of the 'unit'. A unit represents a quantity measurement of the drawing which was used to facilitate contributions from various sources. An electrical power design programme, for example, could consist of several projects, each of which involves people from different technical divisions, who contribute drawings for the same stage of the project. There could be 10,000 drawings produced by each division within a design programme, and it would be impractical to have only one person drawing, rather than a group of people. In this way, the work that is carried out by the technical division could be divided into even smaller units which an individual person could produce.

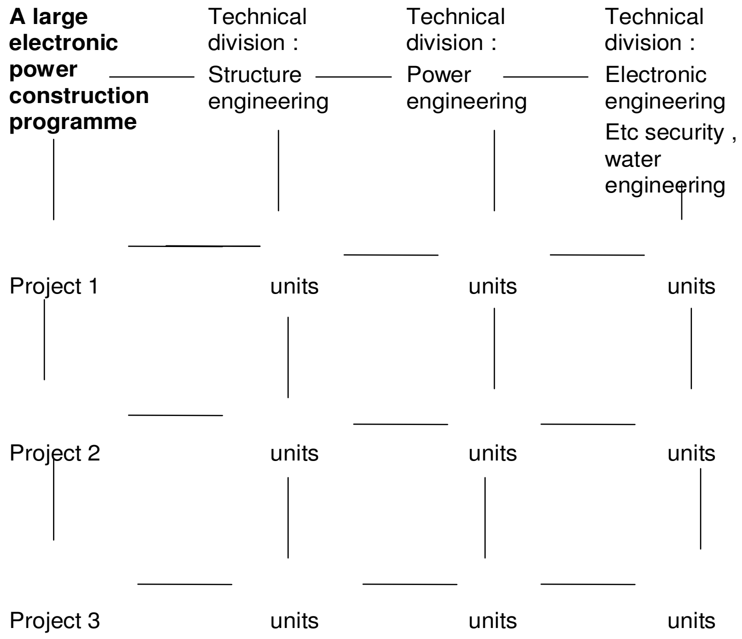


Figure 4: GEPDO working process (Source: GEPDO user requirement analysis report)

Each unit design follows the defined design process. As showed by the above picture, this consists of a complicated matrix structure.

The second challenge is found in the related design process. In the building design organisation, all designs normally go though the same process: design, control and auditing. In the electrical and power sector, however, different levels of design have different processes. The design level is classified by the importance and priority of each particular design within a drawing. There are twenty-six levels in GEPDO, and each level of the design has its own process. For instance, there are five levels for a support material design, and the highest-level design drawing requires a signature of approval from the organisation director. The second-level drawings require a signature from the CTO. The lower-level drawings need to be approved before starting any higher-level drawings.

Thirdly, there is a practical design issue. In theory, the 'unit' should be the smallest measure of the output of the drawings. In practice, however, the unit is not the smallest grouping in GEPDO. For instance, a unit can include up to eighty drawing papers, some of which could be produced and audited first, leaving the remainder to be finished at a later date.

Re-grouping

If LZ intended to meet GEPDO's requirements, this could mean that a completely different integrated system would need to be developed, as GEPDO's working routines look totally different from the practices of architecture design organisations. This could be a very risky solution since LZ could not promise that the developed system could be used in other user organisations. Too closely attending to the demands of GEPDO could lead to problems for later PDM development.

Influenced by the engineering regime, suppliers and engineers maintained the capacity to learn and re-categorise 'similar things together'. Indeed, the GEPDO case challenged LZ's early understandings of the similarities between the design organisations. By analysing the differences, LZ managed to re-assess and modify their assumptions about the generic practices in design organisations. As explained by the LZ CTO, the three problems described above reflected a common issue: what does a construction design organisation manage (it does not matter whether the organisation specialises in building or electrical power design)? He identified this as the 'project', and thus totally different working practices between electrical and architecture design organisations were interpreted as one aspect of the 'project'. He argued that the design process and work breakdown structure (WBS)[24] should be similar, apart from the differences related to this process. In relation to these differences, GEPDO may require a more detailed WBS, since electrical and power design organisations have more complicated and multi-level work details, in comparison to building design firms. In this way, therefore, LZ managed to construct

[24] WBS is a results-oriented family tree that captures all the work of a project in an organised way.

their belief that the existing design management functions could be used in GEPDO, rather than affirm that a totally new system needed to be designed. Meanwhile, a generic difference between architecture design organisations and electrical power design organisations was also produced. By accommodating the generic differences into the existing generic solution, LZ managed to meet GEPDO's requirements with fewer changes than LZ had initially expected.

The PDM v2 was further modified by LZ, on the basis of the study on GEPDO. There were three key improvements made on the technology itself: an improved structure for the system, a new functionality and an extended data structure.

The structure of the system changed from consisting of only web-based applications to a combination of the web-based components with a client-based structure. LZ found that not all users need a web-based application. The web-based applications could more greatly benefit the top management, who might want to check project status at any time or place, rather than the designers. For large drawing organisations, in which the majority of employees are designers, the single web-based system structure could lead to a lowered efficiency, since the size of each drawing could take a huge amount of space and strongly influence the overall speed of the network. As explained by the CTO, LZ realised that for designers, the major task is to draw the designs. Such a task could be done by using their PC, since they would not have an issue with workplace flexibility. Designers could do their drawing on the PC and then submit this work to the web server. When used in such a way, the speed of the whole network would be dramatically increased. Several key functions emerged from the GEPDO project. Prior to this, LZ assumed that quality control only occurred in design processes with fixed procedures. They later realised that they could make quality control a generic function throughout the related departments within the production process. Most of the design organisations were using ISO quality management. This quality management process is involved in design management, project management and marketing management, such that at each stage, the specific department fills in related forms and reports. The project management concept was further explored in GEPDO.

What was the real meaning behind the design process control from a managerial perspective? LZ defined the purpose of the design process control as reflecting a better project process and view of progress. Hence LZ suggested that project managers should focus on the progress of the project. Project management, however, was designed as a part of design process management, and it is not therefore an individual functionality. The individual project management functionality emerged one year later. This will be explained in greater detail in chapter seven, with regard to the CEEDI case. The data structure was further enlarged by extending the user sector from building design to electrical power design organisations. The various WBS, methods, measurements, parameters and standards were added into the software package. Such enrichment was perceived as further increasing the flexibility of the PDM v2 by providing choices to user organisations.

By December of 2003, the GEPDO project was completed. From the early collection of user requirements, analysis, development and implementation, to redevelopment and reimplementation, the GEPDO project experienced several loops. The GEPDO project was an excellent case study through which LZ learned to identify and construct the detailed generality and diversity of management functions within the construction design sector.

Meanwhile, the PDM v2 was gradually evolving into the PDM v3. The emergence of the PDM v3 was marked by the development of another key functionality.

5.5.3 Further developments

At the same time in 2003, around May and September, two important projects had been taken by LZ's other development teams, Chinese Power Planning Consulting (CPPC) and QingDao Building Design Ltd (QDBD). Both of these design organisations signed contracts with LZ to develop similar systems that could provide a general project planning and finance management function. The purpose of this system was described as enabling the top management and related department to view project-related general information, accounting and finance figures to provide better customer management, contract bidding analysis, an employee rewarding system and better finance control for the projects as a whole. This was the first time that two contracts on the development of such a system were signed for LZ. These two projects had a significant influence on the emergence of one of the key systems in the LZ PDM technology, a system called ‘project planning management’ by LZ. This system provided the basis for the later development of the project management model, which will be discussed in chapter seven.

Testing of the hypotheses

CPPC signed a contract with LZ in May of 2003, for the development of three systems: office automation, documentation management and project planning and accounting management. As recalled by a former key member of the CPPC development team,

> *‘From the previous implementations, we had summarised some generic functions regarding the related project marketing, accounting and finance management and began to develop a general application model. CPPC was a great opportunity to try these out, since they required the development of such a system. Later, during the requirement collection stage, however, we found that the representation of the CPPC working practice was doubtful. Its contract management, project management were unique…’*
>
> A former key member of the CPPC development team, October 2004

Eventually, CPPC’s lack of representation delayed the initial internal plans for the development of the generic model of the project planning and finance system. This project, however, was perceived by LZ as an experimental case which enabled them to build from their earlier assumptions (gathered from past implementations of similar function requirements) into a real system, even if to a certain degree, the project had to be suited to specific user needs. For LZ, the CPPC case became one of the many individual user-oriented projects, which were partially built according to user-specific requirements, and in which LZ was forced to compromise their technical needs in order to meet local users’ needs. This compromise was judged to be necessary, since completing the project and learning about the local practices were perceived to be important.

As indicated by the LZ CTO, at that moment LZ also recognised that some parts of the CPPC system could be reused, such as the project's general information management function. As explained by LZ, from a supplier perspective, those parts of the application could be made identically for most organisations.

Alignment with institutional rules

Alignment with the existing institutional rules and standards was also used as one strategy to construct LZ's generic solution and to prevent them from getting too close to a specific user organisation.

The QDBD contract was signed in September of 2003. QDBD differs from CPPC in that it is a medium-sized organisation with 300 employees. As recalled by the person who was in charge of the QDBD project,

> '*QDBD used to have a relaxed management style. There are several production departments and an administration management part. The production departments followed a self-management style. The finances were managed and controlled by the individual production departments. The CEO of QDBD felt that it was very difficult for him to control and manage this organisation as a whole, due to his lack of information, for instance: how much was the department profit, and how were the profits and bonuses distributed among the departments? Moreover, he felt that such a self-controlled system lacked transparency and democracy.'*
>
> The QDBD project leader, October 2004

QDBD required a system that could help them manage each individual department's project finance and rewarding system. Such a system had to be related to the status of the employees' actual tasks, as well as the actual output and profit; this requirement was unique, as it had not been requested by any other organisations. It required a well-established and detailed workflow break-down to track each individual's performance inside the project-oriented organisations, in which the relationships between project and people were complicated.

LZ used to tackle this challenge by starting from an existing industrial guide called 'The Guideline for Accounting Management in the Construction Enterprises' (Ministry of Treasure 2003), as the model for the generic parts. It is a non-regulative standard that was developed to guide the calculation of cost and profit within project-based construction organisations. [25] The importance of this project's accounting management standard was attributed by LZ to its provision of a WBS to the organisations, which served as a platform (process) by which to apply their own calculating methods. At the same time, as argued by LZ, embedding industrial standards into a package also enhanced LZ's authority to discourage the potential of further unique requirements from QDBD and to prevent themselves from getting closer to QDBD's local practice. It can be argued on that basis that LZ was following the national calculating standard, which offers greater accuracy of calculation.

By the end of 2003, the early generic features of the PDM v3, which included design process management, project planning management and quality control management systems, had been established. During the latter part of 2004, LZ extended its product to more and different types of user organisations, such as post-power design and oil design organisations. The feedback from the market was described by LZ as positive.

5.6 SUMMARY AND CONCLUSIONS

In this chapter, we presented the origins of the LZ PDM and the process of its birth and early development in an attempt to demonstrate the nature of the evolution of generic features of OSPs, focusing on the ways in which the supplier managed to construct the package's generic functionality.

Initially, in order to enhance functionality and achieve their economic imperative, LZ chose to get closer to each user organisation and carried out large-scale customisation. The objectives motivating this decision were, firstly, the acquisition

[25] For more detail , please visit : http://www.mof.gov.cn/news/20050228_1546_4243.htm

of a large number of contracts, which would temporarily solve the company's financial problems; and secondly, the gaining of detailed user requirements, which could then be fed back to the initial assumptions about the generic functionality.

With such an approach to development, LZ catered both formally and informally to individual user organisations' requirements, even ones without 'representation of use.' Thus, the functionality of the software package was gradually accumulated through the sequential addition of functions, in attempts to meet specific needs during the development of individual implementation projects.

Throughout the accumulation of functionality, we noted that LZ experienced a distinct process of knowledge acquisition. By conducting reverse engineering, the early assumptions about the generic design organisations' work practises were formulated. These initial assumptions, however, were challenged by customers such as XMIAD and GEPDO through the emphasis they placed upon their unique local practices, in the implementation stage. In recognition of this uniqueness, LZ managed to re-structure their assumptions about the users and use, by accommodating generic diversities in the generic solution.

From the architecture design sector to the electrical design sector, from the design process' system function to project planning and the finance system's function development, each user organisation was treated as a laboratory experiment. In these laboratories, ideas and assumptions about generic features which had been gathered from past implementation cases or other inspirations, such as industrial standards, etc., were analysed and tested. Through this process, as well as investigation, testing and experimentation inside the user organisations, LZ's domain knowledge was incrementally enriched. Such knowledge acquisition built up the early capability of LZ and helped to prepare it for its role as an industrial consultant, at a later date. We will come back to this point in the next chapter.

It is necessary to note that this learning process was not a smooth one. The difficulties which arose with local firms such as XMIAD in the stage of local development and implementation, and the tension between constructing similarities and meeting the local diversity embedded in architecture design and electrical power design organisations' practices, on top of the company's financial problems, together helped to make the construction of users' representations and use a difficult task.

Almost parallel to this process, another strategic and critical event occurred which further enhanced LZ's reputation, as well as its understandings of the representation of users and use in the construction industry. Given the importance of this event, the following chapter is dedicated to exploring it, and particularly the 'real' meaning behind it, including its influence on the shaping of our Chinese PDM.

Chapter Six

From 2000 to 2004: The Development of the Management Information System Software (MISS) Standard

6.1 INTRODUCTION

In 2002, while the technical development teams were busy implementing projects, there was another team in LZ that was working on the development of a related standard, called the Management Information System Software (MISS) standard, for construction engineering enterprises. Both the standard itself and its development process have strongly Chinese characteristics. Officially, this standard is developed with the aim to provide guides to the development of information system functionality and the related implementation practices in construction engineering organisations.

LZ's decision to develop a software standard with a focus on functionality for this particular industry emerged in a context in which the government was attempting to develop Chinese technology with its own intellectual property rights. In addition, the reformation of the Chinese standardisation process also provided the conditions to allow local industries and other social groups to engage the process and lead the development of a standard. As it was strategically engaged with this environment, when LZ proposed itself to draft this standard, its bid was successful, and it was thus selected as the key player by the government for this important task.

Some interaction occurred between the development of the MISS standard and the LZ PDM package. Through the above-described standard development, LZ gained a competitive advantage in their access to information and knowledge in the construction industry, which they had been unable to gain from the PDM development, and they also further built up their industry authority and positive public image. Later, LZ utilised this opportunity to feed their assumptions about the PDM technology and the knowledge that they accumulated through their experience with the LZ PDM implementation back into the development of the standard. As a result, the development of this standard provided an opportunity for LZ to work towards establishing the LZ PDM as the dominant design.

Standards, and the means of their establishment, are important aspects of business strategy in the information and communications technology industry. It is also widely recognised that innovative firms can make above-average profits when their technology or products become an industry standard, as well as create a competitive advantage through marketing, industry reputation and brand image, etc.

There is a strong belief, commonly held within LZ that,

> *'Third-class companies make products; second-class companies develop technology; first-class companies set standards.'*

It seems that the LZ top management team was aware of the importance of standards in their product development. Building up the related software package standards was one of the development strategies formulated at the beginning of the year 2000, despite the fact that LZ still lacked a clear vision for the content of such a standard at that time. This was the same year in which LZ decided to enter the construction management system market, demonstrating the determination of LZ to become the top supplier which would lead software technology development in the construction industry.

This chapter focuses on illustrating the process through which a standardisation effort arises and further explores the impacts and consequences of standard development in relation to the LZ PDM generic solution development. It does this by studying the content of the standard itself, as well as the process of its development. This chapter begins with an examination of the origins and philosophy of the MISS standard, which is followed by an investigation of its content, seeking to assess the particular type of standard in question. The chapter then moves to a reconstruction of the standard development process, to demonstrate how such a process not only helped LZ to generate the domain knowledge needed to build up their product, but also how this process was used as the means to feed the knowledge and experience gained from product implementations back into the construction domain, therefore indirectly guiding the industry, user organisations and other software suppliers.

6.2 THE CONTENT OF THE MISS STANDARD

6.2.1 The origins

The MISS standard is a general industry system/software standard that focuses on the conceptual level of an organisation management information system (The Ministry of Construction 2004). The direct end users of this standard were identified as construction enterprises which are implementing, or will implement, an integrated management information system. The scope of construction enterprises is identified as the organisations involved in the following businesses: engineering design, engineering earth investigation and building construction. The primary stated purpose of this standard, identified on the first page of the final published version, is to provide guidelines and references for the construction enterprises in system development and implementation. As noted by Professor Ma from Tsinghua University's construction engineering department, who was a key participant in the MISS standard development, the second, implicit purpose of this standard is to provide some basic knowledge of the construction domain and a framework for both software suppliers who are unfamiliar with the construction industry, and for the existing software suppliers. An interview with the director of the Construction Standard and Norms from the Ministry of Construction further confirmed this understanding of the government's perspective on initial attempts toward MISS standard development. As he noted, there was a need for such a standard, in order to guide both the supply and use markets in the construction industry while the implementation of information systems was still at an early stage.

For LZ, developing the MISS standard was perceived as potentially impacting, in a very positive way, its related product development. The possible benefits of standard development were anticipated by LZ to be both promising and massive, in commercial and technical terms. From a marketing perspective, being the key member of the industry steering group could effect a magnificent impact on LZ's complementary assets such as marketing and brand image, since the development of a standard is seen as representative of the supplier's capability by the Chinese organisations in general. As described by the marketing director,

> *'Commercially, developing a standard represents a company's capacity. It will have positive impacts on LZ's image and reputation in both the construction software industry and user organisations. Our (LZ) product (the PDM) again is strictly developed on the basis of the standard (MISS), since we are the company developing the standard. Certainly the user organisations would like to use the software which represents or follows related standards. Therefore standard development is a kind of marketing promotion for our product……'*
>
> LZ marketing director, November 2004

Technically, developing the MISS standard was seen as a means to generate more generic user requirements in the construction industry. As recalled by the CTO, the key person in the initiation and development of the MISS standard,

> *'In the early stages of new product development, both financially and technically, the company was constrained by its need to generate cash. We were passively looking for customers in order to survive. Also, user organisations did not want to provide or talk about their own requirements and business process with you if they didn't buy your product. Intensively studying the industry user requirements was impossible to do. Software standard development is helping us to generate some useful industry user requirements. Those requirements are then fed back to our technology development. In turn, the knowledge and experience that we gained from implementation projects could also be used in standard development.'*
>
> LZ CTO, October 2004

Indeed, this development entitled LZ, as a standard editor, to get closer to the user organisations and the industry as a whole, identifying some common requirements, as well as to obtain financial support from both government and application industry organisations, since the industry standard development was a government-delegated project.

Why did the government accept the standard proposal from LZ? Several considerations informed this decision. The primary consideration is described below by the head of the SCCMC (Standardisation Committee of Construction Materials and Components), a third party standards development institution in China.

> *'The government, which is promoting the deployment of information technology within construction business practices, lacked knowledge of the implementation of the modernisation of the construction industry and demonstrated this by using ICT, although they set up their target by the end of 2000, which emphasised the importance of the integrated information system for future construction organisations' operation. Secondly, regarding the ICT standards, the government did not have a systemic standards development plan in mind. LZ's proposal could have been perceived as an opportunity to experiment.*
>
> The director of SCCMC, April 2005

How does such a standard provide 'guides' for construction enterprises' MIS development, as well as the supplier side? Let us examine more closely the content of the standard.

6.2.2 The structure of content

Apart from the small number of requirements for the formatting of data and files, at a low technical level, a large part of this standard concerns system architecture, functionality of an integrated management information system and the implementation process. Conceptually, the MISS standard can be deconstructed into two parts: the features of the MIS and its implementation.

The generic versus diverse user requirements

The features of the MIS system are grouped into two sections, classified according to the commonality of their functions; these two sections are identified, respectively, as the general and the specialised requirements of the system. The general requirements are those which are common to all construction enterprises. Specialised requirements are classified according to the various types of business operations in construction enterprises: engineering design, engineering investigation and engineering building construction. In other words, the standard represents an attempt to demonstrate both the generic and specific functionality requirements to a range of different firms inside the construction industry. In the following part, these two sections will be discussed specifically.

- **The general MIS requirements**

As indicated by LZ's SSD manager, the general requirements were used to demonstrate the generic features/functions of the MIS system in the construction industry by introducing common system architectures and business system models with the required system functionality. In this way, LZ was hoping to help the user organisations recognise the kind of systems that they needed, as well as the fundamental functions that they should expect, in order to undertake any sort of business activities.

As identified in this standard, the common system architecture as illustrated in the following diagram demonstrated the components/parts and structure that a MIS could have (see figure 5).

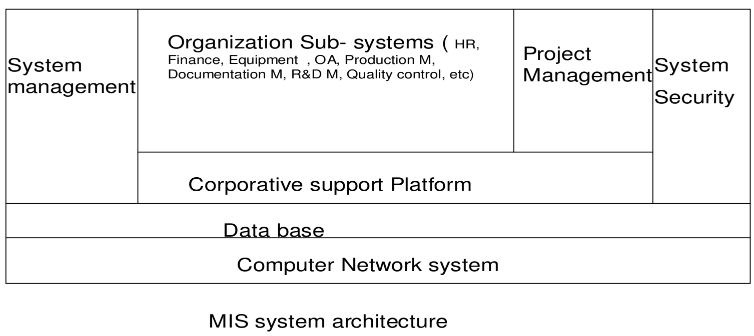


Figure 5: MIS system architecture

As indicated by the above diagram, the MISS standard required that a management information system should at least have three generic application models which are system management, system security and project management, and should be implemented in all construction enterprises. Other business functionalities such as human resources, finance, research and development and customer relationship management can be developed and integrated based on individual organisation's needs.

- **Specialised system requirements**

In regard to the diverse business activities within the construction industry, the MISS standard further classifies the system requirements for each type of organisations. As noted above, there are three types of businesses identified, 'design', 'engineering investigation' and 'building construction'. As clarified in the standard, the main business of design activity is to provide design services, and the product of these services is the design drawing. In the engineering investigation business, the central task is the provision of geographical studies. Such studies help design and construction organisations decide where and how to construct a building. The primary business process involves outdoor data collection activities (e.g. survey, material collection) as well as indoor data analysis. In building construction, the main task is to construct the actual buildings through a combination of labour and materials, following the instructions of architecture and design organisations. The process is related to a more diverse range of special functions, such as preparation and management of related resources, and performance management and assurance. In response to these three types of construction organisations and related business activities, the MISS standard suggests three different system models.

The general requirements for implementation

Apart from identifying system functionality, the MISS standard also clarified the implementation process. As indicated by the LZ SSD manager, the purpose of this part of the standard was to guide user organisations as to the process of developing the integrated management information system. As claimed at the beginning of the section on implementation, the general requirements for user organisations regarding the development of such a system were described as below,

> '*User organisations should diffuse the advanced management style; carry the business reengineering, standardised management behaviour and rules……'*
>
> (Article: 11.1 page 24)

The implementation process was suggested in this standard as consisting of the implementation project initiation, planning, early internal requirements analysis; selection of the suppliers and system development; testing, maintenance and training. At each stage, the standard offered several recommendations. For instance:

> ' *User organisations should select and work with the software suppliers who have enough system development experience and excellent business performance, and who know the figures in the construction industry with the product which has the generic features capable of meeting the general user organisations' requirements……*'.
>
> (Article: 11.2.6 -- Page 25)

Different from other software standards which regulate the technological requirements for software suppliers or designers, this MISS standard was created for user organisations to develop their integrated information system. As demonstrated above, the MISS standard content focuses on a conceptual level of the business process, information system functions and the implementation process. In this way, the standard was constructed to answer questions such as, what kind of fundamental functionality, such as MIS for construction enterprises, should each organisation have, and how could these be implemented? As explained by the LZ manager,

> '*This standard was developed with a focus on functionality. The purpose of the standard is to answer the key questions the user organisations would ask once they decided to develop an information system. When they see the supplier, the first question the users ask could be, what can the software do? What sorts of functions does the software provide? Those questions are on the top of their question list……'*

LZ SSD manger, Nov 2004

6.3 THE INTERACTION BETWEEN THE MISS STANDARD AND THE LZ PDM DEVELOPMENT

6.3.1 LZ's leadership in the MISS standard development

From the submission of the standard proposal in 2001 to the confirmation of its final version in 2004, it took almost three years to reach the final draft. In the following section, we reconstruct some part of the MISS standard development process, aiming to explore the interaction between the MISS standard and LZ PDM development.

