Adoption of Voice Over Internet Protocol by North American Service Operators

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A thesis submitted to the Faculty of Graduate Studies and Research

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May, 2005

0-494-06839-6

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ABSTRACT

This research examines the adoption of voice over Internet protocol (VoIP) technology by North American service operators. Data on 203 service operators, 108 partnerships of four major service operators, and 85 network standards approved during the study period of 1995 to 2004 were used to: (i) examine how company size and product type vary across adoption stages, (ii) identify temporal patterns, (iii) examine the attributes of partnerships formed by service operators and (iv) examine the association of network standards to adoption stages. The results are relevant to executives responsible for VoIP businesses, researchers interested in temporal patterns, market analysts and VoIP equipment suppliers.

ACKNOWLEDGEMENT

I would like to express my gratitude to: God for allowing me to reach this goal; to my late father for his continuous motivation and encouragement to complete this research; to my wife and kids for understanding and supporting me with all the help that I have needed during this tough period of struggle and hard work; and special thanks to my thesis supervisor Professor Tony Bailetti for his guidance, understanding and patience throughout this study. I appreciate the manner and style with which he has supervised this study. He has always been available for consultation and discussions. Professor Bailetti's approach allowed me the freedom to undertake this challenging topic, and made the process an enjoyable and educational one.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Voice over Internet protocol (VoIP) is a compelling alternative to traditional telephony. VoIP technology and VoIP applications have captured the attention of several telecommunication operators and service providers worldwide.

Service operators develop value-added services and multimedia applications. They ensure these operate properly in the network. Typically, service providers market and establish service contracts with customers. In most cases, service operators also function as service providers. Today the term VoIP refers to all forms of IP packetized voice transmission. For the purpose of this research, terms such as Internet telephony, IP telephony, and computer telephony will be used to mean VoIP.[1]

The 1996 Telecommunication Reform Act allowed cable operators to enter new markets. This act contributed to the growth of VoIP. Cable operators like Comcast, Cabletron and Telcordia are using VoIP to exploit voice, video and data opportunities. Telephone, Internet and software operators like Delta three, AT&T, AOL, Skype, Vocaltec, and Microsoft are also exploiting the benefits of VoIP technology.

[1] Appendix 1 provides a brief, non-technical description of VoIP.

1.1 Relevance

Service operator's actions and predictions are based on their understanding and knowledge about market dynamics at various stages. This research is relevant because it describes changes in the behaviour of service operators at various stages of the VoIP adoption life cycle.

Researchers are interested in the study of temporal patterns of new technology adoption. This research adds to what is known about the temporal patterns of technology and new application adoption.

Top management teams of VoIP equipment suppliers are also interested in the temporal patterns of service operators. Changes in adoption stages provide them with signals on what they need to do to satisfy customer requirements at the next adoption stage.

1.2 Objectives

The overall objective of this research is to examine the adoption of VoIP technology by North American service operators from February 1995 to January 2005.

This research has four specific objectives:

1. Compare two attributes of VoIP service operators across the stages of the adoption life cycle: size of firm and type of product introduced.

2. Examine the relationship between entry rate, product diversity and adoption stages.

3. Examine the relationship between the number of partnerships formed, motives for forming these partnerships and type of partner selected and adoption stages.

4. Examine whether the number of standards approved for VoIP is associated with adoption stages, entry rate of service operators and service operators' partnerships.

1.3 Contribution

This research provides three contributions. First, this research validates the traditional density dependence model theory and explains two temporal patterns for VoIP service operators. Secondly, by examining the service operators' behaviour the research provides insights on possible future market scenarios. The third contribution is that this research focuses on the adoption of network products and uses service operators' data to determine the stage transition in adoption life cycle.

1.4 Positioning

This research builds on the theoretical perspective developed by Klepper (1996), Debackere and Clarysse (1998) and theses completed by Peng (2004) and Napoles (2004).

There are three main differences between the research reported in this thesis and the research completed by Peng (2004) and Napoles (2004). First, Peng's research focused on the adoption of an open source operating system. This research focuses on the adoption of proprietary applications. Napoles' research focused on the adoption of UML-based development tools used to automate software development tasks such as software based coding and code-model synchronizations. This research focuses on the adoption of VoIP technology as an infrastructure by VoIP service operators. Thus, instead of focusing on the adoption of a technology by agents in various economic sectors, this research focuses on the adoption of a technology by agents in one well defined sector: service operators.

The second difference is that to identify adoption stage transitions, Peng used suppliers' data and Napoles used buyers' data. This research uses service operator data to identify the stage transitions.

The third difference between the research reported in this thesis and that reported by Peng (2004) and Napoles (2004) is that this research also examines the role of service operators' partnerships and the implementation of network standards in the process of adoption of VoIP technology.

1.5 Structure

This thesis is organized into seven chapters. Chapter 1 is the introduction. It provides the objective, relevance, contribution, positioning and the structure of this thesis. Chapter 2 reviews the relevant literature from four perspectives, technology adoption theories, adoption of VoIP, partnership formation and network externalities and identifies lessons learned. Chapter 3 develops the hypotheses based on the lessons learnt in chapter 2. Chapter 4 describes the method used to carry out the research. Chapter 5 provides the results obtained when testing the hypotheses. Chapter 6 discusses the results. Chapter 7 identifies the conclusions, presents the limitations of this study, and identifies opportunities for future research.

2. LITERATURE REVIEW

This chapter is organized into five sections. The first section reviews the literature on technology adoption theories. The second section reviews the literature about VoIP and its adoption. The third section reviews the literature about partnership formation. The fourth section reviews the literature about network externalities. Finally, section five provides the lessons learnt from the literature review.

2.1 Theories of technology adoption and diffusion

Among different theories and models of technology diffusion and adoption, three are investigated for building the foundation for this research. These are Rogers's innovation diffusion model, Moore's Technology Adoption Life Cycle, and the Density-dependence model. These are selected because of their life cycle perspective on technology adoption as well as the impressive structural synopsis offered in describing the evolution of a market anchored around a new technology from birth to maturity.

2.1.1 Rogers' innovation diffusion model

The innovation diffusion model by Rogers (1983) considers the manner and rapidity with which an individual or other unit of adoption responds to the offer of an innovation. Rogers categorized the adopters into five groups. Rogers observed that adopter distributions closely approach normality and he utilized the two statistics, mean (X) and standard deviation (*SD*) of a normal distribution of adopters to perform the adopter categorization.

Figure 1 shows that the area lying to the left of the mean time of adoption minus two standard deviations includes the first 2.5 percent of the individuals to adopt an innovation. These individuals are referred to as innovators. Similarly, the other four categories of adopters were identified and referred to as early adopters, early majority, late majority, and laggards.

Figure 1 also shows the two important curves of Rogers' innovation diffusion model, one is the bell-shaped curve that represents the adoption rate of an innovation over time and the other is S-shaped curve, which represents the cumulative number of adopters. The characteristics of the five categories of adopters as defined by Rogers are as follows:

- Innovators are eager to try new ideas. They embrace the new technology on its first appearance, in large part just to explore its properties to determine if it is "cool".

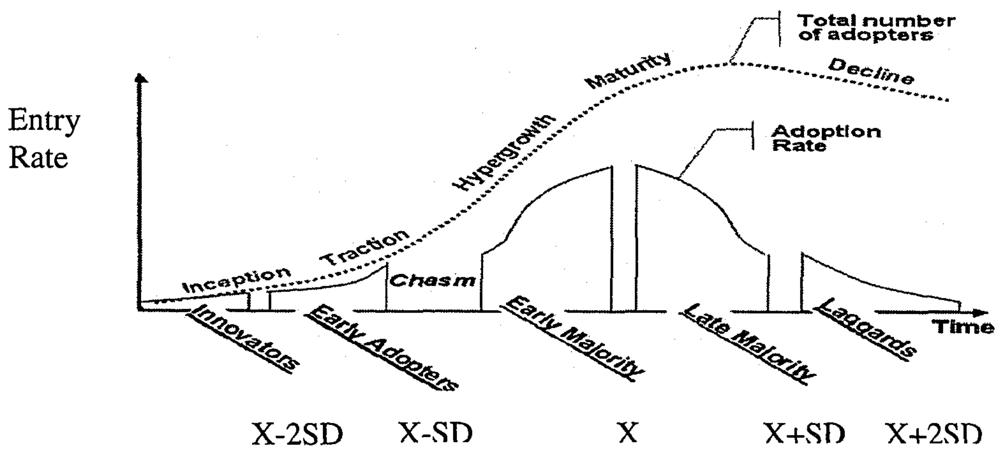
- Early adopters have the vision to adopt a new technology because of business opportunities or technology needs. They adopt it as a means for capturing a dramatic advantage over competitors who do not adopt it.

- Early majority adopt new ideas just before the average number of a social system (Rogers, 1983). They prefer to avoid the associated risk by staying away from bleeding edge technology. They are quick to adopt the technology however, when the early adopters demonstrate benefits.

- Late majority adopt new ideas just after the average number of a social system. They do not adopt a new technology until a majority of others in their systems have done so. The weight of public opinion must definitely favour the innovation before the late majority are convinced.

- Laggards are last to adopt an innovation. They tend to be openly suspicious of innovations, innovators and change agents. When laggards finally adopt an innovation, it may already be superseded by a more recent idea that the innovators are using.

Figure 1: Life cycle of technology adoption



From Rogers' innovation diffusion model, it is evident that there are certain differences in the characteristics of adopters that influence them in their decision to try innovations within various time periods. Moore's Technology Adoption Life cycle (Moore, 1991) which is derived from Rogers' model, clearly illustrates the evolution of a technology-enabled market that develops in a characteristic pattern. This is due to the aggregate effects of a certain population distributing its choices in the proportions outlined by the S-curve.

Moore argues that there is a "market chasm" between early adopters and the early majority. Moore believes that the needs of the early adopters are radically different from those of the pragmatic early majority that constitute the mass market. Moore has observed that many new products failed simply because they were not able to "cross the chasm," in terms of new product design and marketing strategy, from the early market to the mass market. Figure 1 also illustrates the market chasm of Moore's model.

2.1.3 Temporal patterns and density-dependence model

Temporal patterns refer to how entry, exit, network structure, supplier and product diversity and innovation vary from the birth of a new market through to maturity. Temporal patterns of a technology-enabled market provide insights into the evolution and diffusion of a particular technology around which that market has formed and evolved. Among the temporal patterns concerning the evolution of a new market, density (i.e., cumulative number of entrants) and entry rate (i.e., rate of entry of new firms) are the two factors that have received the most attention in previous studies. The relationship between these two factors is usually interpreted by the Density-dependence theory.

Density-dependence theory explains the S-curve of adoption life cycle using the twin forces of "legitimization" and "competition". These two forces help establish new technologies and then ultimately limit their take-up (Geroski, 2000).

Built on the density-dependence model, Debackere et al. (1998) investigated the entry pattern of the emerging technological communities. His results validated previous findings on the Bell-curve relationship between density and entry rate. The explanation for the Bell-curve relationship is as follows: entry rate initially accelerates with an increase in density and then slows down when density reaches a certain critical level.

Another study by Wade (1995), investigating the rate at which communities of microprocessor manufacturers attracted organizational support, also confirmed the Bell-curve relationship between entry rate and density during the evolution of a new market.

In summary, three models of technology adoption offer a life-cycle perspective and a theoretical basis for the study of VoIP adoption by service operators and the VoIP based market that has evolved from its inception to date. There is no existing literature that provides an applicable method to identify the adoption stages of a new technology that has yet to reach the end of its lifecycle.

2.2 Adoption of VoIP

VoIP has been the subject of much talk and speculation over the past few years. According to 10th IEEE International Conference held in 2002 , because of the popularity of the Internet, the increment of network bandwidth, and the improvement of voice compression technologies, VoIP has shown an exploding growth. We can transmit not only text-based applications but also voice/video-based real-time multimedia applications over the Internet by using VoIP technology (Hang, Tan, Chuang, & Lee, 2002).

According to the (Commweb, 2002) report the ability to send voice messages over the internet is a rapidly growing area in communication this year and will continue to grow as more companies adopt it. Experts reports that VoIP will account for approximately 75% of world voice services by 2007.

When VoIP service was introduced in February 1995, it was available only to users with a computer connected to the Internet. However, following the continuous technological evolution, the cost saving benefits of Internet telephony (VoIP) have become available to any user with a telephone connected to the public switched telephone network (PSTN) (Babbage, Moffat, O'Neill & Sivaraj, 1997; Ono & Aoki, 1998). Currently, there are three classes of Internet telephony: PC-to-PC; phone-to-PC (or PC-to-phone); phone-to-phone (Clark, 1997).

2.2.1 Decentralization in communication industry

The most relevant features of VoIP are that it is developed over a distributed, dependence on software, modularized components and non-dedicated packet-switched network. This technology created a market with characteristics like high flexibility, rapid innovations, and low barriers to entry / exit and high level of competition. On other hand the features of the PSTN leads to a market with significant degrees of vertical integration, high barrier to entry and low competition.

The vertical integrated, centrally coordinated, voice-based business model is poised to disintegrate. The Internet was one of the first steps in the separation of service layer from the physical layer of the networks. Connection-oriented technologies were no longer necessary for high-quality secure connections. Centralized intelligence began to move toward the network's edge and became distributed and dynamic (Christensen, Anthony & Ruth, 2004).

The intelligence of network is moving from its center to its edges so in this structure, the data would tell the network where it needs to go. In contrast, in a circuit switch network, the networks tell the data where to go (Isenberg, 1999).

Due to this change in telecommunication industry, telephone operators have started upgrading the Public Switched Telephone Network (PSTN) by investing in packet-switching technologies, such as Asynchronous Transfer Mode (ATM) and Internet Protocol (IP) platforms. They will try to capture returns on their investments by exploiting their infrastructure and by offering as many services as possible on those platforms. Internet service providers and other operators like cable service companies are building IP-based networks, which bypass the PSTN as much as possible. The interplay between incumbents and new entrants is likely to affect the result of the competition between different network configuration as much as technical developments and regulations. The amount of resources that operators are spending to achieve different network technologies and the market potential for new value-added applications such as Internet telephony will determine the emergence of decentralized network configuration.

The next section will discuss some of the strategic options for service operators regarding adoption of VoIP.

2.2.2 Business strategy of different operators

Small companies in the computer industry such as Vocal Tec, IDT, Netscape and Microsoft initiated VoIP in 1995/96. These were new entrants in the telecommunications services sector, but they have increasingly stimulated the interest of large operators. Many of the major international telephone operators like AT&T, MCI-World and Deutsche Telekom have started experimenting with Internet telephony technology after them.

Telephone operators have different strategic options in response to IP telephony. First, they can avoid investing in Internet telephony (VoIP), hoping that the price differential will gradually shrink and the problems of quality of service will prove too difficult to solve in case of VoIP. However this is a dangerous strategy since the revenue from traditional voice services is already decreasing. If telephone operators realize too late the benefits of the IP platform they could find themselves struggling in the market where new entrants have already gained the customers.

A second strategy for telephone operators is to promote Internet telephony to on-line PC users but not to the general users of the telephone. This preserves the quality of the phone service and allows the phone companies to compete directly with other Internet Service Providers (ISP) and to prevent some of the revenue loss.

A third option for telephone operators is to explore the value added aspects of IP telephony for their corporate customers. This could be coupled with the development of systems integration and content provision. However, Internet telephony applications are very different from the core business of telephone operators. A possible strategy for telephone operators could be to separate packet data from connection oriented data before the local switch. This would allow them to keep the appropriate quality of service for the circuit-switched network and to manage the extra traffic from the Internet as efficiently as possible (Sears, 1996).

A specific value chain is emerging in the Internet telephony market: global network operators and settlement brokers provide interconnection agreements, billing information and network management for Internet telephony service providers, which may or may not own the networks over which the services are provided. The structure of the market allows a relatively easy entry even for inexperienced service operators. For players that already have access capacity or an existing customer base, Internet telephony service provision can be set up in a very short time, with minimal investment.

2.2.3 Characteristics of VoIP adopters

Several characteristics of VoIP consistently influence the adoption decision. According to Rogers (1983) and Tornatzky and Klein (1982), these include relative advantage, compatibility, complexity, triability and observability.

Relative advantage is one of the important characteristics of VoIP adopters. When comparing technologies, products or services, individuals consider both economic profitability and other variables like degree of risk, decrease in discomfort and saving of time and effort. Evaluating the relative advantage of Internet telephony is quite difficult, because it is hard to find the appropriate unit of comparison. Some perceive it as a substitute of the telephone; others see it as a platform technology that allows the integration of voice, data and video. Economic profitability considerations therefore vary significantly: for consumers, it is more a matter of savings on international calls; for businesses, Internet telephony allows increasing cost efficiency in network management. As far as risks are concerned, the major problem with Internet telephony is the quality of service. The replacement of the old telephony system may lower significantly the quality of voice applications.

Another important attribute of this innovation is compatibility, which refers not only to technical features, but also to existing socio-cultural values, past experiences and needs of potential adopters. Old ideas are the main tool with which innovations are evaluated both from a technological and from a social perspective (Miles, Cawson & Haddon, 1994). In the case of Internet telephony, technical compatibility has been ensured by the development of standards, which enforce interoperability between hardware and software. However users are still familiar with device dependent modes of communication like video on TV, voice on phone and data on PC.

The extent to which an innovation is perceived is relatively difficult to understand due to the complexity of new technology. Different users have different knowledge and skills with respect to a specific technology and perceive different levels of complexity in its use. If some individuals cannot use the technology because it requires a different knowledge base from the one they have, a process of social exclusion may occur; (Rogers & Shoemaker, 1971). In the case of Internet telephony, some users do not possess enough skills to configure their PC as a telephone and may require easy-to-use solutions.

Another important characteristic is the triability (practical implications) of this innovation. Having opportunity of experimenting a new technology before deciding whether or not to adopt it is an important benefit especially for early adopters, since they can only rely upon available information, while laggards can learn from other users' experiences. Functioning, real world examples are often more important than arguments about advantages and expected functions Rip (1995) and Rogers (1995). In case of VoIP telephony, triability plays a relevant role. However, in terms of growth rate, the number of people who try Internet telephony is much bigger then that the number of actual adopters. For example, in the last few months of 1995, VocalTec has claimed over 600,000 downloads of their trial software (Sears, 1996).

