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Bitpipe vs. Service:
Why do pure service providers outperform fully integrated operators?

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Complexity in the Telecommunications Industry:
The Challenge of Integrating Infrastructure and Services

Abstract: With the emergence of pure internet-based service providers, the business landscape of fully integrated telecommunications providers – industry incumbents that provide services on their own infrastructure – has changed massively. While various pure service providers exhibit successful business models and high performance, the services offered by the integrated telecommunication firms are not able to compete on neither price nor user experience. To shed light on this issue, we build upon work that has applied a complex systems perspective on performance – how firms manage to configure a large set of interdependent activities affects the performance of the overall activity system. We develop a simulation model to illustrate the effects of a) configuring only interdependent service-related activities, while building on an existing (external) infrastructure, and b) configuring both infrastructure-related and service-related activities at the same time. Our results point to a mechanism that helps explain the underperformance of the fully integrated operators. Pure service providers can improve the performance of their services speedily, as they can focus on optimizing only the service-related activities and adapting them to an existing infrastructure. Fully integrated operators, in contrast, will likely be concerned with both infrastructure and service components, taking into account also the interdependencies between these two domains. While this approach can help reap synergy effects and yield a performance advantage in the long run, it requires more time and results in a lower performance in the short run. Put differently, the objective of the integrated operators to integrate their bitpipe and service business puts these firms at a disadvantage when compared to their specialized competitors. We illustrate this mechanism with two case studies that show how fully integrated operators adapted their infrastructure in response to their service activities, which in return triggered further adaptations and coordination effort.

Keywords: Telecommunication industry, complex systems, organizational search

1 Introduction

Over the last decade, firms like Facebook, Skype, or Ebay have enjoyed large successes in terms of customers, revenues, market valuation, and reputation. These firms are so-called pure service operators, as they do not own or operate their own infrastructure, but instead concentrate on the delivery of services such as voice calls, search, transaction, or entertainment, using the “conventional” internet infrastructure of telecommunication providers (Tewes 1997; Dengler 2000). In contrast, telecommunication firms such as Vodafone, Verizon, Telefonica, or Deutsche Telekom are historically-grown infrastructure operators, which operate these “bitpipes,” i.e., the infrastructure that connects our homes to the world via the internet. Yet with the rising popularity and usage of internet-based services, each of these firms started to offer its own services as well, thereby transforming into fully integrated infrastructure operators (van Kranenburg and Hagedoorn 2008).

Since that time, however, these operators have been trying hard to develop and offer services which customers value at least as much than those of the pure service operators. For example, various operators have introduced IPTV offerings, which continue to struggle hard when compared to the growth rates of video portals like youtube or netflix. Despite having constant revenues from their infrastructure business operations, and despite injecting significant cross-subsidies from this business into the development of new services, no fully integrated operator has yet developed a skyrocketing application nor has it been able to compete on the service layer with pure service operators. This paper attempts to shed light on the issue why fully integrated operators typically have a lower overall performance compared to service operators. To do so, the paper takes a complex systems perspective on firm performance – how firms manage to coordinate and integrate a large amount of interdependent infrastructure and service activities will affect the performance of the overall "activity system" (Porter 1996; Siggelkow 2002). In doing so, we are building on the behavioral accounts of organizational decision-making that envision firms to solve such complex problems by engaging in a search for good solutions – configurations of activities that together yield a high overall performance (March and Simon 1958; Cyert and March 1963; Nelson and Winter 1982). Applying this perspective, we develop a simple simulation model to illustrate the effects of a) configuring only interdependent service-related activities, while building on an existing (external) infrastructure (the case of the pure service providers), and b) controlling and configuring both infrastructure-related and service-related activities at the same time (the case of the fully integrated telecommunication firms).

Our results point to a mechanism that helps explain actual underperformance of these fully integrated operators. Pure service providers can improve the performance of their offerings rather speedily, as they can focus on learning about the interdependencies amount the service-related activities, adapting them to an existing infrastructure. Fully integrated operators, in contrast, that control both infrastructure and service activities, will also learn about interdependencies between these two domains and will likely be prompted to making also some adjustments to their infrastructure when developing new services. While configuring both infrastructure and service components simultaneously, however, can reap synergies and yield a performance advantage in the long run, it requires more time and results in a lower performance in the short run. Put differently, the objective of the integrated operators to integrate their bitpipe and service business puts these firms at a short-run disadvantage when compared to their specialized competitors that makes it unlikely that they will ever reap the long-term benefits. We illustrate this mechanism with empirical evidence that shows how fully integrated operators adapted their infrastructure in response to their service activities, which in turn triggered further adaptation and coordination efforts.

Our paper is structured as follows. The following section describes our complex systems perspective on firm performance, both on an abstract level and as applied to the telecommunications industry. In section 3, we describe our model. The results of the simulation experiments are presented in section 4, and section 5 provides conclusions and gives room for discussion and additional research.