According to the standard development rules of the Chinese construction industry, March is the month to propose new industry standards to the government. During March of 2001, LZ submitted its three standards to the relevant authorities in the Chinese construction department. These standards were 'General Management Information System Software Standard for the Construction Enterprise', 'General Geographical Information System (GIS) Software Standard for the Construction Industry' and 'The Information Platform Data Standard in the Construction Industry'. In the same year, the Chinese construction ministry accepted the proposals and published the tasks to develop these three standards.

Although the MISS standard is the one most directly related to the LZ PDM technology development, it is necessary to examine more closely the relationship between those three standards and LZ's general long-term technical and organisational strategies, since this relationship directly relates to the content of the MISS standard.

LZ's ambition was to provide an integrated complex system which consists of both management information systems (OA, PDM, etc.) to control the administrative side and technical systems (CAD and GIS) to complete the actual production tasks. Technically, all of the applications will share the same system infrastructure/platform and the same data standard to achieve interoperation capabilities between the applications. As explained in chapter one, the assumption underlying this was that such an integrated system could solve both management problems, as well as technical production issues, by improving the communication process between individual functions and departments. Furthermore, the shared system platforms could provide the functionality that would allow users to choose different application functions, products or subsystems, based on their local needs, since those functions and systems share the same fundamental system architecture. Installing new application software would provide a 'plug-in' to the platform matter.

As indicated by LZ's top management team, there is a strategic technical link between these three standards. The LZ platform data standard is the low-level technical standard which allows data from different systems/software, provided by different suppliers, to be exchanged and communicated to any construction industry information system/software. Similar to the MISS standard, the GIS software standard identifies the construction industry's GIS system architecture and provides the reference regarding data format, exchange format, saving format, etc. The platform data standard provides the technical foundation for interoperation between the components. The MISS standard identified a common general management information system infrastructure with functionality requirements. These three standards are all very interesting; however, the MISS standard is the central focus of this study, as it has direct links with LZ's PDM technology.

Although LZ was the organisation which proposed these standard developments, this does not mean that LZ must necessarily be the organisation to carry out such important standard development. Why did the Chinese government select LZ to conduct this development? As presented in chapter four (the study of LZ's socio–economic context), the complexity of the construction industry, the broad business range of construction organisations and the specific Chinese technical standards involved in construction represent entry barriers to large software vendors, both domestic and foreign, who might take an interest in supplying general management software applications to this construction market. Most software vendors within the construction industry are small or medium enterprises (SMEs) and provide specialised technical application software systems without involving general management and business functionalities. LZ was one of these, but what differentiated LZ from other SME software suppliers, as indicated by the LZ top management team, was their remarkable success in past product development of, for instance, CAD, GIS and other design software tools. It is hard to evaluate LZ's past success; what is sure, however, is that at that time, apart from LZ, no other suppliers were prepared to develop such a domain-related standard. Given LZ's accumulated reputation and customer base in the construction industry, it is not surprising therefore that LZ was delegated to develop this standard by the Chinese government's construction departments.

On 21 and 22 December 2001, 'The Technological Conference of the Chinese Construction Industry's Information System and Related Software Applications' General Standard' was held in Beijing. This conference was initiated by the CIIIC (Construction Industry's Informatisation Implementation Committee), the DSNC (Department of Standards and Norms for the Construction Ministry) and the DCST (Department of Construction Science and Technology). It was organised by the SCCMC, (Standardisation Committee of Construction Materials and Components), LZ and the CIBSDR (Chinese Institute of Building Standard Design and Research). The SCCMC is a non-profit independent institution concerned with developing material standards in construction. As delegated by the government, its responsibility was the organisation, management and control of standardisation administration throughout the development process. The CIBSDR used to be one of the largest state-owned construction design research institutions in China. After privatisation reform in the construction industry in the late 1990s, the CIBSDR became a self-financed enterprise which provides a building design service and related engineering software development, as well as standard development and management. Their software products specialise in CAD technology. LZ, as the originator of these three construction software technology standards, was convinced that CIBSDR needed to be involved in this conference as a key player.

This conference was a technologically-oriented one. Based on the conference record, approximately three hundred people from the construction software industry, construction organisations, university and research institutions and government departments related to standardisation participated in this conference. The motivation and purpose of the conference were stated in the official document-notice on participation issued by the Ministry of Construction.

> *' …… Due to a lack of relevant standards, the different data format created a barrier to data exchange and data sharing. The individual software application which was used by the users' organisations and could not be integrated leads to the re-entering of data. Meanwhile, due to the lack of systemic strategic planning, the low overall productivity of related software applications became one of the key problems for software suppliers who specialise in the construction industry.........Therefore establishing a technological standards system regarding data processing and information system management is crucial and urgent for both technology suppliers and user organisations…….*
>
> *In order to collect and exchange ideas, opinions and further suggestions to study the latest international technological developments and standards, the technological conference……will be held on 21 and 22 of December……'*

(Notice issued by the Ministry of Construction, R. P. China, 2001)

After this conference, a book called *The Development of the Construction Industry Informatisation Standards and Applications* was published in August 2002. This book is a collection of the conference papers relating to the discussion of standards development, software system features and concepts. The authors were mainly selected from universities and software suppliers. At that time, software suppliers were still willing to be involved in standard development; such participation, however, was not long sustained. As recorded by the LZ manager of the SSD who was responsible for data collection and the drafting of standards, most of the suppliers withdrew from the later standard development due to a range of reasons. One of the main reasons, as he explained, was the clash between other suppliers' interests and the objectives of the MISS standard. Different software suppliers were attempting to apply their product features and concepts to the standard, and these were often different from LZ's priorities. For example, as described by the SSD manager:

> *'One of the suppliers specialised in a construction security system. This company was very keen to participate in and sponsor the standard development. In return, the company wanted some of the features or functions of their construction security information system to be mentioned in the MISS standard. Such a condition could not be accepted by LZ since the objective of the MISS standard had been identified as answering the question, 'what should a MIS have and how should it be implemented'. In the end, the only software supplier remaining who was interested in and participated in this standard development was LZ.'*
>
> LZ SSD manager, November 2004

It is astonishing to observe that the withdrawal of other suppliers from developing the MISS standard was caused by their clash with LZ's interests. In advanced countries, standard development supposedly engages with a range of social groups, to avoid a single actor's control. In this case, however, it seems that LZ was privileged to exclude other technological players by the relevant government departments, specifically through the government's appointment of LZ as the key drafter, as standard development is a government activity in China. This differs from advanced countries, in which standard development is usually a voluntary, inter-organisational activity in a particular industry. The relevant Chinese official appoints the organisations which they perceive to be the right ones for a certain task. This means that having a good relationship with officials is crucial if an individual firm would like to develop industrial or national standards. Indeed, according to the LZ CTO and CEO, LZ did have a strong relationship with the department of standards and norms.

In June of 2002, the related standard development steering group was created. The key standard development team members were identified as consisting of LZ, the SCCMC and the CIBSDR. The first meeting was held to discuss the structures and content of the standards. LZ was officially delegated, within the group, to draft the related standard. The LZ CTO was delegated as the key drafter and editor for two of the standards. It is necessary to mention that, in practice, LZ was the only one who conducted the related business process research and wrote up the content of the standards. Both the SCCMC and the CIBSDR were only involved in the administration of the standard development management, such as determining how to write up a standard, as well as the structure of the standard itself and related procedures and meetings. Their responsibilities also included the selection of experts, organisation of meetings and supervision of LZ and other administration of standard development, such as the meeting of deadlines and the accuracy of the collected user requirements. The detailed intellectual level development was carried out by LZ alone.

The early key debate which occurred in this standard community meeting concerned the application scope of the MISS standard. Who should follow the standard on information system development? 'Construction enterprises' is a fuzzy concept; there is not a clear boundary to clarify which type of organisations should belong to this group. As explained in chapter four, China's construction industry is a very broad field, potentially including everything related to construction, such as property management, construction material manufacturing, engineering design, and building, each in which the business operations vary greatly. In response to this conundrum, LZ reduced the vast diversity in the construction business sectors to three categories, 'engineering design', 'engineering earth investigation' and 'engineering construction'. Its argument was that this classification should be appropriate to the MISS standard, since it represents the conventional definition of construction. From an outsider's perspective, it is difficult to judge the accuracy of this understanding and the related boundary-making. It is clear, however, that these three sectors were set up as LZ product targets at the very beginning of its new product development in 2000.

During the latter stages of development, three kind of knowledge were perceived to be necessary for standard development. As described by the SSD manager,

> *'This [standard development] involves knowledge from standard development, software development, and construction organisation management. [The knowledge from] construction organisation management was the most*

difficult part to gain for LZ. We attended the training course on standard development which was organised by the government. For software development, LZ is the expert……'

LZ SSD manager, November 2004

We shall take a closer look at how SSD managed to gain both domain and technological knowledge.

6.3.2 Collecting domain knowledge

Conducting user organisational interviews

What is most crucial to LZ is the collection of domain knowledge related to construction organisational management practices, which it was not able to obtain from its PDM development teams, since their experience with individual instances of local implementation was not widespread or rapid enough to gain a complete picture of the representation of users and use in the construction field. Similar to the difficulties of collecting market trends and requirements that LZ faced during the PDM development, collecting organisations' requirements through the development of the MISS standard represented another scenario in which user organisations were actually actively engaging user studies. As explained by some of the firms, participating in developing the MISS standard presented a great opportunity for them to see how other competitors implemented the system. For most organisations within the construction industry, this was their first opportunity to gain access to the integrated system development and its applications. The new industry policy that was published at the end of 2000 illustrated the determination of the government to promote the use of the integrated system in the organisation of daily work, by making the system implementation and use part of the evaluation criteria for organisational quality and performance (p. 6). Such a determinant from the top levels of government further enhanced the user organisations' motivation to hunt for the guideline or best practice which would help them to meet the expectations of the government. The benefits of participating in the standard development were obvious to user organisations. Those organisations which were directly involved in content development could achieve both marketing and technical advantages by building their business practices into the standard. For small organisations, standard development community meetings and related conferences represented opportunities to learn from other organisations. Learning from and competing with other organisations in system implementation were perceived to be crucial by most of these enterprises. For instance, LZ has always been asked to provide information on how other organisations developed the PDM system. The intentions behind these questions will be explained in greater detail in chapter seven. In this context, user organisations became positively involved in, and were willing to talk about, their daily application domain experiences since, as participants in the development of the industry standard, they could return the social and technological benefits to their own organisation.

The collection of user requirements took six months to complete. Starting in June 2002, after setting up the standard committee, and continuing through January 2003, more than one hundred user organisations had been interviewed by the LZ standard development team. The main focus of these interviews was the users' business operation processes. The challenge to SSD regarded how to abstract similarities of use and requirements from the broad range of demands and experiences resulting from the diversity embedded in both the structure of the organisations and their management functionality. This user requirement study, however, ultimately benefited the LZ product development. One of the direct consequences of the depth and breadth of the user organisations study was that it generated more domain knowledge for the LZ PDM software development at a faster pace, when compared to their PDM product development team.

Smoothing the content

On the one hand, the benefit from the user organisations study to the LZ PDM product development is clear and direct. On the other hand, this study increased the difficulty of writing up the MISS standard, as the massive diversities embedded in the construction organisations were gradually revealed. SSD, therefore, re-visited the text book, academic and industry experts. For instance, one of the text books, which was called *Project Management* and published in America, was given the role of key reference for the development of the 'project management' part of the MISS standard. As the manager of SSD recorded,

> '*One of the team members in SSD had a masters degree in project management. He suggested this book. In a very early draft, he borrowed a lot of concepts from this book. Actually what we found out later was that those concepts were too advanced for the Chinese construction organisations. Although the level of the standard should be higher than the current practice, the level of this ideal was recognised by most of the people in the standard committee as impossible to achieve, based on the current Chinese construction context.*'
>
> LZ SSD manager, October 2004

This combination of a lack of domain knowledge and of a clear version of the standard's content, as well as the massive differences among the different types of organisations, forced LZ to pull some ideal management concepts and models from the text book. In March 2003, therefore, the first draft of the MISS standard was completed, and a large amount of the content involving the detailed project management process was copied from a text book. Rather than a software standard, it can be described as a guide for industry working practices, since it had little to say about any information system. As recorded by an SSD manager, the inclusion of such detailed prescriptions in the business process part of this software standard was subject to much debate. Most construction enterprises did not agree with this generic working process since their daily practices were widely different from the ideal business process which was proposed. Indeed, the purpose of this standard was to provide a direction for transformation of the Chinese construction organisations through the use of an information system. Going too far from real practice in the Chinese context and involving too much detail in the working routine models, however, seemed not to work well in this case. In the first MISS standard steering group meeting on 26 March 2003, the first draft was criticised as 'not a realistic one in the current context of China, with too much emphasis on business process but not on system functions' (Meeting notes). After all, LZ is only a software vendor, and thus it was perceived by the SCCMC that they could not legitimately develop industrial practices. In recognition of this, LZ decided to keep this standard open and less specific.

Shortly after this first draft, LZ adjusted the style of the drafts. The detailed business processes were replaced by highly generalised and abstracted business processes and models. The required software system functionality was more strongly emphasised. These highly abstracted business models did not involve in any detail the actual implementation process or daily practices; hence as a compromise, it was accepted by most participants. Whether the abstract business models are better than the more detailed ones is uncertain, but what is clear is that this approach at least reduced some of the diversities embedded in user organisations. As documented by the LZ SSD team member, since the standard was drafted by LZ, if no great number of participants challenged the content, it was accepted as representing most of the groups' requirements. If a particular organisation requested different options and requirements, these requests would normally be discouraged as too unusual, since there were no similar requests from other participants. In this way, the representation of use was further developed. Thus, in contrast with the PDM teams in implementation, LZ started to play a positive role and regulate the industrial organisational requirements within this community through the MISS standard development.

Another notable debate in this meeting focused on the name of the standard. Since it is hard to find a similar software standard in other countries, some of the members suggested replacing the term 'software', in its current name, with 'information system'. LZ argued that 'software' is a kind of product, and all products should have a related standard. They further pointed out that the phrase 'information system' invokes a too-abstract concept, and they argued that the phrase 'software standard' is more clear and practical than the idea of an information system standard. From the outsider's perspective, it is difficult to judge which one is more clear or practical. What is clear is that the designation of the product as a 'software standard' was more beneficial to the LZ PDM and other packages' development, since LZ could argue that their product has been developed according to this software standard.

After this meeting, both the principle and objective of this standard were further clarified and enhanced. It was claimed that the purpose of the MISS standard was to provide knowledge, experience and a reference for user organisations on information system software development and implementation. The focus of the standard was identified as centring on the functionality of the software product and the related functions it could provide to meet business practice.

6.3.3 Collecting technological knowledge

Studying the LZ PDM package

In relation to technological knowledge, SSD studied its own company software in detail. As mentioned in the previous chapter, by the middle of 2003, LZ's products were gradually maturing, particularly the low-level applications such as the OA product and platform development. The functions and system structures that were embedded in its product and the knowledge and experience that were accumulated from the implementations were employed as ready-to-use resources. Although the features and functions of the PDM product were designed for design organisations, as understood by LZ, some of the system structures and functions possess universal characteristics and can be used by other types of businesses, such as engineering investigation and building construction engineering. They believed that the general management processes should be similar among design, engineering investigation and building construction organisations. The most significant difference should be found in the production process. In one of the interviews, a SSD manager noted that the way that they chose to tackle the problem resulted from a lack of knowledge and experience regarding software system development for processes relating to engineering investigation and building construction engineering management.

> *'We have identified common system architectures and related business models such as office management, production management, human resources, finance management, project management, etc. [in the MISS standard]. Regarding the special category [a different type of business and related management], although the LZ PDM products are developed for*

design organisations, they can be used in engineering investigation business management easily. Nowadays, few companies provide individual engineering investigation as an individual business. Generally, it is taken as part of the design organisations' service. So our product [PDM] had already covered 75%. Building construction engineering is the only part in which LZ is not yet involved. Apart from the detailed production process, the main management process should be similar. So the general requirements part [including the system architecture, management models, project management] can be applied to all of them. For the building construction engineering production process, the possible level of computerisation is very low. The production process is heavily dependent on labour for its completion. There is only some related documentation management which can be managed by the computer. For the implementation part, our company had a lot of practical experience such that how to implement a system could be summarised based on LZ's past implementation experience…… '

LZ SSD manager, November 2004

This indicates that the experiences of LZ in the PDM product development and implementation were used as knowledge resources, and they had been fed back to the MISS standard development.

Although LZ attempted to utilise the event of developing the MISS standard to promote their product, there were always limits as to the extent to which this could be done. In our case, these limits were caused by the institutions of standard development. In the early versions of the standard, the name of LZ was mentioned in the implementation part as an example of suppliers who had a good reputation in the construction industry. This was directly pointed out by the standard committee and was deleted in the following version. As noted by the SSD manager, although developing such a standard was a strategic move for LZ, they had to keep in mind the limits as to what they could write. It seems that although LZ was deeply involved in the process of developing the MISS standard, it was not possible to fully exploit this prestigious task in their marketing campaigns. There were still some institutions which could (and did) constrain its choices.

Promoting the LZ PDM

The other two conferences were held on 13 October 2003 and 26 April 2004, respectively. As documented, the purpose of these two conferences was to present the drafted standard to the user organisations, in order to collect useful feedback and comments. More importantly to LZ, these conferences offered prime opportunities to demonstrate their related products.

During this period of time, the LZ technical development team had installed their system in a range of construction user organisations from different backgrounds, with varied requirements and needs. LZ utilised this opportunity to further promote its product to the targeted users. As recalled by an SSD manager, at the end of each discussion section, the LZ software demo was used to demonstrate some functions described in the MISS standard.

By August of 2004, the final version of the MISS standard had been submitted to the related government departments for approval of the publication. In May of 2005, the MISS standard was published.

6.4 SUMMARY AND CONCLUSIONS

In this chapter, we investigated the emergence of the MISS standard and its content and structure, to understand the purpose of this standard. We also discussed the related standard development process, to show how and why LZ might benefit from developing such an industry standard, as well as its impacts on the PDM package development.

By now, a relationship of mutual benefit between software package development and software package standard development has emerged.

Distinct from a traditional technological ICT standard, which is generally developed at a lower technical level as a bounded set of specifications (such as a network communication standard or a data standard), as demonstrated, the MISS standard was a much higher-tech general domain-related platform software standard. This standard was created for user organisations as a guide for the development of local information systems.

From a technological perspective, the standard provides a platform which is a sort of framework, allowing different software and components to be integrated and run at the same time, based on the fact that they share same architecture. In other words, all user organisations and even suppliers can develop their systems and connect them to this platform. From this scene, as argued by Nielsen and Hanseth in their research on the Norwegian mobile content standard (Petter and Ole 2006), a standard which has such an open platform should encounter fewer conflicts of interest, since there are no clear boundaries between the inside and the outside of the standard. As a result, those who did not engage with the MISS standard development could also benefit from the use of it. Therefore, implicitly, this standard can also be seen as a reference for other suppliers to develop new system functionalities in the construction domain, to identify the suppliers' future positions within this industry and possible new product categories. Compared to a technical standard, the MISS standard is also less specific and can be characterised by simplicity, as only minimum system functionalities were included with basic requirements. It was developed as an attempt to provide information that covers the diversity of the production process among different user organisations throughout the construction industry. The characteristics of it may help to explain some of the features of the MISS standard development; it requires the involvement of few technological actors in identifying the main platform and thus results in fewer technical conflicts. The only potentially problematic issue for this type of standard is the promotion of the platform's use. In our case, however, the use of the MISS standard was strongly promoted by the state. In the context of China, this means that most suppliers and organisations in the construction industry will follow this standard.

Regarding the development process, as we have seen, the standard was intellectually developed by a software supplier. This situation is highly unusual in advanced countries. In our case study, officially, the MISS standard was developed by a committee. In practice, the content was largely influenced and drafted by LZ. In the context of China, we argue that the unique characteristics of this unusual event were mainly caused by firstly, the central government's determination to catch up with advanced countries by improving their domestic industries' technological capabilities, coupled with a newly upgraded standard related to science and technology policy. The resultant policy created a macro-environment to stimulate local organisations' desire to conceive products with their own intellectual rights through the setting up of the technological standard. Secondly, the reformed standard development process of enrolling industrial organisations is essential. It created the conditions for LZ to strategically engage with standard development. Last but not least, both social groups, the government and other organisations, were still in the early learning stages of dealing with their new relationship, and this left a large space for actors such as LZ to strategically pursue their plans. The last point also provides the hint for our next question.

In relation to the question of why the state accepted LZ as the developer of this standard, some possible factors include the strong relationships which LZ shared with relevant officials, the presence of which is important in China. Secondly, LZ was the first organisation to propose such a standard, and thirdly, as a unique standard, few software vendors were interested in developing it based on LZ's proposal and framework. Furthermore, the state was looking for a national champion to guide technology development. The combination of these reasons may have prompted the state to select LZ to develop this standard.

In relation to the content of the MISS standard and its impacts on developing LZ's generic PDM solution, we can identify two types of diversities that are embedded in this standard. One relates to the diversity of business sectors inside the so-called construction industry. The second one relates to the diversity of user requirements of the generic functionality. In response to its recognition of the first, LZ constructed boundaries by identifying the application scope of the standard on the basis of its own interests. By drawing boundaries according to sectors within the construction organisations, LZ managed to identify the key types of user organisations. In recognising the different participants' opinions regarding functionality, and by emphasising the uniqueness of these requirements, LZ managed to further enhance its influence in the identification of the representation of users and use, because LZ was responsible for drafting the standard in the first place. In comparison to the early PDM development, as demonstrated in chapter five, through this event, LZ actively engaged with user organisations to regulate the market and related user organisational requirements.

Standard development by a single supplier can be criticised as encouraging a monopolistic situation, according to western economists. The impact of LZ's monopoly in this standard development, however, was constrained by the highly structured standard administration and management process, including the required user organisation conferences, expert meetings, critical discussions and debates. The standard development thus provided a space in which to generate industry knowledge and related practices through discussion between different social groups such as universities, user organisations and suppliers, a discussion which could not take place within any other space. The related standard development meetings, workshops and conferences were used as the means to exchange, communicate and shape the industry's business management knowledge and technology requirements by enabling the airing and discussion of related opinions and suggestions and understanding from the players. Throughout the standard development process, the role of LZ can be seen as a construction industry knowledge generator engaging diverse players who were involved with MISS standard development.

As a package software supplier, such knowledge–generating activity resulting from developing the software standard provided LZ with an advantage in accessing a greater depth of industry knowledge. Compared with the information it gained from the individual PDM system implementation, the wider scope of industry understanding that was accumulated in the standard development more significantly increased LZ's capability to identify the representation of users and use quickly, and assisted LZ in the identification of the generic functions throughout their PDM product development process. In turn, the knowledge generated from LZ's past system development and experience in implementation was used as a resource to inform the MISS standard development process.

The impacts of this standard development on LZ's market image and its products were massive. The reputation of and the trust placed upon LZ were dramatically enhanced in both the construction user application industry and the software industry. In relation to user organisations, it is not difficult to see that LZ would, following the publication of the MISS standard, be considered a company with a good reputation. As we noted in the early pages of this chapter, most Chinese consumers believe that the organisations which can develop national standards are the best organisations. As a result, the valuable positive image fostered by the MISS standard development further speeded up LZ's generic solution development process. LZ therefore began to shift to the new development strategies at a later stage in the growth of the PDM. This will be discussed in greater detail in chapter seven.