Finally, an innovation is evaluated according to its observability, which identifies the degree to which its performance and related benefits are visible to users and not only to companies that produce it. With Internet telephony applications, there is a problem of scarce perception of the possible benefits. Most potential adopters still consider the arbitrage bonus as the only advantage, without seeing long-term benefits, because they are not aware of all the existing applications.

These characteristics have a different significance at different stages of the innovation-decision process. At the knowledge stage, when individuals have contact with the innovation for the first time, complexity and compatibility are particularly relevant. At the persuasion stage, when potential users form an opinion on the innovation, economic profitability, low risk, and observability acquire a higher status. Finally, at the decision stage, individuals benefit from the possibility to try the new product/technology (Rogers & Shoemaker, 1971).

2.2.4 Why service operators adopt VoIP

There are number of benefits of deploying VoIP on public Internet or private network such as:

IP technology provides cost reduction on local and long distance calling fee. The cost saving benefits of Internet telephony has become available to any user with a telephone connected to the public switched telephone network (Babbage et al., 1997; Ono & Aoki, 1998).

IP technology is well suited to all traffic types and is independent of the underlying platform. The ultimate objective is to leverage a single network infrastructure using a single networking platform (Corrocher, 1999).

With the convergence of voice and data into a common infrastructure of VoIP, operators will be able to deploy, manage, and maintain one network to serve all communication needs. There will be saving on infrastructure and potential resources in long term. Long-term benefits are also expected to come from multi-media and multi-service applications.

For players that already have access capacity or an existing customer base, Internet telephony service provision can be set up in a vary short time, with minimal investment (Corrocher, 1999). Easy and less costly to implement because there is no need to integrate and synchronize separate voice and data networks

Easier to implement distributed workgroups across multiple sites, including home workers. It saves WAN communication cost by using bandwidth more efficiently. This is particularly significant for multiple sites and international traffic. It reduces the cost of moves, adds and changes within the LAN because each user has just one connection point.

VoIP technology is creating a kind of open standard that will let multiple vendors' products work together. Different platforms and applications can use the same infrastructure, which will lead to broader choices.

2.3 Partnership formation

Various perspectives are used to examine the motives behind partnership formation. These perspectives include: transaction costs (Williamson, 1985; Hennart, 1991), resource dependency (Pfeffer & Nowak, 1976), organizational learning (Hamel, 1991; Grant, 1996), strategic positioning (Porter & Fuller, 1986), and institutional theory (DiMaggio & Powell, 1983; Meyer & Rowan, 1977). From the resource dependence theory perspective, partnership formation is conceptualized as an organization's response to environmental changes demanding improvement or change in its resources or understanding of rapidly changing markets (Kogut, 1988). The resources firms acquire through partnership can enable them to share costs or to gain differentiable product technologies, which outweigh the disadvantages of partnership formations. In contrast if the market is munificent or the firm is pursuing a strategy for which it has extensive resource capabilities, there is much less incentive to cooperate and firms likely to continue alone. Partnership formation mostly occurs when firms are in vulnerable strategic positions such that the payoffs to cooperation are high.

2.3.1 Motives for partnership formation

Dodourova (2003) put forward a framework to classify the motives behind firms forming strategic partnerships. According to this framework, the motives of partnership formation can be classified into eight groups: market-related motives, product-related motives, industry/market structure modification-related motives, timing-related motives, cost-related motives, competencies-related motives, and technology-related motives. Definition of each motive is given below (Dodourova, 2003).

Table 1: Motives for alliance formation

Motives	Description
Market-related motives	Gain access to new markets, create and experiment with new markets, circumvent legal, regulatory, or other barriers, defend/enhance market position in present markets
Product-related motives	Create and experiment with new products, broaden/fill gaps in present product line, differentiate/enter new product domains, add value to a product, property rights protection
Industry/market structure modification-related motives	Reduce (potential) competition, raise entry barriers, alter the technological base of competition
Timing-related motives	Experiment with new product/market/technology opportunities faster by accelerating pace of R&D or market entry
Cost-related motives	Lower R&D/manufacturing/marketing/organizational costs, achieve economies of scale
Risk reduction - related motives	Lower risk in the face of large R&D costs required, technological/market or other uncertainties
Competencies and skills-related motives	Overcome shortcomings in internal competencies; Internalize competencies, enhance knowledge-generation activities, learn new skills, enhance present skills
Technology-related motives	Need to experiment, gain access to technology, gain access to assets that are essential for efficient commercialization of a technology, exploit the potential for broad application of technology, need for technical coordination/develop technological standards, observe technological change but remain flexible, collective protection of technological

2.4 Externalities of network

Network externalities are a quality of certain goods and services such that they become more valuable to a user as the number of user increases. For example, the telephone was of little value to the first individual to have one; with each additional telephone adopter, this innovation became more valuable to all of its users. This definition is based on that of Economides (1989).

Network externalities arise when a user's benefit from using a technology increases with the number of other users employing the same technology (Katz & Shapiro, 1986). A considerable literature on the role of externalities in the adoption of telecommunications services is available such as: Antonelli (1989), Thum (1994), and Schoder (2000).

2.4.1 Effect of network standards

In a public network environment, products and services from different vendors need to operate with each other if VoIP is to become common among users. To achieve interoperability, standards are being devised. For example the most common standard for VoIP is the H 323. This is the ITU-T's (International Telecommunications Union) standard with which vendors should comply while providing VoIP service. This recommendation provides the technical requirements for voice communication over LANs. It was originally developed for multimedia conferencing on LANs, but was later extended to cover VoIP.

Similarly there are number of standards which have been approved for VoIP communication. H series was developed for IP telephony, J series for cable modem telephony, 802 series for LAN/WAN related telephony and some G series standard used by software and Internet companies. The latest protocols being used for VoIP are RTP, MPLS and RSVP. Currently, these standards are strengthening the Internet's ability to handle real-time traffic reliably and maintain requested transmission paths with quality-of-service levels.

In many markets, single technology architecture emerges as a dominant design. Though many technological options may have originally been available, the benefits of compatibility reaped by manufacturers, distributors, and customers may create pressure for a single technology standard to be adopted (Anderson & Tushman, 1990; Arthur, 1989, 1994; Economides, 1989; Farrell & Saloner, 1985; Garud & Kumaraswamy, 1993).

Research in economics has shown that when several technological options become available, sequential adoption by users can rapidly lead to the supremacy of a single option, whether or not it is technically superior (Arthur, 1989; Katz & Shapiro, 1986). Furthermore, pressures for compatibility may induce users to converge around a single technology platform rather than support multiple technology platforms.

2.4.2 Installed base and complementary goods

When an industry is characterized by network externalities, a technology's installed base and the availability of complementary goods will play major roles in user adoption. An insufficient installed base or lack of complementary goods may result in technological lockout (Brynjolfsson, 1996; Cottrell, 1998; Katz & Shapiro, 1986; Shurmer, 1993; Wade, 1995).

A large installed base extends the range of a user's network, increases the value of the user's training in the particular technology, and attracts more developers of complementary technologies, thus increasing the number of options available to the user (Choi, 1994; Katz & Shapiro, 1986). When VoIP was invented by small software companies the installed base for this technology was the Internet. The explosive growth of Internet is the one of main reason for the adoption of VoIP.

Network externality research also points out that the value of a technology may be closely linked to the availability of complementary goods. Many technologies are not desirable to customers without an associated set of such complementary goods as software for computers and videotapes for VCRs. When a technology requires complementary goods, their availability will play a crucial role in a customer's choice between competing technologies (Choi, 1994; Farrell & Saloner, 1985; Katz & Shapiro, 1986). Messaging software, which is a VoIP product, could be considered as a good example of complementary good. Everyone now has a computer with Internet connection. Everyone can make use of VoIP technology by additionally installing any software like Skype, which is easily available on the Internet.

2.5 Lessons learnt from literature

A comprehensive review of existing literature has advanced our understanding of VoIP adoption by service operators and the traditional models of technology adoption. This section provides some interesting lessons learned from the literature review.

Traditional models of technology adoption explain the dominant stylized fact that the use of new technologies over time typically follows an S-curve (Geroski, 2000). The Density-dependence model is one of these models. It explains the diffusion of a new technology with the twin forces: legitimization and competition. Legitimization helps establish a new technology. Competition ultimately limits its take-up.

The second lesson learned from the literature review is that technology adopters can be classified into categories based on level of innovation. Rogers (1983) was able to classify the adopters into five categories. This means that comparisons can be made for the purpose of identifying differences between categories. The model proposed by Moore (1991) is an extension of Rogers's model. It proposes the existence of a market "Chasm" between the early adopters and early majority. These two models provide a theoretical basis on to classify adopters and subsequently identify the differences in attributes of firms that adopt VoIP along the technology adoption life cycle.

The third lesson from the literature review was that a method to define a stage before the technology life cycle ends does not exist. Researchers have not defined how to identify the stages of the adoption life cycle prior to its ending.

The fourth lesson is that the motives behind partnership formations are transaction costs, resource dependency, organizational learning and strategic positioning.

Fifth lesson is that the benefits increase with the increase of number of members of network using the same technology standards. Firms sponsoring technologies that are incompatible with the dominant design may find their technologies locked out which is a situation in which a firm finds itself unable to develop or competitively sell products to a particular market because of technology standards.

The last lesson is about the rapid adoption of VoIP due to number of benefits to vendors (operator and suppliers). Internet equipment manufacturers and software developers for World Wide Web applications are becoming interested in the provision of this service. In this group, Nortel, Lucent, Cisco and Ericsson are exploring and developing innovative applications (Howard, Intven & Zohar, 1998; OECD, 1998).

3 HYPOTHESIS DEVELOPMENT

The purpose of this chapter is to develop a set of hypotheses. This chapter is organized into five sections. The first section develops the hypotheses used to examine the size of the service operator and the type of product introduced across adoption stages. The second section develops the hypotheses used to examine how the entry rate of new firms and the diversity of VoIP products change over time. The third section of this chapter develops the hypotheses used to examine whether the number of partnerships formed by VoIP service operators is related to the adoption stages; whether the motives for partnerships formed by service operators varied over adoption stages; and whether the type of partner selected by service operators was a function of the motives for partnership. The fourth part develops the hypotheses used to examine the relationship between the number of network standards approved for VoIP and adoption stage, entry rate of new operators, and number of partnerships. Finally, part five provides a list of the hypotheses.

3.1 Operator size and new product type

The first research objective is to compare two attributes of VoIP service operators: (i) size of firm and (ii) type of product introduced, across stages of the adoption life cycle. For a firm to enter a market at a certain stage requires a certain level of competence that enables it to successfully compete at that stage.

Firm size is a proxy for technical competence and financial capability. This is consistent with many empirical studies of technology diffusion (Geroski, 2000). Peng (2004) found that smaller firms adopted Linux during the early stages of technology adoption and that large firms followed. However, Napoles (2004) found that large firms adopted UML tools during the early stages of technology adoption and that smaller firms followed. It is expected that the size of the operators that enter the VoIP market to be a function of the adoption stage. What is not known is whether large or small service operators introduced the technology during the early stages of the adoption cycle. Therefore,

Hypothesis 1: Size of a new service operator is a function of adoption stage.

The characteristics and needs of the adopters of a new technology differ across stages along the adoption life cycle (Rogers, 1983; Moore, 1991). Firms with different goals and abilities are likely to adopt the new technology at different times (Geroski, 2000). The new type of products introduced by service operators at each stage reflects the change of the users' needs across the stages. Given that the needs across stages are different, it is expected that service operators will introduce new product types at each stage. Therefore,

Hypothesis 2: Type of product introduced by new operators is a function of adoption stage.

3.2 Temporal patterns for entry rate of new firms and product diversity

The second research objective is to examine the temporal patterns in the evolution of the market for VoIP. The temporal patterns of interest in this research study are two: the entry rate of new firms and the diversity of VoIP products. Debackere and Clarysse (1998) and Wade (1995) use the density dependence model to investigate these temporal patterns.

The adoption of VoIP during the past decade has created a variety of VoIP-based service products in PC-to-PC or Phone, Phone to Phone, IP-PBX and Wi-Fi VoIP classes of service. There are obvious differences between 1995 and today in terms of the diversity of VoIP based services that operators offer. It remains unclear, however, how product diversity changed over time. With an increase in the legitimacy of different VoIP services and evidence of the benefits offered by VoIP technology, it is expected that product diversity will increase very quickly during the early adoption stages and then increase slowly during the latter stages. This expectation is consistent with those examined in Peng (2004) and Napoles (2004). Therefore,

Hypothesis 3: Operator product diversity increases rapidly during the early adoption stages and then increases slowly over the later stages.

The twin forces of legitimization and competition have been used to explain the relationship between entry rate and adoption stages in a new market (Geroski, 2000). At the early stages, VoIP attracted mainly software and Internet companies. Large telephone and cable companies were not likely to invest in VoIP because they were not certain that the technology was going to survive due to technological and legal issues (Corrocher, 1999). With time, VoIP attracted a greater number of adopters due to the number of benefits associated with it and started to gain legitimacy. During the legitimization period, the growth rate rapidly increased. A positive relationship is expected to exist between the number of new entrants per month and the adoption stages during the legitimization period.

The legitimization period does not continue indefinitely. As the cumulative number of firms (or density) grows, competition for a limited number of customers and resources becomes the prevalent environmental force. During the competition period, a negative relationship is expected to exist between the number of new entrants per month and adoption stages. The Bell-curve relationship explains that the entry rate initially accelerates with an increase in density and then slows down when density reaches a certain critical level. Another study by Wade (1995) also confirmed the Bell-curve relationship. The writer expects that the number of new service operators will follow a bell-shaped distribution. Therefore,

Hypothesis 4: The rate of increase of number of new service operators follows a Bell shaped distribution.

3.3 Partnership formation

The third research objective examines the number of partnerships formed by major VoIP operators. Debackere et al. (1998) suggested that potential entrants often face considerable 'searching costs' and that they will tend to evaluate the overall attractiveness of an industry against the prestige position of a limited number of organizations. Debackere et al. (1998) used the number of partnerships established by an organization as a proxy to measure the organization's prestige. It is surmised that as the number of partnerships formed by the major VoIP service operators' increases, so does the legitimacy of VoIP. During the early adoption stages it is expected that a few service providers will establish a small number of partnerships. With time, it is expected that service operators established a greater number of partnerships. Therefore,

Hypothesis 5: Number of partnerships established by operators is a function of adoption stage.

Eisenhardt and Schoonhoven (1996) argues that a greater number of partnerships exists when the number of competitors is large. When a firm faces many competitors, its strategic position is vulnerable. Resources are squeezed, profits are stressed, and even survival is threatened (Klepper & Graddy, 1990). Shan (1990) found that intense competition was associated with alliance formation. In contrast, in markets with fewer competitors, profits are high and survival is more likely (Carroll & Hannan, 1989). In such market, partnership formation is comparatively less. Therefore,

Hypothesis 5a: Number of partnerships is greater during the competition period than the legitimization period.

Dodourova (2003) found a relationship between a firm's motives for forming partnerships and their strategic responses to industry evolution. Motivation for collaboration reflects the complexity and dynamism of social and strategic context in which the relationships and firms are embedded. It is important to examine collaboration as a function of a firm's overall configuration of strategic choices and objectives. Therefore, the writer expects that the motives at each stage will a function of adoption stage. Therefore,

H6: Motives for establishing new partnerships are a function of adoption stage.

Dodourova (2003) found that firms formed partnerships to collaborate with a complementary partner and maximize existing capabilities. Firms enter into collaborative relationships in order to stretch their boundaries and gain access to complementary assets for the purpose of achieving their strategic objectives. Motives for partnering are likely to signal firm strategic directions. Analysis of what resources a company seeks when establishing collaborative arrangements can also indicate what strategic objectives the company pursues and what competitive advantages it aims to create. A company has different motivation and seeks different resources when partnering with companies from different industrial groups. The writer expects that the type of partner selected is a function of the motive for establishing a partnership. Therefore,

Hypothesis 7: Type of partner selected is a function of the motive for establishing the partnership.

3.4 Network standards

The fourth research objective examines network standards. Firms sponsoring technologies that are incompatible with a dominant standard may find their technologies locked out of the market. Technology lockout is defined as a situation in which a firm is unable to develop or competitively sell products to a particular market because of technology standards (Schilling & Melissa, 2002). Every new service that is introduced in the market needs to comply to standards. If service providers do not adopt the same standard, they cannot make the service successful due to interoperability problems. The benefits of compatibility reaped by manufacturers, distributors, and customers may create pressure for technology standards to be adopted (Anderson & Tushman, 1990; Arthur, 1989, 1994; Economides, 1989; Farrell & Saloner, 1985; Garud & Kumaraswamy, 1993). The writer expects that at each stage, network standards are adopted with the introduction of new services. Therefore,

Hypothesis 8: Number of network standards approved for VoIP is a function of adoption stage.

Companies operating in highly competitive markets are more likely to have larger number of partners (Eisenhardt & Schoonhoven, 1996). If the number of competitors is large, then the rate of alliance formation will be greater. It is reasonable to expect that the greater the number of partnerships that are formed, the greater the number of services that are introduced into the market and that the introduction of new services requires a greater number of network standards. The writer expects that the number of standards approved during the competition period will be larger than those approved during the legitimization period. Therefore,

Hypothesis 8a: Number of network standards approved for VoIP is greater for the competition period than the legitimization period.

Service operators enter the VoIP market with new service types. New network standards need to be approved for these services. Regibeau and Rockett (1996) show that with standardization (i.e. compatibility), first entry may be accelerated in order to delay future technology introductions. Kristiansen (1998) shows, that standardization may delay entry because there is no incentive to pre-empt another incompatible technology and build up an installed base. According to Pindyck (1991), standardization reduces the uncertainty of future payoffs and therefore decreases a potential entrant's option value of delaying investment. The writer expects a relationship to exist between the number of network standards and the operators' entry rate. Therefore,

Hypothesis 9a: Number of network standards approved for VoIP is associated with the entry rate of new operators.