2 Theory

2.1 Complex systems and organizational search

Dating back to Herbert Simon's seminal work on the "architecture of complexity," complex systems have often been considered as consisting of a large number of elements that interact in nontrivial ways (Simon, 1962). Because the elements of a complex system are highly interdependent, optimizing any individual part of the system does not guarantee an improvement in system performance, as system behaviour may respond in nonlinear ways to local adaptations. Instead, the different elements need to fit together for the overall system to have a high performance. In the past decade, this perspective has been adopted by scholars of organizations and strategic management. In particular, firms have been considered as systems of interdependent activity choices (Milgrom & Roberts, 1995; Porter, 1996; Siggelkow, 2002). Managers within firms are seen as making choices along many dimensions, for instance, with respect to their activities in marketing, manufacturing, research and development, or human resources. The decisions that a firm's managers face, however, are often highly interdependent. The value of high product variety, for instance, depends on whether the firm's manufacturing system is flexible. Similarly, the value of low inventory levels depends on whether the supply chain allows for just-in-time delivery. In consequence, rather than one particular activity choice, it is often a set of interdependent and mutually reinforcing activity choices that determines a firm's performance and competitive advantage (Porter, 1996).

Yet how do organizational decision makers achieve fit among the various activities that their firms engage in? Behavioral accounts of organizational decision making (Cyert & March, 1963; March & Simon, 1958; Nelson & Winter, 1982) envision managers to be engaged in problem-solving search. Because decision makers are boundedly rational (Simon, 1955, 1956), they do not optimize over a set of commonly known options, but first have to identify potential alternatives before making a decision. Thus, they address complex challenges by engaging in an adaptive search for configuration of system elements that in sum yield high performance (Simon, 1996). Specifically, a firm's strategizing efforts can be considered as a search for configurations of activity choices that, together, create strong performance (Rivkin & Siggelkow, 2006). What makes search in complex systems challenging, however, is the fact that interdependencies between decisions create rugged "performance landscapes" that contain many local peaks (optima) – consistent configurations of choices that cannot be further improved by making changes to individual parts of the system. Given that bounded rationality is considered to result in local search –

the gradual adaptation by making local improvements, the likelihood that a firm will end up on a low local optimum is rather high (Levinthal, 1997).

In this paper, we build on the above body of work by applying a complex systems perspective to the telecommunications industry. In particular, we assume that telecommunication firms search for configurations of a set of interdependent activities along the telecommunication value chain that together yield high performance. Moreover, service providers and fully integrated operators differ in whether they control, and thus consider, only service activities or both service and infrastructure activities. In doing so, we study which implications these different structural arrangements have on the firms' effectiveness in searching a complex performance landscape.

2.2 Complexity in telecommunication value chain activities

Over the past several decades, the telecommunications industry has seen some remarkable changes (e.g., Fransman, 2001; Funk, 2009). Consider, first, the "old" telecommunications world. Telecommunication providers such as Deutsche Telekom or Vodafone buried a network in the ground and then applied services to this infrastructure, renting access to the network for a monthly fee, and charging the customer for additional services (e.g., calls or internet access) based on their consumption. Hence, the old telecommunications value chain consisted of the elements as depicted in the upper half of Figure 1: network provisioning, network operations, network-related service provisioning, billing, value added services, and (after-) sales. In sum, fully integrated telecommunication providers delivered both infrastructure and services "out of one hand" (Dengler, 2000).

< Insert Figure 1 about here >

Consider, in contrast, the development that led to today's convergent telecommunication industry. Due to liberalization and the successful penetration of the internet, pure service providers were able to squeeze into some of the links of the (formerly protected) telecommunications value chain (Li & Whalley, 2002). Based on a standard internet connection, these service operators were able to offer, for instance, additional voice telephony (e.g., Skype) or search and portal services (e.g., Google or Facebook), which could formerly be provided by the fully integrated infrastructure operators only. In consequence, this approach put the former operator model of refinancing infrastructure via high margin services under severe pressure. The intrusion by pure service operators is illustrated in the lower half of Figure 1.

From a complexity perspective, a pure service provider is essentially configuring various service activities to improve its service quality and price. Skype, for example, combines internet IP telephony and gateways into the traditional phone network at low cost locations in order to offer the lowest call rates possible. This rationale can be followed in the same way by a fully integrated infrastructure operator, as this firm does have the same possibilities than the service operator. In addition, it also has access to the physical infrastructure, which a pure service provider has to take as an exogenous variable. The access to the physical infrastructure may allow a fully integrated operator to reap synergies that might exist due to interdependencies between infrastructure and service activities. Synergetic effects for a specific service exist, for instance, in terms of traffic management, routing, or other quality-related parameters, all of which have a positive effect on the overall product quality. These synergetic effects are not always obvious and may in turn have negative effects on other services. In theory, however, the interdependence between infrastructure and service activities might put the fully integrated operator into a superior position, allowing it to configure a “package” (based on consistent infrastructure and service activities) with superior performance in terms of quality and price than what a pure service provider might achieve.

[Can you give some more concrete examples for why infrastructure and service activities are interdependent and why it might be beneficial to control both of them?]

