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The Resource-Based View of Competitive Advantage in Two-Sided Markets

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ABSTRACT Using two-sided markets as a specific market context, we show that cross-group network effects can turn the participants of a two-sided network into critical resources. In two-sided markets such as payment cards and personal computer operating systems, two groups of agents interact with each other via a common network platform; the value of joining the network for agents in one group depends on the number of participants in the other group. In these markets, resource heterogeneity is represented by different sizes of existing networks; resource accumulation possesses all five characteristics of asset-stock accumulation summarized by Dierickx and Cool. The unique resource accumulation process provides an isolating mechanism for large networks to sustain their resource and competitive advantages. Using two dynamic systems models, we show that resource heterogeneity (i.e. varying initial network sizes) is a source of sustained competitive advantage for two-sided networks and has significant impact on long-term competition dynamics. The findings illustrate the importance of incorporating market context in the research of the resource-based view of competitive advantage.

INTRODUCTION

The resource-based view (RBV) has become a major theory in strategy research since the 1980s (Barney, 1991; Grant, 1991; Wernerfelt, 1984). It provides a unique perspective at the resource-level and enterprise-level (Peteraf and Barney, 2003), and complements other schools such as industry analysis (Porter, 1980) and transaction cost economics (Williamson, 1991). RBV shifts the attention of strategy researchers from external (market or industry) factors to firms' internal resources. It establishes resource heterogeneity as one of the most important sources of inter-firm profitability differences (Barney, 1991; Peteraf, 1993) and identifies various 'isolating mechanisms' (Rumelt, 1984) that enable firms with superior resources to maintain their resource advantages and sustain their competitive advantages (Barney, 1991, 1997; Dierickx and Cool, 1989; Ghemawat, 1986; Lippman and Rumelt, 1982).

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Isolating mechanisms may be caused by property rights, reputation, information asymmetries, causal ambiguities, learning curve, switching cost, search cost, firm size and economies of scale (Ghemawat and Spence, 1985; Klepper, 1996; Rumelt, 1987). Dierickx and Cool (1989) summarized five characteristics of resource accumulation process that may create an isolating mechanism. Since firms facing incomplete factor markets have to accumulate critical resources internally, rather than buying them in the factor market, the sustainability of a firm's competitive advantage hinges on the substitutability and imitability of such critical assets. An inimitable asset accumulation process may be characterized by one or more of the following features: *time compression diseconomies*, *asset mass efficiencies*, *inter-connectedness*, *asset erosion* and *causal ambiguity* (Dierickx and Cool, 1989).

In this paper, we show that *network effect* is another cause of the isolating mechanism in certain market contexts. The resource involved is unconventional as compared to those discussed in the RBV literature. As most researchers view resources as a firm's internal possessions, we show that customer relationships, which are usually viewed as external to the firm, may become its *critical resources* (Peteraf and Barney, 2003) within certain market contexts. The findings also indicate that market context, which does not have an explicit function in the RBV literature, plays an important role in determining whether certain factors are critical resources to a firm.

Wernerfelt (1984) wrote in the very beginning of his seminal paper: 'For the firm, resources and products are two sides of the same coin', which called for a balanced perspective between resources and products (or markets). However, as Priem and Butler (2001a, 2001b) point out, many RBV analyses were 'resource only' models. Some recent RBV research suggests that incorporating market contexts into RBV may generate better insight and guidance for both theory building and managerial practice. For example, Eisenhardt and Martin (2000) find that dynamic capabilities take a different form in different market contexts: *high-velocity markets* vs. *moderately dynamic markets*, and RBV encounters a boundary condition in *high-velocity markets*.

Bringing market context into RBV analysis helps determine the value of a firm's resources, which 'must be understood in the specific market context within which a firm is operating' (Barney, 2001). Resources that are valuable in certain markets or industry might not be equally valuable in others. Therefore, putting RBV in specific market contexts will reveal the true relationships among resources, products and competitive advantages. For example, in a similar attempt to bring market context or external environment factors into RBV, Miller and Shamsie (1996) show that in a stable and more predictable market environment, property-based resources in the form of exclusive long-term contracts with stars and theatres have more impact on the financial performance of US film studios, while knowledge-based resources in the form of production and coordinative talent and budgets boost the performance more in more uncertain market environments.

In the present paper, we consider a specific market context: the 'two-sided' market (Armstrong, 2006; Rochet and Tirole, 2003; Rysman, 2004; Wright, 2004), which spans over markets such as payment card, yellow directory, personal computer operating system and video game console markets (Table I). In such a market, two groups of agents interact with each other via a common network platform; the value of participation in the network for agents in one group depends on the number of participants in the other

Table I. Examples of two-sided networks

Network	*Two sides*	*Platform sponsors*
Payment card	Merchants/cardholders	VISA, MasterCard, Amex, Discover
Video games	Game developers/players	Sony, Microsoft, Nintendo
PC OS	PC users/application developers	Microsoft, Apple
Yellow directory	Consumers/merchants (advertisers)	SBC, Verizon, etc
VCR standard	Consumers/content providers	JVC (VHS), Sony (Betamax)
Shopping malls	Shoppers/retailers	Mall owners or developers
Online auction	Sellers/buyers	eBay, Amazon.com, Yahoo!
Nightclubs	Male patrons/female patrons	Nightclub owners
Web browsers	Websites/internet users	Microsoft IE, Netscape, Mozzila, Firefox, etc
High definition DVD standard	Consumers/content providers	Sony (Blue-ray), Toshiba (HD-DVD)
Language	Speakers/publishers, media	Government or the Society
Typewriter keyboard	Typewriter users/offices	Remington, Dvorak
Newspapers	Subscribers/advertisers	*New York Times*, etc
TV channel	Watchers/advertisers	ABC, NBC, CBS, etc
56K dial-up modem	Internet service providers/ internet users	International Telecommunications Union, US Robotics, Rockwell

group. For example, in the payment card network, consumers and merchants are the two sides of the market. If more merchants accept VISA card, it will be more convenient for VISA cardholders to pay for their purchases. On the other hand, if more consumers carry VISA cards, merchants will find it more profitable to accept VISA cards as it would generate extra sales from these cardholders. Thus the decision for a consumer to become a VISA cardholder imposes positive externalities to merchants, while the decision for a merchant to accept VISA card imposes positive externalities to VISA cardholders.