In relation to competition with other suppliers, by building its product into the standard, LZ managed to set up its own PDM package as the dominant design in the construction software industry. A danger inherent in this kind of standard development is the publication of a detailed illustration of its own product's technical structure which was explicitly embedded in the MISS standard and thus made visible to other software suppliers. Exposing the internal secrets of this technology could destroy the initial competitive advantage. As demonstrated, however, the standard development created a competitive advantage of access to industrial knowledge and long-term marketing benefit. In comparison with other software suppliers, the richness and depth of its industry understanding enabled LZ to create more products. The capabilities of new product development will be further examined in chapter eight.

It is necessary to point out that without government and other suppliers' support and participation, LZ could not have achieved its standard strategy. The fundamental enabler was the Chinese government's recent science and technology policy reform, and the motivation of private firms to engage in standard development which tops the governmental reform agenda. From the perspective of the Ministry of Construction, the MISS standard development would help them to guide the reform of construction user organisations and the implementation of ICT, as well as the regulation of the supply side of the technology.

For other technological suppliers, participating in the MISS standard development meant the investigation of potential technological development trends and collaboration opportunities. In particular, in the construction management software industry, suppliers were motivated by the potentially huge demands to be made on a range of different management information systems. By participating in the development of such a standard, other suppliers hoped to influence the standard development, as well as capture information on what kinds of products could be developed in the future. Ultimately, however, other suppliers found it to be difficult to influence the MISS standard development. As identified in social shaping studies, there could be other factors that would motivate supplier collaborations, such as reducing uncertainties by foreclosing options in advance, thereby sharing cost and risks.

For most user organisations, the MISS standard development provided a space in which they might gain access to the latest technology, as well as to related information on the reform experiences of other user organisations and their experience with using ICT technology. As we noted in chapter four, most construction enterprises faced a range of challenges. Learning how to survive without government support, how to improve productivity and efficiency, and how to use ICT technology to achieve those objectives were all competencies which would be critical to their survival and future development. Meanwhile, information resources were very scarce and continue to be so, even in contemporary China. Getting involved in this standard development could provide a great opportunity to see others' performances, as well as to learn about the technology. Meanwhile, as a result of participating in the standard development, the user organisations' socio-economic network was also bolstered. Their knowledge of the technology and its use further enhanced the user organisations' understandings of how to deal with the suppliers.

To summarise, the strategy of developing the national standard had two impacts upon the LZ PDM development. Firstly, it was used as a marketing and political tool in support of LZ's own product development, in particular for the identification of representation of users and use. Secondly, it was used as a knowledge-generating tool to capture both technical and domain knowledge in an interactive learning environment and hence to provide LZ with a greater depth of understanding about the structure of the technology and the commonality and diversity which were embedded in the construction enterprises' daily operations.

Chapter Seven

From 2003-2005: The Third Generation

7.1 INTRODUCTION

From 2003, the LZ PDM gradually entered what we describe as the stage of growth. The growth of the software package is the stage in which the general features of the software package emerge. At this stage, according to the related literature, the supplier increasingly tends to enhance the generic functionality of the OSPs in such a way that the focus is shifted to the development of the generic solution and possible new applications (Clause and Koch 1999, 2002; Hyysalo and Lehenkari 2002; Pollock et al. 2007). Throughout the early evolution of the generic functions, the accumulated domain knowledge and implementation experience enable the supplier to better understand and even evaluate the application industry's business operation process. If early development is a passive learning stage, in which most of the user organisations' requirements will be translated into features of the OSPs, at the growth stage, as pointed out by some current studies, the suppliers tend to positively and actively engage with the user organisations, to work on the generic solution development in a community environment.

In this respect, this chapter will examine how the Chinese supplier LZ actively interacted with different user organisations through the strategic management of customer relationships during the growth stage. It begins by exploring the updating of the features of the LZ PDM technology and its customer relations management strategy. The second part of the chapter presents a detailed ethnographic case study on the interaction between a particular user organisation and LZ on a specific project. In so doing, we hope to demonstrate how, on the one hand, LZ is trying to meet unique requirements, and, on the other hand, is maintaining the integrity of the technology through nudging the users towards existing solutions.

7.1.1 Ethnographic study

Methodologically distinct from the previous two chapters, an ethnographic approach has been deployed in this part of the study with the use of interviews and documentation. The previous chapters reconstructed the historical evolutionary process of the OSPs and LZ, but the main aim of this chapter is to contextualise the supplier design strategies by deploying the research methods of ethnography. The case study of the CEEDI, which is presented here, was conducted during the researcher's data collection period. As a result, the researcher was able to participate in and observe the development process directly. The data gained from informal discussions at the lunch table, attendance at management meetings and training related to an important project further advanced understanding of the biography of the organisation's software package. By undertaking such research, solid support can be established for the reconstruction of the historical development process.

7.2 THE MANAGEMENT OF THE SUPPLIER-USER ORGANISATION RELATIONSHIP

7.2.1 Shift from early development to growth

By the end of 2003, the features of the LZ PDM technology had been expanded from dependence upon the design process management system to the eventual attainment of ISO quality management system support, as well as a project planning management system. The main three functionalities of the LZ PDM technology had emerged: *project planning management with a focus on project accounting and finance management, design process management and ISO quality control.* At the same time, LZ's reputation in the construction industry was consistently increasing, with enormously positive effects. With the achievement of a better management information system market in the construction field, the LZ PDM technology entered the growth stage. An increasing number of user organisations directly contacted LZ, indicating a wish to sign contracts and adopt its management systems.

As demonstrated in chapter five; in the early development of PDM, to attain contracts, LZ had to provide virtually customised solutions in order to make the product fit the local user organisations' requirements. This was mainly caused by the product's lack of representation of users and use, as well as LZ's lack of authority to persuade the organisations that its product represented best practice. These weaknesses, coupled with an urgent need to solve its financial difficulties, which were the result of the saturated CAD market, meant that meeting individual PDM users' requirements was treated as a relatively higher priority, as it was seen as the only way to attract more projects (thus earning the desperately needed cash). As claimed by the LZ CTO

> '*Although we knew in which way the system (that the user organisation(s) required) could be made more generic, so that it could be used by more organisations, if the user organisation did not agree, or the application could not totally meet the user's requirements, most of the time we had to change the design solution to meet individual needs since the contracts had been signed. It is difficult to keep the balance between a short-term and a long-term goal……'*
>
> LZ CTO, October 2004

Indeed, such an early development strategy could only solve LZ's financial difficulty temporarily. It seems that such a strategy was no longer applicable in the stage of growth however, as it became impossible to meet all the user organisations' requirements once the number of customers reached a certain (high) level.

By late 2003, it was indicated by most of LZ's top management that from LZ's perspective, technically, the possible diversities among the design organisations had been revealed in the early development stage. It was time, therefore, to further explore and enhance the generic part of the PDM package. Financially, due to the increasing demand for the adaptation of the LZ PDM, it seems that LZ did not need to attract projects by providing customised solutions anymore. Meanwhile, LZ had gradually built up its social reputation and authority and technological capability through the MISS standard development. At this stage, the increasing number of contracts further illuminated the necessity and urgency of the development of a more generic solution with high flexibility, so as to reduce the implementation costs.

In order to make a software package more generic, the western software suppliers start to shift the design and evolution of the package from one which is based on one individual user's context to one which is based on a group context, in which a range of different user organisations and other social groups are enrolled to enhance a new functionality (Hyysalo and Lehenkari 2002; Pollock et al. 2007). For Koch, such a collective space was described as the 'mass producing community' and was seen as a critical place in which actors influenced the construction of the software solutions (Koch 2003). In Scott and Kaindl's SAP case, a similar approach (between SAP, PWC and the user committees) demonstrated how suppliers managed to enhance the functionality by running user prototyping conferences. Furthermore, Pollock *et al*. described how SAP utilised community spaces such as user group meetings and requirement prototyping sessions, to reverse diversity and detach the individual organisation from the particular requirements, through a range of generification strategies. We noticed that in these cases, suppliers attempted to arrange alliances with other social groups such as business consultants and big user organisations to construct the generic functionality. In our case study, we found a similar shift in the stage of growth. In the early development stage, the aim of LZ was to get as many user organisations to sign contracts, in order to generate cash and acquire domain knowledge. In the stage of growth, the main objective of LZ shifted to the development of the generic solution and determining how to make it work in diverse contexts with few changes and little customisation.

As argued by Hasu (2001), the supplier must learn to succeed in design and customer relations in order to survive, but, at the same time, its original imperatives to achieve economic success, feasibility and competition have not disappeared. The early-stage user relationship allowed LZ to manage the tension between meeting the local user organisations' needs and achieving technological accumulation. In the growth stage, a new approach is required, as noted by Hyysalo, to strike a balance between seeking co-coordinated improvements with users and seeking standardisation. As Hasu explains (2001), in this stage, the relationship between supplier, user organisations and package faces a 'critical transition'. From a supplier perspective, identifying and developing a new method to deal with user organisations through the development of the technology is crucial, in order to manage this ‘critical transition’ (Hyysalo Forthcoming).

In the case of the LZ PDM, on the basis of the result of early learning through the implementation experience of individual projects, the possible diversities embedded in different organisations had been revealed. In the growth stage, the focus of LZ had shifted toward stabilising the generic solution. Meeting individual users’ needs had been replaced by developing generic solutions on a community level, at which only selective requirements are addressed.

7.2.2 Reconstructing new supplier-customer relationships

The segmentation of user organisations

How should LZ decide which requirements should be catered for? According to a range of interviews with top management, during this stage, LZ began to manage its interaction with user organisations by strategically managing the customer community. As explained by the marketing director,

> “*We are not in the surviving stage anymore. In a growth stage, rather than meeting all users’ needs, developing generic applications is at the top of our priority. If we feel that the local user organisations’ requirements represent general practices in this domain, we will consider accommodating them into the generic features……There are some special cases, for instance when the local customer requirements can be met without changing the current system or with minimum adjustment of existing solutions, meeting their needs is not possible…… To summarise, the key principles of PDM development now in LZ (2005) are, firstly, based on existing solutions, secondly, based on the usability and representation in this domain and, thirdly, the profit……* ’
>
> LZ Marketing Director, April 2005

In a later interview with the LZ CEO, she further contextualised what had been stated by the marketing director. She described a range of circumstances to illustrate how LZ would deal with local user requirements at this stage. To summarize, three different suppliers- user relationships can be identified.

Firstly, in relation to those organisations which are large in size and have state-of-the-art working practices and knowledge, LZ perceived the adaptation of its product as a learning opportunity, as well as a starting point from which to explore possible new applications or even to get into a particular market. As stated by the LZ CEO:

> *'Normally in this case, a strategic partnership would be set up. This type of user organisation would be used as a reference site for demonstrations of the uses of LZ technology. This type of customer is vital to us as we enter a new market or decide to develop new functions……'*
>
> LZ CEO, April 2004

When dealing with strategic user organisations, as pointed out by her, technological potential is the key criterion that informs the manner in which customers are approached, rather than profit. The related local user requirements are thus carefully analysed in regards to the potential scope of their application. She further noted that the requirements which LZ believes to represent users and usage are catered to, even if the project has only a small budget.

Secondly, with those organisations which are willing to try new technologies and accept new things, LZ normally is willing to sign a contract, even though the budget of such a project may be small. In such a situation, the users are willing to adapt themselves to the PDM software package or whatever new functions that LZ has just developed. From a supplier perspective, as described by both the CEO and CTO from LZ, taking on such projects could benefit the technical development by allowing the testing of its new ideas and functions accumulated from other implementation projects.

Lastly, it is only for the user organisations which could pay enough to ensure absolute project profit, that LZ would consider developing a system which is closer to the specific user requirements. As argued by the CEO:

> *'For these types of user organisations, unless the project is profitable, we don't take the contract in the first place as we have plenty of projects in hands.'*
>
> LZ CEO, April 2005

Further, catering for local user specific requirements, as indicated by the LZ CEO, does not mean, however, that LZ will develop a system from scratch, to completely fit into local practices. Rather, some techniques will be used, with the aim of fitting organisations into their existing generic solution.

In this way, user organisations are categorised into different groups, based on their potential contributions to the 'generic solutions' development. For each group, LZ has developed an individualised strategy to address the user organisations' requirements in such a way as to maximise the benefits to their own technology development.

Design principle

The key technological development principle, as described by the LZ CTO, is to minimise the customisations of their current PDM product. By the end of 2004, a new sales guide was published internally. As highlighted by both the LZ CTO and the head of the implementation team in a training section, at the top of the list of new principles for selling the PDM and dealing with user requirements was the clarification that solutions should be developed based on 'existing technology'. This meant that before signing any contract, the user requirements need to be assessed on the basis of how much change would be required in the existing PDM technology. If the requirements could not be met by modifying the current LZ PDM technology, 'unique' requirements would be assessed by their potential reapplication in other organisations.

One of the consequences of segmenting user organisations into the groups described above is the constructing of boundaries within the user community. By approaching groups differently, LZ's relationship with user organisations subsequently becomes structured. Following this structuring, the interaction between LZ and the user organisations regarding the building of OSPs can be managed (i.e. users can be treated differently). LZ can gain advantage from treating users differently. For instance, by setting up a partnership with reference sites, LZ is able to abstract new functionalities; by taking organisations that are open to change, LZ can use them to test its ideas and new models. Working with firms who can afford a more specific customisation, LZ is capable of generating more profit and hence contributing to the development of new products.

In the following section, by presenting a case in which the LZ PDM was adapted by a large Chinese design institute, we attempt to illustrate how the supplier LZ interacted with this enterprise, which belongs to a particular group described above, as well as how LZ strategically managed the unique local requirements, knowledge and practices for the support of its own PDM development, in the growth stage and within the context of China.

7.3 THE CASE OF THE CHINESE ELECTRICAL ENGINEERING DESIGN INSTITUTION (CEEDI)

7.3.1 The CEEDI and the reference site

The CEEDI

The CEEDI is a large Chinese domestic design institute and inter-disciplinary engineering construction enterprise. Established in 1953 as a state-owned company, today the CEEDI has been reformed into a group corporation consisting of five holding subsidiaries, ten direct subsidiaries, and five joint-stock companies. As one of the ten key survey and design companies directly under the state council, it possesses state-certified Class A qualifications. As an individual entity, the current number of CEEDI staff is 1,188 in total, of which the technical force accounts for 1,010. The 1,010 includes three state-level design masters, thirty-one senior architects and engineers of research fellow level, two-hundred eighty-six senior architects and engineers, two state-chartered architects, fifty-six state Grade I registered architects, seventy state Grade I structural engineers, three state-registered city planning engineers and twelve cost engineers. Additionally, as a group corporation, the CEEDI owns a dozen individual companies (www.ceedi.com.cn).

The CEEDI has the capacity to offer a full range of services in planning consultation, feasibility study, engineering design, construction supervision, and general contracting for both industrial facilities and civil buildings. This means, as indicated in the previous section, the CEEDI could provide most of the services that an owner would need, from a turn-key to a subcontracting service, or individual function services such as design, and construction management.

Meanwhile, within the 'Research and Test Centre' CEEDI is the only research institution under the Ministry of Information Industry, and contains eight research centres in clean room technology, micro-vibration technology, manufacturing of special equipment, environmental protection, intelligent network engineering, and so on.

At the crossroads of domestic business reform and entry into the WTO, and given the challenge from abroad, CEEDI's mission has been identified as becoming the top-ranked international engineering firm at home (China) and a noteworthy figure in the world's engineering field (see www.ceedi.com.cn). The top management personnel, however, noticed that their fragmented group organisation structure resulted in inefficient communication and management inside the organisation and across the groups. They recognised that if they wanted to enter into international competition, firstly they needed an efficient data system to aid decision-making when bidding for work and secondly they needed to conform with the management systems and strategies found in international construction engineering companies. Thus, they decided to build up an integrated system to help them improve their existing work flow, both within their organisation and across the groups.

LZ's reference site

Due to its size, its complex working process and its reputation in the construction industry, CEEDI was taken on as both a reference site and a 'study' object by LZ. While the application of PDM was still largely developed for construction design enterprises in comparison with the broad business activities within the construction industry, as indicated by the SSD director, LZ foresaw that the CEEDI project could become an important turning point in its future business development. The broader construction business activities in which CEEDI was involved, as well as the services that they provided, could potentially extend LZ's existing knowledge and hence could offer a promising opportunity for LZ to explore new functionality and products. Furthermore, by aligning itself with this multinational organisation, LZ also could benefit from the sale of its PDM product, since successful implementation in CEEDI could serve as an indicator of LZ's credibility.

Reference sites are crucial in the context of generic software packages. The possibility of such an impact results from the nature of OSPs. During the procurement stage, potential customers face uncertainty as to whether or not the capability of a certain package will match their requirement; this is something which can only be discovered after its implementation and usage. As a reference site, CEEDI would be seen as a demonstration of potential fit and also as a demonstration of LZ's competence.

As pointed out by Cusumano, ninety percent of small and medium companies fail due to the lack of a reference customer (2004). Finding a reference site is not straightforward, since creating a partnership requires the involvement of two parties. Securing a reference site is essential, however, to OSP suppliers since it can help to enhance the credibility of a supplier. In our case, CEEDI was an important site for LZ. There was enough evidence to attract LZ's top management's attention to this project.

7.3.2 The early tensions in the adaptation of the LZ PDM

Unique requirements from the reference site

As a member of the drafting committee, CEEDI had met and worked with LZ during the development of the MISS standard in 2004. In November of 2004, the CEEDI officially delegated LZ to be the technology provider developing an integrated management system which could help them improve their current working performance. The system was to be implemented in phases. In the first phase, CEEDI required LZ to initialise an integrated system solution with an incremental implementation strategy, as well as to deliver the first part of the system by 2006. The budget for the first phase was 200,000 RMB (less than 20,000 Pounds). As described in the opening section of '*The CEEDI requirement analysis report'*, which was proposed by LZ, the main task of this first development phase, as written in the contract was, (goal, guidelines)

> '*To achieve the integrated office automation and computerise the general business planning and management functions, to build up the main architecture of the CEEDI system, and therefore to provide a solid foundation for the future development and implementation of project management and other key functions*.'
>
> The CEEDI requirement report, p. 1

Both LZ and CEEDI agreed initially to develop a report which includes the integrated management systems analysis of requirements and the relevant design solutions.

The data collection of user requirements was performed by LZ's SSD team. However starting from December of 2004 and lasting five months, until May of 2005, the whole project remained stuck at the stage of user requirement analysis, which was far behind the project schedule. Explaining LZ's perspective, this problem was described by the LZ CTO as the result of a misfit between the standard 'user requirement analysis' provided by LZ and the one required by CEEDI.

LZ's user requirement analysis report was a standard, detailed technical document which was largely dominated by the descriptions of the functionalities that were proposed by LZ. A detailed assessment of current business practices was, however, strongly demanded by CEEDI. Meanwhile, in relation to the improvement of current practices, an explanation of the rationale behind the design of each system function was also required by the user organisation. From LZ's perspective, however, this demand was considered to be part of an unnecessary, complicated and costly consultant service which did not fit into their standard solution. As indicated by the SSD manager, the user requirement analysis report had been seen as the system specification that would be used as an agreement about the detailed functions development between the supplier and the user firm, to serve as the foundation for the subsequent customisation of LZ's standard software system. The format of the report has also been used in so many implementation projects that it was even understood as an 'internal standard'. As the SSD manager in charge of data collection argues:

> *'It is only a 200,000RMB project. The principle is to write as little and in as general a manner as possible. We have completed so many projects and have been writing a great number of reports. Some of the things, such as the rationale behind the design, are not necessary to mention. We don't have the responsibility to explain the rationale behind each design in our product to them. Even without writing up this requirement analysis, our products can be installed in a very short time. For us, the key thing in the agenda is to implement this system and let them (CEEDI) be able to use it. It is not necessary to spend too much time and energy on anything else. We think the report that we provided is good enough. "We would rather pay more attention to the development of new models. However the users want to get as much as possible, even without paying money……'*
>
> LZ SSD manager, April 2005

It seems that LZ was not willing to change its standard technical report format to fit with CEEDI's requirements. We can see that there was a tension between LZ's desire to get into the development of new generic functions as soon as possible and their need to meet the requirements from local organisation for the development of a specific analysis report. This conversation also illustrates a common perception of software suppliers regarding the provision of a consultancy service in China. Few software product suppliers would like to provide a management consultant service since there is a low value recognition of this activity on the part of the user organisations. We will come back to this point in the section 7.3.3.

Unexpected outcome: user expectations

Apart from the request for a detailed plan of the system infrastructure, the constantly changing requirements from the customer side were perceived as another reason that the user requirement analysis still could not be done. Initially, LZ tried to demonstrate some of the applications that were used by other organisations in order to portray an ideal picture to attract CEEDI. Later, they realised that this demonstration may have brought unexpected troubles upon themselves. As pointed out by the SSD manager,

> '*Each time, when we demonstrated some of the applications that were used by other organisations, they tried to require the same thing even though they did not need them. We realised that this would be a big problem for us later on. It made our job even more complicated. Their problem was that they didn't know their own business process. Inside their organisational group, the information and operation processes were a mess.'*
>
> SSD manager, April 2005

By the end of April 2005, the relationship between LZ and CEEDI was further stretched. After six months of hard work, CEEDI and LZ were still unable to reach a consensus about the content of the user requirement analysis. LZ was not going to dedicate any more energy to the user requirement analysis stage. The user, CEEDI, was dissatisfied with the insufficient work that LZ had delivered. The following two conversations clearly show LZ's frustration.

The 6 April 2005 event

Two conversations were recorded on 6 April 2005 at the standards department on the supplier site, after another supplier-user meeting regarding the content of the 'user-requirement analysis report'. This conversation occurred after a dozen of similar meetings had already been carried out in the past month. The first one involved the manager of the SSD (Z) and a member of the department staff (L). After the meeting, the manager of the SSD came back from the user site and walked into the office. The second conversation took place between the CTO and the manager of the SSD.

Conversation 1:

L: *How were things going?*

Z*: Well, they always have something to change and add. The users wanted everything; (we) showed some examples. They wanted all of them. They want more and more now!!!!!*

L*: This is not a supermarket where you can take whatever you see.*

Z*: I told Mr. Liang (the CTO of LZ) not to show them everything. But he did not take it seriously. Later on, he realized this problem, too late…. Basically, they (the*

CEEDI) just want everything that they saw even without thinking whether they need it.

In common with previous afternoons, Mr. Zhu did not take a lunch break and instead worked on writing up the CEEDI requirement analysis. The CEEDI case is one of the few cases which caught the attention of the top management of LZ. The CTO, the project director and the marking director frequently visited the SSD department to discuss possible solutions.

Conversation 2:

Around 3pm on the same day, Mr. Liang walked into the office. (The conversation between Mr. Liang, the CTO and Mr. Zhu, the manager of SSD was recorded.)

Z: *I showed some detailed examples. Afterwards, they wanted to copy exactly the same thing even though they don't need them. It added to our workload!!!*

L: *We can not continue like this; both of us (users and suppliers) are tired. Just slightly modify the current proposal. We will just keep on following our concepts. Next week on Monday, let them sign it.*

These conversations demonstrate that the project's supplier team members were stressed by the unstable 'high standard' of the user organisation requirements. The SSD manager in particular, who was responsible for the data collection, analysis and report writing, was under great pressure and was frustrated by the unhappy user organisation. The so-called high expectations of the user organisation and the confusion concerning its own system requirements could have been caused by the salesmanship that initially was made by LZ sales team, before signing the contract. This salesmanship might have helped LZ to gain the contract, but once they reached the implementation phase, the high expectations of the customer led to difficulties in the latter stage when faced with the possibility that such expectations could not be met. The reaction from CEEDI was something which LZ had not expected.

On LZ's side, they tried to keep the solution as generic as possible. LZ's project on CEEDI had been seen as a money-losing project by most of LZ management. CEEDI, however, was also considered a strategic customer which was critical to the development of new functionality. Thus for LZ, the issue became on the one hand, to meet the CEEDI's requirement in such a way as to keep them happy, but on the other hand to support their own development. The first compromise made by LZ was to agree to provide the 'tailored' user requirements analysis service which CEEDI strongly requested. From a supplier perspective, this does not mean that LZ was doing it for free. Instead, the price of this consultancy service and the related solutions advice were constructed in such a way as to diminish the value of the local practices or requirements, as well as expectations on the system from CEEDI. In the following section, we shall show you how LZ managed this tension by reconstructing the user organisation's expectations and persuading them to fit their local practice into the standard solutions provided.