Moreover, general market theory suggests that a large customer base should provide a good market position (Christensen, 1997; Genschel, 1997; Ghemawat, 1991). This effect, referred to as persistence of markets, argues that the large number of existing customers under contract requires a firm’s competitors to not only offer slightly better service levels and/or slightly cheaper prices, if they want to convince customers to switch to their product. Competitors do not only have to be significantly better and/or cheaper than existing companies, but they also have to burden customer acquisition costs on top (Bear, 1995). Yet despite these challenges, the level of competition on the pure service layer has increased significantly (Picot, Wernick, & Grove, 2008). Whereas fully integrated telecommunication providers were not able to grow within the service layer, pure service operators have gained significantly market shares within the formerly protected markets (Rao, Angelov, & Nov, 2006). Skype, for example, was able to acquire 13 per cent of total international voice traffic within just seven years after the founding of the company (PriMetrica, 2009). As the overall amount of voice traffic is stagnating, this success implies a cannibalization of voice minutes that were formerly served by fully integrated operators. This phenomenon is also reflected in a recent study that reports decreasing market capitalization, revenues, and returns on sales for incumbent operators worldwide (Wernick & Elixmann, 2009).

3 Model

3.1 General approach

Our goal is to compare pure service providers that build upon an existing infrastructure with integrated telecommunications firms that control both domains simultaneously. To do so, we develop an agent-based simulation model to study firms that are faced with a set of interdependent infrastructure and service activities and that search in an adaptive manner for good configurations of these activities. A computational approach is a good fit for our research focus: although it cannot yield "exact" closed-form solutions as an algebraic approach might, it allows keeping track of the complex phenomena that even small systems of interdependent elements can entail. For instance, as interdependencies between activities – in our model, as in real complex systems – may represent both complements and substitutes, the closed-form analysis of supermodular functions that has been applied by economists to study complementarities (Milgrom & Roberts, 1990, 1995) is not applicable anymore. Furthermore, it is a central building block underlying the behavioral concept of problem-solving search that decision makers are bounded in their cognitive capabilities. Incorporating such considerations into the analysis is rather straightforward with simulations, yet rather difficult with analytical models.

We focus our model on the fundamental interplay of three key characteristics: the configuration of a set of interdependent activities, the resulting system performance, and the time necessary for the configuration process. Hence, while we acknowledge the neglect of other aspects of complex problem solving in the telecommunications industry, we adhere to a time-honored tradition in computational research of devising simple yet insightful models (Axelrod, 1997; Burton & Obel, 1995; Cohen, March, & Olsen, 1972). Following our discussion above, we need to model (1) the task environment – systems of interdependent infrastructure and service activities – that our firms operate in, (2) a representation of pure service providers and integrated telecommunication firms, and (3) how firms search for performance-improving decision alternatives. We elaborate on each construct below.

3.2 Systems of interdependent infrastructure and service activities

We conceptualize telecommunication firms to be facing a system of interdependent infrastructure and service decisions that lead to system performance (Levinthal, 1997; Porter, 1996; Siggelkow, 2002). In order to offer high-performing telecommunication products, a firm's managers need to make a multitude of decisions. On the infrastructure level, for instance, they might need to decide about the technologies used to provide network-dependent services, or about technical issues of routing or traffic management. Likewise, on the service level, they might have to make decisions about the appropriate marketing channels to be addressed or about the kind and number of value added services to be offered. Furthermore, many of these decisions interact with each other. For instance, the value of connectivity increases as an infrastructure provider increases interconnectivty and performance with other infrastructure providers, due to network effektcs. The same is true for offering a higher bandwidth performance as infrastruture provider, which will likely increase performance of the portfoloio offered by service providers. Similarly, the availability of appropriate services will depend on the connection quality offered by the infrastructure provider..

In our model, firms are faced with N decisions a_1, a_2, …, a_N that need to be resolved. Without loss of generality, we assume that each decision is binary. For instance, a_1 might denote the decision to increase products ($a_1 = 1$) or not ($a_1 = 0$). In consequence, the firms face 2^N possible configurations of choices, each of which can be represented by a binary vector $\mathbf{a} = (a_1, a_2, \ldots, a_N)$. Furthermore, we assume that of the N decisions, I decisions i_i relate to infrastructure activities, while S decisions s_j denote service-related choices (with $I + S = N$).

In computational studies of firms as complex adaptive systems, it has become common to interpret the payoffs to configurations of interdependent choices as performance landscapes (Levinthal, 1997; Rivkin, 2000). A performance landscape consists of N "horizontal" dimensions (the N decisions that the firm needs to make), and one "vertical" dimension that denotes the corresponding performance of each configuration. A performance landscape thus represents a mapping of each configuration $\boldsymbol{a}$ (each "point" on the landscape) to a performance value $V(\boldsymbol{a})$ (the "height" of the particular point). The landscape metaphor allows an intuitive representation of organizational search and adaptation: A firm inhabits – subject to its configuration of choices $\boldsymbol{a}$, i.e., how the I infrastructure choices and S service choices are resolved – a particular point on the performance landscape. The firm searches for improvements to its current solution by identifying and evaluating alternative configurations, i.e., it tries to move uphill and reach high points on the performance landscape – configurations of choices that together create a high performance. Figure 2 illustrates this general set-up of our model.