An increased need for VoIP services will increase the demand for the approval of VoIP related standards. Partnerships play an important role in the adoption of VoIP. A large number of partnerships generate a greater number of services. This requires a greater number of new standards to be approved. According to Kretschmer (2002), standards setting have the advantage of avoiding uncertainty and confusion among consumers. This may accelerate technology adoption. This writer expects an association to exist between the number of partnerships established by service operators and the number of standards approved for VoIP. This leads to the following Hypothesis.

Hypothesis 9b: Number of network standards approved for VoIP is associated with the number of partnerships established by service operators.

3.5 List of hypotheses

The nine hypotheses developed for this research are listed below.

Hypothesis 1: Size of a new service operator is a function of adoption stage.

Hypothesis 2: Type of product introduced by new operators is a function of adoption stage.

Hypothesis 3: Operator product diversity increases rapidly during the early adoption stages and then increases slowly over the later stages.

Hypothesis 4: The rate of increase of number of new service operators follows a Bell shaped distribution.

Hypothesis 5: Number of partnerships established by operators is a function of adoption stage.

Hypothesis 5a: Number of partnerships is greater in the competition period than the legitimization period.

Hypothesis 6: Motives for establishing new partnerships are a function of adoption stage.

Hypothesis 7: Type of partner selected is a function of the motive for establishing the partnership.

Hypothesis 8: Number of network standards approved for VoIP is a function of adoption stage.

Hypothesis 8a: Number of network standards approved for VoIP is greater in the competition period than the legitimization period.

Hypothesis 9a: Number of network standards approved for VoIP is associated with the entry rate of new operators.

Hypothesis 9b: Number of network standards approved for VoIP is associated with the number of partnerships established by service operators.

4 RESEARCH METHOD

This chapter is organized into eight sections. The first section describes the unit of analysis and the second describes the study period. The third section describes the three samples used in this research. The fourth section describes how the data was collected. The fifth section describes how class of service, products and operators were classified into types. Section six describes how the adoption stages were identified. The seventh section describes how the variables were measured. Finally, section eighth describes how the data was analyzed.

4.1 Unit of analysis

The unit of analysis is a VoIP service operator that introduces VoIP based services. Service operators develop value-added services and multimedia applications, ensure that the network operates correctly, reliably and provide network access to users via modem or some sort of high capacity network media like coaxial, fiber optic cable or wireless. Examples of operators include: Vocaltec communications Ltd, Telcordia technologies, Cosmocom network and Delta three.

4.2 Study period

The study period comprises 120 months (ten years). The start of the study period is February 1995, the month when VoIP was introduced for the first time. The end of the study period is January 2005, the last month when the data used for this research was collected.

4.3 Samples of interest

Three samples were used to test the set of nine hypotheses: (i) new operators, (ii) partnerships, and (iii) network standards.

4.3.1 New operators sample

The new operators sample is comprised of North American service operators that introduced VoIP based services from February 1995 to January 2005.

The new operators sample was used for testing Hypothesis 1, 2, 3 and 4 and for determining the adoption stages.

Online searches of the Business Source Premier database were performed to identify the service operators that introduced VoIP based services during the study period. Business Source Premier is a widely used database for business research. It includes 3,300 scholarly journals and business periodicals, such as InfoWorld, PC week, Computing Canada, Computer World, PC Magazine, and Byte.com.

This writer first entered the word "VoIP" into the search utility in Business Source Premier and then entered the word "Internet telephony" and the acronym "VoIP". A total of 7,148 entries were examined to identify those that included references to North American service operators that introduced a new VoIP based service during the study period.

A database was created to store the data collected from Business Source Premier and companies' websites. The database is comprised of names of service operators that introduced a VoIP based service during the study period, type of product introduced, type of service operator, date on which the first service/product was introduced. For each operator, the annual revenue data in the database corresponded to the revenue for the year the operator introduced the new service. If the service was introduced in the first three months of the financial year, then the annual revenue of the previous year was collected. Age of service was the number of months the operator has provided services as of January 2005. The year and month an operator started providing services were obtained from the operator's website.

4.3.2 Partnerships sample

The partnerships sample was comprised of all the partnerships established by four operators during the study period.

The partnership sample was used to test Hypothesis 5, 5a, 6, 7 and 9b.

Two steps were used to identify the partnerships sample. First, four operators were selected using the following criteria:

- One operator was selected from each operator type, i.e., one operator from the software company type, one from the telephone company type, one from the Internet company type, and one from the cable company type.

- Each operator selected had been in operations for at least ten years as of January 2005
- Each operator had been identified by at least one news release as having grown quickly during the study period

In the second step, the websites of the four operators selected were examined and the Business Source Premier was searched to identify all the news announcements of the partnerships established over the study period. The searches for the news announcements used keywords such as alliance, collaboration, agreement and partnership as well as one of the names of the selected VoIP service operators.

4.3.3 Network standards sample

The network standards sample is comprised of the network standards approved for VoIP during the study period.

The network standards sample was used to test Hypothesis 8, 8a, 9a and 9b.

To identify network standards approved for VoIP, the the Google utility was used to search the Internet engineering task force (IETF) working groups. Network standards were collected from telephone and QoS related working groups.

Telephone related working groups include: The European Telecom Standards Institute (ETSI), Institute of Electrical and Electronics Engineering (IEEE), International

Telecommunication Union (ITU), IP Telephony, Session Initiation Protocol (SIP), Signalling Transport (SIGTRAN), PSTN and Internet Interworking (PINT), Telephone Number Mapping (ENUM), Media Gateway Control, SIP for Instant Messaging and Presence Leveraging (SIMPLE), Instant Messaging and Presence Protocol (IMPP), and the Internet Messaging Access Protocol Extension (IMAPEXT).

QoS related working groups include Integrated Services (INTSERV), Resource Reservation (RSVP), and Multiprotocol Label Switching (MPLS).

4.4 Data collection

4.4.1 New operators

Service operator's information such as annual revenue of operator (size), age of operator, type of operator, the name of the service that was introduced, the type of service introduced, and the date the service was introduced were obtained from companies' websites and the Business Source Premier database.

4.4.2 Partnerships

Dates of when partnerships were announced, name of operators and their partners, and motives behind the formation of the partnerships were obtained from companies' websites and the Business Source Premier database.

4.4.3 Standards

Names of network standards approved for VoIP based services, their functions and dates of approval were collected from IETF working groups and standards organizations.

4.4.4 Products

Products in this research mean VoIP application services. Products introduced, the names of the operators that introduced the products, and the dates in which the products were introduced were collected from companies' websites and the Business Source Premier database.

4.5 Classifications

4.5.1 Class of service

To identify adoption stages and to test hypotheses 1, 2, 3, 4, 5, 6, 8 and 8a, the writer organized class of service into five types: (i) PC-to-PC, (ii) phone-to-PC (or PC-to-phone), (iii) phone-to-phone, (iv) IP-PBX (IP Private Branch Exchange), and (v) Wi-Fi (short for wireless fidelity, another name for the IEEE 802.11b standard).

Class of service is a way of managing traffic in a network by grouping similar types of traffic (e.g., e-mail, video, voice, and file transfer) together and treating each as a class with its own level of service priority.

This research builds on the classification reported by Clark (1997). According to Clark, there are three major classes of services: PC-to-PC, phone-to-PC (or PC-to-phone), and phone-to-phone (Clark, 1997).

A service operator in the PC-to-PC class of service enables computers to be linked directly to the Internet through modems. This class, the pure form of Internet based communication, does not involve any aspect of PSTN interaction, or interworking with telephone end-node. Voice packets travel entirely over a packet-switched network. Operators in this category provide teleconferencing, consumer multi-person applications, and telework applications.

A service operator in the phone-to-PC or PC-to-phone class of service installed a gateway to link the Internet to the PSTN and sets up a connection with a remote gateway at the other end. The service providers in this class of service deliver applications such as computer telephony, adding voice to the web, and voice access to web information. This application is not strictly Internet telephony, but rather computer-mediated telephony. The concept is to connect the computer to the telephone system at one end so that it becomes a more sophisticated user interface for advanced telephony functions. The computer could receive process and store voice mail, maintain a log of all incoming calls, store catalogues of called numbers, and so on.

The third class of service for Internet telephony is phone-to-phone. Customers continue to use their local phone system and telephones. This type of class contains applications like local loop bypass using cable and IP telephony provided by telephone companies. Applications of this class require technology for interconnection between the PSTN and Internet networks, but do not require access to computer-based end nodes, and can often operate across dedicated regions of the Internet.

In addition to the three classes of services described by Clark (1997), the researcher has observed that VoIP is also being introduced in the form of IP-PBX and Wi-Fi connections. With IP-PBX, the three classes of services identified by Clark (1997) are provided at the same time using an IP based private branch exchange system. With Wi-Fi, the three classes of services identified by Clark (1997) are provided using wireless connectivity.

4.5.2 Product types

To test Hypothesis 2 the writer organized products into two: (i) residential and (ii) business types. This is consistent with Corrocher (1999). The Federal Communication Commission (FCC) in the United States and the Canadian Radio-Television and Telecommunications Commission (CRTC) consider that residential products include services available to all members of society. These residential services include phone-to-phone services such as phone-to-phone IP connection and the IP telephone connection from video cable and calling card.[2]

Examples of business products include services that are available to specific organizations. Examples of business products include and (i) phone to PC services such as adding voice to Web pages and phone to PC calls, (ii) PC to PC services such as teleconferencing and telework, (iii) IP-PBX services such as small independent telephone exchanges in offices, and (iii) Wi-Fi services such as hot spots in airports, coffee shops and so on.

According to Corrocher (1999), business users innovate more than residential users, represent a more profitable market segment, and are more familiar with multimedia applications. Typically, residential users are not aware of the available value-added applications.

4.5.3 Operator types

To select the partnership sample, one operator needed to be selected from each operator type. VoIP operators can be categorized into four types (Clark, 1997). Operators in the software company type provide messaging software packages and service plans on a web site for making long distance and international calls or deliver other applications using computer-to-computer (or computer to telephone) class of service.

Operators in the Internet company type provide modems and VoIP equipment as well as Internet connections for making long distance and international calls. These operators also provide other applications using computer-to-computer (or computer-to-telephone) class of service.

Operators in the telephone company type provide IP connection with VoIP telephone sets or provide IP calling cards and service plans for establishing long distance or international calls using telephone-to-telephone class of service. Networking companies that provide LAN/WAN services are also considered to be a telephone company type.

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[2] Europeans use different criteria to distinguish between residential and business services. According to European Union regulator the residential product type includes phone-to-phone services as well as phone-to-PC services.

Operators in the cable company type provide IP connections and terminal equipment for making long distance or international calls using telephone-to-telephone class of service. These operators use an Internet infrastructure to deliver telephone service over alternative technology (specifically cable infrastructure), bypassing the local loop and the local telephone provider.

4.6 Criteria that mark a stage change

To test hypotheses 1, 2, 3, 4, 5, 5a, 6, 8, 8a, the researcher needed to identify the stages of the VoIP adoption life cycle. No academic study provides a description of the adoption stages of the VoIP life cycle or a process that can be used to identify them. The stages used in this research were identified using a method similar to the one described by Peng (2004) and used by Napoles (2004). Class of service was selected as the main determinant to decide about a change in stages. The key assumption made is that a change in class of service marks a change in stage.

Class of service was selected as a main determinant because of three reasons. One reason was that the writer followed the research of Clark (1997) about the taxonomy of internet telephony. In this research, class of service was used to identify types of internet telephony and related applications. Secondly the class of service taxonomy was very popular as it was being used by the regulators of Europe and North America (EU, FCC, CRTC) in issuing different status notices, directives and regulations about internet telephony. Thirdly this factor was easily available in every news release, so writer decided to use this as an identifier of stage transition.

For this research the criteria to identify stages comprised of three factors. The first focused on changes in classes of service types. A change in classes of service could be PC to PC, PC to P, P to P, IPPBX and Wi-Fi as already explained. The second criteria focused on the length of time between stage changes. The third criteria focused on the minimum percentage of firms classified in a stage. The last two criteria were used in order not to generate a large number of stages.

For the purpose of this research, a new stage begins when all the following criteria are met:

- A new type of class of service is offered by a service operator in the sample of interest (i.e. an important service operator)
- The last stage change occurred more than 12 months ago
- At least 5 percent of the service operators in the sample are classified to be part of the stage.

4.7 Measurement of variables

4.7.1 Stages of adoption

Adoption stages = 1, 2, 3, 4…etc, are identified as per criteria defined in section 4.6.

4.7.2 Density of operators

Density = Cumulative number of operators that introduced a VoIP product into the market for the first time.

4.7.3 Rate of entry

Rate of entry is the number of new service operators that enter the VoIP market at the end of each month.

4.7.4 Size of firm

A firm in this research is the service operator. Firm size can be measured using annual revenue or number of employee. In this research, annual revenue was used to measure size because in certain cases the number of employees was not available. The revenue of the firm corresponds to the revenue of the firm in the year for which the first VoIP product was introduced.

4.7.5 Coding class of services types

If the service provided by Internet telephony allowing the users to communicate using their phones, the service was classified as a phone-to-phone service and its service class was coded as a "1".

If the service enabled computers to be linked directly to the Internet through modems, the service was classified as a PC-to-PC type and its service class coded as a "2".

If the service linked the Internet to the PSTN, the service was classified as a phone-to-PC service and its service class coded as a "3".

If the IP service was provided via a PBX, it was classified as an IP-PBX type and its service class was coded as a "4".

If the IP service was provided via wireless connectivity, it was classified as a Wi-Fi type and its service class type was coded as a "5".

4.7.6 Coding product types

As per Corrocher (1999), there are two types of VoIP products, business and residential. If the product introduced was a phone-to-phone service it was classified as residential product and its product type was coded as a "1". If the product introduced was a phone-to-PC, PC-to-PC, IP-PBX or Wi-Fi service, it was classified as a business product and its product type was codes as a "2".

4.7.7 Product diversity

Product diversity refers to the variety of new products introduced in the market and it is measured at the end of each month.

Product diversity = 1- Σ (pi) ^{2}, where "pi" is the percentage of product category "i" represents among the total number of products introduced. The minimum value that product diversity can take is 0. Low product diversity indicates that the products are similar to one another. The maximum value of product diversity is .9999. High product diversity indicates that the products are very different from each other.

An example will illustrate how to calculate product diversity. Consider that in month 1, the following products were introduced: 2 of type A, 1 of type B, and none of types C and D. Moreover, consider that in month 2, the following products were introduced, none of type A, 1 of type B, 2 of type C, and 3 of type D. The number of products introduced in months one and two are 3 and 6. Thus, at the end of the second month 9 products were introduced. Product diversity for the first and second month are calculated as:

Product diversity for month one = $1 - [(2/3)^2 + (1/3)^2 + 0 + 0] = 4/9 = 0.4444$

Product diversity for month two = $1 - [(2/9)^2 + (2/9)^2 + (2/9)^2 + (3/9)^2] = 0.7408$

4.7.8 Number of new operators

Number of new operators is the count of the number of operators that provide VoIP based service at the end of each month.

4.7.9 Cumulative number of operators (density)

Cumulative number of operators is the cumulative number of operators at the end of each month.

4.7.10 Number of partnerships of operators

Number of partnerships is the total number of partnerships made by major VoIP operators with other operators for each month.

4.7.11 Number of network standards

Number of network standards is the number of network standards approved for VoIP based service for each month.

4.7.12 Partner types

The researcher classified partners into four types: Internet company, software company, telephone company, and cable company.

If the partner's core business was to provide Internet connection, the partner was classified as an Internet company and its partner type was coded a "1". If the partner's core business was to develop and sell software, it was classified as a software company and its partner type coded a "2". If the partner's core business was to deliver telephone services, it was classified as a telephone company and its partner type code a "3". If the partner's core business was to provide video connections, it was classified as a cable company and its partner type coded a "4".

4.7.13 Motives for partnerships types

The researcher classified the motives for partnerships into three types: product/service, technology, and marketing /strategic. The three motive types were those identified by Dodourova (2003) as being the most predominant motives for establishing partnerships.

If the motive identified in the news release of a partnership included the words IP solution, free software with Internet connection and bundle of services the motive was classified as a product/service type and its motive type was coded a "1".

If the motive identified in the news release of a partnership included the words interoperability, traffic interoperability, inter-exchange operation and billing skills the motive was classified as a technology type and its motive type was coded a "2".

If the motive identified in the news release of a partnership included the words marketing, sales and strategic the motive was classified as a marketing/strategic type and its motive type was coded a "3".

4.8 Analysis of data

4.8.1 Descriptive statistics

Descriptive statistics were computed for each variable used in this study including minimum and maximum values, means, standard deviations, skewness and kurtosis. Calculations were performed using SPSS 12.0. Descriptive statistics were also calculated for each parameter at each stage.

Skewness and kurtosis determine the normality of the data.

4.8.2 Testing Hypothesis 1

Hypothesis 1 predicts that the size of a new service operator is a function of adoption stage. To test Hypothesis 1, this writer would first determine the normality of the firm size data distribution at each stage. If the data is normally distributed, a one-way ANOVA test will be used after testing the variance. If the mean difference between a pair of stages is significant at $p < .05$, the writer will conclude that the size of new service operator is a function of adoption stage. If the size data distribution is not normal, then a Mann-Whitney U test will be used to compare the mean ranks of operators' sizes between stages. If the mean rank difference is significant at $p<.10$ this writer will conclude that the size of the new service operator is associated with the adoption stage.

4.8.3 Testing Hypothesis 2

Hypothesis 2 predicts that the type of product introduced by new operators is a function of adoption stage. This writer will first develop a contingency table that shows the relation between product types and adoption stages. The Chi-square test will be used to examine the relationship between product type and adoption stage. If the Chi-square test shows a result significant at $p < .05$, this writer will conclude that product type is a function of adoption stage.

4.8.4 Testing Hypothesis 3

Hypothesis 3 predicts that operator product diversity increases rapidly during the early adoption stages and then increases slowly over the later stages. We will first calculate product diversity for each month of the study period. Then we will check the normality of the data at each adoption stage. If the data was normally distributed, then this writer will perform multiple comparisons of product diversity between every two adjacent stages using a one-way ANOVA test. If the mean difference between a pair of stages is significant at $p<.05$, this writer will conclude that product diversity is significantly different between the two stages. Otherwise, product diversity will be considered to level off over the two adjacent stages. If the data distribution is not normal, then the Mann-Whitney U test will be used to compare the mean ranks of product diversity between different stages. If the mean rank is significantly different between the two stages at $p < .10$, this writer will conclude that the product diversity is significantly different between the two stages. Otherwise, product diversity will be considered to level off over the two adjacent stages.

