



Paper to be presented at the DRUID 2012

on

June 19 to June 21

at

CBS, Copenhagen, Denmark,

## **Performance Implications of Outsourcing in the Mobile Telecommunications Industry**

**Jörg Claussen**

ifo Institute for Economic Research  
Industrial Organisation and New Technologies  
claussen@ifo.de

**Tobias Kretschmer**

University of Munich (LMU)  
Institute for Strategy, Technology, and Organisation  
t.kretschmer@lmu.de

**Daniel Oehling**

London School of Economics and Political Science  
Managerial Economics and Strategy Group  
d.w.oehling@lse.ac.uk

### **Abstract**

We examine how outsourcing of a core service affects firm performance in the context of the mobile telephony industry. We develop hypotheses based on economies of scale, transaction costs, quality advantages from specialization, and bargaining power and test these using a ten-year panel with 50 mobile network operators outsourcing their network operations. We find that operators can decrease costs, increase revenues and improve their profitability in the long run by outsourcing mobile network operation services. This effect is stronger for small than for big operators.

Jelcodes:L22,L96

# **Performance Implications of Outsourcing in the Mobile Telecommunications Industry**

## **Abstract**

We examine how outsourcing of a core service affects firm performance in the context of the mobile telephony industry. We develop hypotheses based on economies of scale, transaction costs, quality advantages from specialization, and bargaining power and test these using a ten-year panel with 50 mobile network operators outsourcing their network operations. We find that operators can decrease costs, increase revenues and improve their profitability in the long run by outsourcing mobile network operation services. This effect is stronger for small than for big operators.

Keywords: outsourcing, vertical firm boundaries, mobile telecommunications industry

## **1. Introduction**

Outsourcing is an important element of business strategy for most companies in Europe and the United States (Kakabadse and Kakabadse 2002). The standard argument for outsourcing is that supply-side economies of scale reduce costs and hence improve the bottom line as long as contractual hazards do not dominate. However, outsourcing can also influence product quality and thus affect firm revenues. This possible revenue-influencing effect of outsourcing and how it influences profits jointly with cost-side arguments is not typically part of empirical work on outsourcing (Walker 2007).

Even though outsourcing is such a widely applied business strategy, evidence on performance implications of outsourcing is surprisingly rare, with the majority of the literature on vertical integration focusing on the governance choice (David and Han 2004). The empirical literature dealing with performance implications of outsourcing mainly considers the impact on perceived performance (Grover et al. 1996, Marcolin and McLellan 1998, Poppo and Zenger 1998, Gilley and Rasheed 2000, Gilley et al. 2004, Tiwana 2008, Weigelt 2009, Mani et al. 2010), but also on customer evaluations (Bharadwaj and Roggeveen 2008), technological performance (Leiblein et al. 2002, Raassens 2011), and shareholder value (Jiang et al. 2007, Raassens 2011). To our knowledge, only Jiang, Frazier and Prater (2006) analyze firm-level financial performance and distinguish revenue effects from cost effects. They find support for cost-savings, but not for increases in revenues or profits. However, this might be due to their limited observation window of only one year after the outsourcing announcement.

We analyze the long-term impact of outsourcing on performance while remaining agnostic of the reasons for the outsourcing decision. In this context, we split our research question into the performance effects of outsourcing on firms' costs, revenues, and profitability.

The empirical setting of our study, outsourcing of network operations in the mobile telecommunications industry, is useful for at least three reasons. First, network outsourcing is an emerging firm strategy in the industry (Marshall et al. 2005), with about 25% of all mobile network operators having their mobile networks managed and operated externally by 2009. Second, outsourcing of network operations is considered to be fairly central to a mobile network operator's strategy (Gottfredson et al. 2005, Marshall et al. 2007). And third, we can observe performance implications of outsourcing for a significant period of time. Most studies on vertical firm boundaries in this industry focus primarily on equipment manufacturers (e.g. Berggren and Bengtsson 2004, Davies 2004, McIvor 2003, Sturgeon and Lee 2001). Moreover, while these studies investigate when

and why companies outsource, they do not analyze if outsourcing has a measurable impact on firm performance. We fill this gap by focusing on network operating services in the mobile telecommunications industry.