We show that *cross-group network effects* can turn network participants, who are customers of a two-sided network, into critical resources that bring sustained competitive advantages to the network. Using dynamic systems models, we show that the resource accumulation process in such markets satisfies all five characteristics summarized by Dierickx and Cool (1989) and creates an isolating mechanism that provides both ex ante and ex post limits to competition (Peteraf, 1993).

In addition, we show that, even within two-sided markets, a refinement of the market context into sub-categories reveals varying impact of resource heterogeneity. To be more specific, the resources must be valued differently in two different types of two-sided markets: they are more critical in 'single-homing' markets than in 'multi-homing' markets. The managerial implication is also different. In multi-homing two-sided markets, small networks may position themselves as market followers, even if their profitability is not as good as the market leader. However, such follower strategy is hard to sustain in single-homing markets because the winner will likely take all in such markets.

The paper is organized as follows. We introduce two-sided markets in detail in the next section. In the third section, we present a simple dynamic system model to describe network growth and competition dynamics for independent networks. The resource accumulation process in this type of market is shown to satisfy the five characteristics summarized by Dierickx and Cool (1989). In the following section, we present a dynamic system model for competing two-sided networks where participants switch between competing networks based on the magnitude of net benefits. We discuss the varying value of resource heterogeneity under 'single-homing' and 'multi-homing' market context in this section. In the final section, we summarize and discuss the contribution and limitation of our research as well as future research direction.

TWO-SIDED MARKETS

By definition, there are two groups of agents in a two-sided market (e.g. the cardholder and merchants in the payment card network). Besides the two sides, there is a third party who creates and operates the network. We call it 'network platform sponsor'. VISA, MasterCard and American Express are representative network sponsors of the US payment card network. As shown in Table I, in most two-sided markets, there are multiple networks that compete against each other, such as the payment card and the PC operating system networks. The network platform sponsors are responsible for designing growth and competition strategies in order to survive and grow. Therefore, the unit of analysis in this paper is the network sponsor (e.g. VISA card network) rather than its participants (e.g. the merchants or card users). Similarly, the competitive advantage refers to that of the network rather than of its participants.

Recent research on two-sided markets is an extension of research on network effects. According to Katz and Shapiro (1985), 'There are many products for which the utility that a user derives from consumption of the good increases with the number of other agents consuming the good'. This definition refers primarily to network effect within one side of the market. For example, telephone subscribers will derive more utility from the telephone network if there are more subscribers. A subscriber may find the telephone useless if nobody else has a phone. We call this type of network effect *within-group effect*.

Literature on two-sided markets distinguishes *cross-group effects* from within-group effects and focuses on the former. In fact, positive cross-group network effects characterize and define two-sided markets. Rochet and Tirole (2003) and Armstrong (2006) provide extensive reviews of the economics literature, which has been growing rapidly in the past few years. The literature covers two-sided markets such as payment card system (Rochet and Tirole, 2002; Schmalensee, 2002; Wright, 2004), telecommunication (Armstrong, 2002), yellow directory (Rysman, 2004), matchmaker (Caillaud and Jullien, 2003) and shopping mall (Pashigan et al., 2002). The economics literature focuses on the entry and pricing decision of network sponsors and their significance on market efficiency and social welfare. Most economics papers on this topic use static equilibrium models or game theory models. Recently, Sun and Tse (2007a, 2007b) use the dynamic system and differential games model to study business strategies in two-sided markets. Following a similar approach, we take a managerial perspective and study what enables a network to enjoy sustained competitive advantage in two-sided markets.

A DYNAMIC SYSTEM MODEL FOR INDEPENDENT NETWORKS

In this section, we develop a simple dynamic system model to study the growth of a network in a two-sided market. To keep the model manageable without loss of generality, we only capture the essence of two-sided markets, namely the cross-group network effects, in the model.

Basic Model Setting

For simplicity of presentation, we assume there are infinite numbers of merchants and consumers who represent the two sides of the market. We denote by X the number of merchants who have joined the network, and by K the number of consumers in the network. Every in-network consumer on average makes one transaction with each of the in-network merchants. So the total number of in-network transaction per in-network consumer is X and the total number of in-network transaction per in-network merchant is K.

We assume a consumer derives an incremental benefit of \$$b$ per in-network transaction as compared to out-of-network transaction (e.g. the convenience for a cardholder to use the card instead of cash, the extra credit a card user obtains from a credit card). Similarly, a merchant gains \$$r$ of incremental profit from an in-network transaction as compared to an out-of-network transaction (e.g. extra sales to card users due to the extra credit provided by the card network, the reduction in the risk of receiving counterfeiting bills). The network sponsor charges a per-transaction fee of \$$z_v$ to consumer participants and \$$c_v$ to merchant participants, in addition to a lump-sum fee of \$$z_f$ to these consumers and \$$c_f$ to these merchants. Therefore, for a consumer, the net benefit of joining the network is:

$$NB_C = (b - z_v)X - z_f. \tag{1}$$

For a merchant, the net benefit of joining the network is:

$$NB_M = (r - c_v)K - c_f. \tag{2}$$

The positive cross-group network effects can be seen from (1) and (2) as increases in the number of network participants on one side (K or X) increase the net benefit to participants on the other side.

Network Growth Dynamics

Consumers and merchants are willing to join the network if the net benefit of joining the network is positive. The larger the benefit, the stronger the incentive to join the network. However, due to incomplete information, technical constraints, consumer inertia or other possible reasons, not all consumers or merchants who are willing to join the network will be able to do so immediately. At the individual participant level, we do not assume heterogeneity in participants' preferences. Instead, we assume the order of participation to be purely random for reasons mentioned above (in other words, who joins the network first and who joins later is a purely random event at the micro-level). But at the macro level, the change in the number of in-network consumers or merchants follows a diffusion process and the speed of diffusion is positively related to the net benefit of joining the network. This approach differs from the neoclassical economics modelling, which typically assumes heterogeneous preferences for individuals as well as from the product diffusion modelling in the marketing literature, which usually distinguishes early adopters from followers. However, it is a typical approach in dynamic systems modelling because, in many cases, modellers are more interested in the long-term system behaviour than in the exact diffusion path, which applies to our study.