7.3.3 Managing the tensions

Managing the tensions by reshaping user expectations

Providing a consulting service is not a new task to LZ. During previous implementations, some consulting tasks had been undertaken in order to convince the users to adopt LZ's design rationale. Providing this service was seen as a necessity forced upon LZ by the customers. It was done free of charge, and perceived to be indirectly and informally embedded in the promotion of the LZ products. As explained by the LZ CTO:

> *"First, in theory we don't provide a management consulting service. Sometimes we have to do some consulting jobs in order to carry out the development and implementation of our products. There are several different types of users. One type knows what they want from the system. They tell you the detailed processes and even design. From a user organisation's perspective, they think the supplier should meet their requirements. We know we can't do it. However, we know that their requirements are not rational and will not work in a computer system environment. We had already worked with so many users and saw so many applications. We know which one may work and which one may not work. In order to persuade the users, we have to demonstrate and explain why we think it will not work by presenting the evidence which we collected to the users.*

Providing evidence requires us to do the relevant research and analysis. Such a process itself is a kind of consulting service. We did not put the price of those services in the contract.

We don't want to be involved in the consulting service. In China, it is difficult to charge for this service. People still do not recognise the value of the service yet. Consulting is knowledge-intensive and time consuming work. But sometimes, we don't have the choice. We are doing that (the consulting service) for free now."

LZ CTO, May 2005

It seems that the same problems occurred in the case of CEEDI. A free consulting service was eventually provided. As recalled by the SSD manager, the top manager from CEEDI even said that the report could be only five pages long, as long as LZ wrote down the problems of the current working process and what kind of functions are required in order to solve them.

As a solution presented by LZ, this consultation was later written up as a short report by LZ entitled *'The CEEDI informatisation management analysis and solution '.*

The objectives of *'The CEEDI informatisation management analysis and solution'* had been posed by LZ as identifying the relevant management issues related to the development and use of the information systems in CEEDI, and furthermore, to provide relevant advice on the features of systems. Meanwhile, due to the increasing demand for this type of report from other user organisations, the top management of LZ planned to formalise the structure of the texts and make it ready to use for future similar cases. The CEEDI project was therefore also used as a case study, in which to explore how to draft this type of report in such a way that the user organisations were kept happy on the one hand, and on the other hand, LZ's own system development was further facilitated. It indicates that the process of genericification is not only related to technology development but also applied to other aspects of OSP development. What LZ tried to achieve is not only reusing the software but also the text and other objects, like the user requirement analysis report.

As indicated at one of the training sessions led by the director of the SSD, the content of the report was organised to explicitly reveal CEEDI internal problems, which could lead to implementation failure in the future. In this way the supplier LZ attempted to achieve two results: 1) Outlining the features of the LZ solutions and how these conflict with the current CEEDI management practice. 2) Indicating how best to integrate the software into CEEDI by providing suggestions as to how CEEDI could reform its own management and production systems. In order to implement such a system, therefore, the key process which is implicitly indicated by this report is the initial performance of an internal reform, normally called 'process reengineering'. In the following section, several examples are presented.

For instance, in the section of 'General Management', LZ interprets the existing management problems of CEEDI as: they lack any clearly identified job descriptions; there is a mismatch between responsibility, right, performance evaluation and salary allocation; the project managers have low levels of competence and they lack understanding on informatisation with unclear user requirements. All of these are identified as potential barriers to the development and implementation of the proposed system successfully. LZ suggests restructuring the department and job descriptions around the project-oriented practice, increasing the effort to train the project management team and identifying the priorities of system implementation, such as identifying the reorganisation of the main task of the current stage (first contract) as managing fragmented data.

It is not difficult to understand the intentions motivating this report, from LZ's perspective. As described in the previous section, during the user requirements collection stage, there were several problems that LZ encountered: the rapidly changeable user requirements and the relatively discrete business practices. These problems caused LZ to put enormous effort into understanding the CEEDI's existing business process, in order to develop a system which would fit into local practices. In the report, these issues have been translated by LZ in a way that can be interpreted as highlighting local internal problems and noting that without internal change, there is a possibility of failure in the latter stage of implementation.

By highlighting the related management problems that were encountered during the requirement collection stage in '*The CEEDI informatisation management analysis and solution*', LZ managed to reshape expectations from CEEDI on the system development. In order to successfully achieve the objectives of the project, LZ suggested that CEEDI should undertake the business reengineering, first, to solve their internal management issues and redesign internal working practices. By the end of May 2005, the user requirement analysis reports had been accepted by CEEDI. They initiated the internal management changes in June 2005.

Managing the tensions by reconfiguring users and use

Apart from the reconstruction of customer expectations for the adoption of the LZ PDM, in relation to new function development, LZ also persuaded CEEDI to follow the standard solutions by indicating that the embedded working practices are the 'best practice'. In the following section, the development of the research and development management model will be presented, to illustrate how LZ configured the CEEDI and its working practices to support its own new product development.

- **The Research and Development (R&D) Management Model**

The current LZ PDM product does not provide a research and development function. Thus the construction of a research and development model for the CEEDI was also an early experiment for LZ. The original CEEDI requirements for the features of research and development management are presented in the following diagram:

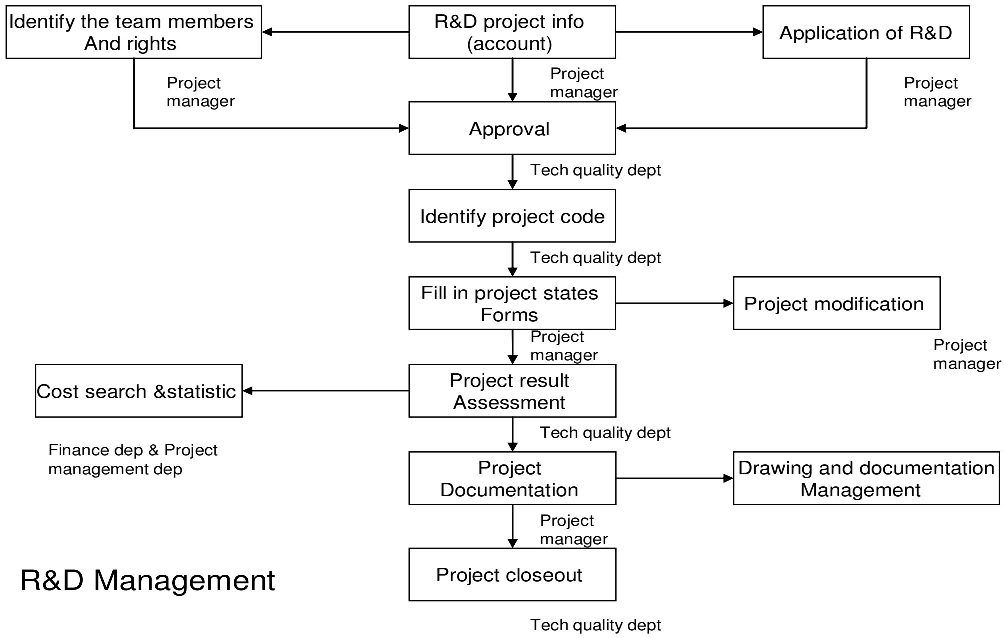


Figure 6: Required features of the R&D function from the CEEDI (Source: the CEEDI user requirement analysis report)

What can be seen from this diagram is a complicated data relationship. This represents a highly structured project management process which starts from setting up the research and development project according to the management of execution process. From a supplier point view, as indicated by the LZ SSD director, a danger in developing this highly structured system could be the difficulty of modifying the system for other user organisation contexts, since this development was only the first test for a potential new function. The representation of this process for the research and development management function would need to be investigated further, in the future. Getting too close to a particular organisation's practice was seen as a dangerous and highly risky thing to do at this stage. After all, LZ was developing the software package for a group of users, not only for one particular organisation.

In *'The CEEDI informatisation management analysis and solution'* report, in order to avoid developing a function too specifically, LZ suggested simply keeping just the project account function, combined with the documentation management. Requirements from CEEDI for the research and development management function were interpreted by the LZ CTO as extremely high expectations which demanded a large commitment to provide support (both financially and implementation-wise) from both the supplier and the user sides.

The LZ SSD director also argued that such a highly structured process could not fit into local non-standardised working practice, as well as the Chinese macro research and development management system. This was because research and development work represents only a very small part of CEEDI business activities and is characterised by a high level of contingency and, additionally, the current research and development practice is not well established in China. In such a context, the LZ SSD director claimed that efficiency and effectiveness are rarely achieved by following the structured process and instead suggested that the flexible approach could be more practical.

The conclusion, as noted by both the LZ SSD director and marketing director, was that from a technical perspective, it is not impossible to develop a well-structured research and development project management functionality, but there was no real need for such functionality. Actually, the well defined, structured research and development process had been taken as a pre-defined for the further investigation by LZ. Due to the complexity of the system, however, such a process requires technical, financial and user organisations' support. As stated by the LZ SSD director, from a practical perspective, taking into account the low priority and small size of research and development management practice within CEEDI's daily business, the best approach for now was to keep the research and development management function both simple and practical. The suggested solution was that the research and development function could be developed on the basis of the combination of the existing standard 'project account' and 'project documentation' functions. From a supplier's perspective, such a combination would not require any large modifications to the standard software package. The existing standard functions could be adapted to the user organisation's setting for a minimum change.

By convincing CEEDI that the research and development model provided by LZ is the best practice in the context of China, LZ managed to nudge CEEDI towards their standard solution. Similar developmental strategies were also applied in the development of other functions, such as CM, EPCM, and PM.

7.4 SUMMARY AND CONCLUSIONS

The focus of this chapter was described as investigating how an OSP supplier could manage to develop a generic solution during the growth stage, in which the user bases are extensively enlarged. By now, the Chinese supplier LZ had gradually built up its credibility and reputation in the field of construction management software systems, through past implementations and the MISS standard development. From early 2003, the PDM product gradually evolved into the growth stage, when the user base, as well as LZ's knowledge of construction engineering's daily practice, was dramatically increased,. What we have not mentioned in the chapter is the related user community conferences. In July of 2004, the first LZ PDM user community conference was also held in Beijing. More than fifty user organisations were engaged in demonstrating their implementation experiences and related organisational change issues, as well as their expectations for future product development. Similar events were also organised in August of 2005, for the third generation of PDM.

As has been demonstrated in this chapter, the way in which LZ approached CEEDI is typical of the means which OSP suppliers use to deal with user organisations in this stage. In this phase, LZ changed its development strategy from a passive one which accommodated all user organisations' requirements, to an active approach, by which LZ strategically segmented its user bases and rebuilt the supplier-user relationship, such that only selective user organisation's requirements, such as those of CEEDI, are catered for. This does not mean, however, that strategic partners can get exactly what they have requested.

In the eyes of LZ, CEEDI was perceived to be one of the strategic user organisations who could potentially contribute to the PDM package by providing new generic function possibilities and even new packages. For such an organisation, LZ was willing to systematically assess the local requirements and make efforts to manage related tensions, but in such a way that supported its own generic solution development.

As discussed above, in the early contract development stage, caused by the salesmanship, LZ tried to uphold a promise to CEEDI that the functions which LZ demonstrated to them could all be implemented and their specific needs would be met. Such high user organisation expectations, however, created trouble in the latter stages of development. Both the requirements from CEEDI for the consulting service and the two conversations included in this chapter clearly indicate the frustrations of LZ.

The early misfit between LZ's solution and CEEDI's local requirements began with the format of the requirement analysis report. At the cost of generic solution development, LZ was indeed forced to meet local requirements for the development of more tailored local requirements analysis. This demand was, however, used by LZ as a tool to manage CEEDI's expectations for the development of their system.

If creating a high level of expectations was their initial aim, in order to get the project off the ground, controlling user requirements upon system development represented LZ's next logical priority. What LZ had done was smoothing CEEDI's expectations by nudging the local practices towards the generic solution through the development of the required consultation report. As we noted in the report, 'the CEEDI management analysis and solution', by diminishing the current practices LZ outlined what should be the practical expectations of implementation if CEEDI was not willing to perform any internal business changes. By encouraging CEEDI to carry out organisational changes, the local practices were moved toward the standard solution embedded in the LZ PDM package. As a result, not only the user expectations could be smoothed but also LZ managed to shift the focus of system success from the supplier who is providing 'appropriate' software to the user who must now implement this software.

Another strategy for managing tensions which LZ employed was the configuration of local working practices according to the standard package, by persuading CEEDI that their packaged solution represented best practice. As we noted, LZ convinced CEEDI to give up its own requirements for research and development management, aiming to keep the changes required of the standard solution as minimal as possible, and favouring their own product development. It is necessary, however, to move a step further and explore why LZ was able to persuade CEEDI to believe that the provided solution represented a better choice. We believe that the main reason behind LZ's influence was the social authority established through the development of the MISS standard, the national software standard.

LZ is not only an industrial software supplier, but it has also been seen and used as an industrial consultant. Koch pointed out that the external consultants play a central role in an IT enabled organisational change process (Koch 2003). In the case study examined here, the impact of the consultative advice on the change in the CEEDI's business process is identical. However the feature of the consultative services is different. In this case, these advice/services were provided by the software supplier instead of the professional consultants. This fact is mainly a function of the special context of China, in which the recognition of the consultant was very low, in particular in the construction industry.

What is interesting are the means by which LZ was enabled to play a consultant role. As presented in this chapter, one of these reasons resulted from the strong demand from the user side. But this does not mean that LZ was capable to perform as a business consultant who has expertise in construction operation management. As mentioned in the MISS standard development analysis, as an intermediate in the MISS standard community, LZ generated different kinds of knowledge from different social groups. Combining this with the capabilities that were accumulated from early diverse implementation projects, LZ became an organisation which knew more than most of the other actors in the MISS standard community. Their depth of understanding regarding domain operations and their established credibility and authority inside the network shifted the role of LZ from that of a mere software supplier to a supplier with domain expertise, which was more familiar with construction relations operation management and the related information technology applications than most of the user organisations.

We also found that the generification is not only related to software development but also can be extended to anything related to OSPs development such as texts and objects related to OSPs. As demonstrated in our case, the user requirements report was developed in a way ready to be reused in next project.

We conclude that segmenting user organisations and treating their requirements differently helps suppliers to manage the diverse requirements more efficiently in the stage of growth, since it facilitates suppliers' building up of structures by which to decide which requirements should be catered for. By doing so, the local practices and knowledge are managed, in support of the generic solution development.

Chapter Eight

From 2004: Moving Onward and Outward

8.1 INTRODUCTION

In the last chapter, through the exploration of a specific CEEDI case, we demonstrated how LZ managed to deal with local specific requirements and build a generic system as the number of user organisations increased. In that particular biographical stage, and as part of the genericification process, we saw that the supplier attempted to reconstruct its customer relationship and diminish the value of local user organisations' requirements and/or reshape them in a way which supported the package development. In the future stage, we speculate that the ambition of LZ is to create 'promising' technologies.

It is necessary to clarify what we mean by 'promising'. As defined by the Oxford English Dictionary, the definition of promising is 'affording expectation of good; likely to turn out well; full of promise; hopeful'. As indicated by the related empirical studies conducted in advanced countries, in this phase, the vendor's focus will shift to how to extend the application of the generic package to encompass an even wider scope(Pollock et al. 2007) in order to achieve better efficiency and financial success through the reuse of existing components, knowledge and resources (Cusumano 1991). Thus, distinct from the concept of system generification, the concept of system promise, in our case, creates an object that can (in principle) move anywhere. This does not imply that it will move everywhere, but that it has many possible options open to it, allowing it to achieve better economies of scale.

After 2004, LZ gradually shifted their focus from the development of the single software (PDM) package to the extension of its application scope onward and outward. As a result, a family tree of products emerged. The future of the PDM and its family of products is described as promising by LZ. The question we ask here is what strategies did they use to extend the application scope of PDM and open up a range of possibilities? Why does the future look promising? In this chapter, we demonstrate how LZ both built and maintained the LZ PDM's promising quality.

8.2 THE GENERIC FEATURES OF THE PDM PACKAGE

In the last three chapters, studies of the evolution of PDM functions and the detailed ethnographic project investigation had illustrated part of the building process of a generic solution. By the time that this thesis was written, the PDM software had gradually became a black box which consists of a range of standardised features and solutions. In this section, we shall take a closer look at the latest features of the PDM to understand how and why it has been portrayed by LZ as promising.

8.2.1 Building and maintaining promise by versioning

In May of 2005, a standardised generic solution mapping table was published. At the related training meeting, LZ's top management from both the technical and the implementation department gave several important talks on how to sell the PDM product and ways to develop related products in the future.

In this meeting, the latest generic solution as described by the LZ CTO could provide eighteen different sub-solutions based on the combination of the different standard components. They clarified several versions of possible solutions with different functionality emphases, such as the completed version of the PDM, the PDM solution without design process management, the simple version of the PDM, the PDM with the marketing management focus and the PDM with an emphasis on project accounting management and finance management. Each solution consists of a different combination of the standard components. Each component represents a task, such as project planning, project documentation, contract management, design process management, commission and bonus management, etc. For instance, the PDM with the accounting and finance focus will only provide the functions related to project finance rather than other functions such as design process or ISO9000 management. As explained by the LZ CTO:

> *'Not all user organisations would like to install all systems in this PDM product. Some of them just want a system to help them to manage customer accounts. Some would like to have a system to manage only the design process, since they had already installed the finance management software from somebody else…… Now the current system allows the users to choose which part of the functionality they would like to buy…… Our current PDM product is able to meet all sorts of user requirements.'*
>
> LZ CTO, May, 2005

From the LZ perspective, a standard solutions mapping table indicates the potentially extended application scope of the Chinese PDM generic solution and its relatively higher possibility of meeting the diverse user requirements of the functionality of PDM, by providing different generic choices in the procurement stage.

More importantly, on the one hand, while LZ claimed that the development of the mapping table is for the good of user organisations, on the other hand, those standard functions and clarified solutions also provide a guideline for themselves as to how to deal with a diversity of the user requirements. It is simply a template to enable the supplier to deal with the individual user organisation's functionality request in a more institutionalised way. These are sub-'generic solutions' with various emphases form different versions within the LZ PDM product category. The original single generic solution therefore grew into several new 'generic solutions' with the promise of better fit within a range of diverse use organisations.

8.2.2 Building and maintaining promise by forming a pathway

By now, we can say that the generic solution is actually not purely generic. As we demonstrated above, there are diversities that are embedded in a single software package. Versioning is one type of diversity, but there are still other types.

As illustrated in chapter five, in relation to the management practices, organisations such as architectural, electrical and power design firms are, to some extent, distinct from one another. The way that LZ dealt with those diversities was by putting some of the diversities which were seen as having certain representation of use back into the generic process. For instance, in chapter six, LZ found it was almost impossible to build up the generic project cost and profit calculating models since there was great diversity between each type (architectural design, electrical and power station design etc; the classification of design organisations in the construction industry can be found in chapter four) of design organisation's practices. As stated by one of the key development team members, each type of design organisations has its own way of conducting cost management, output and profit calculation methods. Those varieties had been included as several templates to provide the choices to the user organisations to fit into their environment. To some extent, however, the above are seen as 'generic diversities' by LZ; the assumption is that firms in the same group should have the same working process. Thus, from the LZ perspective, accommodating three different generic templates allows LZ to cater for all design organisations' requirements in the Chinese construction industry.

Another type of diversity is even greater and exists among a relatively large range of organisations, such as the naming or designation of things, related times, figures, percentages. Some user organisations designate 'project planning' as 'project management' and 'editing' as 'auditing'. As explained by a key technical development member, those related parameters are accumulated into the so-called 'technical library' to provide the choices for the different user organisations. In the eyes of LZ, this type of diversity can be easily catered since the changes of names and figures do not influence the structure and feature of software.

By adding in multi-templates and enriching the 'technical library', it has been seen by LZ top management team as a way that provides better flexibility to meet the needs of the different users' organisations by providing more choices to the adopters in the implementation stage. In this sense, the generic solution is a combination of the different generic components. By fitting different types of generic differences together, similar to a strategy of western suppliers, LZ formed what Pollock and his colleagues termed a 'path of diversities'(Pollock et al. 2007).

The combination of versioning and pathway building, as described by the LZ CTO, forms the base to attract a larger different user groups. The package has been portrayed as more flexible than ever and can meet local requirements by fitting the various combinations of sub-solutions, templates and parameters. Thus, it constructs such an expectation that the packages LZ provides can fit into all different kind of local user organisations as the generic feature can be customised based on local needs. In practice, however, one can not promise this. As indicated by the literature on the adaptation of OSPs (this can be found in chapter two), local contexts and related unique practise always exist to challenge the 'promise' made by the supplier. We will come back to this point later on.

8.3 SHAPING THE FUTURE OF LZ PDM PRODUCTS

In association with the direction of the development of future technology, as pointed out by van Lente, it is strongly related to the social expectations of technology from a range of social actors and groups, as well as society as a whole. For van Lente, expectation is the anticipation of success (1993.p. 49). From a technology supplier's perspective, in order to achieve technological success and maintain a sense of promise, in this stage they would ask questions such as: which are the promising ones with much 'innovative potential'? Which investments in R&D will bring a technological lead? What will be the strong technologies of tomorrow? (van Lente 1993). Based on the answers to these questions, suppliers shape their technology towards the 'promised future'. These questions are answered through a searching process (Nelson and Winter 1982). As described by Rip (Rip and Kemp 1998), such a process is influenced by its situated selection environment in various niches, as well as socio-technical regimes and landscapes (we have already discussed the TT model in the literature review).

This means suppliers' answers to these questions and related choices are guided, granted, constrained and situated in their own socio-economic contexts. In our case, the development of the future LZ PDM was influenced by the large potential market within the construction industry which initially was constructed by the Chinese government, as well as LZ's determination to become the technological leader in the relevant software industry, its existing resources, knowledge and customer base, and the weak technological regime and the changing landscape. In this section, we shall show how LZ made both its short-term and long-term choices concerning the development of future versions of the LZ PDM in the context of China, while maintaining the promising outlook of the product.

