Abstract

What criteria do adopters use when choosing between competing technologies? Traditional arguments center on installed base as a key factor impacting such decisions, especially in platform markets where complementary product producers are important. We find that in a situation with two sponsored technologies and high technical uncertainty, installed base does matter but other factors that are often overlooked, such as the power balance between an adopter and a technology sponsor are also important, and that adopters are willing to choose a technology with a lower installed base and higher uncertainty if that offers them a better power balance. We also find that many firms choose to exit the market or stay with an old technology rather than make an adoption decision when the new technology presents a high level of uncertainty and an unfavorable relationship with the sponsor. We analyze phone companies adoption decisions in the US 2G cellular industry, measuring the impact of power and dependence between the adopters and the sponsors of two competing technologies.
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Abstract

What criteria do adopters use when choosing between competing technologies? Traditional arguments center on installed base as a key factor impacting such decisions, especially in platform markets where complementary product producers are important. We find that in a situation with two sponsored technologies and high technical uncertainty, installed base does matter but other factors that are often overlooked, such as the power balance between an adopter and a technology sponsor are also important, and that adopters are willing to choose a technology with a lower installed base and higher uncertainty if that offers them a better power balance. We also find that many firms choose to exit the market or stay with an old technology rather than make an adoption decision when the new technology presents a high level of uncertainty and an unfavorable relationship with the sponsor. We analyze phone companies adoption decisions in the US 2G cellular industry, measuring the impact of power and dependence between the adopters and the sponsors of two competing technologies.

What factors impact adoption decisions when an adopter will be locked into a long-term relationship with the supplier of a core technology? For network industries a traditional argument states that an early market lead is disproportionally rewarded (cf. Arthur, 1986; Hill, 1987). However, observing the cellular telephony industry in the US, we see an early market leader with a proven technology entering first but only capturing half the market, with the other half captured by a new technology (Cohen,
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Hsu & Dahlin, 2017). Partly explaining this outcome, and nuancing the argument that early installed base determines market dominance, Katz and Shapiro (1986) model a situation with two competing technologies and find that it is only when the technologies are unsponsored (have none-to-low IP ownership) that an installed-base advantage supports a first-mover technology. When instead two sponsored technologies are in competition (that is, sponsors have IP ownership), Katz and Shapiro's model predicts that a second mover with higher potential technological performance will rule the market.

The US second generation cellular technology market had two sponsored competing technologies where the second mover claimed superior technical performance. However, the outcome was not the one predicted by Katz and Shapiro’s model, namely that the technology with greater potential superiority would emerge as winner. The result of the technology battle was a duopoly- both technologies had similar levels of support. We ask what factors beyond technological performance and installed base impacted adopters' technology choices. We analyze the situation from the adopters' perspective, with a particular interest in contrasting whether and how the latent post-adoption power relationships between an adopter and each of the two technology sponsors impact the adopter’s choice.

The importance of adoption decisions

A firm’s adoption of a core technology has a significant impact on its future. Choosing between competing technologies that are still under development is complex and adopters face uncertainty regarding which technology will be the better one, which will gain the larger installed base, and whether more than one version of the technology will survive at all (Libicki, Schneider, Frelinger & Slomovic, 2000).
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Waiting for more information and delaying the decision could decrease uncertainty regarding a technology's success but then the firm risks the danger of playing catch-up with competitors who adopt earlier and might lose out on higher revenues the new technology might offer. When switching costs are high, choosing a worse technology has long-ranging effect. To reduce uncertainty, potential adopters rely on information not just regarding technologies' technical merit and market performance but also about how committed technology sponsors are to future developments and how they are likely to behave towards the adopter post adoption. Below we discuss four factors that have been found to influence adoption decisions and expand on the idea that when there is a choice between sponsors that offer different dyadic power relationships with the adopter, the adopter will prefer a more favorable relationship and that this helps explain the unpredicted outcome in the US 2G cellular phone market.