< *Insert Figure 2 about here* >

We create performance landscapes with a variant of the *NK* model (Kauffman, 1993, 1995) – a model that was developed in evolutionary biology and has been adopted by a number of scholars to tackle issues of complexity in the management sciences (Ethiraj & Levinthal, 2004; Levinthal, 1997; Rivkin, 2000). In the model, each decision a_i is assumed to make a contribution c_i to the performance $V(\boldsymbol{a})$ that a firm receives from a particular configuration of choices $\boldsymbol{a}$. The contribution c_i of each decision a_i not only depends on how a_i is resolved (0 or 1), but also on how K other decisions ($\boldsymbol{a_{-i}}$) are resolved that interact with a_i. Hence, K controls the degree of interdependence between the decisions. When $K = 0$, all decisions are independent, and the performance contribution of each decision depends only on how the decision itself is resolved. In this case, the performance landscape is smooth and contains only a single peak. In contrast, if $K = N$-1, the value of each decision depends on how all other decisions are resolved. Now, the landscape becomes rugged, exhibiting numerous local peaks. The identity of the K decisions $\boldsymbol{a_{-i}}$ that influence the value of each decision a_i is determined randomly for each performance landscape. Particular values for all possible c_i's are determined randomly by drawing from a uniform distribution over the unit interval, i.e., $c_i(a_{i;}\ \boldsymbol{a_{-i}}) \sim u[0;1]$. Finally, the value $V(\boldsymbol{a})$ of a given set of choices $\boldsymbol{a}$ is calculated as the average of its N performance contributions, i.e., $V(\boldsymbol{a}) = [c_1(a_{1;}\ \boldsymbol{a_{-1}}) + c_2(a_{2;}\ \boldsymbol{a_{-2}}) + \ldots + c_N(a_{N;}\ \boldsymbol{a_{-N}})] / N$.

3.3 Pure service providers and integrated telecommunication firms

While both pure service providers and integrated telecommunication firms try to improve their telecommunication solutions, they differ in their set of possibilities to achieve this objective. In particular, a pure service provider has no control over the infrastructure activities *I*, but needs to take them as a externally given. Even if interdependencies exist between the infrastructure and the service domains, it cannot account for them explicitly. Instead, it can only configure the *S* service activities to improve the overall telecommunication solution by adapting them to the given infrastructure. Consider, for instance, Skype, which has control over its own product components like the client software or servers. Issues such as latency time or other network related factors, in contrast, are out of range for the service operator, and synergy effects between the infrastructure and the service layer cannot be exploited.

The fully integrated telecommunication firm, in contrast, controls both infrastructure and service activities, and in searching for high-performing solutions, can configure all activities along the telecommunications value chain. Hence, given that interdependencies exist between the infrastructure and service domains, this firm can be considered to have an advantage, as changes on the service level are likely to make some adjustments on the infrastructure level advisable to further raise the performance of the overall solution. In order words, by controlling both the infrastructure and the service activities, the integrated firm may be considered to reap synergy effects between the two domains, as illustrated by the dark area in Figure 2. Consider, for example, the case of IPTV, i.e., TV over the telephone line. When telecommunication provider introduced this service, they upgraded their infrastructure due to the technical requirements of IPTV in terms of quality of service (Hess & Wilde, 2005). (These changes, however, in turn had negative effects on, e.g., the remaining bandwidth for other internet services.)

3.4 Problem-solving search

To model the firms' search efforts, we assume that in each period, each firm considers one alternative $\tilde{\boldsymbol{a}}$ that differs in one decision from its status quo set of choices $\boldsymbol{a}$.[1] In generating decision alternatives, a firm can modify only those decisions that are under its control. Thus, if an integrated telecommunication firm is currently at 1000 (assuming N = 4, I = 2, S = 2), it would have N = 4 alternatives available (1001, 1010, 1100, and 0000), as it can controls both service and infrastructure activities. Hence, a manager might, for example, think about modifying the firm's current client software or rather some component of the underlying network. Among the N possible alternatives, each manager picks one at random. A pure service provider that is currently at 1000, in contrast, would have only S = 2 alternatives available: 1001 and 1010. As this firm does not have any control over the underlying infrastructure (i.e., the first two choices in this case), it can only search for improvements to the overall telecommunication product by modifying one of the service-level choices (i.e., choices three and four).

Subsequently, the firm evaluates the newly-identified alternative $\tilde{\boldsymbol{a}}$. In doing so, both pure service providers and integrated telecommunication firms are interested in improving the overall telecommunication product, i.e., the system that is made up of both infrastructure and service choices.[2] Hence, if the firm finds that the alternative denotes a performance improvement, i.e., if $V(\tilde{\boldsymbol{a}}) > V(\boldsymbol{a})$, it will adopt the alternative and move from point $\boldsymbol{a}$ to the nearby point $\tilde{\boldsymbol{a}}$ on the landscape. If, in contrast, the value of $\tilde{\boldsymbol{a}}$ is found to be

[1] Overall, our procedure for generating alternatives that are very similar to the existing configuration of choices represents a process of local search – a central feature in both theoretical (Cyert & March, 1963; March & Simon, 1958; Nelson & Winter, 1982) and empirical (Rosenkopf & Almeida, 2003; Stuart & Podolny, 1996) accounts of organizational learning and adaptation.