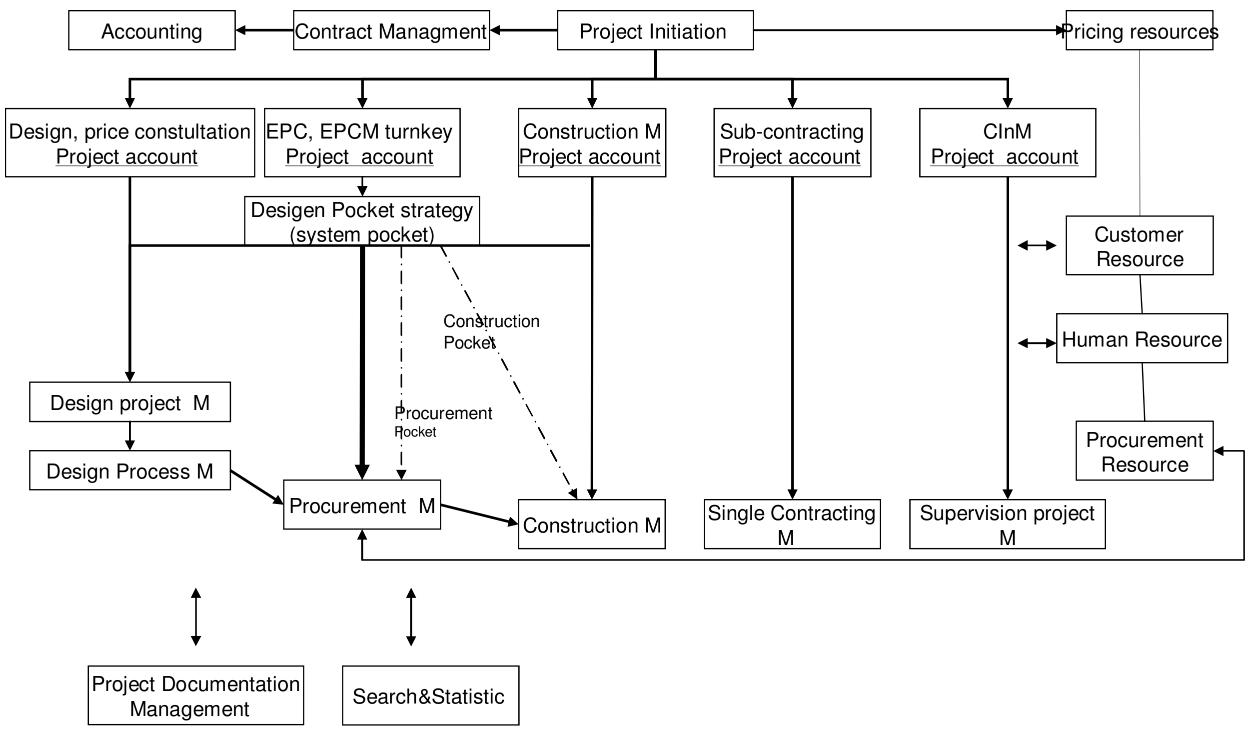
8.3.1 Building and maintaining promise by developing new functionalities and applications

By 2005, the LZ PDM market was still largely limited to construction design enterprises. As we noticed in both chapters four and six, the construction industry itself is a large and fragmented sector which contains a great amount of different business activities such as building construction, material development, quality inspections, etc. Alongside the growth of the Chinese construction industry and business in general, more niche services and labour divisions were emerging. As a software vendor which sees itself as specialising in the construction industry, how to extend the scope of its applications into these vast construction business activities was one of LZ's top management concerns in this stage. As recalled by the LZ marketing director, their question was how to enter these new construction markets with as little cost as possible and with great innovative potential. As indicated in most of interviews with LZ's top management members, by utilising current customer bases and the knowledge accumulated from past implementation projects, LZ managed to develop the early version of some new products. The construction inspection management (CInM) system and the construction management (CM) system are good examples.

What we have not mentioned in chapter seven are the processes that LZ used to create the CInM and the CM systems, based on the CEEDI PDM system. The broad range of businesses in which CEEDI is involved and the complexity among business models offered an opportunity for LZ to study and explore the potential development of the new components.

One of the key functionalities that LZ developed for CEEDI was the 'Project Planning and Management' function. It is a central function used to help managers plan and control the progress of the individual project as well as cross projects. As indicated in the new mission of CEEDI on their website, in the future, they see themselves becoming a project-oriented enterprise. Therefore LZ's rationale for the whole system design was that businesses processes should be organized around the project.

The following picture presents a redesigned CEEDI project–oriented production working process. Under the project management function, this process starts from the project initiation by identifying the project category (their business range: design, turn key project, CM, or sub-contracting, assurance project) and entering the relevant project data. Once a specific category project has been started, the relevant account (EPCM account, CM account, etc) will be opened.



The CEEDI PDM process

Figure 7: the CEEDI project–oriented production working process (Source: the CEEDI user requirement analysis report)

The project planning system was designed as the central portal to manage CM, CInM and other business models, which both can be seen as sharing the same project operation process. As an individual operation business model, however, CM and CInM each have their unique operation management processes. CInM is a business activity where the engineering consultant company provides a quality assurance service along the construction project life cycle. CInM encompasses many functions, such as process control, quality control, investment control, organisation coordination control, project control, etc. The CM is a business operation that is involved in the daily management of a construction project from the early design drawing management, to the construction labor HR management, through the related equipment management and material management.

LZ had perceived that these two business models could be further developed, either as supplements to the PDM system or as individual products. Taking CInM as an example, the following system flow indicates the possible inter-relation between the LZ PDM system, the CInM functions, and the individual CInM software product. This diagram was created to demonstrate the possible feature of CInM system for CEEDI. LZ built a simpler version of CInM as a part of the PDM system, which only has the project administration function. This version was seen as one of the sub-functions which was identified as a project that could be useful for other businesses such as design, CM, sub-contracting in CEEDI, etc. The fundamental functions of the CInM as a sub-system are indicated by the white boxes.

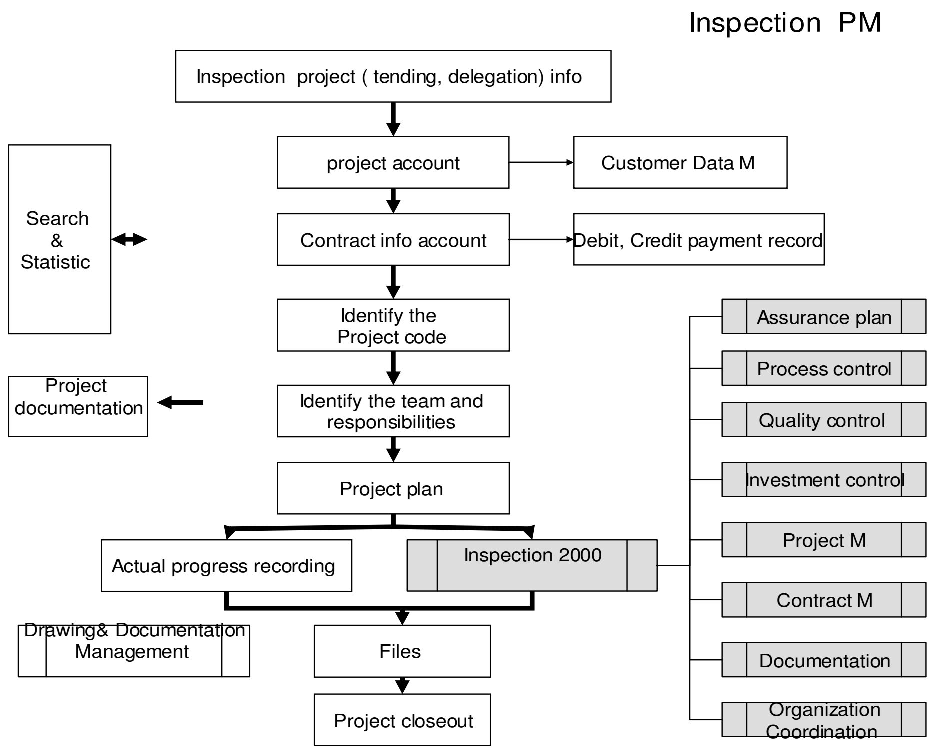


Figure 8: The CEEDI construction inspection working process (Source: CEEDI user requirement analysis report)

Once involved in the detailed CInM process, a more specialised individual software system is required. LZ named this potential new product, 'Inspection 2000'. The 'Inspection 2000' helps the user organisations to manage steps of the inspection process such as progress control, quality control, investment control, engineering project management, etc.

In this way, both the CInM and CM functions could become supplementary to the PDM product, enriching the choices of the construction engineering companies like CEEDI. If developed as an individual product, more customers could be covered since in practice, the CM and CInM could be carried out by independent third party firms who specialise in those areas. As the director of SSD in LZ claimed:

> *'These two systems had been seen as having the potential to be further explored. Whether they will be parts of the PDM system or individual products will depend on the future market needs. The CEEDI is the first case that enabled LZ to be involved in the real construction management system development. Before, we were only talking on paper. Our MISS standard is*

involved in CM-related business processes and system flows. We do have some related knowledge. Now we just need more cases to abstract more common requirements.'

LZ SSD director, May, 2005

By extending its functionality, the PDM package, sooner or later, could cross application domains, moving from developing applications only for design organisations to the broad construction engineering business services, as well. We can see that the decisions to develop the CM and CInM functions and new products were influenced by the external business environment (policy and market demand), as well as internal existing knowledge, experiences and user organisations. By utilising an ongoing project, guided by government policy as well as user requirement studies and feedback from past implementations, LZ saw both CInM and CM as potential functions and determined that they should invest in these new packages immediately. In particular, technically, as indicated in a related development meeting, LZ's top management felt that CEEDI was a good starting point to allow them to abstract and develop the early prototype, which could be further tested in other projects. LZ predicted that in one year's time, CInM and CM packages could be put on the market with a promising future.

8.3.2 Building and maintaining promise by cultivating technological expectations

Apart from the near future of PDM which we have discussed above, LZ also started to plan and work on the long-term strategy for the substantial development of the PDM to extend its life cycle. The first step that LZ used to develop and promote the future version of the PDM involved actively constructing a version of the future design practices: concurrent design (CCD). LZ believed that the advancement of this production tool would lead to the advancement of the management process.

Why concurrent design?

As indicated by the LZ CTO, LZ's expectations of CCD are influenced by the current global technological regime, in which concurrent design is recognised as the trend by both academia and industry in advanced countries. The conventional design process is sequentially updated by passing the drawing onto each department (function-based) whose input is required. Concurrent design is aided by using a software application that involves multi-function design teams which are highly structured and are working on the same part of drawing at same time. Such an upgraded computer-aided design application has been described as a better production process for design firms, as it improves design efficiency and productivity. As promoted, in principle, by copying the related drawing into a concurrent design software repository by all authorised functions, users can be made aware of changes to the design as these are taking place, and therefore feedback loops can be shortened and made more effective. This possibility has been portrayed as a promising technology for engineering design practice.

Is there any relation between the development of PDM applications and the concurrent design tool? Why is it necessary to develop concurrent design applications in order to develop the future of the PDM system? By answering those questions, we hope to reveal the complexity of the development of the future product from a supplier's point of view.

LZ believes that the future version of LZ's PDM is dependent upon the diffusion of concurrent design applications. As claimed by the marketing director:

> '*For a design enterprise there are two main things. One part is the management; the other part is the technical production. The combination of these two should create more high advanced applications. The future version of the design has been called 'concurrent design' within the field. Our CAD product development team is working on the development of the three-dimension concurrent design tools. Once the design techniques and tools have been advanced, there is no doubt that the management system has to be changed to meet the challenge from the design practice as well……'*

LZ Marketing Director, April 2005

Meanwhile, from the previous PDM implementations, some general feedback produced by some of the large user organisations, such as the GEDO case that was mentioned in chapter six, indicated the potential demands on the concurrent design tools with related management applications. It sounds as if the future direction of LZ PDM development will be largely influenced by the diffusion of design applications and tools. The construction of the expectations and promises regarding concurrent design applications has been taken as the first step to develop future PDMs.

The construction of technological expectations

In the context of China, however, concurrent design practice could not be achieved in the short term, since most of the Chinese local engineering firms are still in the early stages of the implementation of the information systems, at which phase the deployment of concurrent design practices with an advanced management system is still far from the reality. As the LZ marketing director predicts:

> *'It is just a version. Such a concept requires a high level of development for both design production and management. However it is definitely the future of the design technology and management software package for design organisations. In the following five to ten years, the Chinese user organisations firstly have to change their management style to meet the current business management and production trends which focus on project-oriented ......Concurrent practice will not be put on the table in probably the next fifteen years in China. '*
>
> LZ Marketing Director, 2005

Compared with the PDM software package application, the related concurrent design software application has strict requirements for hardware and management style, as well as the size of the company and project. The CTO highlighted LZ's key concerns for the development future of concurrent design applications:

> *'For management information systems, no matter the size of the companies, the management process should be similar. But when it is about the design, the size of the companies does matter. The design done by three people is totally different from the design that is done by thousands of people. When the design project is huge, more people and departments will be involved in it. That is the time to use CCD. Therefore the market for CCD could be only for*

> *the large design organisations with large projects. The target market for CCD is still not very clear. China's current management style is another problem which could not match the needs to support the application of CCD which require the efficient communication across individuals, departments and projects ……'*
>
> LZ CTO, April 2005

This indicates the difficulties of developing concurrent design practices in contemporary China, which are caused by its socio-economic context, in which a large number of organisations are just starting to set up their early IS infrastructure, aiming to meet the existing management trends, consisting primarily in project-oriented practice. Being a domestic industry software leader, LZ felt that they had to go much faster than the actual applications in order to reach the technology's leading position in this industry, despite the immaturity of the potential market. Such ambition and determination, coupled with strategic engagement with the Chinese selection environment, led to LZ's proposal, by the end of March 2005, of the *'CCD software technical standard'*, to the Ministry of Construction.

We can see there are several objectives behind this standard development. By building up a national technical CCD standard, LZ can construct the related expectations for concurrent design practice within both the technical and user organisation communities to push the diffusion of CCD. As argued by van Lente (van Lente 2000), once technical promises are shared, they demand action and appear to be a necessity for technologists to develop, as well as for others to support them (p58). As a result, the shared expectations could be transferred into technical requirements. In our case, if the CCD standard was accepted by the industry, it could influence the LZ CCD products to become favourites, as most user organisations would demand a product that would match the CCD standard.

As indicated in the above interview script, LZ believed that once the design tools were upgraded to the concurrent practices which LZ expected, user organisations would automatically expect the relevant advanced PDM version to facilitate them in managing the process and its related data. Needless to say, the features of future LZ PDMs would be developed, based on the requirements of CCD applications, on a management information system. There would be a potential for user organisations to lock into LZ products, and as more people used LZ CCD applications, they would be more likely to use advanced LZ PDMs.

Looking from a higher level (inter-organisational and national level), LZ's future development of PDMs can be understood as a result of the interactions between different expectations of various social groups in China. In his study, van Lente argues that technology development may be structured by supra-individual and stabilised expectations which he conceptualised as a 'cultural matrix of expectation' (p. 47). This means that a shared expectation of the technology could influence the development direction in a niche. Few actors would be required to lead the stabilisation process (Rip and Kemp 1998) in the niche level. As a result, the interaction of diverse social groups' expectations led to technological innovation. In our case, LZ's expectation was to become the technological leader in the construction software field. Most user organisations expected to advance their current working practice (low technical level) by using ICT. The national agenda was also arranged to promote the use and diffusion of ICT in the application industries and improve overall efficiency and productivity, as well as to promote the Chinese technological standard. Indeed there could have been several conflicts between suppliers and user organisations. For instance LZ wanted to develop high advanced applications to keep its leading position; most user organisations were still at a low level of IS implementation. The Chinese national agenda and policy, however, provide the general guideline for the construction industry and ICT development, as well as the future direction of LZ products. Given the central government's determinations, LZ believed that the informatisation of the Chinese construction enterprise would involve the use of concurrent design and the related advanced PDM system in the future. The standardisation policy, meanwhile, legitimises LZ's standard development strategy. Coupling these expectations from the Chinese government and industry user organisations, along with LZ's own considerations, new technological ventures for future PDMs have been created.

8.4 THE REPRODUCTION OF THE LZ PDM

In order to achieve better financial success, normally suppliers would develop new packages which could share and reuse the existing resource (Cusumano 1991, 2004). This means that in this particular biographical stage, building new generic solutions does not necessarily involve creation from scratch; it is rather a process of assembling existing solutions/components and knowledge and reconfiguring them into new forms. We will demonstrate how LZ managed to develop new business applications based on existing packages with little modification and to further make these into 'promising new technology'.

8.4.1 Building and maintaining promise by re-organisation

The development of the PDM was only an early step towards the success of LZ according to both technological and economic perspectives. Technically, the features of LZ PDMs are also the pre-features of a series of applications that are designed for city councils, such as the city planning and building management (CPBM) system, water resource management (WRM) system and land resource management (LRM) systems. From an economic perspective, by changing very little of the PDM system structures and related functions and reassembling them in a different order, LZ reduced the time required for the introduction of new products.

By 2003, LZ had already decided to enter the public sector, targeting city councils. Moving from the private to the public sector would seem like a big and risky shift in some advanced countries, since these sectors have been seen as representing totally different working practices and distinct cultures, both of which could require a lot of a supplier's time and money, in order to develop new products which could fit into the public sector. What enabled LZ to decide to choose to make such a move, which would have a strategic impact on the future direction of LZ's business development? As we noticed in chapter four's context study, the key driver for such a choice was the Chinese government's policy regarding the procurement of official computers and software, as well as its intentions to support local domestic software industry and build up its own national champion, in line with the lack of competition in the governmental software application field, and due to the fact that the industry itself is in an emerging stage. LZ saw this as a huge potential market with vast opportunities.

Managing complexity

In order to catch potential opportunities and extend its existing business applications into the public sector, LZ decided to build a sub-company which would specialise in developing public sector products, in particular for the department of planning and permission for the city council. Products including the CPBM system, WRM system and LRM system were both developed under the name of Leading Co. Ltd. By doing so, LZ transferred their PDM technologies into a new field.

Leading Co. Ltd. is an independent company of which LZ is the majority shareholder. Leading was set up to target the related government applications. Its business involved developing management systems for city planning, water resources, land resources, etc., related to local government and councils. It was set up in June of 2002 with consideration of using it as a technology transfer, financial and operational platform by LZ, and the real operation was started in 2003.

> *'LZ is specializing in the construction industry. The development of the three core technological platforms (management information system platform, geographical information system platform and CAD design applications platform) is the focus of LZ. Leading is focusing on related government software applications development such as power, water, city planning, etc. The technological capabilities that were built up in LZ can be utilised in Leading's government product development.*
>
> *Leading is a Ltd. Company and therefore can be used as the financial operation platform for LZ. By using Leading, LZ can generate more venture capital to develop new products.*
>
> *Such a relationship (between these two companies) created more product development opportunities with different types of operation systems. For instance, once the development of the city planning applications have reached a certain level, the business can be separated from Leading and built up as a sub-Ltd. company to further generate investment and conduct in depth application development……'*
>
> LZ marketing director, April 2005

From a supplier perspective, it seems the combination of LZ and Leading could open up a broad scope of new product development opportunities, with a greater emphasis on shared fundamental technological similarities and secure financing. The director of Leading is the marketing director of LZ. In this case, the information and knowledge that are generated within LZ and Leading could be exchanged and communicated quickly. Furthermore, in principle, by utilising the existing technologies and product solutions, the cost of development of new products could be reduced. More importantly, this combination can also be seen as a strategy for managing LZ's increasing complexity while its product family tree gradually enlarges. By setting up new companies, LZ managed to transfer the responsibility of developing brand new products to other social actors who have direct, close relationships with LZ. Rather than giving attention to the development of every new package, LZ would thus be able to maintain its focus on the core technology development (the LZ PDM and related platform). There are also, however, disadvantages to this strategy. We will come back to this point later.

Moving outward

As argued by the LZ CTO, a strong similarity was perceived between construction design practices and the working processes in the department of city planning. From a technical, financial and user-based perspective, it has been recognised by the top LZ management team that the city planning council was one of the public sectors which required the least amount of capital expenditure and time investment for Leading.

As explained by the LZ CTO, from the angle of the user base, the daily operation of engineering design organisations is strongly linked with the city planning council through the building permission application. From the previous software product development for engineering organisations, the reputation and image of LZ has been transferred to some of the city planning councils; hence it is relatively easier to enter the market, as LZ is not a new and strange name to this domain. It was recognised that the technical development of CPBM, WRM and LRM just required some modifications of existing PDMs, rather than starting from scratch. As claimed by the director of Leading, who is also the marketing director of LZ, there are commonalities between PDM, CPBM, WRM and LRM. He argues:

> '*These systems shared the same management system platform. By 2003, the PDM system was becoming mature. At least the low-level architecture and fundamental functions such as system management and configuration management were more stable. The OA and GIS had already obtained recognition from the market. For the interface of these new systems (CPBM, WRM and LRM), we can just build on the existing interfaces that were built up by LZ. From a technical perspective, the CPBM, WRM and LRM processes are also based on the project. Each project has its own status and related information. Their related management process is similar to the design process management. Both of them have to be signed by different people……'*
>
> Managing director of Leading, May 2005

The Leading CPBM is an integrated software package that manages the planning, issuing, permitting, tracking, scheduling and documenting processes relevant to the operations of town and city councils, as well as office management. There are four functionalities that are included in CPBM: OA, the city planning permission system, inspection system and GIS. Similar to CPBM, WRM and LRM are integrated information management systems that are developed for water resource and land resource management that provide the integration of related process and functions. Both WRM and LRM consist of some of the functions that were developed by LZ, such as OA, project management and GIS, which are described as the core technologies of these systems.

The project management function was originally developed as a function of the PDM. As mentioned earlier, for LZ, whether for city planning, water resources or land resources management, management processes and procedures have been perceived to be similar to the process management of construction design, since both of these processes are project-oriented. As explained by the marketing director of Leading, the only possible differences could be the names of various details and other variables related to the process, such as profit and cost calculation methods, etc. Based on LZ's beliefs, those differences could be solved by configuring the technical library which is embedded in the package. The PDM project management system structure, therefore, could be reused. In relation to OA, which was originally developed based on the construction industry, there was less to be changed since LZ felt that most of the office management processes were similar, apart from the detail names and related figures. For GIS, in theory LZ did not need to change anything, since it is a tool to be used to provide related earth data.

In this way, four apparently distinct packages were made similar in the hands of LZ. By now we see that LZ managed to develop several new generic software packages by smoothing the related actual local contexts and differences, based on an existing universal solution. Smoothing, however, must be distinguished from the erasure of local practice. As we discussed in chapter five, technological suppliers tend to make things similar by 'lumping' them together. Influenced by the engineering traditions, suppliers have their rules and methodologies to help them construct their cognitive recognition on the definition of 'similarity'. By erasing the differences, suppliers can normally lump things which they think are similar together. The construction of similarity among the PDM, CPBM, LRM and WRM provides a good example. By grouping them into the same category based on the idea of 'project management', LZ managed to construct an image by which these four working processes would be perceived as similar. We do not know whether these new packages worked or continue to work successfully in the city council. The empirical research on the appropriation of the generic information system and LZ's previous experiences in the early stage of PDM development (which is demonstrated in chapter five), however, indicate that the universal solution embedded in an OSP will be challenged and 're-contextualized' (Schumm and Kocyba 1994) by the introduction of specific local meanings and practices at the appropriation stage.

8.4.2 Building and maintaining promise by alignment with the State

So far, what we have not mentioned is how LZ promotes its public sector products and the future development of related technologies. Different from PDM development, in which LZ's development strategies were largely influenced and guided by government policy, the public sector development strategies more actively shape and influence the related government agenda. This is particularly true in the construction of the 'smart city'.

In the Chinese tenth 'five year' plan, the initiative of the development of 'smart cities' has been included as part of social and economic development of society and cities. General speaking, the idea behind a 'smart city', also called a 'digital city', is to provide better services to citizen, organisations and related government department by integrating related information (on not only geographic, but also social and economic data) from government, organisations, social groups and even individuals through a single interface. The digital city should have the same functions as a 'real' city. Therefore e-government, e-commerce, e-education, etc. are also parts of the digital city.

In particular, 'e-government' has gained great attention from the Chinese government since the 1990s. Improving the government's working efficiency, effectiveness, openness and democracy has been generally believed to be achievable by using modern ICT. Not only LZ but also a great amount of other suppliers, both local and foreign firms, are eyeing the Chinese e-government market as a huge cake. Given the Chinese government's protection of the local e-government software vendors, as well as the lack of knowledge and experience regarding the development of related applications, there remains a large space for local software vendors who have the capabilities to play.

The mission of Leading was directed toward the promotion of the notion of a Chinese 'Smart City' with a totally Leading solution[26]. As promoted by Leading, in the building of a 'smart city', e-government is a critical starting point. From 2002 to 2005, there appeared a range of articles on the development of a 'smart-city' and related e-government applications drafted by Leading, and news about the experiences of related Leading 'smart-city' implementations have been published in different national science and technology newspapers. Their interpretation of the

[26] For more detail information, please see the company website (http://www.leading.net.cn/lzr/channel.asp?ID=25)

‘smart-city’, its related functions and how to achieve it has been largely introduced through these publications. As identified by Leading, the current problem of the development of the ‘smart-city’ and e-government applications lacks systematic planning and guidance from the central government, as well as standardisation. As promoted in Leading’s website

> *‘Along the building of a ‘smart city’, the construction sector played the leading role. The current extending of the urban city at an extremely fast pace requests the effective control of city space, rational population tendency, efficient resources allocation and deployment, consistent transportation improvement, and substantial environment protection. In order to solve those problems, we must improve the traditional management methods and style of city planning, building construction and city resource management etc……hence along the initiative of the development of ‘smart city’ , the priority should be given to city planning department……’ (Website)*

It was suggested by them that from a government perspective, the first step towards a ‘smart city’ is to design a better city planning and statistic information system, as well as to construct a clear framework with standardised implementation processes and data structures.

