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IT Diffusion Stages in the Network Era of Chinese Companies

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Abstract

One of our recent studies revisited Nolan's stages theory on IT growth in the context of Chinese companies and concluded that IT spending and learning with regard to IT management are not as tightly linked as is implied in Nolan's stages theory. The study also revealed that aggregate IT spending can be better explained by a technology diffusion process on the population level. Based on the findings, in this paper, we re-consider Chinese companies' IT spending growth pattern, and in turn, their IT application history over the past 20 years from a perspective of IT diffusion stages, highlighting the special characteristics of the network/Internet era. We project that the IT diffusion process in China's Network Era would experience four stages and has currently reached the third. Also, we propose some important issues to be further addressed.

Keywords

IT management, Stages theory, Diffusion of innovation, IT spending, Chinese companies.

1. Introduction

Both practitioners and academics have been concerned with the process of IT diffusion and absorption in enterprises since late 1960's. Former research has produced various models to describe the IT growth processes in different organizations during different periods of the history of IT development. Nolan's stages theory, as a well-known model regarding the link between IS management and IT spending in organizations, has shown its practical usefulness and intuitive plausibility while continuing to appeal to practitioners and consultants.

Nolan's theory was based on observations of US organizations. But application of information technology in China started much later and research on IT strategy and IT growth here is also weaker than in the West. Meanwhile, the context of using IT in China, including social, historical, technical, cultural, and management characteristics, is greatly different from that in other countries. In other words, there must be something special about IT growth processes in Chinese enterprises.

On the other hand, empirical studies of various organizations over years have revealed mixed results in different countries and under different contexts. Therefore, there are good reasons to re-assess Nolan's classical theory in the light of new data from Chinese companies and find out in which ways this concept may be a useful guide for IT management decisions, and then may serve as a framework to interpret the IT growth process in China's Network/Internet Era.

Thus, we conducted a survey study to further develop Nolan's stages theory, as well as to analyze the IT growth process of Chinese companies. Based on data collected from 94 Chinese companies, we revisited Nolan's stages theory and concluded that aggregate IT spending can be better explained by a technology diffusion process on the population level. With such findings, we re-considered Chinese companies' IT spending growth pattern, and in turn, their IT application history over the past 20 years, highlighting the special characteristics of the network/Internet era.

2. The survey

In our questionnaire, we asked IT managers to provide absolute values of their organization's annual IT budgets for the period between 1989 and 2001, as well as additional information about company size, ownership structure, profitability, industry, and the year in which they began to use new technologies such as LANs and the Internet. From two rounds of survey, we have in total received 94 answers usable for data analysis after eliminating incomplete or obviously invalid responses. The results of these data collection methods can be seen in Table 1.

The sample characteristics can be seen from Table 2. Manufacturing companies clearly dominate in our sample. This corresponds to the percentage of manufacturing companies among all Chinese companies, which is 44% [15]. Also, the sample is dominated by State-owned firms while privately held firms come second. Thus, our sample can be characterized as predominantly consisting of Chinese firms. Regarding firm size, the sample is rather

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evenly distributed among the four size categories indicating that small, medium, and large companies are about equally represented in our sample.

Table 1 Data collection methods

Round	Method	Enterprises	%
1st (March 2002)	Questionnaire	21	22.34%
2nd (April-June 2002)	Interview + Questionnaire	40	42.55%
	Phone + Questionnaire	29	30.85%
	Email+ Questionnaire	4	4.26%
	Total	94	100.00%

Table 2 Sample characteristics

Characteristics	Groups	Number	Percentage
Sector	HQs of Groups	14	14.89%
	IT and Electronic	7	7.45%
	Traditional Manufacturer	30	31.91%
	Commerce and Trade	17	18.09%
	Service	16	17.02%
	Agriculture	8	8.51%
	Others	2	2.13%
Ownership	State>50%	52	55.32%
	Collective>50%	6	6.38%
	Private Chinese>50%	25	26.60%
	Foreign>50%	6	6.38%
Size (number of employees)	A. <100	25	26.60%
	B. 100-500	30	31.91%
	C. 500-1000	10	10.64%
	D. >1000	29	30.85%