[2] Note that even though a pure service provider has no control over the infrastructure, it needs to make sure that the service-infrastructure has high performance.

lower (or equal) than the value of the firm's current alternative ($V(\tilde{\boldsymbol{a}}) \leq V(\boldsymbol{a})$), the firm will discard the alternative (yet memorize it) and remain on its current "spot" on the landscape, generating another (different) local alternative in the next period.

Once a firm has implemented a configuration and knows that it cannot be further improved by any local alternative, the search ends. In this case, the firm has reached a local peak on the landscape.[3] Because interdependencies between the different decisions result in rugged landscapes (Kauffman, 1993; Levinthal, 1997), there may be various internally-consistent configurations that may act as "competency traps" (Levinthal & March, 1981; Levitt & March, 1988) and terminate a firm's exploratory search.

4 Results

To compare the performance of pure service providers with that of integrated telecommunication firms, we proceeded as follows: To level the playing field, we first placed the integrated firms on random points of the stochastically-generated performance landscapes, letting them improve the various infrastructure activities; based on this (existing and "optimized") infrastructure, we then let both types of firms introduce their services and start to consider the joint infrastructure-service performance. We let them search for 100 periods, by which time all firms had reached a local peak.

The results are organized as follows: First, we report a baseline result for the case of $N = 10$ activities, a medium degree of interdependence $K = 3$, a service size of $S = 3$, and an infrastructure of size of $I = 7$. Subsequently, we modify both K, S, and I to explore when and how our results change. (Changing N does not qualitatively change our results.) To

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[3] A local peak is a configuration of choices $\boldsymbol{a}$ with $V(\boldsymbol{a}) > V(\tilde{\boldsymbol{a}})$ for all $\tilde{\boldsymbol{a}}$ that differ from $\boldsymbol{a}$ in one decision.

make sure that any differences we find are inherent to our model and do not result from stochastic interference, we repeat each experiment for 10,000 performance landscapes. We always report the system-level performance, which represents how both infrastructure and service activities are configured as a whole. We measure system performance relative to the performance at the global peak (the global maximum) of a particular landscape, i.e., the performance is 1.0 if the team reaches the global peak. Unless indicated otherwise, reported performance differences are significant at the 0.001 level.

4.1 Performance trajectories

Figure 3 shows the performance trajectories of a pure service provider and an integrated telecommunication firm. It indicates that pure service providers can improve the performance of the overall telecommunication product more speedily than the integrated firm, because they can focus on learning about a good configuration of the service-related components, adapting them to an existing (and already well-developed) infrastructure to create a well-performing service-infrastructure combination. Intriguingly, the fact that a pure service does not control the infrastructure that it is dependent upon proves to be a valuable constraint, as it reduces the search space that this firm is facing. For example, given $I = 7$ and $S = 3$, a firm that controls both infrastructure and service activities is faced with a search space that contains $2^{10} = 1024$ possible configurations of choices. A firm that controls only the service-related activities, in contrast, faces a search space that contains only $2^3 = 8$ potential configurations of the service activities, while it needs to take the seven infrastructure activities as a given (i.e., as they have been configured by the infrastructure provider). Searching such a smaller space, in turn, allows the service provider to find performance-enhancing adaptations faster, resulting in speedier improvements of overall performance as compared to a fully integrated operator

< Insert Figure 3 about here >

Fully integrated operators, in contrast, which are concerned with both infrastructure and service components, will learn about the interdependencies between these two domains over time and will be tempted to make also adjustments to their infrastructure when developing new services, as it realizes that this can have valuable effects. As expected and indicated by the long-run advantage of these firms, configuring both infrastructure and service components simultaneously can reap synergy effects, because the firm can over time learn to adjust the infrastructure and service domain in a way that exhibits high fit. While this approach will yield a performance advantage in the long run, it requires more time for initial exploration in the short run and thus results in an initially lower performance. Put differently, the objective of the integrated operators to integrate their bitpipe and service business puts these firms at a disadvantage when compared to their specialized competitors.

In sum, the local peaks on the performance landscape that the pure service provider is able to reach are, on average, lower than those that an integrated telecommunication firms can reach by tweaking also the infrastructure activities. In the fast-paced telecommunication industry, however, time to market and fast adaptation is likely to yield also a competitive advantage to the firm that can improve overall quality more speedily. A fully integrated provider, in contrast, which may be on the way to even higher local optima, is thus likely to underperform at the time when the claims in the industry are staked.

4.2 Conditions for a performance advantage

To further probe into the conditions under which a pure service provider can have a short-term advantage, and when a fully integrated operator will have a long-term advantage, we vary in the following the size of the infrastructure domain (*I*), the size of the service domain (*S*), as well as the degree of complexity (*K*).