4.8.5 Testing Hypothesis 4

Hypothesis 4 predicts that the number of new service operators follows a Bell shaped distribution. To test Hypothesis 4, this writer will first determine whether the data distribution of entry rate of service operators is normal at all stages of the adoption life cycle. If the data distribution is normal at all stages, then the one-way ANOVA test will be used to compare the entry rate of service operators at different adoption stages. If the data distribution is not normal, then the Mann-Whitney U test will be used to compare the mean ranks of entry rate of service operators at different stages. The writer will examine the results of the tests and determine whether or not the distribution pattern follows a Bell shaped relationship with adoption stages.

4.8.6 Testing hypotheses 5 and 5a

Hypothesis 5 predicts that the number of partnerships established by operators is a function of adoption stage and Hypothesis 5a predicts that the number of partnerships is greater in the competition period than the legitimization period. This writer will first determine whether the distribution of partnership data at different stages is normal. If the data is normal, a one-way ANOVA test will be used according. If the mean difference is significant at $p<.05$, the writer will conclude that the number of partnerships is a function of the adoption stage. If data is not normal, then Mann-Whitney U test will be used to compare mean ranks of partnerships between different stages. If the mean ranks are different at $p<.10$, then the writer will conclude that the number of partnerships is a function of the adoption stage.

To test Hypothesis 5a, the writer will use the results of testing hypotheses 3 and 4 to determine the legitimization and competition periods. The writer expects that frequent changes in product diversity mark the process of legitimization, whereas infrequent changes in product diversity mark the process of competition. Similarly, a high entry rate of service providers marks the legitimization stage whereas a low entry rate marks the competition stage.

4.8.7 Testing Hypothesis 6

Hypothesis 6 predicts that the motives for establishing new partnerships are a function of adoption stage. To test Hypothesis 6, this writer will first prepare the contingency table for partnership motives and adoption stages. Due to the use of categorical data, the Chi-square test will be used. If the Chi-square test showed that the association between rows and columns was significant at $p<.05$, this writer will conclude that the motives for new partnerships are a function of adoption stages.

4.8.8 Testing Hypothesis 7

Hypothesis 7 predicts that the type of partner selected by a service operator is a function of the motive for establishing the partnership. To test Hypothesis 7, this writer will first create the contingency table for partner type selected and motives for partnerships. The Chi-square test will be used to examine the relationships between partner type and motives for partnerships. If the Chi-square test showed that the result of the association between the rows and columns was significant at $p<.05$, this writer will conclude that the type of partner selected for partnerships is a function of the motives for new partnerships.

4.8.9 Testing Hypothesis 8 and 8a

Hypothesis 8 predicts that the number of network standards for VoIP is a function of adoption stage and Hypothesis 8a predicts that the number of network standards approved for VoIP is greater in the competition period than in the legitimization period. This writer will first determine whether the distribution of network standards data at different stages is normal. If the data is normal, a one-way ANOVA test will be used. If the mean difference is significant at $p<.05$, the writer will conclude that the number of network standards is a function of the adoption stage. If data is not normal, then the Mann-Whitney U test will be used to compare mean ranks of network standards between different stages. If the mean ranks are different at $p<.10$, then the writer will conclude that the number of network standards is a function of the adoption stage.

To test Hypothesis 8a, the writer will use the results of testing hypotheses 3 and 4 to determine the legitimization and competition periods. The writer expects that frequent changes in product diversity mark the process of legitimization, whereas infrequent changes in product diversity mark the process of competition. Similarly, a high entry rate of service providers marks the legitimization stage whereas a low entry rate marks the competition stage.

4.8.10 Testing Hypothesis 9a

Hypothesis 9a predicts that the number of network standards approved for VoIP is associated with the entry rate of new operators. To measure the association between number of network standards and the entry rate of service operators, the writer will use the Pearson correlation coefficient with $p<.05$ if the data for both variables is normally distributed. The writer will use the Spearman correlation coefficient with $p <.05$ if the data for one of the variables is not normally distributed.

4.8.11 Testing Hypothesis 9b

Hypothesis 9b predicts that the number of network standards approved for VoIP is associated with the number of partnerships established by service operators. To measure the association between number of network standards and number of partnerships, the writer will use the Pearson correlation coefficient with $p<.05$ if the data for both variables is normally distributed. The writer will use the Spearman correlation coefficient with $p <.05$ if the data for one of the variables is not normally distributed.

5 RESULTS

This chapter is organized into twelve sections. The first section describes the sample; the second provides the descriptive statistics of the variables used in this research. The third section describes the partnerships of VoIP service operators. The fourth section provides information about the adoption stages. The fifth to twelfth sections provide the results of testing the hypotheses.

5.1 Samples

5.1.1 New operators sample

The new operators sample was comprised of 203 VoIP service operators. The 203 VoIP operators included software, telephone, Internet and cable companies. Firm age data was available for all 203 operators. Annual revenue data was available for 157 of the 203 operators.

Table 2 provides the breakdown of the number of operators in the sample by operator type. The breakdown is shown for the operators for which revenue and age data were available.

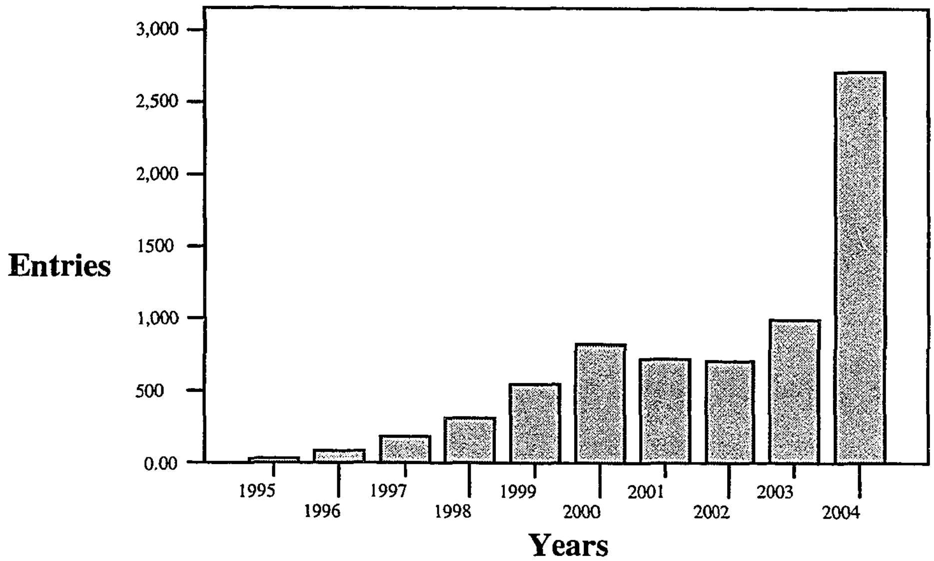
Table 2: Breakdown of new operators providing VoIP services by operator type

	Software companies	**Internet companies**	**Telephone companies**	**Cable companies**	**Number in sample**
Operators with age data	55	14	90	44	203
Operators with revenue data	41	12	76	28	157

A total of 7,148 entries appeared when entering the phrase "Internet telephony" and the acronym "VoIP" in to the search utility of Business Source Premier. Entries included press releases and articles on North American service operators that had started to introduce new VoIP services. Figure 2 shows the number of these entries by year during the study period.

From the 7,148 entries, 203 operators that introduced VoIP from February 1995 to January 2005 were identified.

Figure 2: Number of entries regarding "VoIP" in search utility by year



5.1.2 Partnerships sample

The four major service operators selected were: Vocaltec (software company), IDT (Internet company), Deltathree (Telephone company), and Telcordia (Cable company). The partnership sample was comprised of 108 partnerships formed by the four major service operators of VoIP from February 1995 to January 2005. Appendix 2 provides the partnerships for each of the four service operators.

5.1.3 Network standards sample

The network standards sample is comprised of 85 network standards that were approved for VoIP from February 1995 to January 2005. These standards were identified using the search utilities available in the Internet Engineering Task Force (IETF) working group's websites.

5.2 Descriptive statistics

5.2.1 Entry rate, density, product diversity, partnerships and standards

Table 3 provides the descriptive statistics for entry rate, operator density, product diversity, number of partnerships, and number of standards over the 120 months of the study period.

Table 3: Descriptive statistics for operator related variables

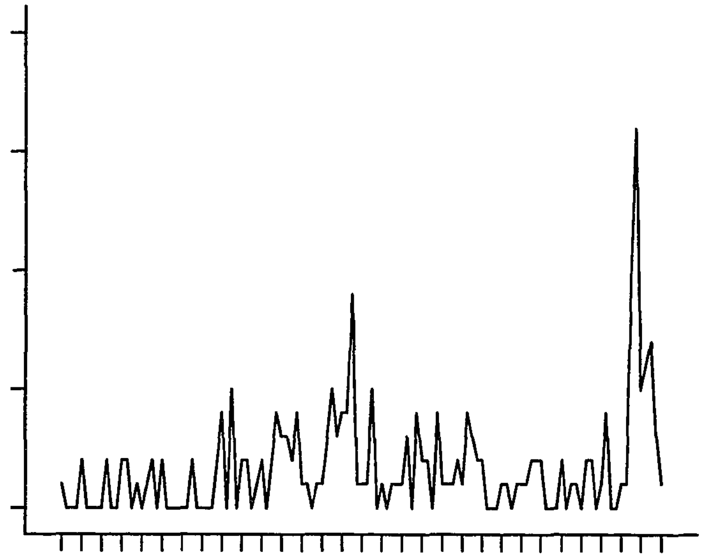
(N = 120 months)

Variables	Min	Max	Mean	Standard Deviation	Skewness Std.Error = 0.22	Kurtosis Std.Error=.44
Entry rate of operators (number of new operators per month)	0	16	1.68	2.2714	3.061	14.160
Density of operators (cumulative number of new operators)	1	203	79.866	58.1652	0.138	-1.306
Product diversity	0	. 94	.8110	.20481	-2.452	6.336
Number of partnerships	0	6	.9000	1.11822	1.740	3.790
Number of standards	0	11	.708	1.541	3.946	19.961

Table 3 includes values for skewness and kurtosis. Skewness is a measure of the symmetry of a distribution around its mean. Kurtosis is a measure of the peakness of a distribution. The results shown in Table 3 suggest that the density of operators is the only variable that is normally distributed. The kurtosis statistic is within –2 and +2 and the skewness statistic is less than twice the standard error. No other variables are normally distributed. The distributions for (i) entry rate of operators, (ii) product diversity, (iii) number of partnerships, and (iv) number of standards have kurtosis statistics that are positive and greater than + 2. This indicates that these four distributions are more peaked than normal (i.e., more observations are clustered around the mean, with fewer in the tails than normal). The distributions for (i) entry rate of operators have skewness statistics that are positive and greater than twice the standard error of the skewness statistic. This suggests that the distribution of this variable has a right-tail skew (i.e., each of these distributions has more observations in the left-tail than normal). The distribution for product diversity has a skewness statistics that is negative and is greater than twice the standard error. This suggests that the distribution has a left-tail skew (i.e., the distribution has more observations in the right-tail than normal).

Figure 3 illustrates the entry rate per month of service operators that introduced VoIP technology during the study period and illustrates the density (i.e., the cumulative number of VoIP operators at the end of each month) over the 120 months study period.

Figure 3: Entry rate and density of operators over 120 months study period



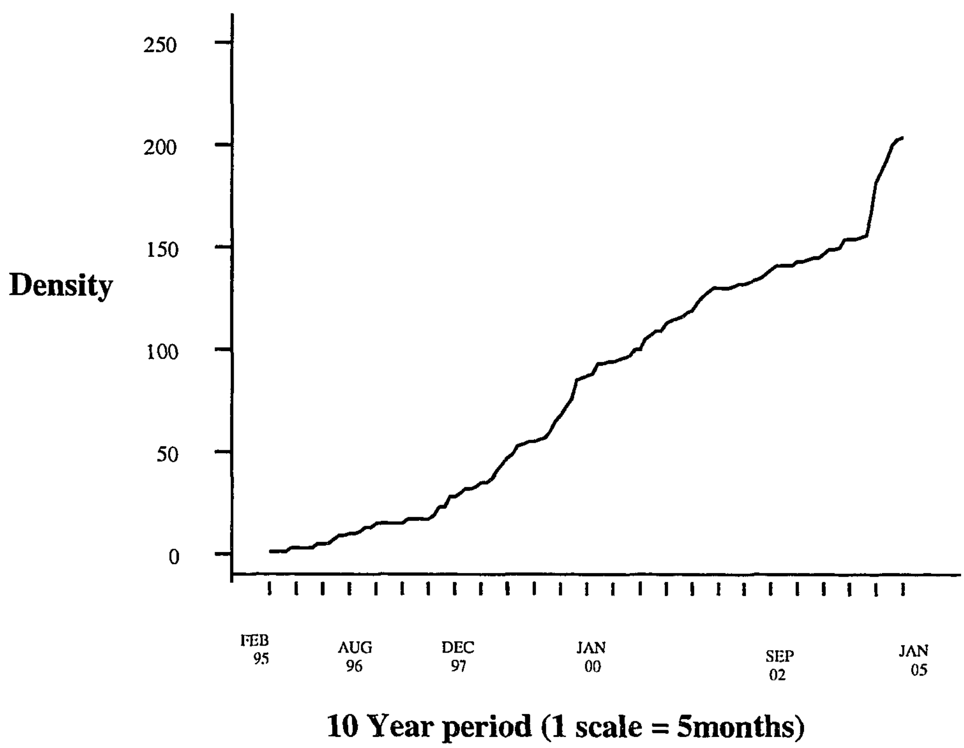
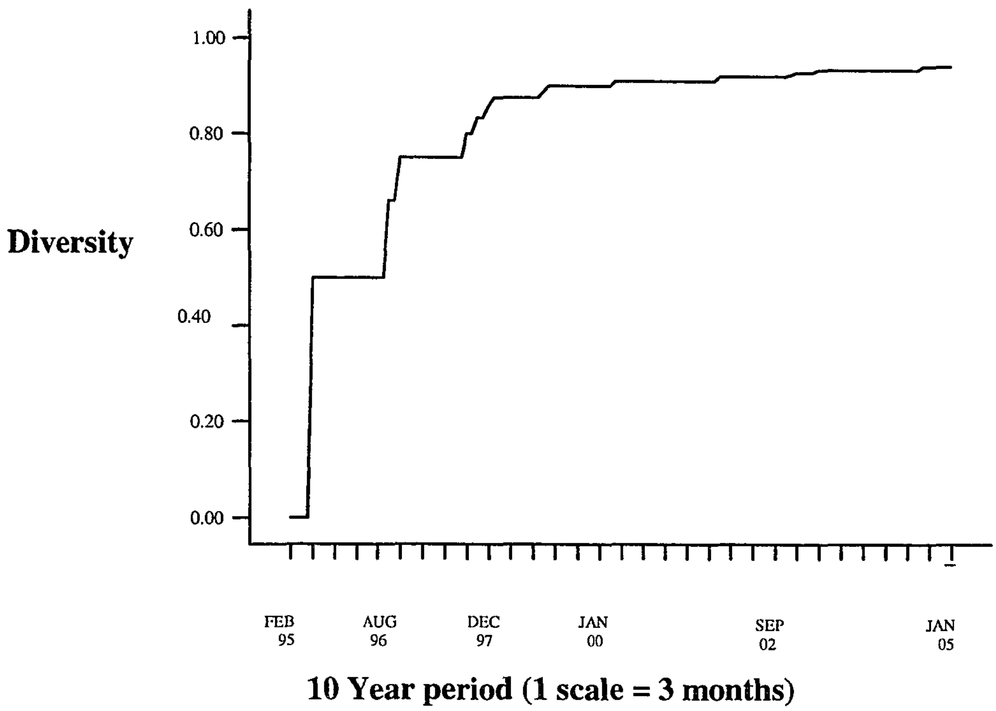


Figure 4 shows how product diversity changed over the study period. Product diversity increases very quickly at the beginning. Product diversity increases from 0 to 0.5 with the introduction of the second product.

Figure 4: Product diversity during the 120-month study period



5.2.2 Annual revenue and age of operators

Table 4 provides the descriptive statistics for annual revenue and age of the new entrants at the time they introduced their first VoIP product. Statistics were calculated for 157 operators for which revenue data was available.

Table 4: Descriptive statistics for new operator's annual revenue and age

(N = 157)

	Min	**Max**	**Mean**	**Standard Deviation**	**Skewness** Std. Error =.194	**Kurtosis** Std. Error =.385
Operator age (Years)	1	160	21.4140	28.57739	3.147	9.719
Annual revenue (Millions of dollars)	0	75,947	3,345.04	11,340.607	4.532	22.011

The results in Table 4 suggest that the two variables are not normally distributed. For each variable, the kurtosis statistic is outside of the -2 to +2 range and the skewness statistic is greater than twice the standard error.

Figure 5 and 6 illustrate the distribution of VoIP operators in the sample by annual revenue and operator age. Both the figures illustrate positive skewness. There are far more VoIP operators of low annual revenue and younger age.