Assuming that the adoption occurs at a pace proportional to net benefits defined in (1) and (2), we can use the following two-dimensional linear dynamic system to describe the diffusion process:

$$\begin{cases} \dot{K}(t) = \alpha[(b - z_v)X(t) - z_f] & (3) \\ \dot{X}(t) = \beta[(r - c_v)K(t) - c_f] & (4) \end{cases}$$

where $X(t)$ is the number of merchant participants in the network at time t and $K(t)$ is the number of consumer participants at time t. $\dot{X}(t)$ refers to the change (i.e. increase or decrease) in the number of merchant participants at time t, and $\dot{K}(t)$ refers to the change in the number of consumer participants at time t. Meanwhile, the parameters α, β measure the speed of diffusion per unit of NB_M and NB_C respectively, and both are positive numbers.

It is clear that the diffusion process described in the system (3)–(4) consists of two parts: asset stock and asset flow (Dierickx and Cool, 1989). The variables $X(t)$ and $K(t)$ represent asset stock at time t while $\dot{X}(t)$ and $\dot{K}(t)$ represent asset flow at time t. Starting from any stock of asset (i.e. network participants), equations (3) and (4) determine whether there will be more potential merchants and consumers joining the network (if $NB_C > 0$ and/or $NB_M > 0$) or existing participants will exit from the network (if $NB_C < 0$ and/or $NB_M < 0$). If the network has a large initial size, the former case is more likely to happen and there will be asset inflow. Asset stock will thus increase in the next period or instant, as described in equations (3) and (4). However, if the initial network size is small, it is likely that asset outflow will occur and asset stock will decrease in the next period.

In systems (3) and (4), we assume that $b - z_v > 0$ and $r - c_v > 0$ because otherwise there will never be a chance for $NB_M > 0$ or $NB_C > 0$, no matter how large $K(t)$ or $X(t)$ is. In other words, if the network does not provide any positive net benefit per transaction, nobody will ever be willing to join it and the network will never exist in the market.

It can be shown that the dynamic system (3)–(4) has a unique equilibrium ($\bar{X}$, $\bar{K}$), which is a saddle point (Sanchez et al., 1988). As a result, there is a saddle path separating the system's long-term behaviour: if the system starts above the saddle path, it will grow towards infinity; if it starts below the saddle path, it will eventually die out; only if it starts on the saddle path, will it converge to the equilibrium point. The dynamics of the system are illustrated in the phase diagram (Figure 1).

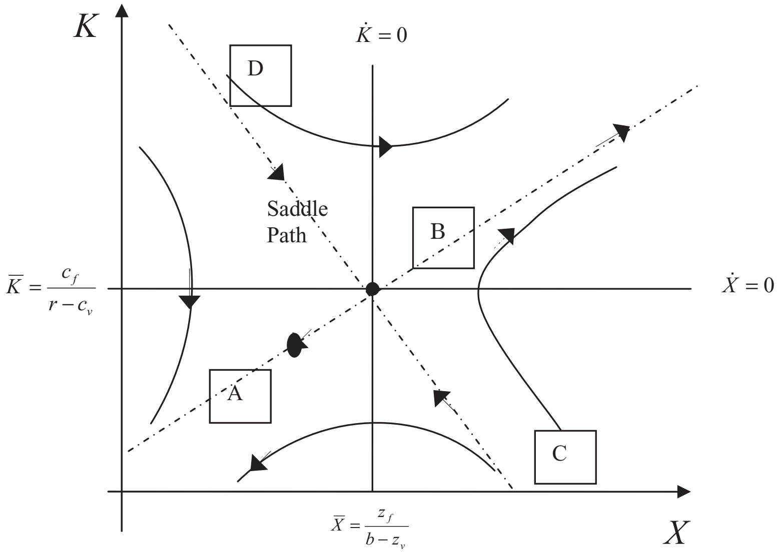


Figure 1. Phase diagram for network growth

Customers as Critical Resources

The phase diagram shows that the initial condition is critical to a network's growth. A network with few participants, such as point A in Figure 1, cannot achieve sustainable growth because the small number of participants on one side of the market cannot provide large enough benefit to attract or keep participants on the other side. However, if a network has gathered enough participants on both sides at the very beginning, such as point B in Figure 1, it will grow forever with its own momentum.

Such observations indicate that participants of a two-sided network, which are usually thought of as the customers, are also critical resources of the network. According to Peteraf and Barney (2003), critical resources are 'those factors that have a significant positive effect on either the economic costs or perceived benefits associated with an enterprise's products'. They are not only 'essential to the firm's effort to generate differentially greater value', but also scarce either temporarily or permanently. In two-sided markets, existing customers are factors that create positive impact on the perceived benefits of the network platform, due to the positive cross-group network effects. As shown in the net benefit functions (1) and (2), the number of existing consumer participants affects the perceived benefits of joining the network to all existing and potential merchant participants, and the number of existing merchant participants affects the perceived benefits of joining the network to all consumer participants.

The scarcity of the resources is reflected by the increasing benefit functions: the higher the existing participants on either side, the higher the net benefit for existing and potential participants on the other side. Since the relationship is increasing, the resources (i.e. existing participants) are always insufficient at any instant of time as compared to the potential demand for them.

It is important to note that, although we assume there are infinite numbers of potential network participants (namely, consumers and merchants), it does not conflict with the scarcity assumption in two-sided networks (namely, existing consumer and merchant participants). The key point is that, until a consumer or merchant joins a network, he/she cannot be treated as the resource of network. This suggests that it is the 'membership' that distinguishes network participants from potential participants, which converts external factors into internal resources. Therefore, the resources of two-sided networks (i.e. network participants) are also scarce as compared to its potential participant pool.