**Technological uncertainty** One of the assumptions in the Katz and Shapiro (1986) model is that market participants agree which technology is qualitatively superior. However, at early stages of technological development and when systems have just begun to be tested in the market, there is no unequivocal certainty regarding the eventual performance of a technology, or even which one of multiple choices is the better technology. Further complicating things adopters might optimize on different technological performance dimensions. Taken together, adopters have to manage technological uncertainty in their decision making. Technologies associated with higher levels of uncertainty should deter adoption when there is an option with less uncertainty.

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1 Personal conversation with managers of one of the largest cellular operators in the 1990s.
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*Market uncertainty* For network technologies, installed base is important to attract complementary product makers, which in turn increases the attractiveness of the technological alternative for end users, further growing the installed base (Greenstein, 1993). Past research has studied factors when firms may have more momentum or less likelihood to adopt a new technology depending upon whether they have a large or small installed base respectively (Farrell & Saloner, 1985, 1986). Whether a technology will attract sufficient adoption to motivate complementary product producers is another factor that contributes to adoption decision uncertainty. Since certainty of resource supply such as complementary products is critical for organizations (Pfeffer & Salancik, 1978) we expect that higher levels of market uncertainty to deter adoption.

*Credible commitment* With most complex technologies that are not one-time purchases, sponsor(s) and adopters have ongoing exchanges. The adopter might pay licensing fees based on the use of the technology and continuously order some parts of the system depending on its own user base. If a sponsor abandons their technology the adopter faces the option of switching to another technology, duplicating investments, or living with a decaying technology with few spare parts. In fact, after an adoption decision, the adopter becomes increasingly dependent on a sponsor being credibly committed to developing and maintaining the technology. Similarly, low credible commitment is an adoption deterrent.

A fourth factor an adopter has to weigh into its decision is the dyadic relationship with the technology sponsor: this relationship conditions the adopters continued access to the technology as well as it impacts the conditions for access (price). We turn to resource dependence theory to develop our understanding of this factor.
Resource dependence factors: dependence and power balance

Dependency

The core tenet in resource dependency theory is that firms want autonomy to freely make decisions but all organizations depend on others for access to resources to operate, what Pfeffer and Salancik (1978) called resource dependence. There are three important aspects of a resource: how critical the resource is for the operation of the organization; the lack of alternative resources; and uncertainty regarding resource supply. If all three of these dimensions are high, the theory posits that the organization should absorb the resource. Moreover, the other side of the resource transaction, the owner of the critical resource (here a technology sponsor), is at the same time dependent on the focal organization, which is paying for the use of the resource. In short, firm i depends on firm j, dep\_{ij}, and firm j depends on firm i, dep\_{ji}. The sum of the two firms dependence is called mutual dependence, \( [\text{dep}_{ij} + \text{dep}_{ji}] \) and the theoretical prediction is that a high mutual dependence leads to constraint absorption, that one of the parties buys the other one (Pfeffer & Salancik, 1978).

The empirical support when testing the role of constraint absorption has been mixed, and the explanation is the power balance between two exchange partners (Casciaro & Piskorski, 2005). The power balance is the difference in the dependency between two actors or \( [\text{dep}_{ij} - \text{dep}_{ji}] \) and when this difference is large we have power imbalance. In situations of high imbalance we do not expect constraint absorption since the more dependent partner is not able to absorb the less dependent one, and the less dependent partner does not need to absorb the more dependent one (ibid.).

However, there are many decisions where absorbing an exchange partner is not a viable decision but power balance still impacts a firm's choices. Adoption of a new technology is often such a decision: it might be of little interest or not possible.
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for the adopter to absorb the supplier (Whu & Ketchen, 2017). In our empirical setting legal restrictions hinder the adopters from absorbing one of the technology sponsors. What is left unexplored then is how power balance impacts adoption decisions, a more common situation than an absorption decision.

Organizations seek to manage their dependency on a resource and on those that control access to that resource (Pfeffer & Salancik, 1978; Casiaro & Piskorski, 2005). Dependency can be managed in four ways: (1) Address the problem of the resource itself and seek alternative resources; (2) absorb organizations that control access to the resource (vertical integration); (3) increase the power over the resource sponsor by boosting own power (horizontal integration or growth); (4) exit. A last option is, of course, to engage in two or more of these activities (Emerson, 1962; Pfeffer & Salancik 1978). See Table 1.