Figure 5: Histogram for annual revenue

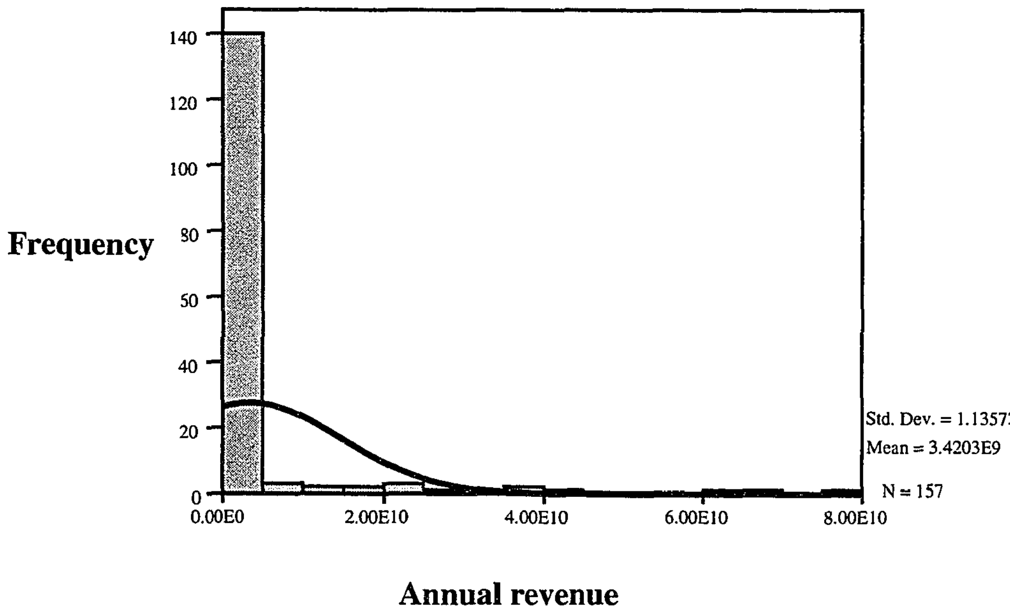
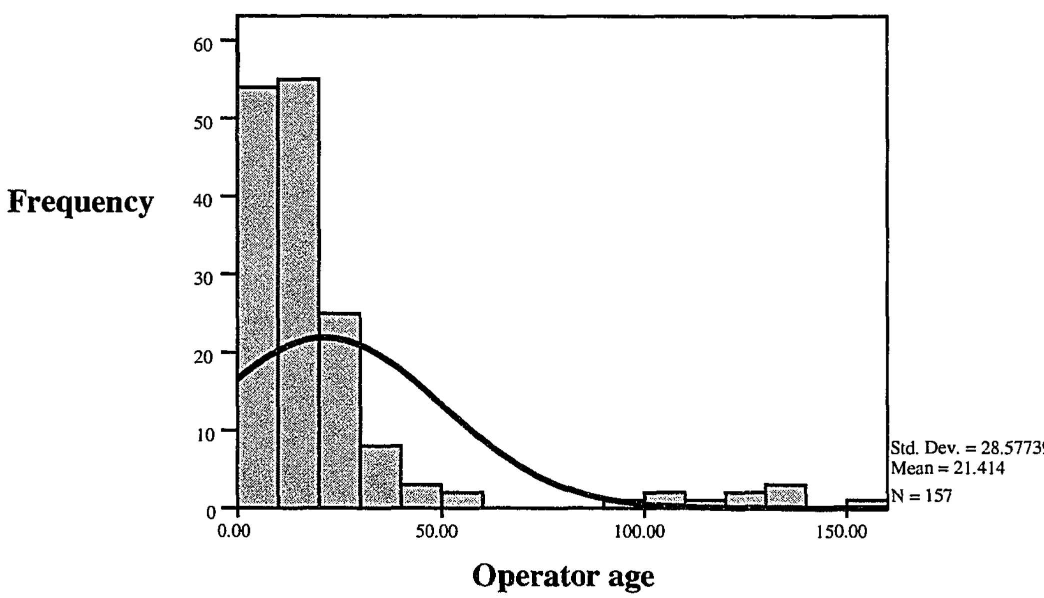


Figure 6: Histogram for firm age



The Spearman correlation coefficient for annual revenue and firm age is 0.441. It is significant at $p < 0.01$, two tailed.

5.3 Operators' partnerships

The four major operators selected for this research established 108 partnerships over the study period. There were 112 motives associated with the 108 partnerships. Four partnership agreements have more than one motive for their formation.

Table 5 provides the number of motives for each motive type identified by Dodourova (2003).

Table 5: Motives for partnerships by motive type

Type of motive for partnership	Count
Product / service related	40
Technology related	35
Marketing / strategic related	37
Total	112

5.4 Adoption stages

5.4.1 Identifying potential stages

The VoIP adoption stages were identified using the criteria described in section 4.6. Table 6 provides the stage transitions identified from the study period.

Table 6: Changes in class of service for stage change

Year/ month	Class of service introduced	Name of operator that introduced the new class of service	Stage transition
1995/02	PC to PC	Vocal tech	Start of stage 1
1996/08	PC to P	IDT Corp	Start of stage 2
1997/12	P to P	Deltathree	Start of stage 3
1998/02	P to P	Qwest	No change
1998/12	P to P	Com Cast	No change
2000/01	All classes of service together	3Com	Start of stage 4
2002/09	All classes of service together with wireless connectivity	Ayaya	Start of stage 5

The first stage begins with the introduction of Internet telephony in February 1995 by Vocal tec, a software company. Vocal tec introduced a PC-to-PC class of service. The product introduction was significant because it was the first time that the Internet was used to provide real-time voice calls with sound quality comparable to regular telephone calls (Sears, 1996). Because both sides must use computers, calling times had to be pre-arranged unless the users always left their Internet telephony application running on their computers.

The second stage started 18 months afterwards. In August 1996, International Discount Telecommunications (IDT) introduced a new class of service, Net to Phone messaging. IDT enabled Internet phone users to use their computers to place calls through the Internet to regular phones (Sears, 1996).

The third stage started in December 1997. Delta three, a telephone company, introduced IP telephony with Phone-to-Phone class of service. Delta three coupled two phone gateways to allow phone calls between two regular phones to be placed through the Internet.

The Qwest Company announced IP calling cards on February 1998 and the Comcast Company introduced IP telephony on the video cable network on December 1998. The stage did not change due to the introductions of these services because both were Phone-to-Phone class of service and were introduced 2 and 11 month after the last stage change.

The fourth stage started in January 2000 when the 3com Company introduced the customer controlled IP-PBX service. Using the Internet, secure communication was provided between different office sites located any where in the world. All classes of service together were introduced in this product.

The fifth stage started in September 2002, when Ayaya introduced Wi-Fi VoIP. In this instance all classes of services were introduced together but this time with wireless connectivity.

5.4.2 Service operators by stage

Five potential stages were identified in section 5.4.1. Table 7 provides the results of classifying the 203 VoIP service operators into the five stages identified in section 5.4.1. These data was used to test hypotheses 2, 3 and 4.

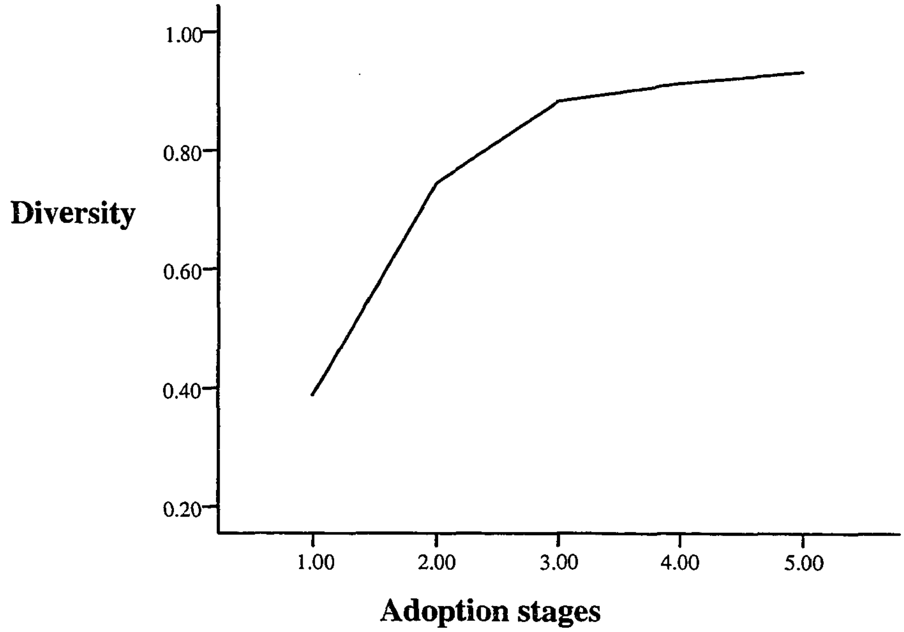
Table 7: Number of new service operators by adoption stage

Stages	Year and month stage started	Number of operators	Percentage	Cumulative percentage
Stage 1	1995/02	11	5.4	5.4
Stage 2	1996/08	14	6.9	12.3
Stage 3	1997/12	59	29.1	41.4
Stage 4	2000/01	47	23.1	64.5
Stage 5	2002/09	72	35.5	100
Total		203	100	

5.4.3 Product diversity by stage

Figure 7 shows product diversity by adoption stages. Product diversity increases rapidly until adoption stage 3 and then increases slowly during subsequent stages.

Figure 7: Product diversity by adoption stage



5.5 Hypothesis 1: Size of new service operator is a function of adoption stage

Hypothesis 1 is to test the association between the size of VoIP operators and adoption stage. Annual revenue was used as the proxy for size. Of the 203 operators in the sample, revenue data was available for 157 operators. Table 8 provides the number of new service operators for which annual revenues data were available by stage of adoption.

Table 8: Number of new operators for which revenue data was available

Stages	Year and month stage started	Number of new operators	Percentage	Cumulative percentage
Stage 1	1995/02	8	5.1	5.1
Stage 2	1996/08	9	5.7	10.8
Stage 3	1997/12	44	28	38.8
Stage 4	2000/01	42	26.8	65.6
Stage 5	2002/09	54	34.4	100
Total		157	100	

Table 4 shows that the distribution for annual revenue was not normal. Thus, the Mann-Whitney U test was used to examine the association between firm size and adoption stage. Table 9 provides the results of using the Mann-Whitney U test to compare firm size at various adoption stages. The results suggest that firm size is not related to adoption stage.

The results do not support acceptance of Hypothesis 1. Appendix 3 provides the detailed results of the Mann-Whitney U tests relevant to Hypothesis 1.

Table 9: Mann-Whitney U test comparing firm size between stages

Revenue by	N	Rank sum	Mean rank	Asymp.sig. (2 tail)
Stage 1	8	78.00	9.75	
Stage 2	9	75.00	8.33	0.564
Stage 2	9	251.50	27.94	
Stage 3	44	1179.50	26.81	0.840
Stage 3	44	2012.50	45.74	
Stage 4	42	1728.50	41.15	0.395
Stage 4	42	1930	45.95	
Stage 5	54	2726	50.48	0.429
Stage1	8	252	31.5	
Stage3	44	1126	25.59	0.310
Stage1	8	261	32.63	
Stage4	42	1014	24.14	0.131
Stage1	8	299	37.38	
Stgae5	54	1654	30.63	0.324
Stage2	9	262.5	29.17	
Stage4	42	1063.5	25.32	0.481
Stage2	9	289	32.11	
Stage5	54	1727	31.98	0.984
Stage3	44	2185	49.66	
Stage5	54	2666	49.37	0.960

5.6 Hypothesis 2: Type of product introduced by new operators is a function of adoption stage

The Chi-square test was used to test Hypothesis 2. Table 10 shows the contingency table and the results of the Chi-square test for the association between service application type and adoption stage.

Table 10: Chi-square test for the association of product types

Contingency table (cells provide counts)

Stages	**Business applications**	**Residential applications**	**Total**
1	11	0	11
2	14	0	14
3	24	35	59
4	20	27	47
5	38	34	72
Total	110	94	203

(Adoption stage*product type cross tabulation)

		Product type		
		Business	Residential	Total
Stage 1	Count	11	0	11
	Expected Count	5.7	5.3	11.0
Stage 2	Count	14	0	14
	Expected Count	7.3	6.7	14.0
Stage 3	Count	24	35	59
	Expected Count	30.8	28.2	59.0
Stage 4	Count	20	27	47
	Expected Count	24.5	22.5	47.0
Stage 5	Count	37	35	72
	Expected Count	37.6	34.4	72.0
	Count	106	97	203
	Expected Count	106.0	97.0	203.0

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	27.805(a)	4	.000
Likelihood Ratio	37.423	4	.000
N of Valid Cases	203		

No expected count less than 5. The minimum expected count is 5.26.

The results in Table 10 show that there is a significant association between service introduced by new operators and adoption stages. The Pearson Chi-square is significant at $p < .05$.

The results shown in Table 10 support Hypothesis 2.

5.7 Hypothesis 3: Operator product diversity increases rapidly during early adoption stages and then increases slightly over later stages

Table 11 provides the descriptive statistics for product diversity grouped by adoption stage. For stages 1, 2 and 3 the data was skewed and the distribution was not normal. Thus, for these three stages, the Mann – Whitney U test was used to examine the association between product diversity and adoption stage. For stages 4 to 5, product diversity was normally distributed. Thus, a One Way ANOVA test for equal variance was used for these two stages.

Table 11: Descriptive statistics for product diversity by adoption stage

Product diversity	Nunber	Min.	Max.	Mean	Std. Deviation	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Stage 1	18	.00	.50	.3889	.21390	-1.461	.536	.137	1.038
Stage 2	16	.66	.80	.7450	.03724	-1.319	.564	2.650	1.091
Stage 3	25	.83	.90	.8834	.02015	-1.252	.464	1.259	.902
Stage 4	32	.91	.92	.9141	.00499	.401	.414	-1.967	.809
Stage 5	29	.92	94	.9333	.00430	.254	.434	.797	.845

Table 12 provides the results of the Mann-Whiney U tests that compare product diversity between stages 1 and 2 and between stages 2 and 3.

Table 12: Mann - Whitney U test comparing product diversity between stages

Product diversity	N	Rank sum	Mean rank	Asymp.sig. (2 tail)
Stage 1	18	171	9.50	.000
Stage 2	16	424	26.50	
Stage 2	16	136	8.50	.000
Stage 3	25	725	29.0	

The results in Table 12 show that product diversity at stage 2 is greater than that at stage 1 and that product diversity at stage 3 is greater than that at stage 2.

Measures for product diversity for stages 4 and 5 are normally distributed and their standard deviations are similar (.00499 and .00445 for stages 4 and 5 respectively). The one way ANOVA Bonferroni test was used to compare the means of product diversity at stages 4 and 5. This test assumes equal variances. Table 13 shows the multiple comparison test results. The third column in Table 13 shows the mean difference between stages. The mean difference of product diversity between stage 3 and 4 is -.03062 and the mean difference of product diversity between stage 4 and 5 is -.01928. The results show that the change in product diversity from stage 3 to 4 was greater than the change in product diversity from stage 4 to stage 5. Product diversity at stage 5 has the highest value. Product diversity at stage 5 is slightly higher than product diversity at stage 4 (by .01928).

Table 13: Multiple comparison of product diversity at stages 3, 4 and 5

Product diversity (multiple comparisons between the stages)		
(I) Stage	(J) Stage	Mean Difference (J-I)
3	4	-.03062(*)
3	5	-.04990(*)
4	5	-.01928(*)

These results show that product diversity increases rapidly from stage 1 to stage 3 and increases slowly from stage 4 to stage 5. Detailed results are shown in Appendix 4.

The results in Tables 12 and 13 support the acceptance of Hypothesis 3.

5.8 Hypothesis 4: The rate of increase of number of new service operators follows the Bell shaped distribution

For each adoption stage, Table 14 provides the descriptive statistics for operators' entry rate. Data distributions were skewed for stages 2, 3, 4 and 5. For four stages, the entry rate was not normally distributed. The Mann-Whitney U test was used to compare the operator diversity at each stage. Detailed results of Mann-Whitney U test are provided in Appendix 5.

Table 14: Descriptive statistics for operator's entry rate in each stage

Entry rate	Number	Min.	Max.	Mean	Std. Deviation	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Stage 1	18	0	2	.6111	.84984	.904	.536	-.963	1.038
Stage 2	16	0	4	.7500	1.23828	1.505	.564	1.580	1.091
Stage 3	25	0	9	2.4800	2.06398	1.267	.464	2.734	.902
Stage 4	32	0	5	1.4375	1.36636	1.070	.414	.477	.809
Stage 5	29	0	16	2.4483	3.53135	2.558	.434	7.448	.845

Table15 provides the results of comparing the entry rate of service operators in stages 1 and 2, 2 and 3, 3 and 4, and 4 and 5.

Table 15: Comparison of entry rate of service operators across stages

Entry rate	N	Rank sum	Mean rank	Asymp.sig. (2 tail)
Stage 1	18	316.50	17.58	
Stage 2	16	278.50	17.41	0.951
Stage 2	16	224	14	
Stage 3	25	637	25.48	0.002
Stage 3	25	852	34.08	
Stage 4	32	801	25.03	0.036
Stage 4	32	951	29.72	
Stage 5	29	940	32.41	0.540

The results show that:

- Operator entry rate at stage 1 is nearly the same as the entry rate at stage 2

- Operator entry rate at stage 2 is significantly smaller than that at stage 3
- Operator entry rate at stage 3 is significantly larger than that at stage 4
- Operator entry rate at stage 4 is nearly the same as the rate at stage 5

The results suggest that new operator's entry rate follows a Bell shaped distribution. The results support the acceptance of Hypothesis 4.

5.9 Hypothesis 5: Number of partnerships established by operators is a function of adoption stage

For each adoption stage, Table 16 provides the descriptive statistics for the number of partnerships established by service operators. The results shown in Table 16 suggest that the distributions are not normal. Thus, the Mann-Whitney U test was used to compare the number of partnerships established by operators across adoption stages.

Table 16: Descriptive statistics for number of partnerships in each adoption stage

Partner ships	Number	Min	Max	Mean	Std. Deviation	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Stage 1	18	0	2	.2222	.54832	2.567	.536	6.363	1.038
Stage 2	16	0	4	.7500	1.18322	1.932	.564	3.411	1.091
Stage 3	25	0	6	1.0000	1.29099	2.652	.464	9.148	.902
Stage 4	32	0	4	.9687	.99950	1.099	.414	1.347	.809
Stage 5	29	0	4	1.2414	1.18488	1.018	.434	.345	.845

Table 17 shows the results of using the Mann-Whiney U test to compare the number of partnerships established by service operators across adoption stages. With one exception, the results suggest that the number of partnerships were not associated with adoption stage. The number of partnerships established at stage 1 was smaller when compared to the number of partnerships established in every other stage. Detailed results of the comparisons are included in Appendix 6.