To answer this question we develop hypotheses based on economies of scale, transaction costs, quality advantages from specialization, and bargaining power and test them using a panel of 50 mobile network operators operating between 2000 and 2009. We find that mobile network operators decrease costs, increase revenues and improve their profitability by outsourcing mobile network operation services. As these effects materialize in the long run, our main regressions measure the cumulative effects up to four years after the outsourcing agreements were implemented. During this period, mobile operators improve their profitability, measured as the ratio of EBITDA to revenues, by about eight percentage points. The effect is stronger for small operators than for big ones.

We proceed as follows: Section 2 gives an industry overview and discusses the outsourcing of network operation services. In section 3, we develop the theoretical framework and hypotheses. Section 4 introduces our data and empirical strategy and gives some descriptive analyses. We present and discuss our results in section 5 and conclude by discussing the limitations of our study and giving suggestions for further research topics.

## **2. Vertical disintegration in the mobile telecommunications industry**

### 2.1. Outsourcing of mobile network operators

Mobile telecommunications are a classical network good in the sense that an infrastructure is built in advance and various services are provided on it. A fully integrated mobile network operator (MNO) would own and manage the network infrastructure, offer services on it, and sell the services to end and business consumers. Most MNOs view the network infrastructure as the key differentiating factor to mobile virtual network operators (MVNOs) and therefore core to their activities, while sales, billing and other peripheral services have been outsourced early on. Recently, operators have started outsourcing network operation services, an activity much closer to the core of an operator.

*Network operation services, or managed services, refers to spare parts management, network operations and field services, which comprise administration, maintenance and operation of the base stations of a mobile network, including transceivers and towers.*

*Network operations* include monitoring the mobile network on capacity overload and breakdowns, resolving software problems, as well as rerouting data streams and coordinating field engineers in case of hardware breakdowns. The term also includes network capacity planning and overall performance controlling of the network (Friedrich et al. 2009). The latter functions are crucial for a smooth mobile network and thus are critical services to outsource.

Field services, spare part management and network operations in a narrow sense are only weakly interdependent, which allows network operators to run or outsource these functions separately (Friedrich et al. 2009). Moreover, firms performing network operation services do not have to legally own the physical mobile network.

## 2.2 Industry overview

### *2.2.1 Historical evolution*

In most countries, the first comprehensive cellular systems were deployed by the beginning of the 1980's (Gruber and Verboven 2001, Koski and Kretschmer 2005). Standards were often country-specific, with seven standards in operation worldwide. Early on, vendors of network infrastructure typically limited their scope of business to manufacturing the respective hard- and software components, while mobile network operators were responsible for network roll-out and management (Anderson and Williams 2004) with a high number of technical staff. Given the lack of external supply and the specificity of network infrastructure, support activities like billing were also managed in-house.

With the introduction of second-generation mobile telephony (2G) in the 1990's, the number of technological standards decreased to four (Gruber and Verboven 2001). Mature standards emerged for the interconnection of different components of the network infrastructure as well as the interconnection to related processes like billing and customer relation management. Standardization was a key driver to enable the modularization of the core components of the 2G infrastructure (Anderson and Williams 2004). This process continues with the ongoing rollout of 3G mobile. The International Telecommunications Union expects an even more extensive modularization and full separation of service-related functions and transport-related technologies with the migration towards *Next Generation Networks*.<sup>1</sup>

---

<sup>1</sup>Source: "NGN 2004 Project description", available online at: <http://www.itu.int/itudoc/itu-t/com13/ngn/9.html> [last accessed Jan 5, 2012].

The unbundling of network operations from other elements of the value chain has been made easier since the launch of 2G due to increasing standardization and modularization, which led to the formation of a market for network infrastructure design and network operation services.

### *2.2.2 Suppliers of network operation services*

The main vendors of network equipment are active in the market for network operation services. In 2008, this industry generated revenues of USD 5.8 bn (Goldstein 2010).

While field services and spare part management are performed locally in the customer's country, most suppliers run a few *Global Network Operation Centers* for operation services in a narrow sense, serving the mobile networks of all customers in a region or a continent.