However, not all the dependency management options are feasible. There is a difference between what firms would like to do and what they are able to do. In many settings there are no substitutes for a critical resource; legal limits to vertical and horizontal integration limits this option (as in our case); and small resource-poorer organizations are unlikely to be able to absorb larger ones. Exit always remains a viable and often understudied option. In addition, while mutual dependency provides the incentive to decrease dependency, its counter-part power imbalance, or the difference between one party's dependence on another, acts as a disincentive, since a powerful partner in a dyadic relationship does not need to change the status quo and a powerless partner might not have the resources to do so.

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Insert Table 1 about here

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**Power balance**

Power balance or advantage is a dynamic concept that can change over time and influences how firms evaluate their relationships (Rogan & Greve, 2014). Power in dyadic exchange relationships situations has been discussed since Emerson's theory of power-dependence relations (Emerson, 1962; Thompson, 1967; Pfeffer & Salancik, 1978; Casciaro & Piskorski, 2005). An important factor in power is the notion of reciprocal dependency and its impact on power relations in a dyad between two actors i and j (Emerson, 1962). While i may have some power over j, j also has some power over i. While j needs the resource controlled by i, i too needs j to require the resource. But the needs of the two actors may not be of the same intensity, resulting in a situation of power advantage of one actor over the other and mutual dependency of varying intensities. Casciaro & Piskorski (2005) point out that for a particular level of mutual dependence there can be varying levels of power advantage or what they refer to as power (im)balance in the dyad. When organizations need each other for survival, mutual dependency is the highest and so is the power that they exert over each other.

While technical and market uncertainty and credible commitment are known to impact firm choices, a fourth aspect, that of fair access, has been mainly ignored in empirical studies. Fair access has two components, one that characterizes the nature of the technology sponsor who might have a stable set of behaviors when it comes to managing access (such as not charging for access, participating in standards setting committee work and then following FRAND -fair, reasonable and nondiscriminatory rules, or predictably blocking access and charging licensing fees) and a set of behaviors that change with the adopter (price discrimination, allowing some adopters
to make changes to the technology, etc.). The second, dyadic, access factor puts some adopters in a better position vis-a-vis the technology sponsor, as the sponsor depends more on them (the adopter's share of the sponsor's revenues is greater), that is, we expect a more favorable treatment of adopters that have a favorable power balance with the sponsor.

Two factors can be the basis for an adopter's power position relative to a technology sponsor. The first factor is simply market size: the more of a market the adopter represents the more of the sponsor's revenues it will represent. The second factor is the adoption order. Even an adopter representing a small share of the total market can achieve a balance of power with a sponsor if at the point of adoption it is representing a larger share of the sponsor's current revenues. The adopter's power position is especially strong in a situation when a technology is new and its future success is not clear. However, as the technology is able to attract more adopters, the dependency of the sponsors on each adopter is reduced while adopters continue to be equally dependent on the sponsor(s) for access and development of the technology. Over time, and if more adopters are added, the power advantage of the relationship tilts in favour of the sponsor.

As discussed above, dependence is usually studied as a dyadic concept, focusing on mutual dependence. One reason for this is data considerations when testing vertical and horizontal integration: most studies use input-output tables on the industry level and the dyadic interaction is actually an industry-to-industry dependency measure. We are interested in the adopter-sponsor dependency and the dependency of the adopter on the sponsor. More specifically we consider the difference in dependency when the adopter chooses between sponsors. As a consequence, we theorize that an adopter will face the same dependency on either of
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the sponsors, while the power balance will be different due to the sponsors' dependence on the adopter.

We expect that high dependence of the adopter on the new technology is an adoption deterrent for either technology. We expect that a high power imbalance in favor of a sponsor also is an adoption deterrent. We therefore expect that the adopter prefers the sponsor it has the more favorable power balance with.
Multiple sponsors

Further impacting the power situation, a sponsor's control can be lowered by the nature of the technology (Teece, 1987). A complex technology is usually developed by sequential and simultaneous contribution of a number of actors. In case of technical standards, the greater the number of firms that invest in it, the stronger the signals that many believe in the technology, and market uncertainty and any fears about a sponsor's commitment to a technology should be lowered. However, more sponsors might be even more important for the question of access: an increase in the number of sponsors indicates that no single sponsor has complete say over the terms of access to the technology. Since users often fear complete dependency on one sponsor (Pfeffer & Salancik, 1978: 52), having multiple sponsors imply that no one sponsor has total or final say over the terms of access to a technology. In case a particular sponsor is not willing to oblige, others can step in and help in access negotiations.