Therefore, resource heterogeneity, which is central to RBV, is reflected in two-sided markets by the size differences of competing networks. A network with a larger number of participants on the two sides is able to generate higher values to both existing and potential participants than those with smaller sizes, *ceteris paribus*. As a result, a large network enjoys competitive advantage, both in terms of growth and in profit (or total rent), over small networks. To see this, consider three networks with different initial sizes in a two-sided market. Network 1 has 60 consumer and 40 merchant members, network 2 has 50 consumer and 30 merchant members, and network 3 has 20 consumer and 10 merchant members. Assuming they all set the fee and benefit parameters at the same levels, then the only differences among them are initial sizes. For certain parameter values, the growth trajectories are illustrated in Figure 2, where initial gaps among the three networks increase over time. In particular, network 3 failed to survive because its initial size is so small that no participant is willing to join and/or stay in the network. In other words, the initial differences in resource endowment are not only preserved but also enlarged forever.

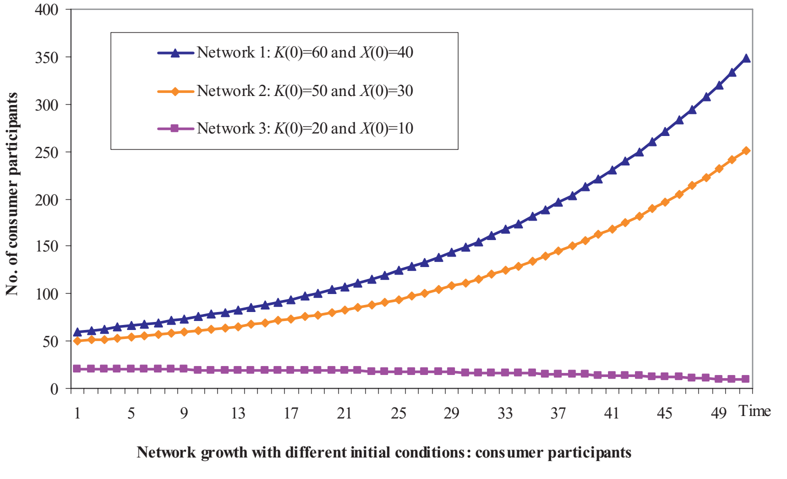


Figure 2. Network growth with different initial conditions

Note: The following parameter values are assumed in the simulation of Figure 2 and Figure 3: $r = b = 1$, $z = 5\%$, $z_f = 10$, $c_y = 10\%$, $c_f = 20$, $\alpha = 0.05$, $\beta = 0.05$

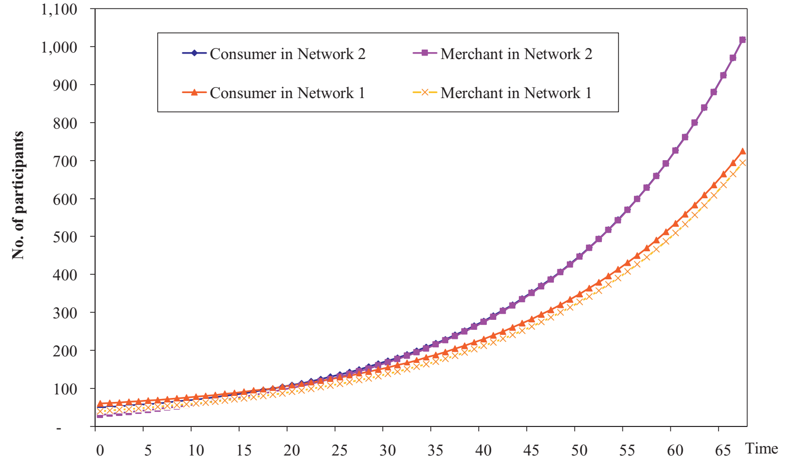
Resource Accumulation Process

The simulation shows that, under the functional forms specified in (3)–(4), resource heterogeneity is maintained permanently among the competing networks shown in Figure 2. Therefore, the resulting competitive advantage is sustainable. To understand what isolating mechanism is involved in maintaining resource advantage, we study the resource accumulation process using the framework by Dierickx and Cool (1989).

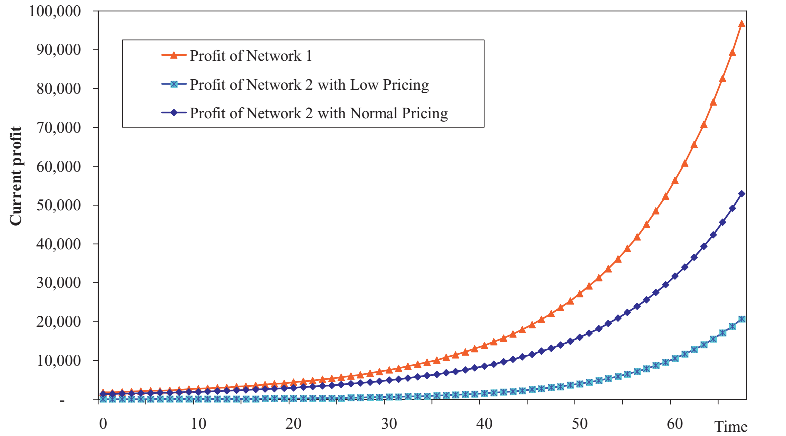
The existence of a saddle path (as shown in Figure 1) for the dynamic system (3)–(4) indicates that there is a critical mass of hurdles that a two-sided network needs to overcome in order to achieve sustainable growth. In other words, there are *asset mass efficiencies* in the accumulation of network participants. According to Dierickx and Cool (1989), asset mass efficiencies exist when 'historical success translates into favorable initial asset stock positions which in turn facilitate further asset accumulation'. It is worth noting that, in two-sided markets, asset mass efficiencies overlap with *interconnectedness*, which refers to the phenomenon that 'accumulating increments in an existing stock may depend not just on the level of that stock, but also on the level of other stocks' (Dierickx and Cool, 1989). It can be seen from equations (3) and (4) that the flow of one asset (say, new merchant participants $\dot{X}(t)$) at any time t is positively related to the stock of the other asset (correspondingly, existing consumer participants) at that time: more participants on one side will result in faster growth in the number of participants on the other side. While in the RBV literature interconnectedness only refers to one-way dependence (i.e. one asset depends on the other, but not the other way around), cross-group network effects create a two-way feedback cycle and thus lead to 'two-way interconnectedness'.

Because of asset mass efficiency and interconnectedness, potential entrants to two-sided markets will face greater difficulties in surviving as network sponsors. Unless they gather enough initial participants on both sides, they cannot survive even if there is no reaction or retaliation from incumbents. Therefore, as a critical mass hurdle to potential entrants, asset mass efficiency and interconnectedness help protect incumbents from potential competition of new entrants.