It seems that Leading’s suggestions and understanding of a ‘smart-city’ have gained great recognition from local governments. In 2003, the company was selected by the Beijing local council to develop the ‘Digital West Beijing’ project which was one of four reference sites for the national ‘digital Beijing’ programme. Based on this project, by the end of 2003, they developed their own Leading ‘smart city’ and related e-government solutions. The key component of these solutions was their CPBM system which included the three core technology platforms: OA, MIS and GIS. The detailed system features have been discussed in the above section. Such a solution has been portrayed as best practice by the national science and technology newspaper (see the website). In early 2004, the Chinese government appointed Leading as a member of the committee for the national research project on the standardisation of ‘smart city’. Between 2004 and 2005, they have also participated in a range of conferences on the implementation of e-government to present their experiences as well as their solutions. By the end of 2005, as described by the Chinese government, due to its excellent e-government application development, Leading had been delegated as one of the 100 best e-government software suppliers in China.

By now we can see a picture in which the supplier is actively engaged with the development of the 'smart city'. By promoting its own understanding through newspaper and media and demonstrating its solutions by using the reference site, this Chinese domestic supplier LZ managed to construct the general expectations on such a system through the use of its sub-company Leading. The invitation to develop the national 'digital Beijing' project and the government's decision to building up the related smart city standard can be seen as the result of LZ's influence upon expectations since they suggested that a lack of standardisation, was one of the bottlenecks to the implementation of the 'smart-city'. We can argue that LZ's technology and suggestions start to guide the direction of 'smart city' development. In this senesce, LZ strategically managed Chinese local government including influencing related policy development on smart-city development. As a result, LZ public sector products can be seen as representing the 'promises' of the future e-government applications. Hence, both the future of public sector products and the future of LZ's sub-company (Leading) are promising.

8.5 SUMMARY AND CONCLUSIONS

In this chapter, we distinguished the concept of system genericification from the concept of system promise. This is different from a generic system in which suppliers focus on community building and management; building and maintaining system promise requires a supplier to focus on how to construct the expectation of success within the package and how to persuade user organisations and the market in general to believe that using their products is likely to turn out well.

Using strategies like versioning; cultivating a pathway; developing new functionalities/products; re-organizing company structure, and coupled with alignment with the government, LZ started to make PDMs promising to customers and markets. LZ starts to build a belief that LZ PDMs can cater to local diversities, or at least, the package has the capability to do so by providing different configurations. Actively engaging with the building of technological expectations on future CCD and managing local government also enabled LZ to further enhance their software and industrial solutions as the 'best practice' through alignment with government.

Regarding the features of the PDM package, we also noticed a diversification process. As illustrated in the following diagram, an LZ PDM product family tree gradually emerged with many possible opportunities opening up.

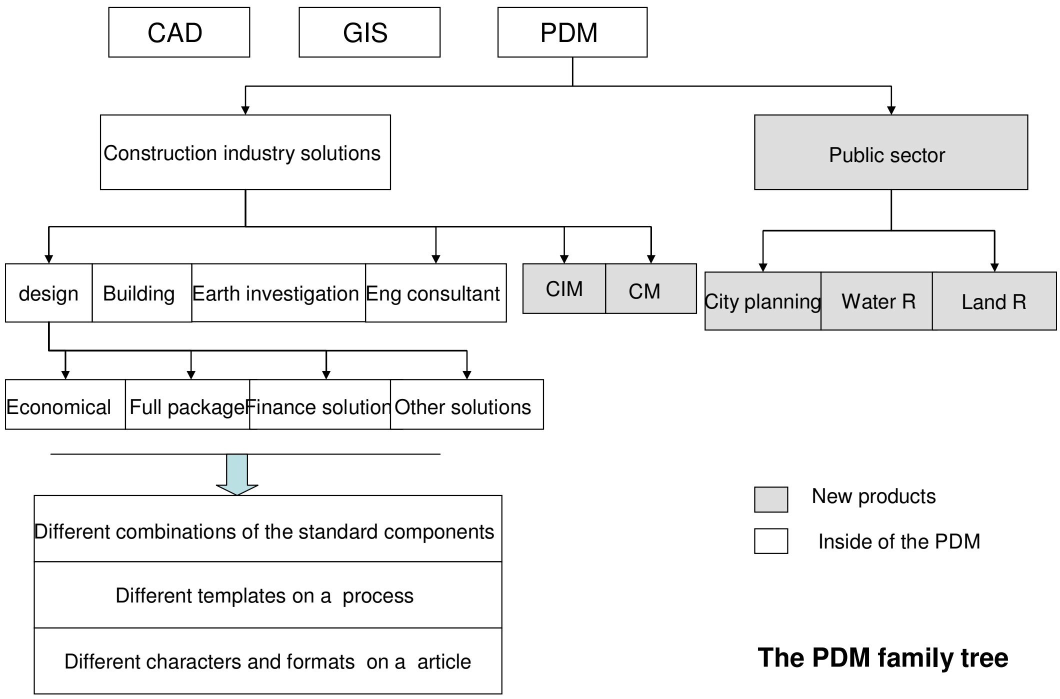


Figure 9: The PDM family tree

In relation to the features of the family tree, we found that they are largely shaped by the socio-economic context that they are embedded. In our case, LZ extended its business scope across a range of different sectors and application domains in a relatively short period of time. This could be seen as a dangerous strategy to adopt in developed countries. Diversification could also increase the management complexity. However such a choice by LZ can be understood as the result of opportunism which emerged in the particular context of China. The decision for the development of

CPBM, WRM, LRM and other related public sector systems was strongly affected by recent policies regarding e-government development and environmental protection, as well as government procurement.

Indeed, product diversification is also associated with increased complexity of development and management. We noticed that in order to control the complexity, LZ set up a new and totally independent company (from a legal perspective), Leading Co. Ltd to manage the increased complexity of the product family tree. In addition to recognizing the advantages of using such a strategy, from a long-term perspective, we also noted that there are risks as well. The risk of making system generic in this circumstance is technological dependency. Highly depending on the core generic technologies transferred from LZ could lead to the 'lock in' where the development of new packages in Leading will be limited by the possible technological capabilities that are provided by LZ. As a result it could increase the business risk of Leading and other potential sub-companies. The question is what if LZ failed to upgrade its core technologies and platforms?

As we noticed from this case study, LZ has successfully attained its leading technological position as top of the '100 best e-government software vendor' list. Its implementation projects have also been collected and published in the newspapers as the best practice and provided as learning materials to the local city councils. It is hard to predict whether LZ can continue to achieve success in such a dynamic and contingent environment. However, the future of LZ PDMs could be seen as promising, if user organisations follow the technological expectations on the use of CCD and the related management information system applications, and if government policy and the socio-economic context remain the same.

Chapter Nine

Conclusions and Wider Implications

9.1 INTRODUCTION

By now, we have demonstrated the evolution process of the LZ PDM package. This final chapter seeks to present the overarching conclusions of this study, linking the empirical research findings to the theoretical framework and concerns of this research. The chapter proceeds as follows: after revisiting the concerns of this study, its research framework and methodology, we examine some concluding points linked to each of the research questions raised earlier in the thesis. We further examine the relevance of these findings to the OSPs' development and related management issues. This is followed by a reflection on the conduct of the study and possible directions for future research. From the extremely detailed data that this study provided, we then draw wider implications both for the applicability of concepts used within SST and the policy issues for China's future technological development. The chapter ends with a final summary of the research and related findings.

9.2 GENERAL DISCUSSIONS AND CONCLUSIONS

In principle, large complex information systems are normally tailored for each specific user context due to the complexity and sophistication of these systems, as well as their huge resource requirements (Hobday 1998, 2000). However an OSP is a generic technology which is designed for a group of users, rather than for a specific local context. Its successful diffusion throughout the global software market is evidence of its technical and economic potential. This diffusion also, creates a design dilemma for the OSP suppliers. There is a tension between the need to develop global solutions driven by the economic advantages and the need to cater to local user requirements. This is because local knowledge and practices are also important to the success of adaptation, a fact which has been highlighted by a range of implementation studies in the field of technology studies (Hanseth and Braa 2001;

Hartswood et al. 2003; Hobday 1998, 2000; Newell et al. 2000; Schumm and Kocyba 1994; Timmermans and Berg 1997). Given this paradox between ‘local’ and ‘global’, this study has examined how a supplier managed to deal with these tensions and achieve a generic system. Based on figure 3: the evolution of Chinese PDM, which was introduced in chapter three, we developed the following figure 10 to summarise our case study and present the LZ PDM’s innovation trajectory over a decade. As indicated in this figure, we investigated LZ’s actions and related events, in connection with the evolution of the artefact, by exploring their interactions with other social groups, such as user organisations. Following the evolution of the technological design, we noted some changes in LZ’s activities and strategic focus, as the biography progressed from 1998 to 2005. At the macro level, we used a multi-level technological transitional model to explore the impacts of social, economic and political factors on the shaping of the Chinese OSP.

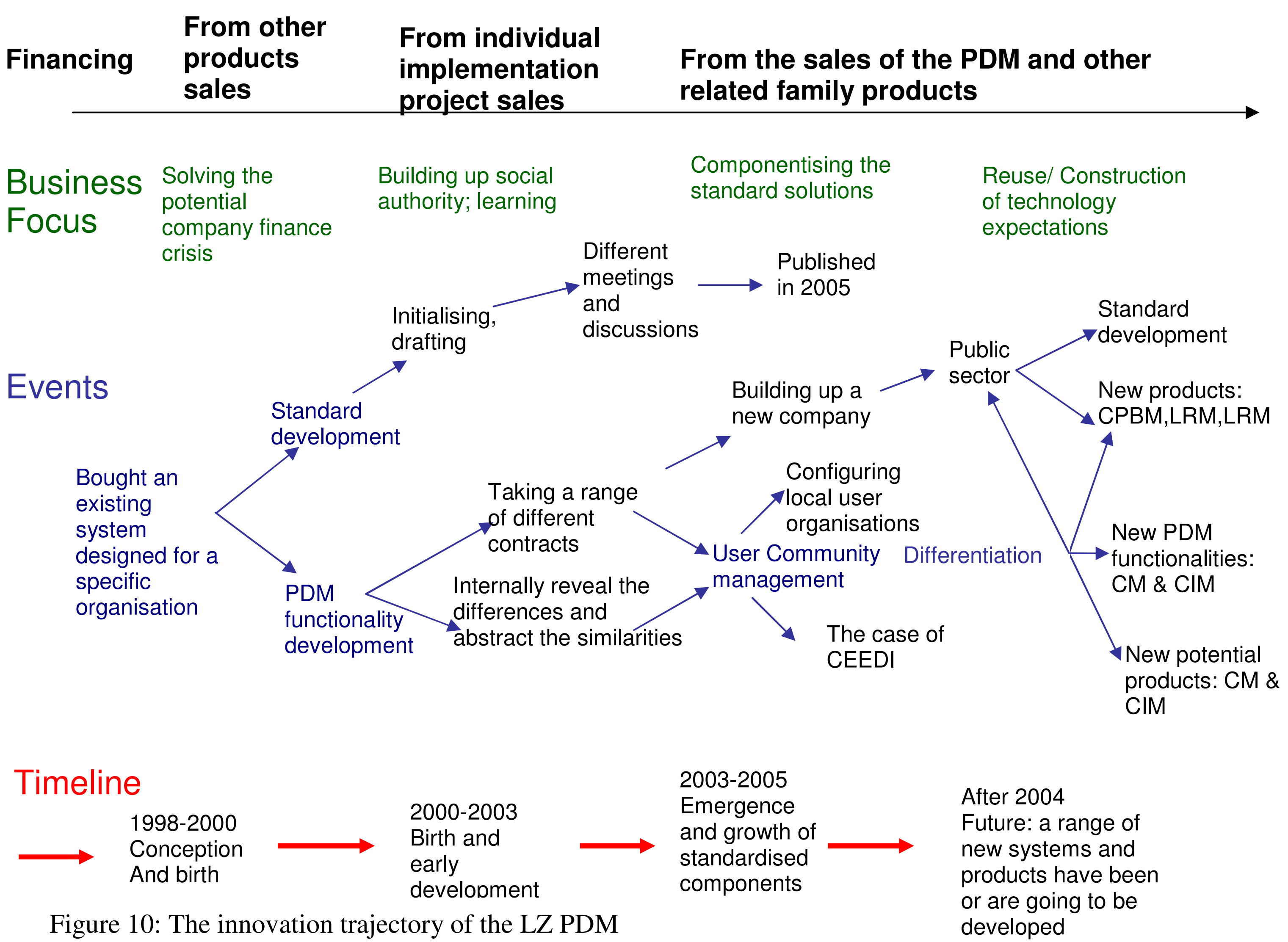


Figure 10: The innovation trajectory of the LZ PDM

In this chapter, our aim is to integrate the most important findings generated in the chapters of the case study into more concise descriptions about how the generic information system has been cultivated by suppliers through their interactions with users and usage. This is carried out through the addressing of the research questions we initially identified in chapter one, which consist of:

- Which struggles and tensions did the Chinese supplier face through the development of the generic solution? Which strategies did they use to enable them to deal with these problems?
- How did the Chinese supplier develop its early assumptions as to users and use? How and where did the Chinese supplier interact with user organisations and other social actors in the development of OSPs? What did the Chinese supplier learn in relation to building the generic solution from those interactions?
- How did the Chinese socio-economic context and institutional arrangements influence the ways the generic solution was developed?

These questions have been designed in a sequential order to help us gradually unpick the OSP development process. In the conclusion chapter, to strengthen our intellectual arguments, on the basis of the findings of the empirical case study, we shall answer each of these questions, but in a different order. Firstly, based on the findings of the first two groups of questions, we demonstrate the biography of the Chinese PDM in order to show how the features of the package evolved through each biographical stage. By highlighting the relevant characteristics, we proceed to the groups of questions, illustrating how the Chinese supplier LZ managed to develop this 'standard' solution, as well as their learning process and its dynamics. Finally we analyse the Chinese participants involved in the innovation process, addressing the last research question.

9.2.1 Social shaping of the construction of the generic solutions

Our research findings demonstrate that it is by no means impossible to create a generic system, but that the process is rife with difficulties and struggles. In contrast to the conventional information system development perspective and other simplified studies, our study of the construction of the LZ PDM in China has offered us a different understanding of the process of OSP development, as well as a distinct analytical angle.

The biography of the Chinese PDM

In contrast to the presumptions by information system specialists of a smooth indeed linear process of package system development, the findings of our study explicitly demonstrated that the design and development of the generic solution was not carried out in a static manner; instead it emerged through an evolutionary process in which the supplier suffered from a range of struggles and tensions. Based on our empirical exploration (chapters five through eight), we have developed the following diagram 11, illustrating the biography of the LZ PDM.

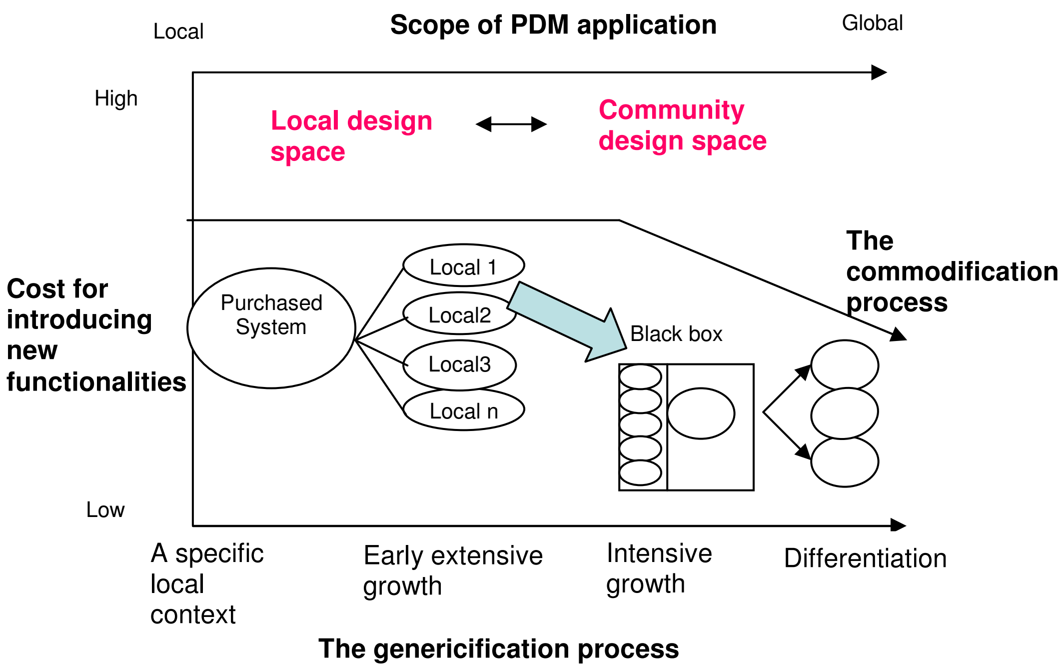


Figure 11: The biography of the LZ PDM

To summarise, we have studied the following biographic stages of the Chinese PDM, conception and birth, early development, maturity and its further development/future. As demonstrated in the above diagram, we found that within this evolutionary process, the features of the PDM emerged out of a local specific context in the birth stage and proceeded to extensive growth in the stage of early development, in which numerous local requirements were added to the generic functionalities. The PDM further evolved to a mature stage, characterised by intensive growth in functionality, after which only selected user requirements were addressed once the user base had reached a certain level of complexity/diversity of practice. The final stage of PDM development was defined by a process of differentiation, such that one single package could gradually become a group of packages for different niches. This thus introduces a range of new possibilities.

Through this process, drawing upon the concept of 'design arena' and studying the learning process of LZ, we have conceptualised two design spaces: a local design space and a community design space, in order to illustrate the different types of relationships and interactions between LZ and their user organisations. Social learning is not a smooth process; rather it is filled with struggles and difficulties. (SØrensen 1996; Williams et al. 2005). In recognition of this, within these two spaces, we examined the strategies that LZ used to deal with a range of conflicts and manage tensions. We have argued that each biographical stage reflects the development strategies which the supplier has adopted in response to the particularities of the learning progress. By linking these stages and strategies, we are better able to clarify the OSPs' supplier innovation process. In the following section, we shall more closely examine the Chinese PDM development process, in order to explicitly articulate our intellectual arguments in regards to the cultivation of standard information system solutions.

Struggles and tensions

What kind of struggles and tensions did the Chinese supplier encounter through the development of the generic solution? What kind of strategies did they use to enable them to deal with these problems?

Our study showed that in order to construct the 'universal solution' and make it 'work', suppliers must deploy various development strategies in order to manage tensions and bridge the gap between the generic system and the working practices of individual organisations, as well as ensure the balance between social, technical and commercial requirements of the development. This coupling process can be summarised in figure 12 below.

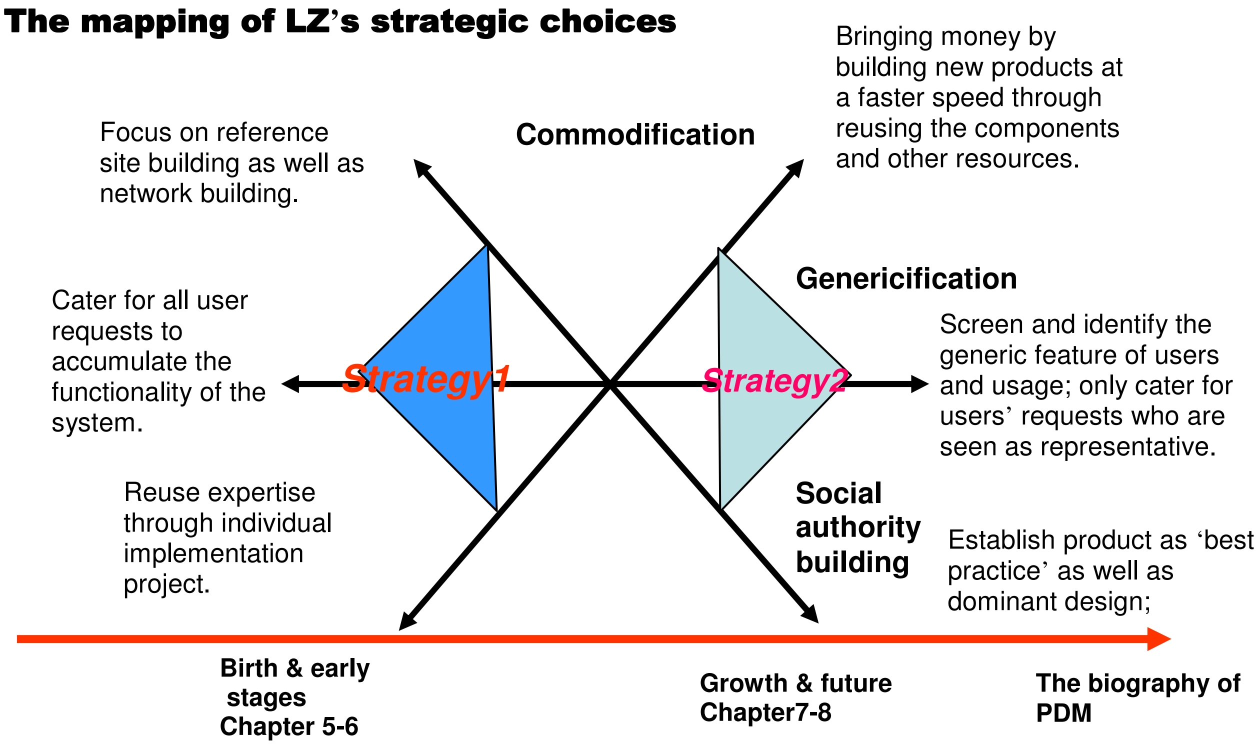


Figure 12: The mapping of LZ's strategic choices

This figure has three axes representing three dimensions: commodification, genericification and networking, each of which is directly related to the development of the generic solution. Each axis has two opposite sides which represent an individual strategy LZ used at different development stages as indicated by the red time line.

It is necessary to point out that although we clarify three dimensions, this does not mean that we consider them to be separate and non-interrelated. As we discussed through the case study, they are interlinked and connected to each other. Therefore, this classification is not an ontological description of reality but rather an analytical conception to understand the complex dynamics of OSP development.

From a generification perspective, the tension for LZ was between catering for user organisations' needs and the need for generic functionality development. From a commodification perspective (an economic dimension), the challenge for LZ was the enhancement of the development process, such that an economy of scale could be achieved through the reuse of related resources. In this case, LZ also worked on network building through developing the MISS standard and later user community to construct and enhance their social authority related to the development of their products as the best practice and dominant design. Each end of this list represents actions that LZ took in order to solve the problems and challenges they were facing at each particular biographic stage.

By linking LZ's choices to address problems that arose within each dimension throughout the biography of the LZ PDM, we clarified two distinct development approaches which LZ adopted. As indicated in the diagram above, the early LZ development strategy is characterised as catering for all user requirements in an attempt to extensively enrich the content of the package, as well as generating profit from winning individual projects through the reuse of expertise, in addition to establishing a customer network and reference sites. The later development strategy represents a reversed orientation, as LZ sought to cater specifically only for selected user organisations' needs, dependant upon their representation and potential contributions to the development of standard functionality. Regarding the supplier's economic strategy, rather than reverting to mass production, LZ shifted its production process from one characterised by a model we could describe as technological craft production, to an enhanced process which aimed to achieve the advantage of economic scale by introducing more products through the same development process and the reuse of existing components and knowledge. As a result of early network and reference site building, LZ also started to develop their PDM as the 'best practice'.