We expect that more diffused sponsor ownership should reduce the effect of power. Or, put in deterrence terms: concentrated ownership deters adoption.

In summary, we predicted that the following factors will have negative impact on adoption:

1. Market uncertainty
2. Technical uncertainty
3. Lack of credible commitment
4. Adopter's dependency on the new technology
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5. Unfavorable power balance with sponsor
6. Concentrated technology sponsorship

To explore the role of access in adoption decisions, we study a setting where two sponsored technologies compete in a market. The adopters have four choices when they consider adoption in this setting: They can choose to not adopt a new technology while keeping their current technology, they can adopt technology 1, they can adopt technology 2, or they can choose to exit the industry (if possible by selling their license to another licensee, allowing some adopters to grow).

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Insert Figure 2 about here

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**Empirical Setting**

We test our hypotheses using data from the US cellular telecommunications industry. The birth of the cellular communications industry in the US took place in late 1983 with the analog technology (AMPS). AMPS, the first generation of technical technology was very successful but started facing capacity problems by the late 1980s. The decade of the 1990s saw the shift to digital technology. Field trials of TDMA (time division multiple access) began from 1989 and firms could either adopt it right away or wait for further improvements. The standard was simultaneously debated and updated in Telecommunications Industry Association’s (TIA) committee (TR 45.3). Another digital standard, CDMA (code division multiple access) standard started being discussed in the TIA from 1992 (TR 45.5). But Qualcomm had already presented the standard at the cellular operators’ forum— the Cellular Telecommunications Industry Association (CTIA) in 1989 and some operators started
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Field trials with CDMA in 1990. While TDMA was accepted as the industry standard in 1992, CDMA too was being discussed and revised at TIA².

The Federal Communications Commission (FCC) divided US into 734 markets and gave two licenses per market to cellular operators to start cellular telephony operations. One license was given to the local wireline carrier (the B Block), and the second license was auctioned (the A block). These 734 markets comprised 306 urban areas called Metropolitan Statistical Area (MSA) and 428 Rural Statistical Areas (RSA). The MSAs had a higher population density than the RSAs. The cellular industry grew manifold from 91,000 subscribers in 1984 to approximately 44 million in 1996; a compounded annual growth rate of 67.4% (Wireless Industry survey, CTIA, 1998).

Cellular technology functions by dividing the different geographic areas into “cells”. Each cell contains a receiver, signalling equipment and a low-power transmitter. The system keeps a watch over the subscriber’s signal strength as the subscriber traverses through the network and when the strength falls below the minimum level, the system automatically “hands-off,” the call to the adjacent cell. Since cells are placed near each other, radiowave frequencies can be re-used and the number of calls that can be made are greatly enhanced vis-à-vis the analog telephone systems. But even though the cellular concept enabled increased capacity it became difficult and expensive to set up base stations. The analog technology’s subscriber capacity was nearly exhausted and better voice quality and efficient spectrum utilization was desired paving the way for the second-generation digital system.

Digital systems could use the same frequency range and signalling as the analog

² TIA also set up a committee TR-46, to discuss implementation of the GSM standard but this standard was mainly used for Personal Communication Services (PCS). GSM belonged to the TDMA standard family and is considered as part of the TDMA group as only two firms adopted that standard during the study period.
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system. Hence, the second-generation system was backward compatible, but the analog system could not place calls on the digital network.

Unlike analog technology, two competing second-generation technologies were available in the US market. The FCC adopted a “technology neutral” position as it wanted to promote a free market approach to foster competition among the players. Ericsson and Motorola were the main proponents of TDMA while Qualcomm and Sony promoted CDMA. Both groups claimed various merits of their respective system. CDMA supporters argued that CDMA systems provided larger bandwidth efficiency, spread-spectrum technology security, higher transmission quality, and increased resistance to multipath distortion than TDMA. However, the superiority of the CDMA technology was difficult to ascertain in the early years and prior to adoption. TDMA supporters claimed that CDMA was a very expensive technology ($300,000 per base station compared with $80,000 for TDMA). The two systems resulted in distinct market rivals (Prasad, 1998; Rapport, 1996).

