

Technology Attribute-Diffusion Pattern Nexus: Evidence from the Early Experiences of 3G Mobile Communications

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ABSTRACT

The diffusion patterns of 3G cellular technologies indicate that the reality is not matching the optimistic estimates of various consulting firms regarding the size of the network. What factors influence the diffusion of rapidly developing network goods? This paper draws upon innovation diffusion literature and the early experiences of 3G mobile technologies to examine the influence of supply-side factors on the 3G diffusion trajectory. We also propose a model that classifies various 3G related attributes in terms of their influence on present utility vs. expected future utility and the mechanism of influence: via 3G device vs. via 3G network. The central argument of this paper is that while the breadth of offers has been wider in 3G compared to lower generation cellular technologies, there has been digression rather than progress on some dimensions (e.g., bulky 3G handsets, very short battery lives, small geographical coverage, and lower network externality effects). The problems are compounded by the lack of strategic pricing and industry-regulator coordinations.

Keywords: 3G mobile communications, diffusion, supply-side, technology attributes, upgradability, utility of network goods

1. INTRODUCTION

The diffusion patterns of 3G cellular technologies indicate that the reality is not matching the optimistic estimates of various consulting firms. The early experience in Europe and Asia-Pacific indicates dismal consumer response to 3G mobile communications. For instance, Hutchison 3G (H3G), which launched 3G services in the UK and Italy in March 2003, had set a target of target of 1 million subscribers in each country by December 2003. The company achieved only 30% of its target in Italy and 21% in U.K. by that time (Table 1).

This paper draws upon innovation diffusion literature and the early experiences in Europe and Asia to explore the connection between attributes of a technology and its diffusion pattern. Although we focus on 3G, the issues examined in this paper have broad implications technology marketers.

2. SUPPLY SIDE OF TECHNOLOGY DIFFUSION: RELEVANT THEORIES

The existing literature indicates that supply side factors that influence diffusion of network goods include price, breadth and depth of technology products, complexity, positioning, government-supplier coordination and modularity and upgradability, degree of supply abundance and expected size of the network (Table 2). It should, however, be noted that these factors are not necessarily orthogonal. In the case of network goods such as 3G mobile communications, some of these

factors are more relevant to the device whereas others are more relevant to the network. These attributes can also have differential impact on the perception of present utility and expected future utility. Table 3 classifies the attributes in two dimensions: device specific vs. network specific and present utility vs. expected future utility.

The demand for a network good is a function of the expected size of the network (Katz and Shapiro 1994). Too small new market may result in the failure of a new technology (Lin 2003). The expected size of the network is a function of various factors including price of the technology product, quality, degree of compatibility with previous generations of technologies, and upgradability.

Suppliers can modify product characteristics and price structure to fit the needs of a market segment (Robertson and Gatignon 1986). The price of a technology influences consumers' adoption timing (Kamakura and Balasubramanian 1988) and the rate of adoption (Jain and Rao 1990) at the micro-level and for a network good, the demand and the market potential (Kalish and Lilien 1986; Katz and Shapiro 1994) at the macro-level. Since the network externality is positively related to the network size, the number of users has a higher significance than the intensity of use for network goods. For networks that require two part fees, a reduction of the fixed component is thus a more appropriate way to stimulate the growth of the network than a reduction in variable costs (Perrot 1995).

Table 1: 3G Mobile networks in selected economies

	Hong Kong	Japan	Italy	U.K.
Launched in	January, 2004	September 2001	March 2003	March 2003
Service provider(s) and technology	H3G (W-CDMA)	DoCoMo (W-CDMA) KDDI (CDMA)	H3G (W-CDMA)	H3G (W-CDMA)
Number of subscribers (Date)	3,000 (February 1, 2004)	DoCoMo: 2 million (January, 2004) KDDI: 13 million (October 2003)	210,000 (December 2003)	300,000 (January 2004)
ARPU		US\$77.8 (October-December 2001)	Euro 79 (2003)	

Mason's (1990) study, on the other hand, provided empirical support that product attributes and not cost affect the adoption decision. For rapidly developing technologies such as mobile phones, modularity and upgradability have a strong impact on the diffusion pattern. Rosenberg (1982) found that if a technology is upgradable, it allows a firm to offer product innovations continually that users can integrate into their current product configuration. He argues that users will be reluctant to purchase products that cannot be upgraded and rapid technological change further

increases the reluctance since their investments become obsolete under such conditions (Rosenberg 1982). Upgradability is found to be one of the major factors that influence the selection of a desktop computer. PC buyers are concerned about the possibility of upgrading the processor, adding the memory, availability of drive bays for additional hard drives (Grier and Bryant 1998). Product standardization and modular upgradability also affect and are affected by network externality and compatibility requirements (Kotabe et al. 1996).