Table 17: Comparison of number of partnerships by service operators

No. of partnerships	N	Rank sum	Mean rank	Asymp.sig. (2 tail)
Stage 1 Stage 2	18 16	275.50 319.50	15.31 19.97	0.088
Stage 2 Stage 3	16 25	299 562	18.69 22.48	0.282
Stage 3 Stage 4	25 32	711.50 941.50	28.46 29.42	0.816
Stage 4 Stage 5	32 29	938.50 952.50	29.33 32.84	0.413
Stage1 Stage3	18 25	290.5 655.5	16.14 26.22	.004
Stage1 Stage4	18 32	324 951	18 29.72	.003
Stage1 Stage5	18 29	282.50 845.50	15.69 29.16	.000
Stage2 Stage4	16 32	342 834	21.38 26.06	0.241

Stage2	16	298.00	18.63	
Stage5	29	737.00	25.41	0.077
Stage3	25	634.50	25.38	
Stage5	29	850.50	29.33	0.324

The results suggest that the number of partnerships established by service operators in stages 2, 3, 4 and 5 are the same. The number of partnerships established in stage 1 was smaller than the number of partnerships established in all other stages.

The results shown in Table 17 do not support Hypothesis 5.

5.10 Hypothesis 5a: Number of partnerships is greater during the competition period than the legitimization period

From the results of Hypothesis 3 and 4, it is reasonable to assume that the legitimization period is comprised of stages 1, 2 and 3 and that the competition period is comprised of stages 4 and 5. Stages 1, 2 and 3 exhibit a higher number of changes in product diversity and a higher operators' entry rate when compared to Stages 4 and 5.

The five stages were organized into two periods. The first three stages were combined and named the legitimization period. The last two stages were combined as the competition period. Table 18 provides the results of the Mann–Whitney U test used to compare the number of partnerships between the legitimization and competition periods.

Table 18: Comparing partnerships in the legitimization and competition periods

Partnerships	N	Rank sum	Mean rank	Asymp.sig. (2 tail)
Legitimization period	59	3098.50	52.52	0.008
Competition period	61	4161.50	68.22	

The results in Table 18 show that the number of partnerships established during the competition period is greater than the number of partnerships established during the legitimization period. Detailed results are shown in Appendix 7.

5.11 Hypothesis 6: The motives for establishing new partnerships are a function of adoption stage

Hypothesis 6 was designed to examine the relationship between motives for partnerships and adoption stages. Table 19 provides a contingency table for the motives for forming partnerships and adoption stages. The numbers in the cell are counts of the motives type per stage. Dodourova's (2003) classification was used to organize the 112 motives identified after examining 108 partnerships.

Table 19: Contingency table for motives of partnerships and adoption stages

Partnership Motives	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
Product/service	3	2	4	10	21	40
Technology	1	8	14	7	5	35
Marketing/strategic	0	2	9	15	11	37
Total	4	12	27	32	37	112

Table 20 provides the results of the Chi-square test measuring the association between partnership motives and adoption stages using cells for all five stages.

Table 20: Chi-square test for partnerships motives using cells for five stages

Adoption stage * Partnership motives Cross tabulation

		Partnership motives			
		Marketing/ strategic	Product/ service	Technology	Total
Stage 1	Count	0	3	1	4
	Expected Count	1.3	1.4	1.3	4.0
Stage 2	Count	2	2	8	12
	Expected Count	4.0	4.3	3.8	12.0
Stage 3	Count	9	4	14	27
	Expected Count	8.9	9.6	8.4	27.0
Stage 4	Count	15	10	7	32
	Expected Count	10.6	11.4	10.0	32.0
Stage 5	Count	11	21	5	37
	Expected Count	12.2	13.2	11.6	37.0
	Count	37	40	35	112
	Expected Count	37.0	40.0	35.0	112.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	28.447(a)	8	.000
Likelihood Ratio	29.229	8	.000
N of Valid Cases	112		

a 6 cells (40.0%) have expected count less than 5. The minimum expected count is 1.25.

The two-sided Pearson Chi-square test is significant at $p < .05$. The likelihood ratio is very close to the Chi-Square. This is because of the relative large sample size. Table 20 shows that six cells have observed value less than 5. The minimum expected count is 1.25. To fulfill the requirements of a Chi-Square test, the cells in stage 1 and 2 were merged. A Chi-square test was performed using the cells for four stages. Table 21 provides the results when four stages are examined. The results show that partnership motives are associated with adoption stages.

The results shown in Table 21 support Hypothesis 6.

Table 21: Chi-square test for partnerships motives for using cells for four stages

Adoption stage * Partnership motives Cross tabulation

		Marketing/ strategic	Product/ service	Technology	Total
Stage 2	Count	2	5	9	16
	Expected Count	5.3	5.7	5.0	16.0
Stage 3	Count	9	4	14	27
	Expected Count	8.9	9.6	8.4	27.0
Stage 4	Count	15	10	7	32
	Expected Count	10.6	11.4	10.0	32.0
Stage 5	Count	11	21	5	37
	Expected Count	12.2	13.2	11.6	37.0
	Count	37	40	35	112
	Expected Count	37.0	40.0	35.0	112.0

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23.670 (a)	6	.001
Likelihood Ratio	24.243	6	.000
N of Valid Cases	112		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.00.

5.12 Hypothesis 7: Type of partner selected for partnership is the function of motives for establishing a partnership

Hypothesis 7 examined the relation between type of partner and partnership motive type. Table 22 provides the contingency table that shows the association between partner type and partnership motive type. Table 23 provides the results of the Chi-square test for Hypothesis 7.

Table 22: Contingency table for type of partner and partnership motive

Motives	Software companies	Internet companies	Telephone companies	Cable companies	Total
Product/service	10	9	18	3	40
Technology	8	1	25	1	35
Marketing/strategic	12	9	15	1	37
Total	30	19	58	5	112

Table 23: Chi-square test for the association of type of partner and motives

Partner type * Partnership motive type cross tabulation

		Partnership motive			
		Marketing/ strategic	**Product/ service**	**Technology**	**Total**
Cable partner	Count	1	3	1	5
	Expected Count	1.7	1.8	1.6	5.0
Internet partner	Count	9	9	1	19
	Expected Count	6.3	6.8	5.9	19.0
Software partner	Count	12	10	8	30
	Expected Count	9.9	10.7	9.4	30.0
Telephone partner	Count	15	18	25	58
	Expected Count	19.2	20.7	18.1	58.0
	Count	37	40	35	112
	Expected Count	37.0	40.0	35.0	112

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.852 (a)	6	.065
Likelihood Ratio	13.576	6	.035
N of Valid Cases	112		

a Three cells (25.0%) have expected count less than 5. The minimum expected count is 1.56.

The Chi-square results shown in Table 23 suggest support for Hypothesis 7. However, three cells had expected counts less than 5. In order to fulfill the requirements of the Chi-Square test, five data points relating to Cable Company type were removed. This resulted in all expected cells with a count of 5 or more. The Chi-square was recalculated. Table 24 provides the results of the Chi-square for the association between partner type and partnership motive type when three and not four partner types are included in the analysis. The results also support Hypothesis 7.

Table 24: Chi-square with three partner types

Type of partner * Partnership motives Cross tabulation

		Partnership motives			
		Marketing/ strategic	**Product/ service**	**Technology**	**Total**
Internet partner	Count	9	9	1	19
	Expected Count	6.4	6.6	6.0	19.0
Software partner	Count	12	10	8	30
	Expected Count	10.1	10.4	9.5	30.0
Telephone partner	Count	15	18	25	58
	Expected Count	19.5	20.1	18.4	58.0
	Count	36	37	34	107
	Expected Count	36.0	37.0	34.0	107

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.382 (a)	4	.034
Likelihood Ratio	12.299	4	.015
N of Valid Cases	107		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.04.

5.13 Hypothesis 8: Number of network standards approved for VoIP are a function of adoption stage

Table 25 provides the distribution for network standards at each adoption stage. The skewness statistics shows that the data was skewed. Thus, the distributions are not normal. The Mann-Whitney U test was used to examine the relationship between adoption stages and approved network standards for VoIP.

Table 25: Descriptive statistics for network standards in each stage

Network standard	Number	Min.	Max.	Mean	Std. Deviation	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Stage 1	18	0	3	.2778	.75190	3.208	.536	10.955	1.038
Stage 2	16	0	2	.2500	.57735	2.375	.564	5.314	1.091
Stage 3	25	0	7	.8800	1.69115	2.451	.464	6.614	.902
Stage 4	32	0	11	1.3438	2.30860	2.990	.414	10.230	.809
Stage 5	29	0	2	.3793	.62185	1.451	.434	1.164	.845

Table 26 provides the results of comparing the number of network standards approved at each adoption stage. Detailed results of the Mann-Whitney U test are provided in Appendix 8.

Table 26: Comparing the number of standards across stages

No. of Standards	N	Rank sum	Mean rank	Asymp.sig. (2 tail)
Stage 1 Stage 2	18 16	316.50 282.5	17.36 17.66	0.897
Stage 2 Stage 3	16 25	303 558	18.94 22.32	0.258
Stage 3 Stage 4	25 32	655.5 997.5	26.22 31.17	0.216
Stage 4 Stage 5	32 29	1122.0 769.00	35.06 26.52	0.035
Stage1 Stage3	18 25	357 589	19.83 23.56	0.210
Stage1 Stage4	18 32	350 925	19.44 28.91	.021
Stage1 Stage5	18 29	397.00 731.00	22.06 25.21	0.315
Stage2 Stage4	16 32	297.0 879.0	18.56 27.47	.019
Stage2 Stage5	16 29	341.00 694.00	21.31 23.93	0.408
Stage3 Stage5	25 29	713.00 772.00	28.52 26.62	0.590

The results in Table 26 show that there is no association between adoption stages and network standards approved for VoIP at stage 1, 2, 3 and 5. Results shows that at stage 4 a larger number of network standards were approved when compared to the other stages.

Results provided in Table 26 do not support the acceptance of Hypothesis 8.

5.14 Hypothesis 8a: Number of network standards approved for VoIP is greater for the competition period than the legitimization period

To test Hypothesis 8a, stages 1, 2 and 3 were combined and referred to as the legitimization period. Stages 4 and 5 were combined as the competition period. Table 27 provides the results of the Mann -Whitney U test comparing the number of network standards approved during the legitimization and competition periods

Table 27: Comparing number of standards in legitimization and competition periods

Network standards	N	Rank sum	Mean rank	Asymp.sig. (2 tail)
Legitimization period	59	3259.50	55.25	0.051
Competition period	61	4000.50	65.58	

The results of the Mann-Whiney U test show that the number of standards approved for VoIP during the competition period was greater than those approved during the legitimization period. Detailed results of the Mann-Whiney tests are shown in Appendix 9.

The results shown in Table 27 support Hypothesis 8a.

5.15 Hypothesis 9a: Number of network standards approved for VoIP is associated with the entry rate of new operators

Hypothesis 9a is used to examine the association between entry rate of new service operators and approved network standards for VoIP. As the distributions for entry rate of service operators and approved network standards were not normal, Spearman correlation was used to examine the relationship between these two variables.

The Spearman correlation coefficient for entry rate of new service operators and approved network standards is 0.190 with sig. of 0.036, two tailed test. The coefficient is positive and significant at $p < 0.05$. This suggests that there is a positive relationship between the number of new entrants and number of network standards. Detailed results are shown in Appendix10

The results suggest support for Hypothesis 9a.

5.16 Hypothesis 9b: Number of network standards approved for VoIP is associated with the number of partnerships established by service operators

Hypothesis 9b was used to examine the relation between the number of partnerships established by service operators and approved network standards for VoIP. The distributions for number of partnerships and approved network standards were not normal. Thus, the Spearman correlation coefficient was used to measure the association between the two variables.

The Spearman correlation coefficient for number of partnerships and approved network standards is 0.237 with sig. of 0.009, two tailed test. The coefficient is positive and significant at $p < 0.01$. This suggests that there is a positive relationship between the number of partnerships and the number of network standards. Detailed results are shown in Appendix11

The results suggest support for Hypothesis 9b.

6 DISCUSSION OF RESULTS

This chapter has two sections. The first section describes the key findings and the second section discussed these findings and their links to the existing literature.

6.1 Key findings

This research had four objectives. The first objective was to compare two attributes of VoIP service operators, size of firm and type of new service, across adoption stages. The Mann-Whiney U test results in Table 9 show that the size of the service operators that introduced VoIP products is not different across various adoption stages. Size of firms cannot be considered a factor that distinguished the firms that entered the VoIP market during the study period. The Chi-square results in Table 10 show that type of product introduced by service operators is a function of adoption stage.

The second objective of the research was to establish whether product diversity and the entry rate of new service operators followed the distribution of two temporal patterns. The results in Tables 12 and 13 show that product diversity increased rapidly from stage 1 to stage 3 and then increased slowly from stage 4 to stage 5. The results in Table 15 show that entry rate of service operators increased rapidly from stage 2 to stage 3 and then it decreased rapidly from stage 3 to stage 4. This behavior is consistent with a Bell shaped distribution of entry rate for service operators.

The third objective was to examine the attributes of partnerships formed by four major VoIP service operators during the study period. The results in Table 17 show that there is no significant association between number of partnerships established by service operators and adoption stages. It was found that the number of partnerships established at Stage 1 was less than the number of partnerships formed at other stages.

Table 18 shows that the number of partnerships established during the competition period is greater than the number of partnerships established during the legitimization period and

Table 21 shows that the motives for establishing partnerships are a function of adoption stage and Tables 22 and 23 show that the type of partner selected is a function of the motive to form the partnership.

The fourth objective of this research was to examine network standard implementation during the ten-year study period. Table 26 show that there is no association between adoption stages and network standards approved for VoIP at stage 1, 2, 3 and 5. Results, however, indicate that the number of network standards approved at stage 4 was greater than the number of standards approved at every other stage.

The results of the Mann-Whiney U test reported in Table 27 show that the number of standards approved for VoIP during the competition period was greater than those approved during the legitimization period.

The Spearman correlations reported in sections 5.15 and 5.16 suggest that there is a positive association between the number of network standards approved for VoIP and (i) the entry rate of new operators and (ii) number of partnerships established during the adoption stages.

6.2 Discussion

6.2.1 Comparing firm size and type of product across the stages

Many studies report that firm size is positively related to the speed of diffusion, while several other show negative or insignificant effects (Geroski, 2000; Mansfield, 1963; Oster, 1982).

This research suggests that the size of firm is not associated with adoption stages and cannot be considered a deciding factor for a firm to adopt VoIP at any adoption stage. In each stage, small and large companies entered the VoIP market.

According to Schumpeter (1934), small entrepreneurial firms are most likely to be the source of most innovation. This is true in the context of VoIP technology adoption. While examining the collected data it was found that the first firm that introduced VoIP service was a small software operator Vocal tech; immediately after that, some larger firms like Intel Corporation and IBM entered the VoIP business. The entry of these prestigious, larger firms at stage 1 increased the attractiveness of the market.

To obtain additional insights, firms in the sample were grouped into three categories based on their annual revenue i) firms with annual revenue that is less than $100 million, ii) firms with annual revenue between $100 million and $999 million, and iii) firms with annual revenue equal to or greater than $1000 million. Table 28 shows the number of firms in the sample by the stage in which they entered the market and by annual revenue.

Table 28: Firms grouped by annual revenue

Stages	**Revenue categories**			Total
	Less than $ 100 million	**Greater than $100 and less than $1000 million**	**Greater than $1000**	
1	3	3	2	8
2	4	5	0	9
3	27	13	4	44
4	27	14	1	42
5	29	18	7	54

Figure 8 provides a graphical illustration of the results obtained when testing Hypothesis 1.

Figure 8: Size of firm across adoption stages

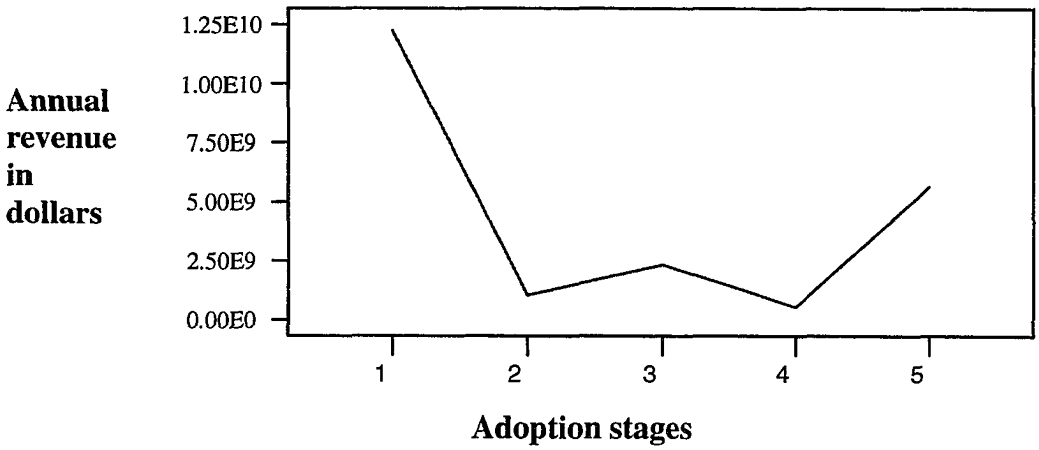


Figure 8 shows that at Stage 1 some smaller and some larger companies entered the VoIP business. While examining the collected data it is found that all these companies were either software or Internet operators. Due to the entry of small firms mean firm size rank decreased. In the second stage again some small and large software and Internet companies legitimized the adoption of VoIP. Prestigious telephone companies like AT&T, MCI, GTE Corporation, ICG Inc, Lucent. and Sprint etc, which were initially not in favor of this technology, began to legitimize the VoIP technology by introducing IP telephony service in stage 3. According to computer law and security report telephone operators AT&T, MCI , Sprint and other members of ACTA filled a petition on march 4,1996 to FCC USA requesting that Internet telephony be regulated as a common carrier telecommunication service. According to this report all the defendants were software and Internet companies. From stage 3 to stage 4 some cable operators also started this business and appeared as the main competitor of telephone operators. Stage 4 to stage 5 seems to be the stage of competition where variety of service operator got into the business of VoIP adoption.