Data and Methods

We used various data sources to examine the hypotheses. These are grouped as follows:

1. Two industry directories: RCR’s cellular handbook and Phillips wireless industry directory, which give details about firms (phone companies) in the cellular industry.

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3 Though equipment manufacturers were involved in a standard’s development, we do not study their adoption pattern as the decision to use a particular standard and offer it to the final consumers rests with phone companies. “The manufacturers did not drive these decisions, but waited for the carriers to decide. Carriers have the power to choose any technology that they want to use in their licensed spectrum. Their end customers (subscribers) and the manufacturers of equipment do not have this legal power.” (personal email from Richard Levine ex member of TR 45.3). Also see Cohen et al. (2017) on how sponsors managed the equipment manufacturers by forming different types of strategic alliances with them.
2. The details about adoption of a technology were taken from Lexis-Nexis and Factiva.

3. Patent data was downloaded from USPTO and Delphion patent database. We first downloaded patents that had AMPS, TDMA or CDMA either in the title or in the abstract from Delphion. We then checked these from the USPTO site. These corresponded to the following fifteen technology subclasses in the USPTO site, 331, 333, 340, 341, 342, 360, 365, 367, 370, 371, 375, 379, 380, 385 and 455. In contrast to some prior research we used all these classes to ensure that almost all the patents in these technologies were included. The bulk of the patenting in this industry was done by the equipment manufacturers. As we concentrated on the adoption of a technology by the cellular operators, the impact of cross trading among the patentees on the decision to adopt did not arise.

In the study period, 1990-2000, there were 431 firms and 103 adoptions of either of the two new technologies.

Measures

The resolution of technical uncertainty over time is measured as the number of new patent applications for that technology. In robustness checks we also included an alternative measure, which we built as a clock variable for the two digital technologies, capturing important steps in technology acceptance. Namely, we marked down the year in each of the two technologies were accepted by the US standards setting organization, the first year the first system was operational in the world, and the first year the first system was operational in the US. Each event reduced uncertainty by one, and we had a step function for each technology.
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The resolution of *market uncertainty* is captured by the cumulative number of markets that had adopted digital technology, the CDMA and TDMA alternatives, respectively.

*Credible commitment* is measured as the degree of dispersion of patent ownership. The higher the dispersion the higher the number of organizations patenting in that technology area, and the higher the likelihood that a larger range of market participants are making substantive investment in the technology, which in turn should encourage adoption.

A number of variables are firm or year-specific. *Adopter size* refers to the number of markets in which the adopter has been operating that year. We created a dummy variable to mark down the *spin-offs of Bell Labs*. We also controlled for the adopter’s *market share of rural vs urban areas*, ranging from exclusively rural to exclusively urban. We created two separate variables to capture a firm's *positive or negative growth* in terms of number of markets bought or sold.

The main predictors are the adopter’s dependence on the technology sponsor and the sponsor’s dependence on the adopting phone company. The *adopter's dependence* on the technology sponsor is a proxy for the share of revenues a digital adoption would represent and is measured as $1/(\text{number of alternative phone technologies})$ the adopter provides. Alternative phone technologies are wireline operations, analog cell services and digital cell services. The *sponsor's dependence on an adopter* is measured as the adopter's share of the markets that use the sponsor’s technology. That is, if adopter A holds licenses for 50 markets (cells) and at time t previous adopters representing 100 markets have chosen sponsor I's technology, then sponsor I's dependence on adopter A is $50/150$ ($A$ will represent $1/3$ of all markets using sponsor I's technology). At the same time t, if earlier adopters representing 200
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markets have adopted sponsor II's technology, then sponsor II's dependence on A is 50/250 (A will represent 1/5 of all markets using sponsor II's technology).