Table 2: Supply side factors influencing the diffusion of network goods

Factor	Impact on innovation diffusion	The case of 3G
Expected size of network (NS)	Influence network externality effects	<ul style="list-style-type: none"> • Incompatibility with lower generation phones and PCs. • Too small coverage in some countries
Modularity and Upgradability (MU) Price (PR)	Allows users to integrate innovations continually Influences: <ul style="list-style-type: none"> • Adoption timing • Rate of adoption • Market potential 	Cellular technologies lack consumer-level upgradability <ul style="list-style-type: none"> • Higher prices. Suppliers focused more on reducing variables prices (VPR).
Number of versions/standards (NV)	Multiple versions/standards increase complexity	Uncertain standards and complexities of 3G applications
Degree of supply-abundance (SA) Depth and breadth (DB) Industry-government coordination (IG)	Slow growing and fast declining diffusion pattern under supply restriction. Increase choice and value Inadequate coordination leads to failure.	Shortage of 3G handsets 3G has a wide breadth of uses <ul style="list-style-type: none"> • Market fragmentation • Supply-side crowd • Unrealistic expectations of governments H3G's confused positioning
Communication/promotion (CP) Other characteristics (OC)	Positioning influences attractiveness.	Size, battery life, reliability of devices and network, etc. H3G's confused positioning
Communication/promotion (CP) Other characteristics (OC)	Positioning influences attractiveness.	Size, battery life, reliability of devices and network, etc.

Modular upgradability and its benefits are also illustrated by Sun's SPARCstation 10 series. SPARCstation enables users to increase system performance by plugging in faster microprocessors and memory modules as they become available. SPARCstation 10 series can also be upgraded easily to multiple processing and other future technologies. The SPARCstation 10 provided integrated services digital

network (ISDN) capabilities as a built-in feature. Moreover, SPARC modules and bus architecture can accommodate advances in microprocessors technology. Sun also offered "no penalty upgrades" to its users--the price of an upgrade plus user investment in an existing system would be equal to the price of a new system (Garud and Kumaraswamy 1993).

Inadequate coordination among firms and governments is another source of failure of a new technology (Lin 2003). The failure will also imply the inappropriateness of the industrial policy to other firms and they can avoid that failure by not following the policy (Lin 2003). The diffusion pattern of telecom-related products is also a function of the focus of national industrial and technological policies on fostering and strengthening this sector (Beise 2001, p. 263).

The degree of supply-abundance also influences the shape of diffusion curves. For instance, Simon and Sebastian (1987) found that a diffusion curve exhibits slow growing and fast declining (that is, negatively skewed) pattern under conditions of supply restriction.

Past research has also found that variety and uncertainty of multiple versions increase complexity (Frizelle 1998). A technology's possibility of forking into numerous versions increases the uncertainty. For instance, UNIX in the 1970s was broken into several proprietary formats (Kogut and Metiu 2001), which increased its complexity.

In the case of radical innovations, firms with greater depth and breadth in their product portfolio tend to be more successful (Sorescu et al. 2003). Broader and deeper product portfolio increases consumer choice and hence value of technologies offered by a company. For instance, breadth of product line is found to be positively related to consumers' workstation purchase decisions (Kaplan 1991).

Suppliers can also influence the adoption rate of a product by communicating ideas through advertising and promotion (Narasimhan and Mendez 2001; Rogers 1995) and setting fashions (Abrahamson 1996). Like all other products underpositioning, overpositioning, confused positioning and doubtful positioning (Kotler 2003, p. 311) will slow down the adoption rate.

Table 3: A two-dimensional representation of supply side factors influencing 3G diffusion

	<i>Present Utility</i>	<i>Expected Future Utility</i>
<i>Device Specific</i>	PR, DB, CP, NV, OC (Size, battery life, reliability of device, etc.).	MU, NV, FPR, OC (Size, battery life, reliability of device, etc.).
<i>Network Specific</i>	PR, DB, CP, OC (e.g., reliability of network).	NS, FPR, OC (e.g., reliability of network).

3. SUPPLY-SIDE FACTORS INFLUENCING THE DIFFUSION OF 3G MOBILE COMMUNICATIONS

3G cellular technologies are characterized by different types of network externality compared to lower generations. Whereas second generation (2G) phones could communicate with first generation (1G) phones

as well as with fixed phones, this is not the case with 3G phones. Only 3G devices can exploit combined voice/picture capabilities of 3G networks and lower generation mobile phones and many PCs could be excluded from such application networks (Lehrer et al. 2002). Limited geographical coverage in most countries has exacerbated the problem. Lack of coverage hindered the initial success of FOMA in Japan, NTT DoCoMo's 3G service launched in October 2001. In Italy and the U.K., H3G's coverage started with half the population (Norton, Leslie P 2002). Even by the early 2004, H3G offered 3G services to only 55% of the Italian population (Taaffe 2004).

In a survey conducted by *ChangeWave Alliance*, the Number 1 concern about 3G services of 18% of the respondents was too expensive services and that of another 4% was too expensive handsets. Consider the prices of 3G handsets. In Korea, SK Telecom and KTF had set the price of 3G handsets from US\$581-\$830 in 2003 (Business CustomWire, December 28, 2003). In U.K., immediately after the launch of 3G services, H3G had to reduce the price of its handsets by half to pounds 199 which was still much higher compared with the "free" phones offered by 2G operators to those signing up to their monthly plans (Economist.com 2003).