The accumulation of network participants also demonstrates *time compression diseconomies* because competitors need to sacrifice profitability in attempts to narrow the resource gap in a shorter time. To see this, consider the scenario where a small network wants to catch up with a large one. Since fees can be adjusted to change the dynamics of network growth (Sun and Tse, 2007b), a small network may lower fees in order to catch up with larger networks. But it will incur *time compression diseconomies*: the faster the growth a network wants to achieve by lowering fees, the lower its profit. This is shown by the simulation in Figure 3 where a small network manages to catch up with a large network by lowering the fees charged to both merchants and consumers.[1] Although the small network can surpass the large network in size within 25 periods, its undiscounted current period profits are consistently lower than the large network until period 267 (not shown in Figure 3b due to large scale). If discounted cumulative profit is used, the time horizon required for the small network to exceed the large one will be even longer. Time compression diseconomies are reflected by the long-lasting gaps between the current profits for network 2 with normal pricing and with low pricing: network 2 has to sacrifice



(a) Network growth with different pricing strategies and initial conditions



(b) Network profits with different pricing strategies and initial conditions

Figure 3. Network growth and profits with different pricing strategies and initial conditions
Note: The following parameter values are used for network 1:

$$X(0) = 60, K(0) = 40, r = b = 1, z_v = 5\%, z_f = 10, c_v = 10\%, c_f = 20, \alpha = 0.05, \beta = 0.05;$$

The following parameter values are used for network 2 with low pricing:

$$X(0) = 50, K(0) = 30, r = b = 1, z_v = 1\%, z_f = 0, c_v = 1\%, c_f = 0, \alpha = 0.05, \beta = 0.05.$$

The following parameter values are used for network 2 with normal pricing:

$$X(0) = 50, K(0) = 30, r = b = 1, z_v = 5\%, z_f = 10, c_v = 10\%, c_f = 20, \alpha = 0.05, \beta = 0.05.$$

huge amount of profits for a long period of time in order to catch up with network 1 in size (i.e. in the critical resource).

Since asset stocks such as physical plant and equipment will generally depreciate or 'decay' over time, a firm's resources will erode if no maintenance or reinvestment is done. Firms with resources subject to high decay rate are thus hard to sustain their resource advantages, unless the 'maintenance' cost is low. This property is termed as *asset erosion*. The dynamic system model (3)–(4) implies that the assets of a two-sided network, namely the merchant and consumer participants, will erode only when net benefits (NB_C and NB_M in (1) and (2)) are negative. This is likely to happen only when the size of the network is small. In that case, asset erosion will make the network even smaller and thus NB_C and NB_M more negative, which translates into even faster asset erosion. On the other hand, if a network is large enough to generate positive benefits to participants on both sides, its assets will grow rather than erode. As the network grows, the positive net benefits will become even larger, translating into even faster growth. Therefore, in two-sided markets as modelled in (3)–(4), asset erosion takes an asymmetric form: the assets will erode at an increasing rate if the network starts below the saddle path as shown in Figure 1, but will grow at an increasing rate if it starts above the saddle path. Such an asymmetric pattern indicates that the resource advantage enjoyed by a large network can be easily maintained over smaller networks.

Causal Ambiguity

When asset stock accumulation is stochastic and discontinuous, the underlying process may be hard to understand and control. This is termed as *causal ambiguity* (Lippman and Rumelt, 1982) since it is unclear what helps one firm to successfully accumulate certain critical resources. Therefore, 'imitation of those stocks by other firms becomes next to impossible' (Dierickx and Cool, 1989). The random walk model in Denrell (2004) provides one example of causal ambiguity. The persistent resource heterogeneity is found to be a result of pure random events, which is out of the control of both the firm and its competitors. It is to some degree 'luck' that determines which firm achieves sustained competitive advantage when resource accumulation is purely random.

In a dynamic system model, explicit functional forms of the differential equations are usually assumed. Basic understanding of the resource accumulation process needs to be in place before we can build the model. Thus causal ambiguity must be absent if we use this modelling approach. However, causal ambiguity may still arise, not because the process is inherently stochastic and incomprehensible, but because firms may fail to correctly understand the specific market context and the underlying resource accumulation process. For example, when Apple succeeded in its Apple II computer in the late 1970s, it might have attributed its success to product superiority, innovation capability and/or brand name, instead of realizing that the open system of Apple II had created a two-sided market where third-party software developers had written over 500 application software programs for this operating system (Shy, 2001). Due to incorrect judgment of the cause of its success in Apple II, Apple introduced Macintosh in 1984 with a proprietary operating system that discouraged third-party software developers to write applications for it. With limited application software, the value of Macintosh to computer users was significantly reduced. In summary, Apple threw away the two-sided market network it had already created for Apple II when it introduced Macintosh, and created a platform with a limited number of participants on one side. Without viewing the operating system (OS) market as a two-sided market and without correct understanding of the unique market dynamics, the causes for Apple's success and failure may be thought 'ambiguous'.

Though such 'causal ambiguity' differs from the notion that is commonly referred to by RBV researchers, it does cause serious problems to strategy formulation. Even IBM suffered from such 'causal ambiguity'. Leveraging on its brand, relationship and financial resources, IBM successfully launched its PC business in 1981 by assembling an ally for its 'IBM-compatible' PC, including Microsoft (operating system), Intel (microprocessor) and third party software developers (application software including Lotus 1-2-3). The availability of application software, especially Lotus 1-2-3, helped IBM PC to gain popularity in the market. By 1985, IBM had 80 per cent of the market share in the PC market. As the co-sponsor of the DOS network (with Microsoft), IBM had created a two-sided market and became both a network sponsor and a distributor (PC maker). However, IBM might not have correctly understood its role in this two-sided market. In 1985, it renegotiated its rights over DOS with Microsoft and gave up its role of a network sponsor (i.e. royalties on DOS) in exchange for free installation of DOS on IBM manufactured PCs. In 1987, it launched a new proprietary operating system called OS/2, which did not fare well because little software was available to use on this OS due to its incompatibility with DOS. As a result, IBM suffered huge losses in both market share and profit. In 1990, IBM's market share in the PC market dropped to 14 per cent. In 1992, the company lost $5 billion in profit (Carrol, 1993).