Results and analysis

In our setup (a nested logit model) firms can choose between exiting (usually by selling the license to operate), staying with the analog technology, or going digital. In the digital branch they can choose TDMA or CDMA (see Figure 2 above). Our modeling approach assumes that the IIA condition holds within the digital nest but not across nests: an improvement in the attributes of CDMA or TDMA draws proportionately more adoption of one technology over the other and disproportionately from the alternatives outside the nest, i.e. exiting or staying analog.

We find that adoption of a certain alternative is strongly influenced by alternative-specific attributes. In particular, technical and market uncertainty both matter. As the number of new patents applications in that alternative increase, the probability of the alternative to be chosen also increase. This is an indication that the resolution of technical uncertainty triggers adoption. Likewise, the installed base also matters. A technology becomes more attractive as the cumulative number of firms, and
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subsequently, the cumulative number of geographic markets adopting that technology becomes larger. 4

Moving down to the choice between TDMA and CDMA we are interested to observe the extent to which the dependence variables influence decision. The results show that the dependence of the adopter on the new technology played an important role in the decision: the higher the dependence of the adopter on the technology, the less likely it is for the adopter to choose the technology. There are no significant differences between the impact of this variable across the TDMA and CDMA options, which shows that in both cases the dependence of the adopter on the technology owner was an important adoption deterrent. The size of the adopting firm is also important, with larger firms being more likely to adopt. Again, the coefficients of the adopter size variable are statistically equal across the two options (a Wald test showed that the difference is not significant), which means that both standards had equal chances to be adopted by large firms. However, the dependence of the standard owner on the adopting firm is statistically significant only for the TDMA alternative. The higher the dependence of the TDMA owner on the adopting firm, the less likely that the standard owner exerted the necessary effort to attract a firm to adopt. Furthermore, because statistically, the coefficients of the adopter dependence on the owner are equal across the two technologies, but the coefficients of the standard owner dependence on the adopter are statistically different, the analysis allows us to draw conclusions about the role that power imbalance between the adopter and the standard owner played in the decision. What we observe is that power imbalance has a negative influence on the probability of adoption, but the effect is larger in the case of CDMA

4 We coded the variables Technical and Market Uncertainty such that higher values indicate less ambiguity or uncertainty about the technology.
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technology. This finding is consistent with the qualitative evidence that adopting firms were concerned at the time about CDMA owners’ behavior when it came to granting fair access to the technology.

Our results also show that the choice between digital (either CDMA or TDMA) and analogue (that is, non-adoption) is influenced by year and firm-specific attributes. Positive growth is a good predictor for both analogue and digital, but the choice of digital is subject to bandwagon effects (firms do what their peers do: the share of all markets that have adopted digital technology is significant) and geographic location effects (digital technologies matter more for firms operating in urban markets).

**Conclusion**

In our paper we suggest that whether firms will adopt a new resource depends upon how they evaluate the asymmetry of power between themselves and the sponsors. When the potential adopters do not envisage a power disadvantage they are more likely to adopt the resource. Additionally, they also evaluate the dependencies between themselves and the sponsor(s) of the new resource. A higher dependency reduces the attractiveness of the technology.

This paper advances recent research in resource dependency by studying the case of adoption of a new technology, a situation where firms evaluate their dependencies ex ante. Their decision to adopt the resource depends upon whether they see themselves as equal with the sponsors.
References


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Table 1. Resource management theory prediction options, and empirical observation options and their occurrence in our data set.

<table>
<thead>
<tr>
<th>Theory prediction</th>
<th>Empirical observation</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Seek alternative resource</td>
<td>Non-adoption</td>
<td>23 firms had not adopted by the end of the study period</td>
</tr>
<tr>
<td>2. Constraint absorption</td>
<td>No</td>
<td>Not legally possible</td>
</tr>
<tr>
<td>3. Growth (through horizontal integration)</td>
<td>Yes</td>
<td>Yes. The average adopter went from covering 4.75 markets to 13.75 markets in 11 years. The maximum adopter size went from 93 markets to 395 markets.</td>
</tr>
<tr>
<td>4. Exit</td>
<td>Yes.</td>
<td>188 exits in 11 years (mainly license sales)</td>
</tr>
</tbody>
</table>
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Figure 1. Illustration of how dependence develops with increasing cumulative number of adopters.