< Insert Figure 4 about here >

As Figure 4 shows, we find that in the long run, the integrated telecommunications provider enjoys a performance advantage over the pure service provider under all conditions. The number of service activities (*S*) relative to infrastructure activities (*I*), however, affects the size of this performance advantage. The degree of interdependence among activities, in contrast, has fewer performance implications. As Figure 4 likewise indicates, the performance advantage is the highest for a somewhat even mix of service and infrastructure activities. In these situations, the integrated telecommunications provider, by reaping synergy effects between its service and infrastructure activities, can make the highest use of the fact that it controls both types of activities. If the service is rather simple as compared to the infrastructure (i.e., if *S* is small), in contrast, the synergy potential between infrastructure and service is rather small, and the integrated telecommunications provider will likely not adjust its infrastructure overly much once it starts experimenting with its service activities. Similarly, if the service is rather large compared to the infrastructure (i.e., if *S* is rather large), the synergy potential between infrastructure and service is likewise small, and the fact that the integrated telecommunications firm controls the infrastructure does not have much bite.

< Insert Figure 5 about here >

As Figure 5 shows, we find for the short run that the pure service provider enjoys the highest performance advantage if the size of the service domain is not overly large compared to the infrastructure activities (i.e., if *S* is rahter small) and if the degree of interdependence is rather small. Under these conditions, the pure service provider can focus on improving its service activities without worrying overly much about synergies with the infrastructure world. As the (relatively larger) infrastructure is already well-honed, improving the service will likely improve the overall infrastructure-service system, too. The pure service provider, in contrast, can "see" the (long-run) synergy potential between its infrastructure and service activities, and will engage in time-consuming adjustments to various activities, letting the firm underperform in the short run. If the degree of interdependence is high, in contrast, or if the service is very large as compared to the infrastructure, then a pure service provider will either have a disadvantage due to the synergies that it cannot reap, or look much like the integrated telecommunications firm, which controls only a few additional infrastructure activities.

Here again short case: this is resembeld currently within the situation of the DTAG…

5 Discussion and conclusions

Our paper provides insight into the discussion, whether infrastructure operators should focus on their bitpipe role or rather become fully integrate operators, offering both services and bitpipe functions. Furthermore, it contributes to explaining the performance of firms that follow either of two opposite strategies – becoming a fully integrated operator or a pure service provider. Specifically, our simulation model provided evidence for a theoretically higher overall performance of a fully integrated infrastructure operator that controls the entire value chain. Compared to this firm, a pure service operator can only achieve a lower overall performance, as it needs to make use of an existing infrastructure, which it cannot further adjust to its specific needs. On the other hand, however, a pure service provider can improve performance much more speedily, since its space of potential configurations of activities is more limited. The theoretical long term advantages in overall performance of the fully integrated operator are overcompensated by the massive advantages of the service operator in the shorter run.

Adding market uncertainty to our findings might make the situation even worse for the fully integrated infrastructure operator. Uncertainty can be caused by, for instance, innovation, instable markets, or complexity in value creation. The example of an incremental innovation in terms of a service leads to the situation, where the service operator is able to adapt much faster to this new service. The fully integrated infrastructure operator, in contrast, will again be concerned with infrastructure and service activities simultaneously, and will thus require much more time to reach the same performance level. In sum, the most important driver of market success might thus be time to market, i.e., being the first to building up a customer base. In the presence of uncertainty, a pure service operator might thus eventually even gain a comparative advantage in the long term.

Overall, our paper helps to explain the strategy and justify the efforts of fully integrated infrastructure operators to engage in service provision. As these firms could finally outperform the pure service operators, becoming a fully integrated operator might denote a feasible business strategy. On the other hand, however, it is also reasonable for pure service operators to engage in service provision, even knowing that they might lose the performance battle finally. If the industry shakeout occurs early on in the lifecycle of a new industry segment, as is typically the case in the fast-paced telecommunications industry, the speed advantage of the pure service providers will trump the long-term performance advantage of the fully integrated operators. Taking this finding into account, it might thus be appropriate for a fully integrated operator to structurally separate its service activities from its infrastructure business.

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Figure 1: Changes in the telecommunications value chain