These cases indicate that incorrect understanding of the market context and resource accumulation process can be detrimental to a firm's business, even for those with strong brand name, innovation capability and financial resources. Both Apple and IBM may have incorrectly attributed their successes in earlier products to factors other than their relationship resource with two-sided market participants. They were unable to recognize that they were operating in a two-sided market and the cross-group network effects between the consumers and software developers were critical to the success of their OS network. If they had been able to eliminate such 'causal ambiguity', they might have pursued a different strategy and the PC market may look quite different today.

Discussion

We have shown that positive cross-group network effects can turn the participants (or the existing customers) of a two-sided network into its critical resources. Such resource advantages can allow a large network to earn 'quasi-rents' (Peteraf and Barney, 2003) as compared to smaller networks. The resource accumulation process demonstrated for two sided markets creates an isolating mechanism that limits competition both ex ante and ex post (Peteraf, 1993), allowing larger networks to enjoy sustained competitive advantage.

The findings illustrate the importance of incorporating market context in RBV analysis. In most markets and industries, customers are external market factors which cannot be viewed as resources of any producer, because they have no direct positive effect on the economic costs or perceived benefits associate with the products. However, in two-sided markets, existing customers, as the participants of a two-sided network, are shown to be critical resources that give the network sustained competitive advantage or disadvantage, depending on its initial size. Therefore, it is an important first step to identify market context before RBV analysis is conducted. Otherwise, it may lead to incorrect identification of critical resources, which may lead to business failures that Apple and IBM had experienced.

In the dynamic system model (3)–(4), we have assumed that the number of potential participants is infinite. This allows the exponential growth of the network to last without a boundary: the system will eventually explode if it ever passes the saddle path. While this assumption may seem unrealistic, it is not an essential one that affects our findings on asset-stock accumulation of a two-sided network. In fact, if we were to assume that there are finite potential participants, our system can be easily modified accordingly. In that case, the long-term system dynamics suggest that the network will grab 100 per cent of the market share if it ever surpasses the saddle path, and all other characteristics of asset-stock accumulation remain unchanged. However, the modification does make the dynamic system model much more tedious to solve. Since our main points are well presented by the simple model in (3)–(4), we decided to avoid these complications.

Even if there are infinite potential participants of the network, the exponential growth of the network may be limited by other factors such as competition among participants. This is called *congestion effect* in the two-sided market literature (Rysman, 2004) and it represents negative network externalities among the participants on the same side of the market. Sun (2007) finds that when such negative externalities exist, the growth of a two-sided network has a finite limit.

A DYNAMIC SYSTEM MODEL FOR SINGLE-HOMING NETWORKS

In the simulation scenarios shown in Figures 2 and 3, we have assumed that the competing networks are independent of each other and there is no interaction among them. In other words, network participants may join multiple networks without having to switch between networks. However, in reality, networks compete for participants. It is possible that each individual participant may choose to join only one network or multiple networks. In the two-sided market literature, the former scenario is termed *single-homing* and the latter *multi-homing* (Rochet and Tirole, 2003; Sun and Tse, 2007a). The simulations in the previous section are based on the multi-homing scenario where a network is allowed to sign up participants from competing networks without requiring them to give up memberships in the rival networks. This assumption allows mutual independence of the competing networks.

Multi-homing is a common phenomenon in many two-sided markets, including payment card, yellow directory, online auction site, etc. The findings of the dynamic systems model in this section suggest that multiple networks may coexist, although some networks can enjoy sustained competitive advantage. For example, in the payment card market, four major systems coexist: VISA, MasterCard, American Express and Discover. In yellow directory markets, multiple directories exist in almost every local market, with the one published by the local telephone company dominating the market.

On the other hand, single-homing is also widely seen in two-sided markets. For example, the VCR standard market is two-sided, where most consumers purchase only one format (Beta or VHS) on one side and most content providers sell the contents in only one format on the other side. Similarly cases exist in markets such as typewriter keyboard design, PC OS, video game console, etc, although the degree of single-homing varies across these markets. In the single-homing scenario, participants give up their membership in one network before joining the other. Correspondingly, competing networks will attract participants from each other, thus creating the 'churn' of customers. To understand such competition dynamics, we now present a model for the single-homing scenario.

Model Setting

Assume there are two competing networks and infinite numbers of potential participants in the market. We denote by $X_i(t)$ and $K_i(t)$ the numbers of existing merchant and consumer participants in network i ($i = 1, 2$) at time t, respectively. Under the single-homing scenario, we assume that each consumer participant in network i will on average make one transaction with each of the merchant participants in the same network, but has no transaction with merchant participants in the competing network. So the total number of in-network transaction per consumer in network i is X_i and the total number of in-network transactions per merchant participant in network i is K_i.

Merchant participants benefit from joining the network by reaping an incremental profit of $\$r_i$ per transaction made through network i. They incur a fixed cost of $\$\,c_f^i$ for joining network i and a variable cost of $\$\,c_v^i$ per transaction through that network. Consumer participants derive incremental benefit of $\$b_i$ per transaction via network i, as compared to out-of-network transactions. However, they are charged a lump-sum fee of $\$\,z_f^i$ and per-transaction fees of $\$\,z_v^i$ for transactions in network i.

An out-of-network consumer is willing to join a network if the net benefit of joining the network is positive, i.e. if

$$\mathcal{NB}_C^i = X_i(b_i - z_v^i) - z_f^i \geq 0 \quad i = 1, 2.$$

Similarly, out-of-network merchants are willing to join a network if the latter provides a positive net benefit, i.e. if

$$\mathcal{NB}_M^i = K_i(r_i - c_v^i) - c_f^i \geq 0 \quad i = 1, 2.$$

We also assume that consumers in network 1 have incentives to switch to network 2 if $\mathcal{NB}_C^2 \geq \mathcal{NB}_C^1$, and vice versa. Merchant participants in network 1 have incentives to switch to network 2 if $\mathcal{NB}_M^2 \geq \mathcal{NB}_M^1$, and vice versa.[2] The adoption decision logics for both consumer and merchant participants are illustrated in Figure 4.