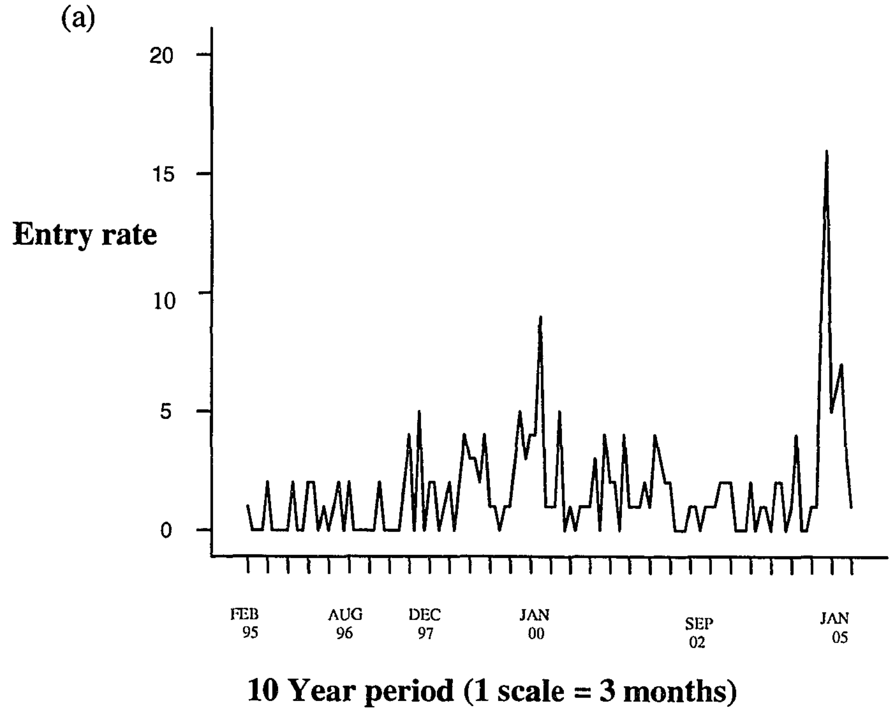
According to Rogers (1983) and Moore (1991), the characteristics and needs of the adopters of a new technology differ at varied stages along the adoption life cycle. The results of this thesis support the observations made by Rogers (1983) and Moore (1991). This research found that the type of service offered by service operators was a function of adoption stage. At stage 1 and 2 business application type services were offered. At stage 3 mostly residential application type services were offered. At stages 4 and 5 business application types were mostly introduced but with different class of services.

6.2.2 Comparing product diversity and entry rate of service operators

Hypotheses 3 and 4 were developed to examine the product diversity and the entry rate of service operators. The twin forces of the density dependence model; legitimization and competition, shape the market of VoIP adoption. Figure 9 illustrates how the entry rate and product diversity changed over the five stages. It suggests that variety of changes in product diversity mark the process of legitimization, whereas low numbers of changes in product diversity mark the process of competition. Similarly, a higher entry rate is observed for the legitimization period and a low entry rate is observed for the competition period.

Figure 9: Product diversity and entry rate across adoption period

(a)



(b)

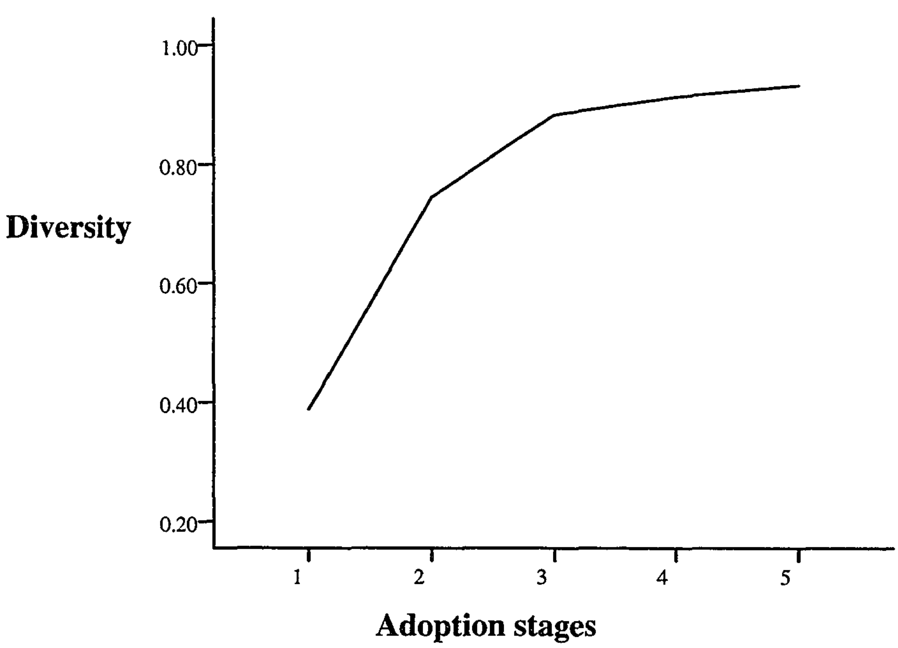


Figure 9 shows that the VoIP technology life cycle starts from stage 1 (February 1995). Product diversity increases rapidly during the first three stages and a large number of service operators enter the VoIP market. This was the period of legitimization of VoIP technology, where large and small sized firms supported this technology by providing various types of VoIP services.

Figure 9 shows that product diversity increased slowly from stage 4 to stage 5 and a smaller number of firms entered the VoIP market. This was the period of competition. At the end of stage 3, all four types of operators had entered the market of VoIP. Starting stage 4, the new entrants needed to compete with the first movers who were already providing VoIP based products. Increased competition caused firm entry rate to slow down.

6.2.3 Attributes of number of partnerships

The results show that the number of partnerships during the competition period was greater than the number of partnerships in the legitimization period. According to Eisenhardt and Schoonhoven (1996), the reason for this behavior is that firms in highly competitive markets have vulnerable strategic positions because margins are low and product differentiation is difficult. Therefore firms acquire resources through alliances.

Examining the data collected for stage 1, it was observed that only two types of service operators entered the market of VoIP: software and Internet companies. The first partnership was established between software and an Internet company. The software company developed a messaging software product for making long distance and international calls but needed an Internet media to establish calls between two computers. Therefore, the software company made an alliance with the Internet company to obtain the requisite complementary assets. The partnership provided customers with free software with an Internet connection.

Motives for establishing partnerships during the first adoption stage were product / service related mostly.

In the second stage when more and more software and Internet companies entered the VoIP market, interoperability became a problem. At that time technology related alliances were established between software companies to enable subscribers who were using the soft switch of one company to communicate with the subscribers using a soft switch of another company.

Most of the prestigious telephone companies entered the VoIP market in stage 3. The partnerships formed by other VoIP service operators with these established telephone companies further legitimized the process of VoIP adoption. These telephone companies introduced IP telephony service using hard switches. They did not need any messaging software for this service. Also, they did not need media because they had their own. However, they had to make partnerships with software companies. There was the problem of interoperability and they made alliances because they wanted their customers to be able to communicate with those customers who were already using softswitch services. Thus, during stage 3 most partnership motives were technology related.

In stage 4, most of the cable companies entered the VoIP market. They offered IP telephony capability through their cable modems along with the video connection. They did not need messaging software and were very rich in media. They were also not much concerned about interoperability because most of the issues had been solved. They did not make much alliances. In stage 4 companies mostly made strategic / marketing related and product / services related partnerships to get access to the customer base of other operators.

In stage 5 most of partnerships were made for product or service related motives. Operators who were not in position to provide all services (voice, video and data) together made alliances to provide bundle of services.

6.2.4 Role of network standards

The results suggest that the number of network standards approved for VoIP was greater during the competition period than the legitimization period. Entry rate of operators and operators' partnerships are positively associated with the number of network standards approved during adoption life cycle. The results provide insight that as the process of VoIP adoption proceeds, the number of operators enters the market and establish partnerships which bring new services. For new services, new network standards are approved to make them successful.

7. CONCLUSION, LIMITATION AND SUGGESTION FOR FUTURE RESEARCH

7.1 Conclusions

The results of this study leads to the following conclusions:

- Operators size is same across stages, product type is different
- Twin forces of legitimization and competition shape VoIP market evolution
- Entry rate of operators and their service diversity follow the distribution of two temporal patterns
- Partnerships formation and adoption of network standards accelerates the process of VoIP adoption
- In the competitive environment the importance of partnerships and adoption of network standards increases for the survival of new entrants
- Operator companies select partners according to the motives and establish partnerships to acquire resources needed to survive and compete in the changing market place

7.2 Limitations

There are three limitations of this research.

First, the research only focuses on VoIP service operators. VoIP equipment suppliers were not considered in this study.

The second limitation is that the research excluded non-North American operators. It is difficult to generalize the findings to operators in Europe and Asia.

The third limitation is that no in depth-interviews with executives were carried out. The research was conducted using publicly available information.

7.3 Suggestion for Future Research

To gain additional insights, future researchers can examine the differences in other firm-level factors across the stages in the adoption of VoIP. For example, they can examine strategic concerns and top management team's reasons to adopt VoIP across adoption stages.

This research examines the attributes of partnerships formed by four major service operators. Researcher can also examine the partnerships formed by other individual companies that have played an important role in the VoIP market.

Future research can examine the European and Asian markets and find out how VoIP is being adopted around the world. It will be interesting to know the characteristics of adoption in different geographical areas.

Supplier data can also be used to measure company attributes. It will be interesting to compare the results obtained by using supplier data with those obtained in this study.

It is interesting to dig out the reason of spike that appeared in the figure 10 (a) about the entry rate of service operators. In the month of August and September 2004 total 24 service operators entered the VoIP market with new services. Looking at the results of Mann-Whitney U test for the entry rate this difference is not visible because results shows that there is no significant difference between number of new operators in stage 4 and stage 5, but this spikes seems to appear in the end of stage 5.

7.4 Managerial applications

The following managerial insights were generated.

VoIP technology reduces barriers to enter the market. Any size of firm can start the business as a VoIP service operator by examining the identified stages of VoIP life cycle. Manager of a new service operator can decide which application is suitable to provide customers at that particular stage. For example, at present Phone to Phone VoIP service is required for residential customers and Wi-Fi VoIP service for the business customer.

The temporal pattern of service operators provides insights to managers responsible for VoIP equipment suppliers; they could bring new designs or applications which are required to satisfy the customers. Presently, new designs of VoIP telephone set for Phone to Phone class of service, Wi-Fi telephone set and Wi-Fi chip set for laptops or computers are required for Wi-Fi VoIP services.

Service operators can provide bundle of services to get customers' base. If they are not able to provide all services together, they can form partnerships. As per collected data of this research Vocaltec formed partnership with Netcom and GNN to provide voice and data services together. Telcordia formed partnership with Opennet telecom and T system to provide voice, data and video services together.

As a new service operator it is necessary for their success to follow the existing network standards in the market. For example Avaya's introduced Wi-Fi VoIP service in Sep 2002; it was based on wireless multimedia extensions (WME) standards available in the market. They enabled voice communication over 802.11 standard. After them Vonage Inc provided Wi-Fi VoIP service using same standards. Sun Microsystem Inc introduced S/W for VoIP in Feb, 2001. This S/W was compatible with H323, T120 and T127 conferencing standards available in the market. Cable companies like Comcast and Telcordia used G711 and G764 standards for modulation and packetization which were already being used by S/W companies.

In the competitive environment service operators should do maximum possible partnerships for their success. From the collected data, writer can quote the example of delta three who formed about 16 partnerships in 34 months in fourth stage. These partnerships were established for product/service, technology and marketing related motives.

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Appendix 1: Explanation of terms relating to VoIP

VoIP:

It is an application that encodes and digitizes a voice signal, converts the signal to data packets, and transports the packets over a data network running Internet protocols (IP).

Computer telephony (CT):

A general term, that encompasses a wide variety of technologies and applications that utilize computing to add intelligence to telephony functions and combine these functions with data processing.

Internet Protocol:

The method or protocol by which data is sent from one computer to another on the Internet .Each computer on the Internet has at least one IP address that uniquely identifies is from all other computers on the Internet. When voice or data is send or receive, the message gets divided in to little chunks called packets. Each packet contains both sender Internet address and receiver address. Any packet is sent first to a gateway computer that understands a small part of the Internet. The gateway computer reads the destination address and forwards the packet directly to the computer whose address is specified.

Internet service provider (ISP):

An organization, that provides access to the Internet for individuals and organizations.

Packet switched telephone network (PSTN):

PSTN refers to the international telephone system based on copper wires carrying analog voice data. This is in contrast to newer telephone networks based on digital technologies, such as ISDN and FDDI. Telephone service carried by the PSTN is often called plain old telephone service (POTS).

IP telephony/Internet telephony:

If telephony application stays over IP networks instead of circuit-switched networks, it is called IP telephony. Internet telephony, on the other hand, refers to the voice traffic over Internet.

VPN:

It is private network connected to the Internet but uses encryption to scramble all data sent through the Internet. So the entire network is virtually private. It has three types: Intranet, extranet and dialup.

Intranet

A network which allows communications securely between various corporate sites.

Extranet

A network which allows communications securely between partner sites.

Remote access

Connect remote dial-up users securely to corporate networks.

Modem:

A device used to connect computer to a phone line. It allows computer to communicate to other computer.

Multimedia:

A combination of media types on a single document, including text, graphics, animation, audio and video.

Protocol:

A set of rules by which computers communicate with each other.

IP telephony gateway:

Device, converts an analog voice stream or digitized version of voice in to Internet protocol data packets.

PBX:

A private telephone switching system usually located on a company premises that connects internal extension to one another as well as to the outside telephone network.

Unified messaging:

Integrated delivery of voice mail fax and email communication through a common system or interface.

Voice portal:

Anywhere anytime access via telephone devices to web based information.

Contact centre:

Call centre capable of processing inquiries from multiple communication media, such as phone, fax and VoIP, using the same distribution, queuing and control system.

Bandwidth:

Measurement of a network transmission speed or data a network can transfer in a given amount of time.

Soft phone:

A soft phone is software that runs on a PC and uses the PCs speakers and microphone (or headset) as the telephone instrument.

IP PBX

The Internet Protocol Private Branch exchange (IP PBX) is telephone switching equipment that resides in a private business instead of the telephone company. An IP

PBX delivers employees dial-tone, the ability to conference, transfer, and dial other employees by extension number as well as many other features. Voice transmissions are sent via data packets over a data network instead of the traditional phone network.

Service Provider

This entity which has a commercial relationship with the subscriber. The aggregated services are delivered to the homes of subscribers. The service provider will usually have primary marketing responsibility but that MAY be shared when the commercial model is that of a franchise.

Service Operator

In many cases, once a service has been contracted between a Service Provider and the Subscriber, much of its operation will be simply that of ensuring its correct and reliable operation. In this case the Service Provider will contract to the Service Operator to carry out this task and will only become involved if invoked by predefined events calling for its attention. Many home based systems and applications that operate within the home environment or are repetitive in operation are of this nature.

Appendix 2: All partnerships of four major operators

Operator	Partner	Date	Partnership motives
Vocaltec	Netcome	Apr-95	Product/service
Vocaltec	GNN	Dec-95	Product/service
Vocaltec	IBM	Dec-95	Technology
IDT corporation	Genie	May-96	Product/service
IDT corporation	Macromedia	Aug-96	Marketing/strategic
Vocaltec	Intel	Oct-96	Technology
Vocaltec	Microsoft	Oct-96	Technology
Vocaltec	Radvision	Oct-96	Technology
Vocaltec	Datacom	Jan-97	Product/service
Vocaltec	Motorola	Mar-97	Technology
IDT corporation	Cable and wireless	Apr-97	Technology
Deltathree	RSL comm	Jul-97	Marketing/strategic
IDT corporation	Quicknet technology	Jul-97	Technology
Vocaltec	ITXC corporation	Jul-97	Technology
Vocaltec	AT&T	Jul-97	Technology
Vocaltec	Surf&Call	Oct-97	Product/service
Vocaltec	Deutsche telekom AG	Dec-97	Product/service
Vocaltec	Eye bill	Jan-98	Technology
IDT corporation	Executive telecard	Feb-98	Marketing/strategic
Deltathree	ITXC corporation	Mar-98	Technology
IDT corporation	Yahoo inc	Mar-98	Marketing/strategic
IDT corporation	Broadcast.com	May-98	Marketing/strategic
Vocaltec	Lucent	Jun-98	Technology
Deltathree	Ericsson	Jul-98	Marketing/strategic
Deltathree	Ericsson	Jul-98	Technology
Deltathree	The globe.com	Aug-98	Marketing/strategic
Vocaltec	Deltathree	Aug-98	Technology
Vocaltec	Radlinx	Oct-98	Product/service
IDT corporation	1-800-flowers	Nov-98	Marketing/strategic
Vocaltec	Ascend	Dec-98	Technology
Vocaltec	Cisco	Dec-98	Technology
Vocaltec	Clarent	Dec-98	Technology
Vocaltec	Dialogic	Dec-98	Technology
Vocaltec	Natural micro systems	Dec-98	Technology