3. Revisiting Nolan's stages theory

Nolan proposes that companies progress through a series of well-defined stages, labeled Initiation, Contagion, Control, and Integration, as they learn to absorb new information technologies. According to this 'stages theory', companies have to start a new learning cycle with each major innovation in the field of information technologies as has happened with the mainframe computer, the micro computer and the Internet (ushering in the so-called Data Processing, Micro and Network Eras respectively). In each learning cycle, IT budget growth curve would display an S-shape, which is tightly linked to companies' learning curve regarding the management and use of (successive waves of new) information technology (see Figure 1). Also, Nolan has specified a number of dimensions (called growth processes), or benchmark variables, along which learning must take place such as the application portfolio, technology characteristics, user awareness, and management techniques [19].

Initially proposed in 1973, the stages theory has itself evolved considerably over 20 years driven by both Nolan and others [7][16][17][18]. Some empirical studies also found support for the stage concept in this theory [21][11][9]. Some other studies, however, have provided negative evidence for the stages theory [12][1][10][13][5]. Generally, most of the critiques come down to two basic questions. Namely, does the S-shaped IT-budget (or spending) curve really hold for Chinese companies, both on population and company level? And furthermore, if the curve does hold, is it tightly linked to the organizational learning process regarding IT management, as Nolan has addressed?

Our first effort was to clarify the above ambiguities and further develop Nolan stages theory (details of this study are specified in another working paper). Based on data collected, we found that aggregate spending behavior of these companies follows an S-shaped growth curve, as would be predicted by Nolan's stages theory, while patterns of individual companies appeared to be differing. A further investigation with a 'del' test for the cross-classification data indicated that such aggregate behavior of company spending could be better accounted for by a population-level diffusion process, rather than a company-level learning process, which is implied in Nolan's stages theory.

Thus, we concluded that IT spending and IT management learning are not as tightly linked as is stated in Nolan's stages theory. But on the population level, as well as for large companies, the stages theory could still provide an insightful framework from a diffusion perspective. In these cases IT spending curves could serve as an indicator of the diffusion process, along which a series of diffusion variables could be specified and

aligned in the light of the context studied, so as to evaluate and predict the overall trends of innovative technology applications.