These two development strategies, combined with LZ's parallel balancing of the financial, technical and social factors in different stages of the package's life cycle, indicates that the development of the generic solution is an incremental process which requires a supplier's strategic management. We must also note that LZ's decision-making regarding development was neither simple nor straightforward. The process was rather painful, and strategies which were used to deal with tensions were deployed as necessary responses rather than well-planned exercises.

In terms of the ways in which the OSP suppliers dealt with specific local user requirements, similar to the recent sociological analysis of the development of the advanced country's software packages, our case study shows that LZ's PDM also experienced the process of 'generification' (Pollock et al. 2007; Pollock et al. 2003), by which an OSP supplier's relationship with user organisations changes throughout the evolution of software package. This research further contributes to studies of the concept of 'genericification' by exploring the future stage of an OSP. The concept of 'system promise' is developed to demonstrate how OSP suppliers ensure that their generic packages remain promising in this particular stage. This case also shows that one type of risk in generification at the future stage could be the technological dependence, or 'lock–in', as a number of new OSPs are developed on the basis of the initial, core generic model.

It is also noteworthy that our case study painted a picture in which, the development of OSPs is distinct from the conventional economic understanding of the commodification process of a software package, in which profit can be gained from the reuse of software, and software is seen as a static generic artefact which can be installed and used by all organisations (Cox 1990; Jacobson et al. 1997; Reifer 1997). We argue that the conventional economies of scale, in which mass-producing a good through a single production line results in a lower average cost, can not be achieved in the production of OSPs, since they are not a finished product until it is configured in the hands of the local user organisations. Products, like OSPs, can not be easily reused by different user organisations. In our case, LZ employed a differentiation strategy which was based upon the existing enhanced development process, according to which the cost of introducing a new functionality and new products could be reduced by reusing the existing package components and other resources. A profit can therefore be obtained from the introduction of new products and models to the market at a greater speed.

Supplier learning and the (re)construction of representation of users and use

As we demonstrated in chapter two, existing social studies of OSPs focus on the deployment of the generic solution. Indeed they point out the gulf between standard packages and non-standard user organisations, as well as the importance of implementation and usage to the success of OSP delivery and technical innovation. The innovation process of the generic solution, however, remains understudied. Our study goes "upstream" in the innovation process to investigate the supplier side of innovation and hence close the innovation loop, by coupling our supplier's learning process with its employment of innovation. In the previous section we demonstrated LZ's struggles and the strategies used to tackle them throughout the evolution of the Chinese PDM. In this section, we focus on the associated learning dynamics across the biographical stages.

How did the Chinese supplier develop early assumptions as to the users and use? How and where did the Chinese supplier interact with user organisations and other social actors on the development of OSPs? What did the Chinese supplier learn in relation to building the generic solution from those interactions?

Design is inevitably generic, in that it is always based upon some existing concepts and beliefs of designers. Indeed, the design and development of artefacts requires the designer's confident anticipation of users and the ways in which the artefacts will be used (van Lieshout 2001). Representation of users and use, however, cannot simply be collected all at once, and the construction of representations of users and use is not a job which uniquely belongs to designers. As discussed in chapter two (P20), the early micro-sociological account of concepts (Woolgar's notion of 'configuring the users' (1991) and the concept of 'inscriptions' and their associated processes from Akrich (1992; Akrich and Latour 1992) from science and technology studies to explain the relationship between designers and users have been criticised as overplaying the capabilities and influence of designers and design within a simplified narrative. As pointed out by Williams, Stewart and Slack, the main reason underlying such a narrow view is the snapshot approach of related studies, in which researchers attempted to look only at a particular moment in the technology's life cycle (2005, p99). By following the evolution of technologies, the later 'social learning' studies (Hyysalo Forthcoming ; Williams et al. 2005) indicated that user organisations also engage the development of representations of users and use and sometimes even positively contribute to the related construction. User organisations, in this way, directly introduce local 'scripts' into the technology.

Drawing upon this co-construction view, and based upon the findings of our empirical case, the following diagram (figure 13) has been developed to clarify OSP suppliers' learning processes by taking into account their interactions with user organisations across each biographical stage. During the evolution of the LZ PDM package, within the social learning design arena, we identified two design spaces which are located in both the local user organisations and at the collective inter-organisational level. The concept of 'space' is used to capture the time and location which LZ used to conduct their learning through the evolutionary process. Each space comprises its own cyclical pattern of supplier learning activity related to the development of the representation of users and use.

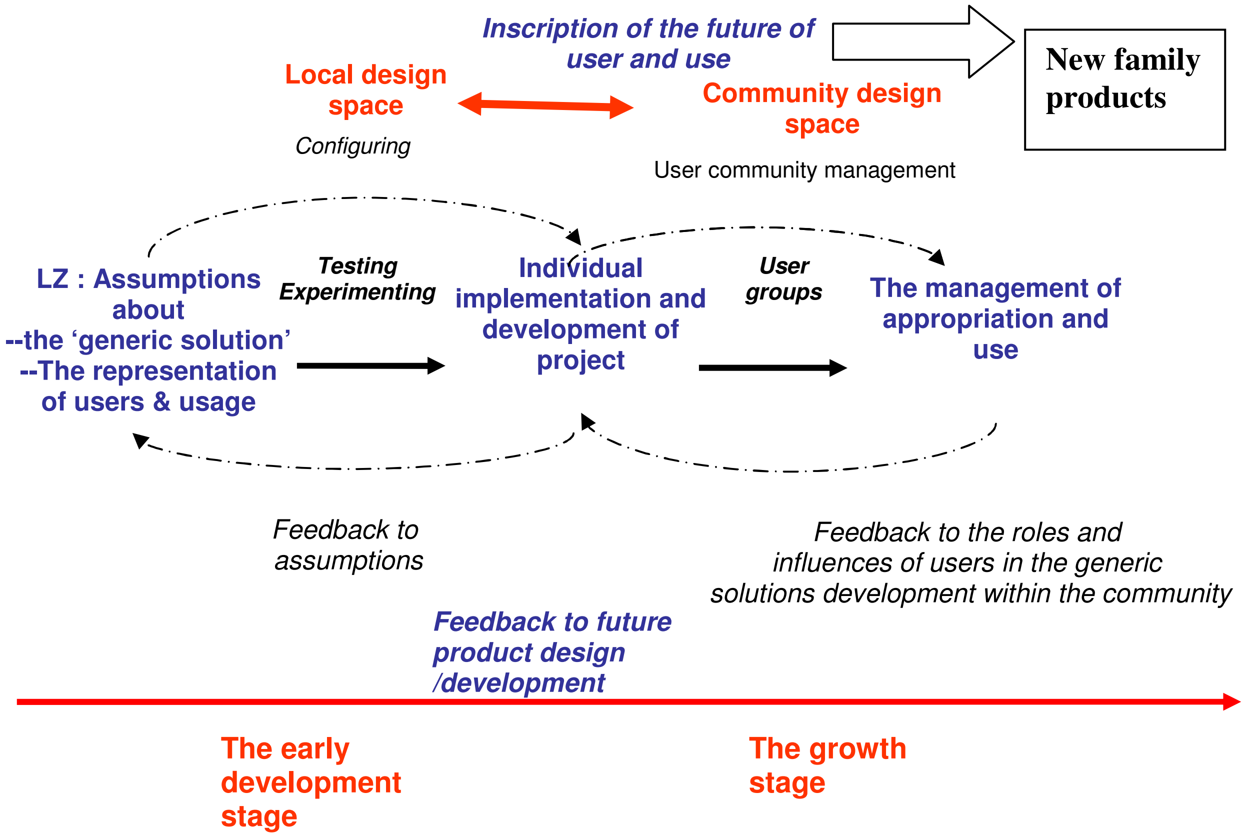


Figure 13: The multi-cycle of OSPs innovation process

- **Local design space and knowledge acquisition**

In the early development stage, we found that LZ was focusing on knowledge acquisition, whereby they attempted to extensively augment their understanding of the representation of users and use by implementing as many diverse user organisations' adaptation projects as possible.

LZ's knowledge acquisition began as an attempt to reverse-engineer a purchased pre-existing system and converted it into a more widely-applicable generic solution. This choice confirms that today's ICT development occurs differently than traditional models of technology development would suggest, such that, rather than starting from scratch, development tends now to start from an established foothold somewhere. This pre-existing system represents one of LZ's earliest design resources.

LZ early learning process was still a local, project-based and passive learning activity whereby the supplier's knowledge of the representation of users and use was advanced by managing and solving the challenges presented by local organisations through the conducting of local adaptation projects.

By providing virtually customised system solutions, LZ managed to get very close to each individual user organisation and thus to investigate and learn more about the uniqueness of their contexts. In this stage, the representation of users and use largely developed according to the supplier's own assumptions and experiences, gained through the implementation of local adaptation projects rather than other resources.

As we noticed in chapter five, there was a clear learning process related to the identification of similarities and diversities in the construction design field during the implementation and use of the early version of the PDM. LZ's understanding of the possible generic features, which was generated from interactions with design organisations, was further tested in the electrical power sector. Assumptions about quality control, project accounting, and finance management which had been accumulated in previous implementations were further subjected to experimentation and developed within the CPPC and QDBD projects. This empirical evidence supports the idea of design that can be seen as a hypothesis about the user (Lobet-Maris and van Bastelaer 1999; Stewart and Williams 2002; Williams et al. 2005).The implementation and adaptation can therefore be seen as experiments testing a hypothesis. The local organisations can thus be understood as a laboratory of innovation. As a result, these findings further enhance Fleck's (1988; 1992) notion of 'innofusion', according to which technological innovation continues after the early development in the hands of suppliers.

This learning process was not smooth. As has been demonstrated in Chapter five, the early innovation of LZ's PDM is distinctly characterised by a process that is termed by Zerubavel as 'lumping and splitting'(1996). Each time, LZ introduced their generic package to local user organisations, the assumptions about users and use that were embedded in the package were immediately challenged by the local user organisations' actual work practices. The price of LZ's early learning was to accommodate most of the local practices into their standard solution. This was a painful process, as LZ had to carry out mass-customisation. However LZ's knowledge gradually increased with each collision between its early assumptions about users inscribed in the package and the actual local user practices. Such an OSP supplier learning process further indicates that the representation of users and usage could not be collected at once, and these representations are not always available explicitly; rather the collection is an incremental process which requires interaction between the suppliers' lumping activity and user organisations' splitting activity, throughout what has been described as an iteration between the materialisation of user representations in a particular design, the testing in the innofusion and domestication process, and feedback to future functionality development (Akrich 1995; Williams et al. 2005) . This is the first learning loop LZ experienced. The significance of LZ's early learning is that the acquired knowledge provided the foundation for later knowledge management at a community level.

- **Shifting: the community design space and knowledge management**

As the PDM development evolved into the growth stage, we found that LZ changed its learning approach. The extensive knowledge acquired from early development, combined with the associated accumulation of power, enabled LZ to become more capable of developing a generic solution without passively accepting user organisations' local requirements or the challenges they addressed to the standard package. As we discussed before, this was also the time in which they enrolled user organisations to develop the package in a collective environment, because the supplier's individual acquisition of all the requisite knowledge would be a virtually impossible undertaking. As Williams, Stewart and Slack (2005) argue, knowledge of new product development is not simply made available to a single organisation; instead the related knowledge is distributed among different participants, spread throughout a variety of geographical places. In our case study, it is very clear that from late 2002, it became difficult to conduct LZ's quasi-handcrafted production style, due to its great and increasing costs, as well as LZ's need to continually develop standardised software components. Similar to cases discussed in recent technology development studies of advanced countries (Hyysalo 2004; Koch 2003; Pollock et al. 2007), LZ shifted its design space from local implementation projects to a collective environment. We call the latter space a 'community design space', in which interorganisational learning and community collaborative design occur.

Hyysalo's analysis of the biography of an ICT application draws attention to a 'critical transition', a concept adopts from Hasu (2001), to point to a stage at which the supplier sought to establish a new cycle which would move between seeking co-coordinated improvements with users and seeking standardisation (Hyysalo 2006). Within this community design space, we found similar action; based on early implementation experiences and understandings, LZ re-structured its relationship with user organisations with the aim of developing a more standardised functionality. As we demonstrated in chapter seven, and similar to the findings of Pollock's study (Pollock et al. 2007), the Chinese user organisations were segmented into different categories on the basis of their potential contributions on the development of the generic solution identified by LZ. Regarding each group of users, the supplier used different strategies to respond to local requirements with different learning foci. The CEEDI case, demonstrated in chapter 7 is a prime example that illustrates how LZ managed the local requirements and practices in order to develop its new functionality in the stage of growth with a specific type of user organisations. The segmentation and classification of user organisations can be understood as a means of the supply firm learning about capturing, managing and maximally utilising the selected user organisations' requirements in its product innovation.

It is important to note that the classification of user organisations is neither permanent nor unchangeable. From a supplier perspective, these classifications depend on their 'contribution' to the development of the generic solution. In our case study, the feedback from the appropriation and use of the PDM in the LZ user community conferences, as well as the feedback from individual implementation projects provided the references for later classification of user groups. Some of the user organisations could be moved from one group to another group. This point can also be found in Pollock's studies (Pollock et al. 2007) on developing generic solutions for a university.

Comparing the passive manner by which knowledge was acquired in the early development stage to the modes of knowledge acquisition in later OSP development stages, we found that this passivity was replaced by an active engagement with user organisations and market regulations as well as strategically managing the dynamic supplier-user group relationship in a collective environment. The process of building and managing this user community represents the second learning loop that supplier learning occurs at an inter-organisational level.

One highly distinctive feature of this case study, concerns the intermediary which channelled the early interorganisational learning and the mechanism which cultivated early design practices in a collective environment. This was the development of the national software standard, MISS, enabled by the intervention of the government. This process is very different from the practices found in developed countries, in which the organisation of user community conferences and the arrangement of alignments with user organisations are becoming more popular. The first LZ user conference was organised in 2004, once the LZ PDM had relatively stabilised. In chapter six, we demonstrated how LZ used the MISS standard development as a learning tool to support its own product development, how such an event enabled other social groups to engage with the development package and, more importantly, how this event became the learning intermediary, exchanging information and aligning perspectives between user organisations, the supplier LZ and other institutions.

- **Co-existing: local design space and community design space**

In our case study, although these two design spaces were constructed in sequential steps, they were co-existent by the time of the later development stages. On the one hand, the supplier LZ selectively generated local knowledge from related local adaptation projects; on the other hand, at the community level, LZ managed to achieve local innovation by building up community structures to formalise the selection of user requirements. As a whole, this feedback provided general information relating to future product development functionality and design. In turn, the new assumptions on the representation of users and use related to the PDM and other new products were fed back to the design through the 'in-scription' of the future of users and use into new functionality and products. Equally important, the accumulated domain knowledge gained from previous development and implementation, as well as the accumulated knowledge of related government policies and operation strategies, further enhanced LZ's abilities in the development of a family of related products.

The processes related to learning and the accumulation of knowledge for LZ can be summarised as follows: (1) building up early assumptions of the representation of users and usage, (2) testing and experimenting in the local user implementation space with a focus on knowledge acquisition, and (3) (re)constructing and managing the representation of users and use in the community design space, as well as incorporating local design practices with a focus on knowledge management (4) extending the scope of knowledge and achieving efficiency through the production of new functions and products by reusing the same solutions, knowledge and processes. Although this innovation process has been abstracted from the Chinese PDM development, we would suggest that these learning dynamics are inevitable for all OSP suppliers, albeit through a loose and less-defined sequence and possibly involving more diverse or differing learning mechanisms and intermediaries depending upon the specific context in which the supplier is located. We shall come back to this point in the next discussion - the shaping of socio-economic context on OSPs development.

This multi-level and multi-cycle innovation process raises a concern related to the management of innovation including both inside and outside the suppliers' firm. Our research emphasised the complex and dynamic nature of the OSP innovation process. From the perspective of the supplier's learning, the management of design and development must attend to both internal and external innovation processes.

We believe that the internal challenge for OSP suppliers is the management of cross-project innovation. Most software package developing organisations today, such as LZ, are project-based. Particularly in the case of the PDM, in which the reuse of experts was employed as an early method of capturing the representation of users and use, the management of knowledge captured by these experts through different development projects is crucial. The success of innovation largely depends on the management of those projects which are conducted in multiple locations. In such a context, the key factor is the manner in which suppliers learn and preserve what has been learned across projects, even as each project is seen as possessing a unique identity. Equally important, what should be 'forgotten' from each project must also be taken into account. As indicated in Pollock and Williams' study(Pollock et al. 2007) , getting too close to a specific individual could be dangerous for the supplier, since the generic solution is designed for a group of user organisations. This study indicates that remembering too much and too many details of each specific user organisation's practices could increase the difficulty of usage in other implementation projects.

The external challenge for suppliers centres on the management of external social participants, in particular, the user organisations. The results of our study highlight the fact that the knowledge needed for the development of OSPs is not always located inside the firm. There is a range of knowledge which is to be found outside the firm, for instance, in the user's hand. In order to reveal and construct 'generic functionality', it is necessary to build up a communication linkage with a range of user organisations, often functioning as a community. Within such a community, we start to see the supplier attempting to use a range of strategies to motivate different user organisations to contribute. Within a community space, to a supplier, the first key question for the design of such a product is how much the supplier should do and how much the user organisations should contribute, in order to achieve the final satisfactory product design. Giving too much responsibility to user organisations in technological innovation is risky, since they may not able to handle it due to the complexity and diversity within the community. We believe that setting up and managing a boundary within the community is crucial for suppliers, since it allows some structures and rules to be created which user organisations can follow and thereby contributing to better dynamics and richer exchange of knowledge.

The influence of the broader socio-economic context

The key issue which remains to be discussed is how we are to understand the features of this Chinese development. Our research has confirmed some conclusions related to the development processes of OSPs and their relationships with commodification, generification and network–building which are described in existing SST literature, the bulk of which has been generated in western countries. This case study also brings to light some substantive differences, in terms of individual features of the development process, between western countries and China. In particular, we have noted that some of LZ's developmental approaches possess significant Chinese characteristics. How are we to understand these specifically Chinese features? What is their significance for OSP development?

How did the Chinese socio-economic context and institutional arrangement influence the development of the generic solution?

Based on the SST approach, regardless of the particular choices made by a supplier regarding strategies for dealing with tensions and struggles or where and when to capture the representation of users and usage, the broader socio-economic context mediates certain influences to the process of development. This section seeks to further explore, holistically, how Chinese socio–economic factors influenced technological change and the resultant impacts upon PDM development, by deploying Rip's 'Technology Transition' (TT) model (Rip and Kemp 1998).

According to TT, technology change is caused by interaction between the landscape, socio-technical system and particular niches. A more detailed explanation of this interaction can be obtained from chapter two. Applying this concept to the case of the Chinese PDM, we develop the following diagram to show the Chinese transition process.

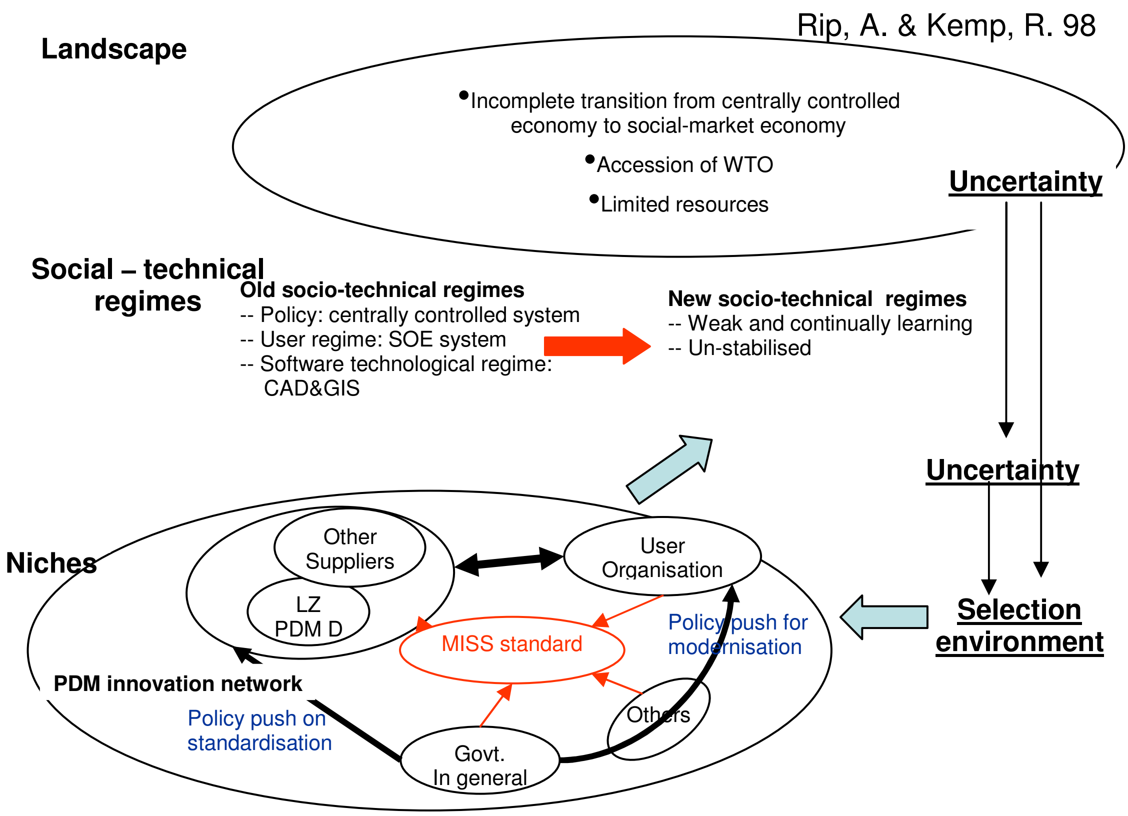


Figure 14: The Chinese socio-technical system

As we noted in chapters two and four, China's landscape is marked by uncertainties, as it is in the middle of transition from the old centrally controlled system to a new socio-economic market. As a result of the two economic systems (centrally controlled and market) existing at the same time, the relationship between the government and industry was unclear and not well-defined. As illustrated in above figure, this stage of incomplete transition also meant that the Chinese socio- technical regimes underwent similar experiences and were likewise characterised by uncertainty and fragmentation.

Compared to a regime change in a well-established socio-technical system, this incomplete socio-technical regime provided much more room for actors at the niche level to change and construct related regimes at a relatively rapid rate. As demonstrated in figure 14, the multi-level uncertainty stemming from both the landscape and these regimes impacted on the selection environment, including a range of institutional and structural factors. In principle, these factors influence the definition of profit, cost and direction of potential demand and new product development in the niche level. Normally in a more stabilised system, the market is seen as the key selection environment which drives new technology development. In the case of Chinese PDM, however, the government acted as the key player in the building up of the selection environment, by electing modernisation as a priority plan for the advancement of China's construction organisations' capabilities, as well as in the creation of technology development policies which sought to support its own intellectual property rights.

- **The 'Co-evolution' in transition**

Following this, we discovered a co-evolution process, whereby the regime and niche were developed at the same time. The intervention of the government in both the regime and niche development created the early market of the PDM. The technology supplier LZ spontaneously and creatively engaged with the opportunities that arose in the selection environment. As a result, the formation of niches (including the coupling of expectations, an accumulated learning process and network building) was undertaken with guidance from a single supplier, LZ.

With support from government policies and a need for the establishment of new socio-technical regimes arising in response to the pressures of the transitioning market context, the supplier LZ was selected as the national champion, and its product was explicitly recognised as the industry's best practice, useful for enabling user organisations to achieve greater productivity through the national standard development. As a result, the PDM and the related architecture itself also became dominant designs in this technological regime. As a consequence, the innovating network emerged through niches, while the new rules of both the construction industry's working practices and the related software functionality rules were gradually built up through the processes of PDM and MISS standard development. Equally importantly, in consideration of a future stage of PDM development, we found that by engaging with such a selection environment, as a result of learning from the PDM development experience, LZ even began participating in the construction of future technology expectations, in order to lead new technology development by influencing the government's relevant development agenda.