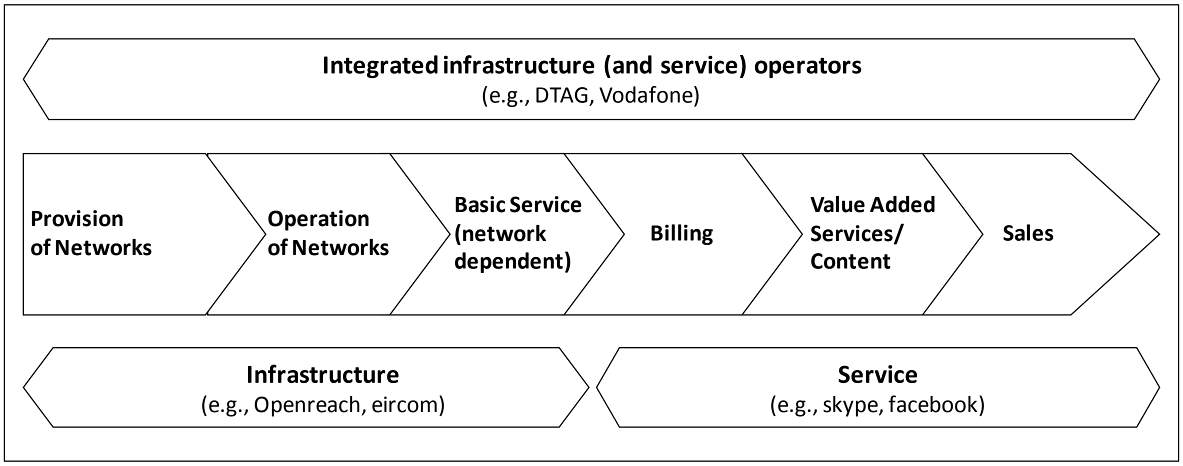


Figure 2: Systems of interdependent infrastructure and service activities

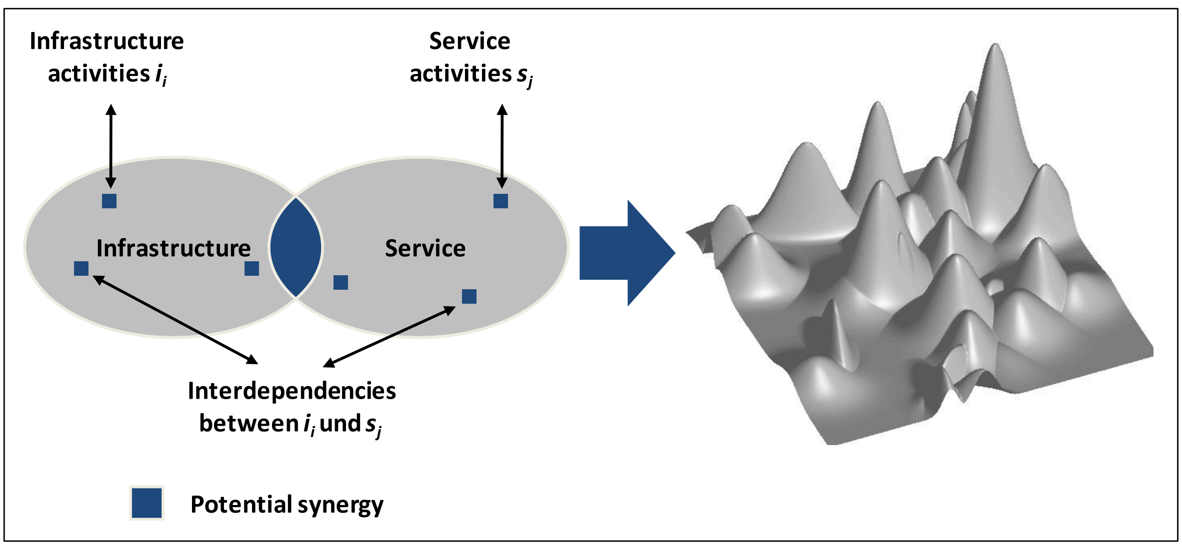
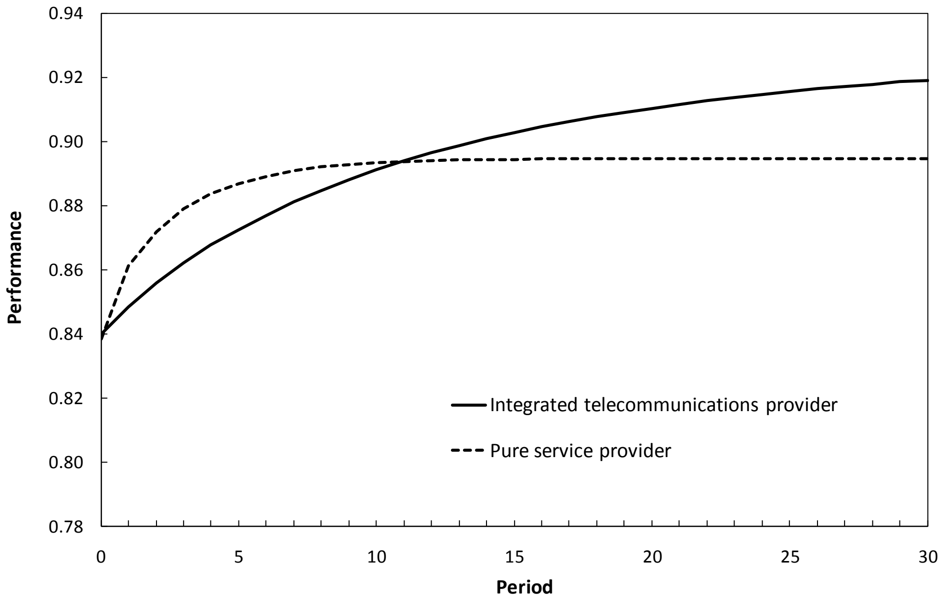
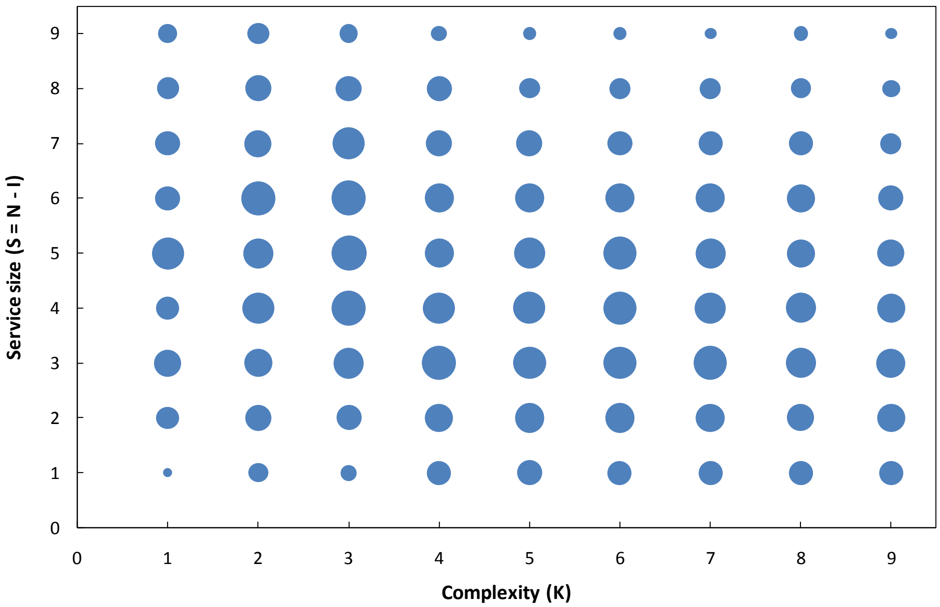