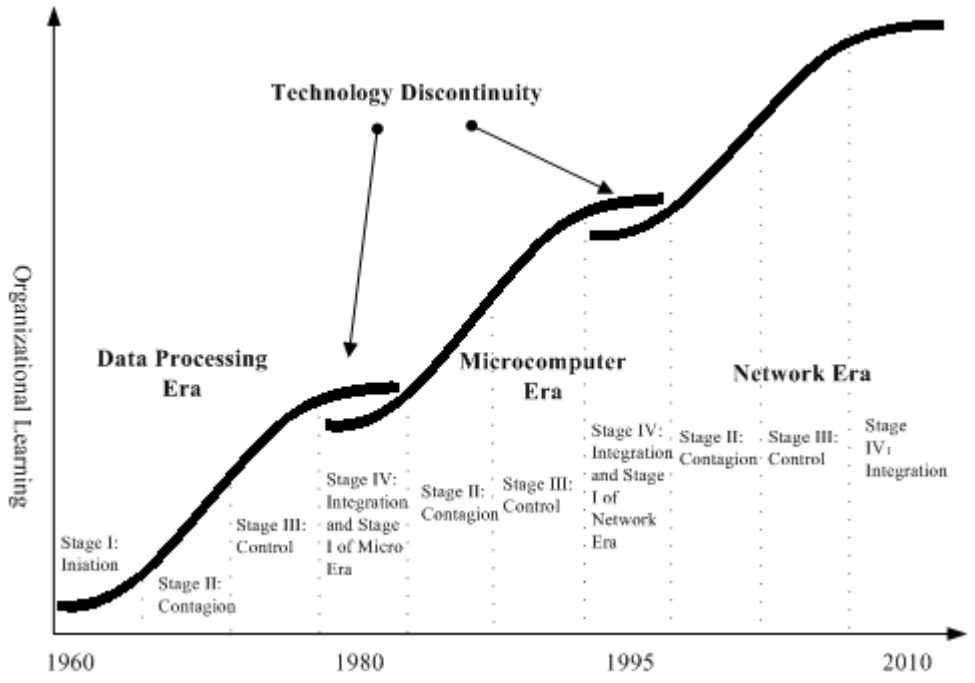

Figure 1 Nolan's stages theory

4. IT Diffusion Stages in the Network Era of Chinese Companies

A few years ago, we conducted a survey study about Chinese companies, comparing the characteristics of these organizations' IT application processes with those of US organizations featured in Nolan's stages theory and highlighting some of the key factors that affect the IT growth and management of IT in China [2]. Due to limitation of survey extent, many important issues were left untouched. Besides, in that study we have followed the concepts and terminology of the 'learning' stages model Nolan proposed. But the above discussion indicates that the 'learning' explanation does not hold the promise as a good framework for interpreting such processes. Based on the above findings, it seems warranted to re-consider Chinese companies' IT growth process from a perspective of IT diffusion.

The aggregate IT spending curve for our sample is shown in Figure 2. Visual inspection clearly indicates that this curve follows an S-shape which has been manually fitted on the data in this figure too. To confirm this impression, we have statistically fitted several functional specifications on our data. With the results of the tests, we conclude that our data can indeed be best described as following an S-shaped growth pattern on the aggregate level.

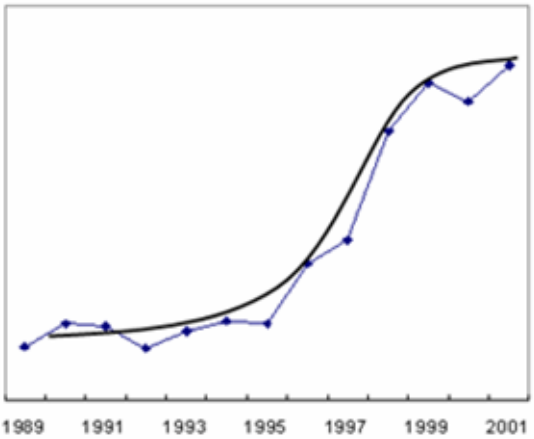

Figure 2 Aggregate IT spending growth in sample companies

It was not until 1992 had Internet been introduced into China [3], so we assume that the Network of Chinese companies started around 1992. To link the IT spending growth with diffusion stages, we first plotted the adoption frequency of Internet in companies against time, as illustrated in Figure 3. To confirm this impression, we have statistically fitted several functional specifications on our data. With the results of the tests, we conclude that our data can indeed be best described as following an S-shaped growth pattern on the aggregate level.

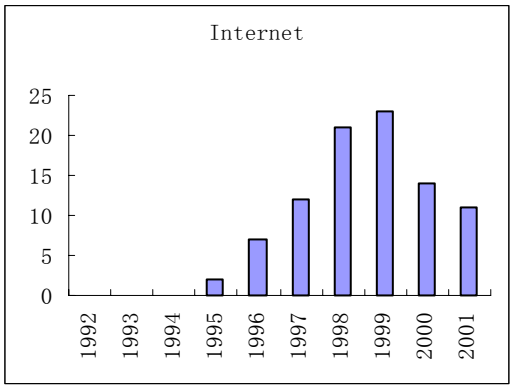

Figure 3 Adoption frequency of Internet in sample companies

The diagram displays a bell shape, which is indicative of a diffusion process on the population level [20], resulting from adoption being spread across time and companies, with a few companies (usually called innovators) leading the adoption of a new technology, followed by the majority of their peers (often separated into the early and late majorities) and a few companies adopting the technology late relative to their peers (usually called laggards). By combining the IT spending growth curve and the Internet adoption frequency pattern, the IT diffusion stages in the Network Era of Chinese companies can be roughly distinguished. As illustrated in Figure 4 (these smoothed curves are generated by Microsoft Excel, based on real data of 1992 through 2001, as has been used in Figure 2 and Figure 3, and predicted data of 2002 through 2006, as shown with the shadowed area), we project that the IT diffusion process in China's network era would experience four stages and has currently reached the third.