We must note, however, that LZ's strategic engagement with this selection environment for the building up of its innovation network and related dominant design was motivated by the pressure to survive and acquire necessary funding. The strategy, in other words, emerged as a result of 'searching for solutions and selecting options' under problematic circumstances. This phenomenon further indicates that the co-evolution process in this transition environment was not smooth but occurred through great difficulties.

The analysis of these rich empirical data has demonstrated how the socio–economic context and institutional arrangement shaped the construction of OSPs. In turn, this shaping process also indicated that the practices of mass software development could vary within different contexts, in which the landscape, regime and niches take different forms. It is thus hard to define a 'best practice' of OSP development. The development approaches used by western suppliers may not apply in China and vice versa. The way in which the supplier deploys strategies and its development approach is largely constrained by the broader socio-economic context in which they are embedded. For a supplier of OSPs, it is crucial to the construction of standard features to recognise the learning dynamics of OSP development throughout its biography, as well as systematically managing the producer-user relationship and strategically applying tools and techniques to conduct collaborative development with user organisations.

9.2.2 Contribution to theory

In response to the claim that large complex information systems can usually only be tailored to specific users, due to the sophistication of such systems (Hobday 1998, 2000), our case study demonstrates that the construction of such 'generic', large and complex organisational information systems is not impossible, but this achievement can only be attained through the negotiation of great difficulty and complexity. The development of the commercial software package can not be seen as a single issue. As argued by Hughes (Hughes 1999; Hughes 2001), the construction of technology can be characterised as ‘heterogeneous engineering’, in which social, political, economic and technical factors interact in the shaping of technology features. In our case study, we found that for a OSP supplier, the practice of the development of the generic solution is a multi-layer, internal coupling process between generification, network building, commodification and the management of learning activities, as well as involving the externally coupling of user organisations and other social actors.

Furthermore, the findings of this study challenge traditional perceptions of the features of OSPs. In the related management and implementation literature, OSPs have been portrayed as monolithic systems which are highly structured and which can hardly allow any change; hence user organisations are forced to adapt themselves in order to fit into the single ‘black box’. Our research on the biography of a Chinese PDM provides evidence that the generic solution is not a purely generic, monolithic system. When we opened the ‘black box’, we discovered that the inside of the generic solution is actually less defined than generally perceived, with permeable boundaries. The features of the standard package can be defined and redefined, based upon individual circumstances, such as the supplier’s interest in the potential contribution of user organisations to the development of package, and the users’ belief that the package represents the ‘best practice’. We argue, therefore, that the final feature of the OSPs is the result of a fix between supplier and user organisations through negation, subject to conflicts, and differences of power and interest while the ‘standard solution’ met the ‘non-standard user organisations’.

Taking a step further, we articulate the idea of complementary ‘universal solutions’ and ‘local contingency’. By studying the learning process of an OSP supplier related to the (re)construction of the generic solution, we contribute to the debate between ‘universality’ and ‘locality’ by illustrating their interdependent relationship. The existing literature on how local contingencies and practices changing the initial features of the universal solutions at the stage of implementation and adaptation (Hartswood et al. 2002; Suchman 1987, 1994), somehow, portrayed a picture in which ‘local’ and ‘global’ are opposed to each other. Our study of LZ’s learning process indicates, that these two concepts intermingle as two sides of a coin and are inseparable. By using the notion of ‘lumping and splitting’ (Zerubavel 1996), we demonstrated iteration between the development of the generic solution from accommodating local practices, the taking up of the organizational change caused by the adaptation of the generic solution, and the contribution of local innovation in the domestication/innofusion process to future new generic functionality and technology supply and design. The collision and the interaction between a generic solution and local diversities raised our next finding.

Our study further contributes to the social study of OSP development by clarifying a supplier innovation process with multiple cycles and levels. The multiplicity, dynamism and continuity of the OSPs supplier’s learning process indicates that in order to achieve the ‘generic’ and make it work, suppliers have to work with user organisations in order to develop standard features through a cycle of design, development, implementation and use. Within this collaborative development, OSP suppliers should pay attention to the management of user relations throughout the evolutionary process. Apart from interacting with and learning from user organisations and other social groups, OSP suppliers must also be aware of the challenges of internal innovation management. The achievement of learning on the part of the designers does not equate to the software firm itself benefiting from this learning. Managing the knowledge acquired by individual engineers from local implementation projects is also critical to successful learning by the supplier firm.

9.2.3 Reflections on the study and further research

Apart from the analytical, theoretical and empirical value of our study, there are a few constraints and limitations that need to be mentioned and are related mostly to the nature of the study which is associated with our initial research interests, and the design choices that we made. Those limitations are important and could contribute to the planning of possible future research in the field.

The primary concern of this research was set out to understand how the supplier manages to construct the attempt to build up the almost impossible generic solution. We were specifically interested in the supplier's development strategies and innovation processes; this was due to the lack of empirical investigation and the related theoretical gap in the field of the social study of OSPs, in which a great amount of attention is given to the implementation, adoption, and use of such software systems. This choice directed our research focus towards the under-researched field of the construction of the generic solution, focusing on the supplier side of the story. As a result of this choice, however, we only investigated the construction of the universality of the Chinese software package. The adaptation of technology was taken for granted in the literature. It does not mean the implementation of technology is not important. We acknowledge its important role in innovation and during the framework-building of our research, we fully integrate this understanding of the selection of concepts and perspectives.

Following the framework that we constructed on the basis of SST studies, our single case was designed to include a bundle of elements: Chinese domestic software, a PDM designed for the construction industry, by a local supplier in the context of China. The main reasons for selecting the PDM stem from the availability of extensive access to the supplier and to the extremely complex relations between those elements which characterise its development process. Easy access enabled us to get inside the firm's top business strategy space, which can not normally be attained by an outsider, as well as to observe the supplier's internal daily life, in order to observe and experience their frustrations and concerns. This choice of case selection may have incurred certain constraints for the explanation of other software development, for instance those packages which are developed by international suppliers and then redesigned on the basis of a local context in China, and/or those which are developed for other industries such as the bank and financial sectors, both of which are relatively more mature than the construction industry. Our case study provides extremely detailed data, however, as well as a context for understanding the construction of OSPs from a supplier angle. This study could be used as the foundation for future research to test the diverse software packages and possible impacts on the development process, in order to identify those potential differences which may be embedded in them.

There are so many different approaches which can be employed to conduct research on a software supplier's development process, such as the investigation of labour process, internal politics, project management or observing interactions with other actors. Rather than following the current technology studies fashion for local ethnographic studies, we took a more holistic view of development which links detached design choices to implementations and adaptations. Following the approach of 'social learning', inside the design arena, we studied the supplier's development strategies and innovation through its interaction with other actors. One of our most important contributions to research in this field is our clarification of a supplier innovation process which involves multiple layers and cycles. The potential constraints on this innovation process would be the possibility of the supplier's inability to explain its internal projects and innovation management in detail, as well as to demonstrate the importance of the end-users to OSP development. In relation to the supplier's internal knowledge management, although this study addressed a process in which the supplier reused their expertise in each implementation project, little explanation was given to the researcher as to how such work was conducted by the supplier. This limitation was caused by the research objective, which was created in order to enable the investigation of supplier strategies regarding interactions with users. Some of our findings, however, draw our attention to the OSP supplier's internal project management and its possible impacts on the shaping of the generic solution for the future research.

Despite these limitations, the findings of this research enriched our understanding of the design and development of OSPs, the mass production of the complex generic system, by providing detailed, fresh empirical data. It also broadened base of technology studies by extending the base of empirical research located in developing countries. This richly detailed empirical case study has built up the foundation for further knowledge exploration. In order to continue and advance our knowledge of the construction of generic and complex information systems, further work is required.

First, along with the journey of a software package's innovation, we need to continue to advance our understanding of the biography of the software package by taking diversity into account. This means that it is necessary to further explore the interrelation between development strategies, the supplier, software packages, the industry and the broader socio-economic context in the shaping of the generic solution. For instance, in comparison with the Chinese construction industry, the United Kingdom's construction industry has a similar ICT automation application level, as well as similar historical perceptions (not as advanced in comparison with other industries). It would be interesting to investigate how the UK construction industry builds up a complicated software package. Regarding China's construction industry, we can further investigate how foreign suppliers have developed their version of the PDM in the context of China. Inside China, we can compare the development processes of different kinds of application software to investigate the influences of industry structure on the development of OSPs. Further as we noted from this case study, the Chinese indigenous OSPs such as PDM and ERP has followed a different route to the west. It would be every interesting to explicitly compare the evolution and significance of these two technological pathways. To this end, it is also necessary to develop an appropriate framework and provide a sophisticated platform to conduct comparative analyses of the evolution of an OSP across both national and industrial boundaries.

Secondly, it is necessary to explore in greater detail how innovation and its management occur within the OSP supplier firms. The increasing competition, rapidly changing technology and markets' needs exert pressure for suppliers in the OSPs industry to develop better quality product with lower price. The traditional system lifecycle approach simply would not get the job done. To remain competitive, OSP suppliers need to build speed and flexibility into their development process. Today, most OSP software firms are project-based with a concurrent approach that development is organised across project/or functional teams(Dube 1998). In the case of the PDM, we noticed that LZ gained early technological capabilities through its reuse of development team experts across multiple implementation projects with the concurrent management and planning of new functions development. Response to the increasing popular concurrent development approach in OSPs development, our case study has raised a question as to how OSP suppliers are able to capitalise on knowledge which is acquired during the execution of one project, as well as how they manage to transfer this knowledge to other projects or parts of the organisation. Sophisticated studies of a team based OSPs development approach with a contextual focus will be extremely beneficial to augment our intellectual understanding on the features of innovation taken up in different OSPs firms.

Thirdly, in relation to capabilities of Chinese technological innovation, this study has provided a detailed account of the social shaping of technology, design and development in China, with an emphasis on social learning. The empirical research also highlighted the potential capability of Chinese users and other social actors to contribute to the artefacts' design. In order to provide a complete picture and assessment of China's capabilities for technological innovation, rather than concentrating solely on the supplier firm's innovation process, it is necessary to fully explore in detail the Chinese appropriation and domestication process. For example, in the case of the PDM, more investigation is needed on the subjects of the Chinese user organisations' adaptation of this technology, the means by which they made it meaningful inside their organisations, the ways in which the Chinese users 'work around' the generic solution and their approach to 'making sense of the technology'. Indeed, in the field of SST, there is a range of literature on the use of technology which was conducted in advanced countries. Little attention had been given to the appropriation process in developing countries. The study of Chinese technology appropriation and use could help us to build a better understanding of China's capabilities for technology innovation, which consists of a completed cycle—the innovation of supply as well as the innovation of use. The distinctive role of standardisation in this case also merits further research, as it raises important issues for Chinese technology policy in the context of economic transition (discussed further below) as well as Western concerns about alleged techno-nationalism.

9.3 WIDER IMPLICATIONS

9.3.1 Implications for SST in technology studies

In order to overcome the conceptual limitations of the classical single disciplinary approach, this study employed a SST perspective. This is an interdisciplinary approach to the understanding of complex social phenomenon related to the design of a software package. Our study has confirmed the value of SST, as a case study combining the detailed focus of actor-related studies with approaches which address the influence of broader structural and historical factors. It emphasises the importance of detailed analysis encompassing the content of technology and the processes of technological innovation. It also provides a theoretical guideline which allows a better understanding of the changing behaviours of the actors involved in OSP development, in response to changes in the broader social and economic contexts of China's economic transition. Equally important, our study allows us to identify the changing characteristics of a supplier's technological learning over time, throughout the evolution of a software package. We discovered, however, that there are also some limitations and potential problems which should be discussed.

The 'biography' of the software package and generification strategies

The concept of the biography of the software package helped us to identify the time dimension which follows the evolution of artefacts, as well as related supplier development strategies. It usefully draws our attention to the supplier side of the story, illustrating the travel of the generic software package and thus overcoming the weaknesses of the 'snapshot' approach, which emphasised only single phases or aspects of the software package's life cycle. To some extent, however, we found that there are limitations to the understanding of future development of the software package.

For instance, how are we to understand the phenomenon of the software package family tree in the future stage? This is an exciting moment, in which the end of one software package overlaps with the birth of another. This future stage in the development goes beyond the explanation of the 'path of diversity'. This limitation on the explanation of the future stage may be caused by a lack of research resources, time and finances experienced by scholars in the field. Certainly, if these researchers could obtain sufficient resources, they would explore this concept further. The results of our study indicate that other concepts could be added as researchers want to explore the future dimension of an OSP.

Furthermore, regarding supplier generification strategies, the existing notions related to this concept have their own limitations in identifying the various possible features of strategies which could be used by the diverse suppliers. Our empirical case study has demonstrated that the features of the development process are strongly influenced by its external environment. Catching these diversities embedded in the development is crucial to understanding the national and industrial shaping of the software package development. The limitations noted above may be related to the lack of empirical research in the field of OSP studies, in which most related research on OSPs is conducted in advanced countries. The final empirical evidence of this research calls our attention to the studies of diversities which may be embedded in the practices of OSP development.

Technological transition (TT) model: a multi-level perspective

The original motivation to use TT was caused by a secondary concern to understand the potential influences of the Chinese context on the shaping of the generic solution. The TT model helped us to understand the interrelation between the dynamics of the Chinese PDM development process and the structure of the innovation process, as well as other socio-economic factors. The value of such a multi-level perspective on understanding technological change has been confirmed in this study. Our research has proven that the TT model is a very useful analytical tool. It helped to provide a better understanding of the changing behaviours of the actors involved in technology development in response to changes in the broad social and economic context of

China's economic transition. It also highlighted the importance of interplay between three conceptual levels for assessing technological change.

From this perspective, we can see that the construction of the PDM was an interactive process between China's landscape, regimes and niche levels. At the niche level, this construction involved technological innovation by a single Chinese supplier, as well as related standardisation development, in association with the selection environment, which was framed by related government policies, and has contributed to the formation of the niches themselves. Meanwhile we also can see that Chinese socio-technical regime systems gradually emerged alongside the development of the niches under the pressure from the Chinese landscape. The dynamics of technology development and the learning process have also been stimulated by a range of government policies and institutional changes. This study showed that under such conditions, the Chinese government is building up regime systems through the formation of the niches.

To some extent, however, the notion of TT, the multi-level perspective, with its neat diagrams, conveys an image of a linear and ordered process. In the TT literature, several phases (Geels 2002, 2004, 2005; Rip and Kemp 1998) have been identified to describe the sequence of the socio-technical change[27]. The landscape and socio-technical regimes have been perceived as relatively stable and hard to change or modify.

The findings of this study have demonstrated the nature of an existing system which was characterised by instability and contingency. There were multiple uncertainties located in the both the Chinese landscape and socio-regime levels. In this context, the pressure from the landscape regarding the need to create regimes can speed up the new regime building process through the creative management of niches. Meanwhile,

[27] First, radical innovation started from niches, then continued to be stabilised through a process of experimentation and learning, hence creating challenges and threats to the existing regime system. Meanwhile, the pressure from the landscape and the further push from the niche's social actors started to modify the regime. Once the regime has been changed; the landscape will be transformed gradually since there is a mismatch between the three levels. As one of the important assumptions of this model, the stability of the existing landscape and regime system is taken for granted.

due to the incompleteness of the socio–technical regime system, much more room was made available for actors to creatively engage with the external environment at the niche level. More importantly, we saw a co-evolution of regimes and niches in China.

Thus, although the multi-level perspective on technological change has usefully drawn attention to the interrelation between structure, process and the related dynamics of social actors, it may not be useful to explain the possible diversities which exist in different socio-technical systems. The findings of this study also call for attention to the possible differences of socio-technical changes in advanced and developing countries, as well as the associated role of government and policy concerns. In the next section, based on our study, we point out the policy implications for Chinese socio–technical change.

9.3.2 Policy implications for China's future technological development

The concerns of China's 'technology push' policies

This study of the Chinese PDM development has indicated that the promoting of a technology is still strongly influenced by the government in China.

China has a historical record of the 'technology push' policy. As we mentioned in the context of chapter four, science and technology are promoted as a universal remedy to improve productivity as well as the quality of life. Associated with this we see that China's government presumed a 'linear model' of innovation, involving a one-way flow of innovation, ideas and solutions from basic science, through applied research and development to industrial production and the diffusion of finished artefacts through the market to the consumer.

The consequence of such a top-down policy push is that most of the users and usage are neglected in the innovation process; their potential contributions are down-played (Tait and Williams 1999). Western countries' technology appropriation and domestication studies explicitly highlight the importance of user and use in innovation. From the PDM case, we can also see the contributions of Chinese user organisations to technology development, despite their lack of knowledge and understanding in the early stages. Perhaps, the Chinese user organisations were weak in that they lacked their own ideas as to what they needed and what they wanted from the technology. Our empirical research on the PDM has proved that they do have the capability to learn, and once they gain design capabilities, they will be able to creatively engage in technology innovation.

Thus, in order to create a real 'technology play place' ,emphasised in the 1990s Chinese science and technology policy(International development research centre and the State science and technology commission 1997), in which technology development is led and financed by the market, the Chinese government should pay attention to the market of users and the use of technology, since these represent the critical knowledge resources to innovation. Only with users who are well-informed and educated, can a healthy organic technology development be built up. The related policies should be developed to promote interactive learning and, in particular, to facilitate users to learn about the technology and its usage, to promote these technologies, and to actively engage in their design and development. This demand upon policy raised our next concern.

Policy practice: the need to build up a long–term linkage

In relation to interactive learning, the current operation of the Chinese 'learning economy' noted in this case study of the PDM has indicated that some positive steps have been taken by the Chinese government, but there are a range of issues still left unsolved.

Successful innovation had been conceptualised as a matter of a two-sided/coupling activity by Freeman (1982). He stated that a coupling process is not only a matching activity between supply and market but also a continuous creative dialogue during the whole of the technology development process. As we mentioned in the literature review, such a ‘coupling’ is seen as the basis of the ‘learning economy’ by the later evolutionary economists. As a mechanism of the ‘learning economy’, the linkage of the dialogue between supply and market is strategic and represents a critical focal point for innovation.

In our case, the coupling process emerged under the intervention of Chinese government. Given that both the Chinese landscape and regime systems are incomplete and unstable, we saw that the Chinese government employed a range of policies and used the reform of standardised institutional arrangements at the regime level to promote network building and the participation of enterprises in technology development, as well as the creation of market demand in niches. The result was relatively positive, such that a range of social players did indeed communicate and learn from each other in such a collective space. The state, however, needs to be aware of the possible risks of such a ‘coupling’ approach, in which the government heavily intervenes.

Firstly, state intervention in technology innovation could place tremendous burdens on the government to plan and implement a particular technology. In the early stages, it is possible that the government’s intervention in the use of low-level technology would bring positive impacts to the process of adaptation. As the technology gets more and more sophisticated, however, government intervention in later implementation could become difficult if user organisations are not capable to help them since related upgrading requires more in-depth local knowledge.

Secondly, one of these risks is related to the formation of innovation networks. As we notice that the MISS standard development was used as a political tool by LZ to develop and favour its own product, and the user organisations’ perceptions of related PDM systems and business operations was thereby also directly influenced. LZ, as the key actor, prevailed to influence conceptions of this particular ICT. One of the dangers, therefore, could possibly be an unexpected monopoly on the part of the particular key player in the industry. In theory, the standard development process itself could be a reliable means to control the power of the single supplier, by involving other social players; however, in the context of China, national champions tend to, by nature, carry more power than the immature user organisations, which are seen as lacking expert knowledge. The Chinese government should consider, therefore, how much power they should bestow on those ‘system builders’, as well as, for example, the means by which they may be regulated.

Another concern centres on how the government chooses the standard developer. The Chinese government was lucky, as LZ was able to lead the technology development. The decision to use LZ for the MISS standard development was made on the basis of the fact that LZ was the first organisation to initiate the standard and develop a better relationship with the government. What if LZ had not ultimately proved capable or failed to carry the responsibilities of such a position? Excluding other suppliers, meanwhile, whether they are domestic or international, potentially excludes an important body of knowledge and possible technological choices. It is necessary to develop a sophisticated framework to select and measure the organisations who have the potential to become ‘system builders’. Also it is dangerous of the standard becoming too closely attached to a particular proprietary player. The standard can become a means for advantaging monopoly players and this distorts the ‘free market’.

Furthermore, the success of the standard-oriented policy and its operation in the PDM development draws our attention to the potential deployment in the development of other technologies. Can the Chinese government, however, apply the same strategy in other fields? The current problem relates to the motivation behind the standard-oriented policy, in that this motive contradicts the commitment which the Chinese government promised to the WTO. Government protection can not always work, especially in a globalising environment. The commitments made by the Chinese government, which were to be achieved five years after the accession to the WTO, means that the door will open even wider after 2007. The issue is becoming, how long and how far can the Chinese government continue along this road, while under pressure from international organizations and other countries? Although the domestic industries are weak, the Chinese government should create a selection environment at the niche level to facilitate the building of an innovation network, as well as learning mechanisms to support long-term substantial development with an emphasis on positive collaboration, interactive learning and healthy competition.

In moving to the social–market economy, in which market forces play a critical role in product development, the role of the Chinese government should be shifted from central control to that of a facilitator stimulating the co-evolution of supply and demand, for desirable outcomes in both the short and long term. For the short term, the Chinese government should keep building and promoting the dynamics of a socio-technical system and change. In the long term, it is necessary to develop a long-term technology strategy/framework to guide the direction of technology development, as well as to clarify and draw a boundary between the state and industry, in order to maintain a balance between the regulatory and dynamic markets. Meanwhile, rather than setting up a policy to constrain technology development, the Chinese government should engage in the development process to ensure that the direction of the socio-technical system change follows the desired direction, by exerting pressure at both the regime and niche levels.

Perhaps, there is still a long way to go for the Chinese government to find its own, appropriate position in this transitional context, as there are no previous lessons from which China can learn.

9.4 FINAL WORDS

An extremely detailed study has been undertaken on how a Chinese OSP supplier managed to build up the seemingly impossible goal of a generic solution (Pollock et al. 2007). Most of it has been informed by related concerns that are developed within the social shaping of technology perspective.

The distinctive contributions of this study are that empirically, we have provided an extremely detailed account of how the goal of developing a 'universal solution' has been achieved by a supplier in a real situation which has been largely neglected. As a result, we clarified an OSP supplier innovation process. Analytically, moving from a conventional information system perspective and drawing upon the social shaping of technology approach, we have provided a different understanding of generic information system development with an emphasis on continuity, dynamics and contextual factors. Additionally, we contributed to the recent theoretical debate on the role of 'local practices and knowledge' and the role of 'universal knowlege' in the development of OSPs by pointing out their complementary relationship. Furthermore, due to the complexity of the case study, we have also drawn theoretical implications from some of the concepts we used and for policy implications on China's future technology development.

Our study on the social shaping of OSPs has demonstrated that the building up of the generic solution is an evolutionary process which is filled with struggles and tensions from both internal and external factors, rather than a smooth and simple, straightforward process. Suppliers have to maintain a balance between a range of contextual factors with technical, financial and social dimensions. Two distinctive development styles can be identified in the evolutionary process. The results of our research further enhanced the related concerns such as the generification process in the construction of OSPs, as well as the related phenomena of network building and alignment in today's ICT development, which are emphasised by the literature of SST. We also developed the concept of 'system promising' to demonstrate an OSP supplier's strategies for the construction of future OSPs.

In relation to the continuity of the innovation, this study examined a complex innovation process. In contrast to the traditional life cycle model, the design of OSPs required a range of interactions between supplier and users, both in the local and community environment. It is a process that requires suppliers and user organisations to work together.

Eventually, the generic solution emerges from the internal coupling of different development strategies and related learning performances and from the external coupling of the market and other actors. Furthermore, the findings also support the view that the broad socio–economic context and institutional arrangement also play important roles in the shaping of the features of development process. The national context, industrial structure and related policies can not be ignored in the study of OSP design and development, as they determine the features of the development process.

Thus, this thesis claims that for suppliers, building up the generic solution is not impossible but indeed extremely complex in terms of technical, financial and social factors, each with its own associated learning to be done. The ability to couple these factors and develop both local and collective learning spaces is crucial to the design and development of OSPs.

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