Figure 3: Performance trajectories of a pure service provider and an integrated telecommunication provider



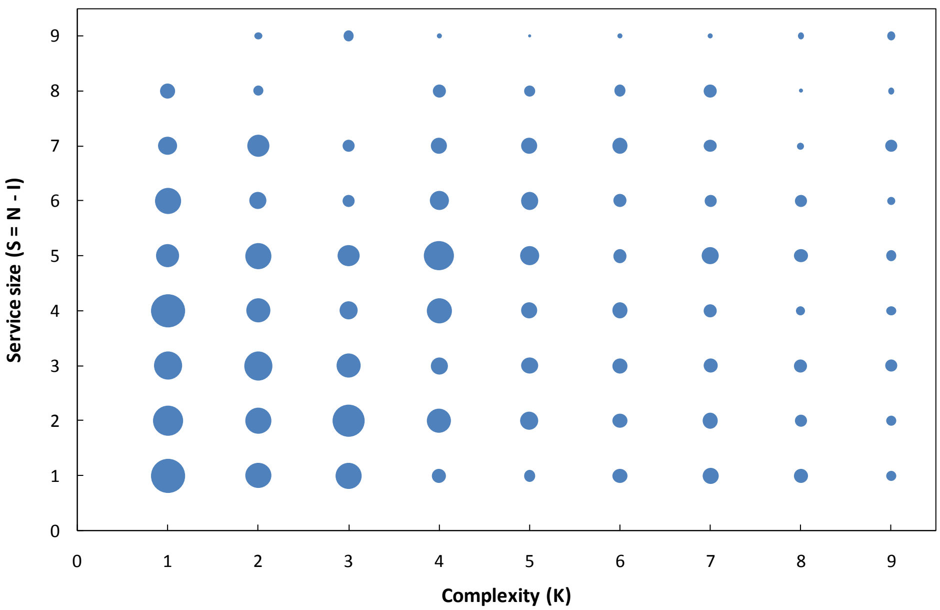
This figure reports the performance trajectories of a) an integrated telecommunications provider and b) a pure service provider. Performance values are averages over 10,000 landscapes with $N = 10$, $K = 3$, $S = 3$, and $I = 7$. Starting in period 1, both firms try to improve the joint performance of infrastructure and service activities (i.e., $P(I + S)$), building upon an infrastructure that is assumed to have been provided and improved prior to this point. To improve the joint infrastructure-service performance, i.e., $P(I + S)$, the integrated telecommunications firm can make adjustments to both service and infrastructure activities, while the pure service provider can only adjust the activities it controls, i.e., the service activities.

Figure 4: Long-run Advantage of the Integrated Telecommunications Provider



This figure reports the long-run performance advantage of an integrated telecommunications provider over a pure service provider given the set-up of Figure 2. Performance values are averages in period 100 over 10,000 landscapes with $N = 10$, given different sizes of the service activities (S) relative to the infrastructure activities (I, with $I + S = 10$), and for different levels of interdependence (K) among both types of activities.

Figure 5: Short-run Advantage of the Pure Service Provider



This figure reports the maximum performance advantage in the short run of a pure service provider over an integrated telecommunications provider given the set-up of Figure 2. Performance values are averages over 10,000 landscapes with $N = 10$, given different sizes of the service activities (S) relative to the infrastructure activities (I, with $I + S = 10$), and for different levels of interdependence (K) among both types of activities. As the maximum performance difference is measured, the period in which this difference occurs differs across the different set-ups.