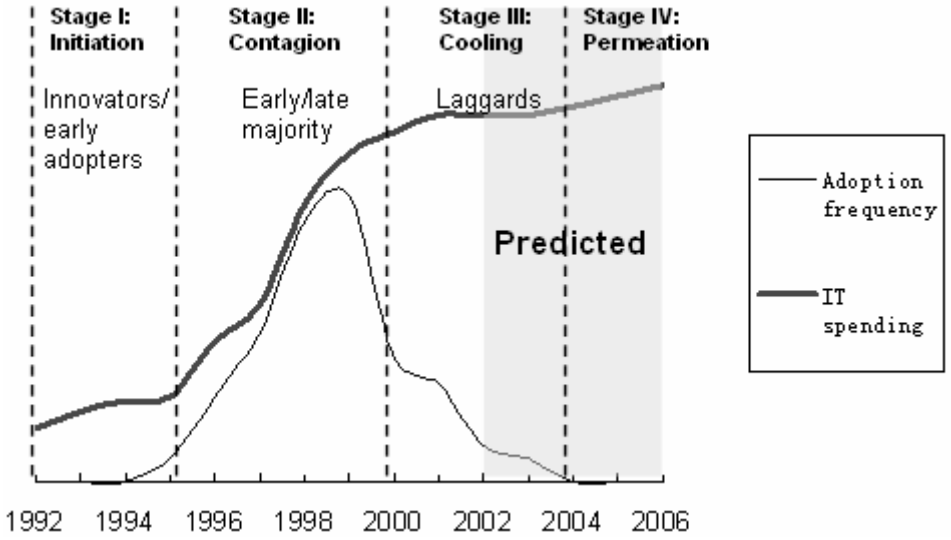

Figure 4 IT Diffusion Stages in the Network Era of Chinese Companies

In Nolan's stages theory, the terminology used to describe individual stages seems to be derived from both company level learning and aggregate level diffusion explanations. Specifically, the terms 'Initiation' and 'Contagion' are indicative of an explanation referring to an epidemic process while the terms 'Control' and 'Integration' seem to refer to a management-level learning process. Such mixture brings confusion into the

framework and restricts it from better describing the diffusion process on the aggregate level. In fact, learning is an individual behavior and can not be explained on the aggregate level. For better description, we suggest the usage of "cooling" and "permeation" for Stage III and Stage IV.

4.1 Stage I: Initiation (1993-1995)

Between late 1992 and early 1993, the Internet came into being in China. In 1994, the first backbone network was built and connected to the Internet [3]. Activated by the "Golden Bridge" Project of the Chinese central government and influenced by the "Information Highway" of the US, Chinese enterprises noticed the great future of business networks and the Internet. Some enterprises went on building local area networks and a few started trying emails. These companies acted as the innovators. But generally speaking, the emphasis of Chinese enterprises' IT application was still on how to control and integrate microcomputers. So it is reasonable to say that between 1993 and 1994, Chinese enterprises' IT diffusion process was in the ending period of Micro Era and also the initiation stage of the Network Era.

From the second half of 1994 onwards, development of the Internet in China took off. The most significant achievements during that period were the construction of ChinaNet and CERNET [3]. In a very short period, all kinds of Internet services came forth and the influence of the Internet expanded continuously. Meanwhile, microcomputer applications in enterprises matured. Most enterprises actually benefited from the value that IT brought to business. Thereupon, more and more enterprises turned their eyes to the Internet, started to build network applications, and became early adopters of the Internet technology. By 1995, the adoption of the Internet technology had reached a critical mass, which is significant for technologies strongly subject to network externalities [14], and preparation for network expansion was generally finished.

It is worth noting that the initiation stage of the Network Era in China is rather short comparing to the corresponding stage of the Micro Era. In the study of Chen and Jiang [2], the initiation stage (the study treated it as two related stages, namely initiation and penetration, partly because of its long time-span) of the Micro Era lasted all through 1980s.

There are three possible reasons for this observation. First, having experienced the Micro Era, managers of Chinese enterprises had realized the strategic importance of information technology and paid active attention to IS application and IT development. In this situation, when companies moved on into the Network Era, Chinese enterprises proactively embraced the new technology and started to apply it immediately. In contrast, the beginning stages of the Micro Era are much longer because, at that moment, IT application in Chinese enterprises was almost non-existent and it took a relatively much longer period to prepare for expansion.