System Equilibrium

The decision logic in Figure 4 leads to the following dynamic system:

$$\begin{cases} \dot{K}_1 = \alpha[X_1(b_1 - z_v^1) - z_f^1] + \gamma\{[X_1(b_1 - z_v^1) - z_f^1] - [X_2(b_2 - z_v^2) - z_f^2]\} & (5) \\ \dot{K}_2 = \alpha[X_2(b_2 - z_v^2) - z_f^2] + \gamma\{[X_2(b_2 - z_v^2) - z_f^2] - [X_1(b_1 - z_v^1) - z_f^1]\} & (6) \\ \dot{X}_1 = \beta[K_1(r_1 - c_v^1) - c_f^1] + \delta\{[K_1(r_1 - c_v^1) - c_f^1] - [K_2(r_2 - c_v^2) - c_f^2]\} & (7) \\ \dot{X}_2 = \beta[K_2(r_2 - c_v^2) - c_f^2] + \delta\{[K_2(r_2 - c_v^2) - c_f^2] - [K_1(r_1 - c_v^1) - c_f^1]\} & (8) \end{cases}$$

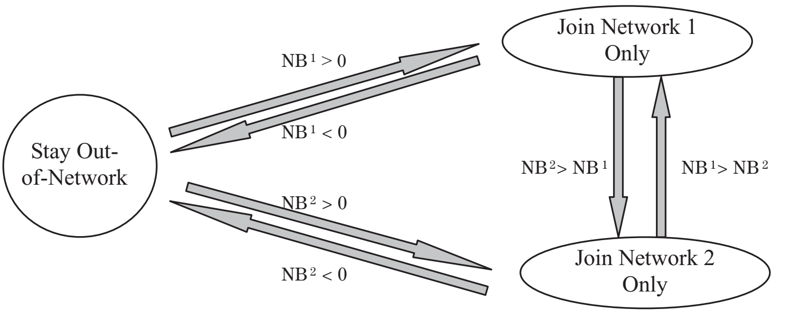


Figure 4. Adoption decision logic under single-homing scenario

where $\alpha > 0$, $\beta > 0$ measure the speed of diffusion, and $\gamma > 0$, $\delta > 0$ measure the speed of switching from one network to the other due to differences in net benefits between the two competing networks. We assume that the diffusion parameters are the same between the two competing networks (i.e. we use the same α, β for both networks) so that the difference in network growth comes solely from differences in net benefits. The 'switching' parameters (δ, γ) are the same across two competing networks because the loss of participants by one network results from the gain of participants by the other. We also assume that $b_i - z_v^i > 0$ and $r_i - c_v^i > 0$ ($i = 1, 2$).

It can be shown that if the growth of two networks follows the dynamics described by system (5)–(8), it is most likely that, in the long-run, only one network can survive and achieve sustainable growth (Sun, 2007).

Given the assumption that there are infinite populations of potential participants from which the network can draw new participants, it is surprising to find that one network will eventually fail, even though it provides positive net benefits to network participants on both sides of the market (recall Figure 4). This could happen when one network, say network 1, provides less incentive/benefit to its participants than network 2. Initially, the number of participants switching from network 1 to network 2 might be smaller than the number of new participants it draws from the out-of-network population pool. Thus at every moment, the size of network 1 is still increasing. However, since network 2 grows faster than network 1, the incentive gap for network participants between the two networks becomes larger. This induces more and more participants to switch from network 1 to network 2 because the number of switching participants is positively related to the benefit gap. At some point, the number of switching participants exceeds the number of new participants that network 1 draws from the out-of-network population. From then on, network 1 starts to shrink and cannot sustain its growth any more.

Resource Heterogeneity and Competitive Advantage

As established in the previous section, network participants are critical resources to two-sided networks. Networks with different sizes (in terms of the number of participants on both sides) are viewed as possessing heterogeneous resources. The finding that only one network will survive in a single-homing two-sided market is striking: resource heterogeneity in this type of market will not only affect inter-firm profitability difference, but also survival opportunity.

To give an intuitive understanding of the impact of resource heterogeneity (i.e. differing size of existing network) on survival, we examine system (5)–(8) with a simplified assumption that both networks have the same fee and benefit structure, i.e.

$$b_1 = b_2 = b, r_1 = r_2 = r, z_f^1 = z_f^2 = z_f, z_v^1 = z_v^2 = z_v, c_f^1 = c_f^2 = c_f, c_v^1 = c_v^2 = c_v.$$

Thus the only difference between the two networks is the initial size: the incumbent (network 1) has a larger initial size than the entrant (network 2), namely $K_1(0) > K_2(0)$, $X_1(0) > X_2(0)$.

Under these assumptions, the system (5)–(8) can be simplified as

$$\begin{cases} \dot{K}_1(t) = \alpha[X_1(t) * (b - z_v) - z_f] + \gamma[(X_1(t) - X_2(t))(b - z_v)] & (9) \\ \dot{K}_2(t) = \alpha[X_2(t) * (b - z_v) - z_f] + \gamma[(X_2(t) - X_1(t))(b - z_v)] & (10) \\ \dot{X}_1(t) = \beta[K_1(t) * (r - c_v) - c_f] + \delta[(K_1(t) - K_2(t))(r - c_v)] & (11) \\ \dot{X}_2(t) = \beta[K_2(t) * (r - c_v) - c_f] + \delta[(K_2(t) - K_1(t))(r - c_v)] & (12) \end{cases}$$

We assume both networks provide positive benefits to both sides of the market initially. Thus all four equations in (9)–(12) have positive values and both networks grow at the beginning. However, since $K_1(0) > K_2(0)$, $X_1(0) > X_2(0)$, the second brackets in (10) and (12) are negative and those in (9) and (11) are positive at time 0: participants of the entrant network are attracted to the incumbent due to network effects. The switching participants, plus the fact that the first brackets in (9) and (11) are larger than those in (10) and (12), enable the incumbent network to grow at a faster speed than the entrant, resulting in a widening gap between the two networks' sizes. At some point, the number of switching participants will exceed the number of new participants that the entrant attracts from the out-of-network pool, which will result in equations (10) and (12) becoming negative. Starting from this point, the entrant network shrinks while the incumbent keeps growing until the entrant disappears from the market.