Mobile telecommunications equipment manufacturers offer network operation services not only to customers with their own hard- and software products, but also to those who use equipment from rival suppliers or multi-vendor networks (Friedrich et al. 2009). In cooperation with capital investment groups, most suppliers also offer the full outsourcing of mobile networks, including the takeover of legal ownership.

### *2.2.3 Demand of external operation services by mobile network operators*

Up to the end of 2009, networks of 50 mobile operators were managed externally. In the majority of the deals only some of the network operation services functions were outsourced. In many cases, network operators decide to outsource less critical functions like field services or inventory management in a first step and extend the initial contract to include a larger scale of network operations functions (Friedrich. et al. 2009). Outsourcing contracts commonly run for between three and five years. As mentioned previously, mobile network operators established in the 1990's or earlier built their own capacities for network operation services. These operators state cost reductions as primary driver for network operations outsourcing and expect operational expenditures savings between 20 and 30 percent (Friedrich et al. 2009). Further, outsourcing of network operations is mainly associated with "the ability to manage those large workforces more flexibly as demand changes" (Friedrich et al. 2009, p. 3). Often, mobile network operators bind the external supplier to employ the technical staff that was originally part of their own workforce. Only a few operators outsource to achieve higher service levels through improved operation services and enhanced processes.

A second group of mobile network operators was established in the era of 2G mobile. These operators only built up limited internal knowledge of network operations, but cooperated with equipment vendors in network management since the beginning of their network roll-out.

Some operators pool their base stations to a common network infrastructure managed by an external supplier, for example the joint network infrastructure program of *T-Mobile* and *3* in the UK.<sup>2</sup> Most operators see their network as an important strategic asset (Friedrich et al. 2009) and outsource network operation activities while claiming legal ownership and the responsibility for strategic decisions (Anderson and Williams 2004,). The physical network is their main differentiator towards mobile virtual network operators.<sup>3</sup>

### **3. Expected performance implications of network operation services outsourcing**

We now hypothesize how outsourcing network operation services may affect the performance of mobile network operators both in terms of costs and revenues, and finally profits.

#### 3.1 Cost effects of network operation services outsourcing

Following transaction costs economics (TCE), external suppliers can achieve production cost efficiencies through economies of scale and specialization (Marshall et al. 2007), which provides a motive for outsourcing (Poppo and Zenger 1998). However, other costs related to the exchange of services within or across firm boundaries, such as search, selection, bargaining, monitoring and enforcement (Madhok 2002), may offset the production cost savings of external suppliers given the higher likelihood of opportunistic behavior of an external supplier compared to an internal unit (Williamson 1991). Frequency, asset specificity, and uncertainty are the key drivers of transaction costs. A higher frequency of transaction, higher asset specificity and higher uncertainty all favor internal sourcing as they cause transaction costs across firm boundaries to increase disproportionately (Williamson 1971, 1975). To predict the overall cost effect of network operation services outsourcing we first analyze if suppliers can achieve economies of scale and then assess if the relative transaction costs related to market governance may outweigh possible cost advantages.

Network operation services have significant economies of scale. As mentioned above, external suppliers build *Global Network Operations Centers* to serve the networks of many customers. These few but large operation centers presumably work more efficiently than the sum of all small operation centers managed by and serving single network operators. This is in part due to fixed costs, for example in problem-solving teams. Suppliers serving several networks need only one such team as

---

<sup>2</sup>Source: Nokia Siemens Networks Press Release "T-Mobile and 3 UK build Europe's largest shared 3G network", available online at: [http://www.nokiasiemens.com/sites/default/files/document/NokiaSiemensNetworks\\_2010\\_04\\_16\\_en\\_MBNL.pdf](http://www.nokiasiemens.com/sites/default/files/document/NokiaSiemensNetworks_2010_04_16_en_MBNL.pdf) [last accessed Jan 5, 2012].

<sup>3</sup>Mobile virtual network operators follow a different business model. They typically do not own infrastructure but use the established network of a traditional operator that has spare capacities (Anderson and Williams 2004).

network breakdowns rarely occur in multiple networks simultaneously. Hence, specialized external suppliers can offer network operation services at lower cost than internal departments at operators (Hecker and Kretschmer 2010).