Secondly, from 1992 the reformation and opening policy in China was further quickened. Driven by the government's economic policies, enterprises were eagerly searching for development opportunities. When looking back to the Micro Era, we find that in the first half of the 1980s economic reforms were tentative and just beginning while most enterprises were still taking their bearings. In this atmosphere, initiation and penetration in the Micro Era could not be quick.

The third reason for the "quick-in" characteristic of Network Era is related to the Internet, the most important technology of this era. The IT growth processes of Chinese enterprises in the Network Era resemble that of the Internet in China. The speed of application and development of the Internet significantly exceed those of microcomputers.

4.2 Stage II: Contagion (1995-2000)

Late in 1995, the contagion stage of the Network Era began. Majority of the companies became adopters and the aggregate IT spending started rising remarkably. Surrounded by the atmosphere of global networks, encouragement from governments, seduction of firms, and the prospect of magnificent new products, many enterprises augmented their network applications in a hurry and the phenomena of expansion without planning once experience in the Micro Era were repeated. Redundant projects and waste of resources were rather common phenomena in those years.

In 1997 and the years thereafter, the emergence and flourishing of e-commerce pushed the "leaping" pattern to its climax. The tide of e-commerce firstly hit the foreign trade industry before sweeping across various industries. Still, the accelerating forces from governments could not be ignored during this period. It was not until 1999 that the "Network Economy" began cooling down. With the collapse of the "Internet bubbles", more and more enterprises sat down to consider the actual importance of networking and e-commerce for their long term business plans of IT applications. The contagion stage of the Network Era was coming to an end and the cooling stage, labeled as few adopters and limited spending growth, set in.

4.3 Stage III: Cooling (2000-2004)

The majority of the companies would have adopted the networking technology and only a few laggards would become adopters in this stage. Most of the companies that have adopted the new technology shift their focuses to better control of IT applications and start to ponder upon the real value that IT might bring. Since the year 2000, "Reengineering" has been popular in Chinese enterprises. Adjustment of business processes and improvement of IT applications have been complementing each other [4]. Through BPR and Information Resource Planning, the enterprises tried to obtain highly centralized control of IT applications and

strove to get beyond the redundant projects and isolated information islands left behind by the expansion. Meanwhile, IT strategic consulting played an increasingly important part in IT application and some famous consulting firms strengthened their presence in China's IT consulting market. Many of the enterprises in our survey cut down budgets for IT implementation and increased budgets for IT consulting. Overall, the cooling stage lasted for nearly three years and may well carry on into 2004.

4.4 Stage IV: Permeation (2004-?)

Judging from the patterns of the aggregate IT spending curve and the adoption frequency diagram, the last stage of the Network Ear may start around 2004. By then, most Chinese companies would have adopted the Internet technology and generally few would-be adopters would still be left. It is a stage in which the technology completely penetrates and the adopters gradually development their applications. Meanwhile, a new major innovation may bring the next technology era, and the IT diffusion process would step into the initiation stage of that era. We think that the technology which will dominate the next era might be M-Commerce or business intelligence. However, it is quite possible that the innovation is still to appear in the coming years.

5. Issues and discussions

We feel that our findings may arouse some worthwhile endeavors and re-open the discussion of some important issues on IT management, especially the issue of introducing new IT into organizations.

First, we have shown that IT spending curves could serve as an indicator of the diffusion process. Therefore, along the aggregate IT spending curves, a series of diffusion variables could be specified and aligned in the light of the context studied, so as to evaluate and predict the overall trends of innovative technology applications. In a review, Fichman discussed 18 empirical studies of innovation diffusion theory and provided a framework mapping two classes of technology (low knowledge burden, low user interdependencies, versus high knowledge burden, high user interdependencies) against locus of adoption (individual versus organizational) and resulting in four IT adoption contexts [6]. We feel that this classification seems meaningful also to the stages analysis. It would be worthwhile that these specifications of contexts are incorporated into the aggregate level stages theory and some variables are borrowed from that framework.