Discussion

We have shown that resource heterogeneity also plays an important role in affecting competitive advantage in single-homing two-sided markets. In fact, its impact is even more relentless than in the multi-homing scenario. In the multi-homing scenario, though a large network enjoys sustained competitive advantage over small networks, the latter still have chances to survive and coexist with the former. However, in the single-homing market, the competitive advantage over smaller networks is even more striking in the sense that smaller networks are unlikely to survive in the long-run.

The findings again demonstrate the importance of incorporating market context in RBV analysis. Though the prime theme of RBV analysis is valid in both single-homing and multi-homing markets, the prediction of long-term dynamics between the two scenarios can be quite different. Therefore, the resources must also be valued differently in two market contexts because they are obviously more critical in single-homing markets than in multi-homing markets. The managerial implication is also different. In multi-homing two-sided markets, small networks may position themselves as market followers or niche players, even if their profitability is not as good as the market leader. Such 'modest' positioning is, however, hard to sustain in single-homing markets because the winner will most likely take all in such markets. In addition, for potential network sponsors, their entry decisions may be quite different, depending on whether they plan to enter multi-homing or single-homing two-sided markets.

CONCLUSION

Using two-sided markets as a specific market context, we show that cross-group network effects can turn the participants of a two-sided network into its critical resources. The resource accumulation process satisfies the five characteristics of asset-stock accumulation summarized by Dierickx and Cool (1989), providing an isolating mechanism for large networks to sustain their resource and competitive advantages via both ex ante and ex post limits to competition (Peteraf, 1993). We build dynamic systems models for both single-homing and multi-homing two-sided markets and show that resource heterogeneity is a source of sustained competitive advantage in both contexts, although its impact on long-term system dynamics (the survival chance in particular) is quite different.

The paper contributes to the literature by incorporating market context into the RBV framework and by showing how market contexts affect RBV analysis. This is demonstrated by two findings. First, we show that network participants, who are customers of a network, are also resources that bring sustained competitive advantage to the network. While customers are generally external factors to a firm and do not qualify as resources of the firm in most markets, the specific market context, namely the two-sided market, makes them critical resources of a two-sided network due to cross-group network effects. Failure to recognize this specific market context may result in incorrect identification of critical resources and lead to business failures that Apple Computer and IBM experienced. Second, even within the two-sided market context, the long-term system dynamics between the single-homing and multi-homing scenarios are also different, indicating that a refined distinction of market context within a broader market will likely affect the valuation of resources and change long-term competition dynamics.

The dynamic systems approach is unique in the RBV literature. The approach is based on systems of differential or difference equations and has been widely used in the study of ecology, systems engineering, population, marketing, economic growth, and evolutionary economics. The modelling approach is descriptive, without explicit consideration of control variables. Explicit functional forms are usually assumed to describe how variables change from one period to the next in discrete time systems (or from one moment to the next in continuous time systems). The complete evolution path of the system can be found by solving or analysing the dynamic system, as we did in the third and fourth sections. For RBV analysis, the dynamic systems approach may prove very useful because the accumulation of most resources, such as brand, knowledge base, human capital, and culture can be best described in differential equations as has been shown in the marketing and economics literature.

A limitation of our model is the specificity of its results. The results derived from the model may not be applicable to markets other than two-sided markets. However, one of our goals is to demonstrate the importance of market context in RBV analysis. We believe that, as more RBV research is conducted in specific market contexts, such as that by Eisenhardt and Martin (2000) and Miller and Shamsie (1996), our understanding of RBV will be greatly enhanced and more refined formal theories of RBV with market context elements may be developed in the near future.

In the dynamic systems models, network platform sponsors are not allowed to control the system by adjusting prices or products explicitly. Therefore, we have assumed away strategic interactions among competing two-sided networks and network platform owners do not react to each other's strategy. Our intention is to isolate the strategic competition effect from the effect of resource heterogeneity and focus on the latter. Sun and Tse (2007a) build a more comprehensive model that allows network sponsors to control network growth by adjusting prices as well as playing non-cooperative pricing games against each other. The model uses the differential game framework (Dockner et al., 2000) and involves solving a system of 12 non-linear differential equations with 12 dynamic variables. Sun and Tse (2007a) find numerical solutions which generate similar insights from those which are presented in this paper.

Two issues deserve further research. First, given that the initial condition plays such an important role in determining the competitive advantage of a two-sided network, it may be worth extending our model to make the initial condition endogenous. Our models have all assumed the existence of initial differences in resource heterogeneity and studied how it can get magnified by cross-group network externalities. However, we did not touch the crucial issue of how resource heterogeneity is created. Therefore, making resource heterogeneity endogenous may help us to dig deeper into the root causes of resource advantage, and may link the research with other theories of competitive advantages, such as co-evolution (Koza and Lewin, 1998; Lewin and Volberda, 1999) and dynamic capabilities (Eisenhardt and Martin, 2000; Teece et al., 1997). Second, in some circumstances, the identity of the network participants could matter more than the size of the network. For example, in choosing an instant-messaging network, a consumer may be more concerned about who are using the network than how many people are using it: he/she would rather choose a small network which most of his/her friends are in, than a large one with few acquaintances. Lee and Song (2005) call such networks as small-world networks. The existence of such small-world networks suggests that a broad two-sided market may be segmented into smaller segments, each forming a relatively independent network. Therefore, extending our model by allowing the existence of multiple heterogeneous market segments may be an interesting future research direction, and it remains to be seen whether incorporating these new market contexts further changes our perception on the value and even the definition of resources in two-sided markets.

NOTES

[1] Without loss of generality, we assume zero maintenance cost for the networks, making the profit equal to the revenue. The profit function of a network sponsor is thus $\Pi(t) = K(t)z_f + X(t)c_f + K(t)X(t)(c_v + z_v)$.

[2] We assume that, due to technical constraints (e.g. some participants have access only to one network), incomplete information (e.g. some participants are not aware of the existence of another network) or marketing efforts (e.g. some networks may provide a one-time reward to new customers in their marketing campaigns), some participants may join one network while others join another initially (i.e. at time 0), instead of assuming that all participants choose the highest-benefit network at the very beginning. See Sun (2007) for detailed analysis of how marketing strategies can be used to affect the competition dynamics.

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