\[ \text{Dep}_{ij} = \text{Sponsor } i \text{'s dependence on adopter } j \]

\[ \text{Dep}_{ij} = \text{adopter } j \text{'s dependence on sponsor } i \]

\[ \Sigma_j = \text{adopters} \]
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Figure 2. Phone company adoption choices.
Table 2. Summary statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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</thead>
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<td>1 Technical Uncertainty</td>
<td>0.275</td>
<td>0.159</td>
<td>0.000</td>
<td>0.933</td>
<td>1.000</td>
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<tr>
<td>2 Market Uncertainty</td>
<td>1181.682</td>
<td>602.341</td>
<td>0.000</td>
<td>1809.000</td>
<td>-0.188</td>
<td>1.000</td>
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<tr>
<td>3 Credible commitment</td>
<td>0.080</td>
<td>0.047</td>
<td>0.000</td>
<td>0.280</td>
<td>0.382</td>
<td>0.092</td>
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<tr>
<td>4 Adopter J’s dependence on the sponsor I</td>
<td>0.031</td>
<td>0.135</td>
<td>0.000</td>
<td>1.000</td>
<td>0.676</td>
<td>-0.551</td>
<td>0.360</td>
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<td>5 Sponsor I’s dependence on adopter J</td>
<td>0.003</td>
<td>0.030</td>
<td>0.000</td>
<td>0.524</td>
<td>0.054</td>
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<td>6 Adopter size</td>
<td>4.307</td>
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<td>-0.298</td>
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<tr>
<td>8 Firm positive growth</td>
<td>0.370</td>
<td>2.756</td>
<td>0.000</td>
<td>64.000</td>
<td>0.000</td>
<td>0.004</td>
<td>-0.016</td>
<td>-0.004</td>
<td>0.173</td>
<td>0.354</td>
<td>-0.132</td>
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<tr>
<td>9 Firm negative growth</td>
<td>-0.279</td>
<td>2.352</td>
<td>-65.000</td>
<td>0.000</td>
<td>-0.007</td>
<td>-0.009</td>
<td>0.019</td>
<td>-0.014</td>
<td>-0.011</td>
<td>-0.049</td>
<td>0.132</td>
<td>0.016</td>
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<tr>
<td>10 Babybell</td>
<td>0.008</td>
<td>0.091</td>
<td>0.000</td>
<td>1.000</td>
<td>-0.008</td>
<td>-0.012</td>
<td>0.030</td>
<td>0.012</td>
<td>0.211</td>
<td>0.222</td>
<td>-0.192</td>
<td>0.121</td>
<td>-0.048</td>
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<tr>
<td>11 Share of digital markets</td>
<td>0.490</td>
<td>0.275</td>
<td>0.112</td>
<td>0.941</td>
<td>0.115</td>
<td>0.153</td>
<td>-0.346</td>
<td>0.030</td>
<td>-0.134</td>
<td>-0.010</td>
<td>0.008</td>
<td>0.016</td>
<td>-0.053</td>
<td>-0.058</td>
<td>1.000</td>
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Table 3. Results of nested logit analysis.

<table>
<thead>
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<tbody>
<tr>
<td>Technical Uncertainty</td>
<td>1.770***</td>
<td>0.483</td>
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<tr>
<td>Market Uncertainty</td>
<td>0.002***</td>
<td>0.001</td>
</tr>
<tr>
<td>Credible commitment</td>
<td>-2.581</td>
<td>1.722</td>
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</table>

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Adopter J’s dependence on the sponsor I</td>
<td>-5.795***</td>
<td>0.621</td>
<td>-6.845***</td>
<td>0.957</td>
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<tr>
<td>Sponsor I’s dependence on adopter J</td>
<td>-4.819***</td>
<td>2.434</td>
<td>-1.341</td>
<td>1.728</td>
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<tr>
<td>Adopter size</td>
<td>0.208***</td>
<td>0.047</td>
<td>0.203***</td>
<td>0.047</td>
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</table>

Note: 2142 firm-year observations, each observation choosing among four alternatives (exit, analogue, TDMA and CDMA). We used nlogit command in Stata.