Second, we have stated that the company-level IT spending curves do not commonly follow an S-shape and cannot be directly regarded as indication of organizational learning, but our survey has revealed that many large companies' IT spending indeed display an S-shape on the company level. We think that the S-shaped spending pattern of large companies could itself be the result of a diffusion process on the company level. A learning process is about the behavior of an individual, while a diffusion process is about an aggregation. From this point of view, large companies are special because they incorporate the characteristics of the two levels. On the one hand, they are individual companies and would follow a learning path to effectively managing IT; on the other hand, large companies are themselves aggregations of a number of smaller units and therefore diffusion processes are likely to take place inside the bodies. The classification of Fichman [6] on locus of adoption also implied the importance of paying attention to the diffusion inside an individual company body, as well as in a body of many companies.

The difference between a company- and a population-level diffusion process is that, on the company level, diffusion is relatively more constrained and, to some extent, determined by the level of the company's IT management. Briefly, the company level diffusion process could be, on the same level, tightly linked to the company's learning process regarding IT management. Also, we note that Nolan's stages theory was originally proposed based upon observations on some large US companies [16]. Therefore, it may be reasonable to say that the S-shaped spending growth pattern is indicative of and caused by company level learning for, and only for, large companies.

The third issue of further interest is the different IT spending growth patterns of different sectors of companies. As mentioned, in our survey, we divided the companies into 6 major sectors, namely headquarters of groups, IT and electronic, traditional manufacturer, commerce and trade, service, and agriculture. IT spending growth curves for these sectors are illustrated in Figure 5. For better comparison, we have normalized the resulting data by taking the number of 1992 as the base.

Visual inspection reveals that although 3 of these 6 curves follow a clear S-shape, patterns of different sectors vary significantly. Furthermore, the IT spending curve of commerce and trade sector is very special. There is a significant oscillation with a clear peak and trough in the growth process of this sector. Thus, it can be inferred that each sector has its own characteristics which significant affect the diffusion process. In an early stages model introduced by Greiner [8], it was stated that companies in different industries of different growth rate would take different paths of organizational development. This implies that industry growth rate may be taken as one of the factors that determine the IT diffusion process on the sector level. However, such a variable seems inadequate to explain the IT spending curve of commerce and trade sector shown in Figure 5. There must be some other characteristic factors whose effects should be taken into considerations.

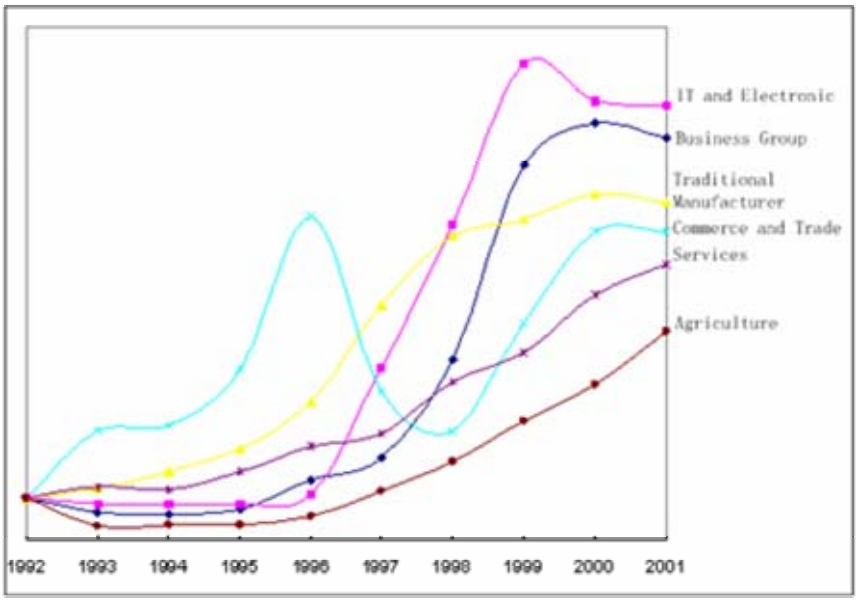

Figure 5 IT spending growth curves of different sectors

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