Not only the fixed costs but also variables costs of 3G are expensive. Higher average revenue per user (ARPU) of 3G services reflects unattractive variable costs. In Italy, for instance, ARPU from 3G services was Euro 79 per month in 2003 which compares with 2G ARPU of euro27 in Europe (Taaffe 2004). In Japan, NTT DoCoMo reported that the mean 3G revenue per user in April – June, 2002 was \$65.43 a month (Georgi 2002). In July 2003, 3's UK customers spent an average of £45 a month -much higher than its rivals' £25-£35 (Payton and Bowen 2003).

In an attempt to make 3G services more attractive, the operators have reduced variables costs for some attributes. In U.K. a new tariff introduced by Hutchison 3G in June 2003, offered subscribers 500 minutes for \$40 per month, which compares with the plans of the incumbent 2G operators which averages \$72 for 400 minutes (The Economist, September 20, 2003). In Hong Kong, Hutchison offers three basic service plans to customers at monthly charges of US\$34 (Business CustomWire, January 19, 2004). To stimulate 2G consumers to sign up, NTT DoCoMo cut 3G fees by up to 55% for existing subscribers (Kakenaka 2002).

The wide breadth of uses of 3G has not translated into improvement on each dimension. In the *ChangeWave Alliance* survey, 4% respondents were concerned about current technology's capability to carry high-quality calls (Business CustomWire, November 19, 2003). Subscribers complain of lost calls, bulky handsets that

were awkward to handle and inadequate battery life. In Italy, 15% of early customers took their handsets back (Payton and Bowen 2003).

H3G's pre-launch brand-building campaign, designed to "cultivate curiosity" could not achieve its goal (Payton and Bowen 2003). Hutchison also made too many claims and too frequent change of the positioning of its brand, resulting in confused positioning. Hutchison, for instance, first launched a huge advertising campaign promoting the video capabilities and high-speed internet access of 3G handsets. In September 2003, Hutchison started promoting its 3G services as the cheapest ways to make voice calls instead of touting advanced features such as videoconferencing and Web-browsing (The Economist, September 20, 2003, Ramstad et al. 2003). In fact, the killer application of 3G has become voice communications (Payton and Bowen 2003).

In the ChangeWave Alliance survey, the number 1 concern about 3G services of 17% of the respondents was the reliability of technology and equipment (Business CustomWire, November 19, 2003). Many 3G subscribers are reported to carry their 2G handsets as back-ups. Hutchison 3G mobile in Australia received several complaints of calls dropping out not being able to deliver video and Internet service on the 3G handsets (Business CustomWire, December 28, 2003).

The slow growing diffusion pattern of 3G is can also be attributed to the shortage of 3G ready handsets (Business CustomWire, December 2, 2003). Hutchison also failed to launch the pre-pay service due the lack of suitable handsets. Vendors like Nokia, Motorola, and Ericsson could not ease the supply-side bottlenecks to ensure the availability 3G ready handsets for W-CDMA services. Even 2.5G handsets were seriously delayed by Nokia (Reinhardt et al. 2001).

Many operators around the world enjoy supplier-level upgradability in the cellular network. Economies with CDMA-based 2G networks such as South Korea, Brazil, India and Mexico can easily upgrade to 3G in the form of CDMA2000 (The Economist 2002). Thanks to its CDMA-based 2G standard, South Korea was able to launch the 3G network as early as in 2000. Consumer benefit of the supplier-level upgradability in the cellular network, however, has been minimal. Consumers, for instance, are required to buy a new handset for 3G services. 2G handsets thus cannot be upgraded. There is thus no "no penalty upgrades" (Garud and Kumaraswamy 1993) in cellular networks.

In the 3G mobile industry, there seems to be the lack of proper coordination among governments and mobile players. First, the lack of coordination resulted in market fragmentation. The European Commission for instance, allowed individual governments to make their own decision on 3G spectrum. Such move converted

otherwise homogeneous European cellular market into different licensing regimes, networks and services (Wallage 2000).

Second, cellular operators got into heavy debt because of expensive 3G licenses postponed 3G investments. For instance, Vodafone paid about £ 15 billion to acquire 3G mobile licenses in the U.K., Germany, Italy, Holland and Spain, which doubled its debt level to GBP 13.2 billion in November from GBP 6.64 billion in March 2000 (Naik 2000). Many operators asked governments to ease various requirements and reduce costs (Latour 2002). A petition signed by 2000 European businessmen in April 2001 asked governments in Germany, the U.K. Italy and other countries to return 3G auction proceeds to operators and conduct new auctions (Ryan 2001).

Third, the lack of government-industry coordination also resulted in supply-side crowd in the 3G industry. For instance, consider the European 3G cellular market. In September 2002, Germany had four 3G competitors, the U.K. had six, the Netherlands, Sweden, Finland and Italy each had five, and Spain had four (Latour and Delaney 2002).

These problems are compounded by a lack of policies to foster 3G sector and unrealistic expectations from national governments. For instance, Hutchison faced problem in getting the building permits needed to set up base stations for 3G in Sweden. The Swedish government also specified the requirement of 3G coverage of 99.9% of the Swedish population (Latour 2002).

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