Vocaltec	Siemens	Dec-98	Technology
Deltathree	Telenor nextel	Mar-99	Product/service
Deltathree	Telenor nextel	Mar-99	Marketing/strategic
IDT corporation	Siemens	Mar-99	Technology
IDT corporation	Real networks	Mar-99	Technology
Vocaltec	ECI telecom	Apr-99	Technology
IDT corporation	Zdnet	May-99	Marketing/strategic
IDT corporation	Geo cites	Sep-99	Marketing/strategic
Vocaltec	Bell atlantic	Oct-99	Product/service
Deltathree	Telstra	Mar-00	Technology
Deltathree	Zimba	Mar-00	Marketing/strategic
Deltathree	Store runner.com	Mar-00	Marketing/strategic
Deltathree	Visitalk.com	Apr-00	Marketing/strategic
Deltathree	Hotbar.com	May-00	Marketing/strategic
Deltathree	2dobiz.com	Jul-00	Marketing/strategic
IDT corporation	Click the button	Jul-00	Technology
Deltathree	Poltalk	Aug-00	Marketing/strategic
Deltathree	Gorilla guide.com	Sep-00	Marketing/strategic
Deltathree	Easy every thing	Nov-00	Marketing/strategic
Deltathree	Earthlink	Feb-01	Marketing/strategic
Vocaltec	Uniplex	Feb-01	Product/service
Vocaltec	Fujitsu supply system	Mar-01	Marketing/strategic
Deltathree	MHL comm	Apr-01	Marketing/strategic
Deltathree	RSL comm	Jul-01	Marketing/strategic
Deltathree	Iconnect here	Jul-01	Product/service
Vocaltec	IP unity	Oct-01	Product/service
Vocaltec	Pactolus comm	Oct-01	Product/service
Telcordia	IBM	Nov-01	Product/service
Vocaltec	Cosmocom	Nov-01	Marketing/strategic
Vocaltec	Cosmocom	Nov-01	Product/service
Telcordia	ONI systems	Feb-02	Technology
Deltathree	Cisco system	Mar-02	Product/service
IDT corporation	Winstar	Mar-02	Marketing/strategic
Telcordia	i2	Mar-02	Product/service
Vocaltec	Next tone comm	Mar-02	Product/service
Telcordia	CTC communication	Apr-02	Technology
Deltathree	Pingtel	May-02	Technology

Telcordia	Marconi	May-02	Technology
Deltathree	Earthlink	Jun-02	Product/service
IDT corporation	Worldcom	Jul-02	Marketing/strategic
Vocaltec	Verint	Aug-02	Technology
Vocaltec	Alvarion	Sep-02	Product/service
Vocaltec	Iperia	Sep-02	Product/service
Deltathree	IP plant	Oct-02	Product/service
Telcordia	Openet telecom	Oct-02	Technology
Telcordia	Openet telecom	Oct-02	Marketing/strategic
Vocaltec	TTJ telecom	Feb-03	Marketing/strategic
Telcordia	Capgemini	Feb-03	Marketing/strategic
Vocaltec	Audiocodes ltd	Mar-03	Technology
Vocaltec	Telica inc	Mar-03	Product/service
Vocaltec	Audiocodes ltd	Mar-03	Marketing/strategic
Deltathree	skyvision	May-03	Marketing/strategic
Vocaltec	DataAccess American	May-03	Product/service
Vocaltec	Adesemi Nigeria	May-03	Product/service
Telcordia	Granite	Jun-03	Product/service
Deltathree	D3 acquisition	Jul-03	Marketing/strategic
IDT corporation	Global crossing	Aug-03	Product/service
Telcordia	Comanage	Sep-03	Product/service
Telcordia	Sheer networks	Sep-03	Product/service
Telcordia	Concept wave	Sep-03	Marketing/strategic
Vocaltec	T-system	Sep-03	Marketing/strategic
IDT corporation	Global crossing	Dec-03	Marketing/strategic
Telcordia	Steleus	Jan-04	Product/service
Deltathree	Free serve	Mar-04	Product/service
IDT corporation	AOL	Mar-04	Product/service
Telcordia	Juniper networks	Mar-04	Technology
Telcordia	MESA	Mar-04	Product/service
Deltathree	Iperia	Apr-04	Product/service
Telcordia	T system	May-04	Product/service
Vocaltec	Acme packet	Jun-04	Marketing/strategic
Deltathree	Verizon comm	Jul-04	Product/service
IDT corporation	Cablevision	Aug-04	Product/service
Telcordia	Acterna	Sep-04	Technology
Vocaltec	Nova telefonia	Oct-04	Product/service

IDT corporation	Liberty media corp	Dec-04	Marketing/strategic
Deltathree	Xo comm. Inc	Jan-05	Product/service
Deltathree	Level3	Jan-05	Product/service
Vocaltec	Audiocodes ltd	Mar-05	Technology

Appendix 3: Testing Hypothesis 1 - Firm size across stages

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	1.00	8	9.75	78.00
	2.00	9	8.33	75.00
	Total	17		

Test Statistics(b)

	Firm size(Annual revenue)
Mann-Whitney U	30.000
Wilcoxon W	75.000
Z	-.577
Asymp. Sig. (2-tailed)	.564
Exact Sig. [2*(1-tailed Sig.)]	.606(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	1.00	8	31.50	252.00
	3.00	44	25.59	1126.00
	Total	52		

Test Statistics(b)

	Firm size(Annual revenue)
Mann-Whitney U	136.000
Wilcoxon W	1126.000
Z	-1.015
Asymp. Sig. (2-tailed)	.310
Exact Sig. [2*(1-tailed Sig.)]	.323(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	1.00	8	32.63	261.00
	4.00	42	24.14	1014.00
	Total	50		

Test Statistics(b)

	Firm size(Annual revenue)
Mann-Whitney U	111.000
Wilcoxon W	1014.000
Z	-1.508
Asymp. Sig. (2-tailed)	.131
Exact Sig. [2*(1-tailed Sig.)]	.137(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	1.00	8	37.38	299.00
	5.00	54	30.63	1654.00
	Total	62		

Test Statistics(a)

	Firm size(Annual revenue)
Mann-Whitney U	169.000
Wilcoxon W	1654.000
Z	-.987
Asymp. Sig. (2-tailed)	.324

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	1.00	8	32.63	261.00
	4.00	42	24.14	1014.00
	Total	50		

Test Statistics(b)

	Firm size(Annual revenue)
Mann-Whitney U	111.000
Wilcoxon W	1014.000
Z	-1.508
Asymp. Sig. (2-tailed)	.131
Exact Sig. [2*(1-tailed Sig.)]	.137(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	2.00	9	29.17	262.50
	4.00	42	25.32	1063.50
	Total	51		

Test Statistics(b)

	Firm size(Annual revenue)
Mann-Whitney U	160.500
Wilcoxon W	1063.500
Z	-.704
Asymp. Sig. (2-tailed)	.481
Exact Sig. [2*(1-tailed Sig.)]	.488(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	2.00	9	27.94	251.50
	3.00	44	26.81	1179.50
	Total	53		

Test Statistics(b)

	Firm size(Annual revenue)
Mann-Whitney U	189.500
Wilcoxon W	1179.500
Z	-.201
Asymp. Sig. (2-tailed)	.840
Exact Sig. [2*(1-tailed Sig.)]	.843(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	2.00	9	32.11	289.00
	5.00	54	31.98	1727.00
	Total	63		

Test Statistics(a)

	Firm size(Annual revenue)
Mann-Whitney U	242.000
Wilcoxon W	1727.000
Z	-.020
Asymp. Sig. (2-tailed)	.984

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	3.00	44	45.74	2012.50
	4.00	42	41.15	1728.50
	Total	86		

Test Statistics(a)

	Firm size(Annual revenue)
Mann-Whitney U	825.500
Wilcoxon W	1728.500
Z	-.851
Asymp. Sig. (2-tailed)	.395

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	3.00	44	49.66	2185.00
	5.00	54	49.37	2666.00
	Total	98		

Test Statistics(a)

	Firm size(Annual revenue)
Mann-Whitney U	1181.000
Wilcoxon W	2666.000
Z	-.050
Asymp. Sig. (2-tailed)	.960

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Firm size(Annual revenue)	4.00	42	45.95	1930.00
	5.00	54	50.48	2726.00
	Total	96		

Test Statistics(a)

	Firm size(Annual revenue)
Mann-Whitney U	1027.000
Wilcoxon W	1930.000
Z	-.790
Asymp. Sig. (2-tailed)	.429

a Grouping Variable: Adoption stage

Appendix 4: Testing Hypothesis 3 - Product diversity across stages

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Product diversity	1.00	18	9.50	171.00
	2.00	16	26.50	424.00
	Total	34		

Test Statistics (b)

	Product diversity
Mann-Whitney U	.000
Wilcoxon W	171.000
Z	-5.282
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
Product diversity	2.00	16	8.50	136.00
	3.00	25	29.00	725.00
	Total	41		

Test Statistics(b)

	Product diversity
Mann-Whitney U	.000
Wilcoxon W	136.000
Z	-5.515
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

	(I) Adoption stage	(J) Adoption stage	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Bonferroni	3.00	4.00	-.03062(*)	.00307	.000	-.0381	-.0231
		5.00	-.04990(*)	.00311	.000	-.0578	-.0426
	4.00	3.00	.03062(*)	.00307	.000	.0231	.0381
		5.00	-.01928(*)	.00292	.000	-.0267	-.0124
	5.00	3.00	.04990(*)	.00311	.000	.0426	.0578
		4.00	.01928(*)	.00292	.000	.0124	.0267

Dependent Variable: Product diversity

* The mean difference is significant at the .05 level.

Appendix 5: Testing Hypothesis 4 - Entry rate across stages

Ranks

	Adoption stages	N	Mean Rank	Sum of Ranks
Entry rate of operators	1.00	18	17.58	316.50
	2.00	16	17.41	278.50
	Total	34		

Test Statistics(b)

	Entry rate of operators
Mann-Whitney U	142.500
Wilcoxon W	278.500
Z	-.061
Asymp. Sig. (2-tailed)	.951
Exact Sig. [2*(1-tailed Sig.)]	.959(a)

a Not corrected for ties.

b Grouping Variable: Adoption stages

Ranks

	Adoption stages	N	Mean Rank	Sum of Ranks
Entry rate of operators	2.00	16	14.00	224.00
	3.00	25	25.48	637.00
	Total	41		

Test Statistics(b)

	Entry rate of operators
Mann-Whitney U	88.000
Wilcoxon W	224.000
Z	-3.093
Asymp. Sig. (2-tailed)	.002
Exact Sig. [2*(1-tailed Sig.)]	.002(a)

a Not corrected for ties.

b Grouping Variable: Adoption stages

Ranks

	Adoption stages	N	Mean Rank	Sum of Ranks
Entry rate of operators	3.00	25	34.08	852.00
	4.00	32	25.03	801.00
	Total	57		

Test Statistics(a)

	Entry rate of operators
Mann-Whitney U	273.000
Wilcoxon W	801.000
Z	-2.094
Asymp. Sig. (2-tailed)	.036

a Grouping Variable: Adoption stages

Ranks

	Adoption stages	N	Mean Rank	Sum of Ranks
Entry rate of operators	4.00	32	29.72	951.00
	5.00	29	32.41	940.00
	Total	61		

Test Statistics(a)

	Entry rate of operators
Mann-Whitney U	423.00
Wilcoxon W	951.00
Z	-.612
Asymp. Sig. (2-tailed)	.540

a Grouping Variable: Adoption stages

Appendix 6: Testing Hypothesis 5 - Partnerships across stages

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	1.00	18	15.31	275.50
	2.00	16	19.97	319.50
	Total	34		

Test Statistics(b)

	No# of partnerships
Mann-Whitney U	104.500
Wilcoxon W	275.500
Z	-1.704
Asymp. Sig. (2-tailed)	.088
Exact Sig. [2*(1-tailed Sig.)]	.175(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	2.00	16	18.69	299.00
	3.00	25	22.48	562.00
	Total	41		

Test Statistics(b)

	No# of partnerships
Mann-Whitney U	163.000
Wilcoxon W	299.000
Z	-1.076
Asymp. Sig. (2-tailed)	.282
Exact Sig. [2*(1-tailed Sig.)]	.333(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	3.00	25	28.46	711.50
	4.00	32	29.42	941.50
	Total	57		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	386.500
Wilcoxon W	711.500
Z	-.232
Asymp. Sig. (2-tailed)	.816

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	4.00	32	29.33	938.50
	5.00	29	32.84	952.50
	Total	61		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	410.500
Wilcoxon W	938.500
Z	-.818
Asymp. Sig. (2-tailed)	.413

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	1.00	18	16.14	290.50
	3.00	25	26.22	655.50
	Total	43		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	119.500
Wilcoxon W	290.500
Z	-2.919
Asymp. Sig. (2-tailed)	.004

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	1.00	18	18.00	324.00
	4.00	32	29.72	951.00
	Total	50		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	153.000
Wilcoxon W	324.000
Z	-3.017
Asymp. Sig. (2-tailed)	.003

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	1.00	18	15.69	282.50
	5.00	29	29.16	845.50
	Total	47		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	111.500
Wilcoxon W	282.500
Z	-3.549
Asymp. Sig. (2-tailed)	.000

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	2.00	16	21.38	342.00
	4.00	32	26.06	834.00
	Total	48		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	206.000
Wilcoxon W	342.000
Z	-1.172
Asymp. Sig. (2-tailed)	.241

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	2.00	16	21.38	342.00
	4.00	32	26.06	834.00
	Total	48		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	206.000
Wilcoxon W	342.000
Z	-1.172
Asymp. Sig. (2-tailed)	.241

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	2.00	16	18.63	298.00
	5.00	30	25.41	737.00
	Total	45		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	162.000
Wilcoxon W	298.000
Z	-1.768
Asymp. Sig. (2-tailed)	.077

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of partnerships	3.00	25	25.38	634.50
	5.00	30	29.33	850.50
	Total	54		

Test Statistics(a)

	No# of partnerships
Mann-Whitney U	309.000
Wilcoxon W	634.500
Z	-.987
Asymp. Sig. (2-tailed)	.324

a Grouping Variable: Adoption stage

Appendix 7: Testing Hypothesis 5a - Partnerships in legitimization and competition

Ranks

	Adoption periods	N	Mean Rank	Sum of Ranks
Partnerships	1.00	59	52.52	3098.50
	2.00	61	68.22	4161.50
	Total	120		

Test Statistics(a)

	Partnerships
Mann-Whitney U	1328.500
Wilcoxon W	3098.500
Z	-2.661
Asymp. Sig. (2-tailed)	.008

a Grouping Variable: Adoption periods

Appendix 8: Testing Hypothesis 8- Network standards across stages

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	1.00	18	17.36	312.50
	2.00	16	17.66	282.50
	Total	34		

Test Statistics(b)

	No# of Standards
Mann-Whitney U	141.500
Wilcoxon W	312.500
Z	-.130
Asymp. Sig. (2-tailed)	.897
Exact Sig. [2*(1-tailed Sig.)]	.932(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	2.00	16	18.94	303.00
	3.00	25	22.32	558.00
	Total	41		

Test Statistics(b)

	No# of Standards
Mann-Whitney U	167.000
Wilcoxon W	303.000
Z	-1.132
Asymp. Sig. (2-tailed)	.258
Exact Sig. [2*(1-tailed Sig.)]	.389(a)

a Not corrected for ties.

b Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	3.00	25	26.40	660.00
	4.00	33	31.85	1051.00
	Total	58		

Test Statistics(a)

	No# of Standards
Mann-Whitney U	335.000
Wilcoxon W	660.000
Z	-1.341
Asymp. Sig. (2-tailed)	.180

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	4.00	32	35.06	1122.00
	5.00	29	26.52	769.00
	Total	61		

Test Statistics(a)

	No# of Standards
Mann-Whitney U	334.000
Wilcoxon W	769.000
Z	-2.106
Asymp. Sig. (2-tailed)	.035

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	1.00	18	19.83	357.00
	3.00	25	23.56	589.00
	Total	43		

Test Statistics(a)

	No# of Standards
Mann-Whitney U	186.000
Wilcoxon W	357.000
Z	-1.253
Asymp. Sig. (2-tailed)	.210

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	1.00	18	19.44	350.00
	4.00	32	28.91	925.00
	Total	50		

Test Statistics(a)

	No# of Standards
Mann-Whitney U	179.000
Wilcoxon W	350.000
Z	-2.502
Asymp. Sig. (2-tailed)	.012

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No# of Standards	1.00	18	22.06	397.00
	5.00	29	25.21	731.00
	Total	47		

Test Statistics(a)

	No# of Standards
Mann-Whitney U	226.00
Wilcoxon W	397.000
Z	-1.006
Asymp. Sig. (2-tailed)	.315

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	2.00	16	18.56	297.00
	4.00	32	27.47	879.00
	Total	48		

Test Statistics(a)

	No# of Standards
Mann-Whitney U	161.000
Wilcoxon W	297.000
Z	-2.336
Asymp. Sig. (2-tailed)	.019

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	2.00	16	21.31	341.00
	5.00	29	23.93	694.00
	Total	45		

Test Statistics(a)

	No# of Standards
Mann-Whitney U	205.000
Wilcoxon W	341.000
Z	-.828
Asymp. Sig. (2-tailed)	.408

a Grouping Variable: Adoption stage

Ranks

	Adoption stage	N	Mean Rank	Sum of Ranks
No of Standards	3.00	25	28.52	713.00
	5.00	29	26.62	772.00
	Total	55		

Test Statistics(a)

	No# of Standards
Mann-Whitney U	337.00
Wilcoxon W	772.00
Z	-.539
Asymp. Sig. (2-tailed)	.590

a Grouping Variable: Adoption stage

Appendix 9: Testing Hypothesis 8a - Standards in legitimization and competition

Ranks

	Adoption periods	N	Mean Rank	Sum of Ranks
Standards	1.00	59	55.25	3259.50
	2.00	61	65.58	4000.50
	Total	120		

Test Statistics(a)

	Standards
Mann-Whitney U	1489.500
Wilcoxon W	3259.500
Z	-1.948
Asymp. Sig. (2-tailed)	.051

a Grouping Variable: Adoption periods

Appendix 10: Testing Hypothesis 9a - Relation of network standards and entry rate

Correlations

			No# of Standards	Entry rate of operators
Spearman's rho	No# of Standards	Correlation Coefficient	1.000	.190(*)
		Sig. (2-tailed)	.	.036
		N	121	121
	Entry rate of operators	Correlation Coefficient	.190(*)	1.000
		Sig. (2-tailed)	.036	.
		N	121	121

* Correlation is significant at the 0.05 level (2-tailed).

Appendix 11: Testing Hypothesis 9b - Relation of partnerships and network standards

Correlations

			No# of partnerships	No# of Standards
Spearman's rho	No# of partnerships	Correlation Coefficient	1.000	.237(**)
		Sig. (2-tailed)	.	.009
		N	121	121
	No# of Standards	Correlation Coefficient	.237(**)	1.000
		Sig. (2-tailed)	.009	.
		N	121	121

** Correlation is significant at the 0.01 level (2-tailed).