For transaction costs, Crandall et al. (2009) argued for the telecommunications market that negotiating issues such as “prices for maintaining the network, connecting subscriber lines, and replacing network elements as they depreciate” (p. 506) are complex and that the efficiency of market governance is likely to be low. We analyze market-related transaction costs in detail based on the three major drivers for transaction costs.

First, consider the *frequency of transaction*. Network operators communicate on a daily basis with their external services partner about technical issues. However, they do not change their service supplier frequently but sign contracts for three to five years, avoiding high costs due to ongoing searching and negotiating. Second, we assess *asset specificity* of network operation services for a network operator. These assets do not have to be of a physical nature (Klein et al. 1978) and can be interpreted as the knowledge and expertise employees of an external supplier have developed. A network operator may rely on the operation service expertise of a specific supplier to offer reliable mobile services. Otherwise the network may not work smoothly and the operator’s past investments into the network may be obsolete. In this case, the specific supplier can pressure the operator after the outsourcing contract is signed and renegotiate higher prices for their services. Avoiding such opportunistic behavior would cause complex contracts as well as high costs. However, it is implausible that a network operator is dependent on a specific external service supplier. As mentioned earlier, all four network equipment vendors have the ability to manage not only their own equipment, but also infrastructure initially built by a competitor. Both the interfaces between billing systems or customer management databases and the network infrastructure have been standardized since the launch of 2G mobile. Hence, operators can easily switch suppliers. Third, we consider *uncertainty*, in particular environmental and behavioral uncertainty. The latter considers the inability to verify compliance with established agreements after contract signing (Rindfleisch and Heide 1997) and is difficult to analyze on a general basis. Environmental uncertainty primarily refers to the inability to predict market demand (McNally and Griffin 2004), which is constantly “shifting and evolving” in the Telecommunications industry (Crandall et al.2009). Despite this, mobile network operators cannot adapt their physical network quickly to demand fluctuations. Conversely, expanding or downsizing a network is generally protracted as it depends on the physical infrastructure. Demand for network operation services is primarily linked to the size of the network infrastructure rather than recent demand for mobile services. Therefore, renegotiating and updating

network operation services contracts with external suppliers is only necessary if infrastructure modifications are taking place. Moreover, mobile network operators often plan network expansions carefully in advance (Laiho et al. 2006, p. 4). Hence, demand increases for operation services can be integrated into the contract when first negotiating it.

In summary, from a TCE perspective specialized external suppliers of network operation services can realize economies of scale and other cost benefits and can offer services at lower prices than internal suppliers at network operators. We further find that transaction costs from market-based transactions do not exceed the cost advantages of external purchasing.

The knowledge based view (KBV) posits that firms create sustained competitive advantage with resources that are rare, valuable, imperfectly imitable and not substitutable (Barney 1991). Absent heterogeneity in capabilities and resources, firms with the same transactions and the same scale should end up with the same structure of vertical integration. Recently, scholars started to emphasize the specificity of activities as most relevant for boundary choice. The efficiency of producing as well as governing an activity internally increases with the degree to which this activity is central to a company. However, in contrast to TCE scholars, KBV scholars emphasize the role of language within a firm (Poppo and Zenger 1998, Arrow 1974). Firms as constructs of human interaction tend to develop their own language for codifying knowledge and their own routines to enhance internal processes. If an activity is highly specific to a company, it is embedded in the company's language and routines. Employees are then familiar with this "common organization communication code" (Monteverde 1995). In contrast, markets do not generate shared languages and processes across firm boundaries to the extent that integrated organizations are able to (Monteverde 1995). Thus, activities can be governed more efficiently within the firm. KBV then does not predict how efficient an external purchase can be, it rather points out that the more firm-specific an activity, "the greater use it makes of firm-specific language and routines, and hence the more efficient is internal governance" (Poppo and Zenger 1998, p. 858).

As argued, network operation services are not operator-specific but processes are similar across the industry due to standardized technology, modules and interfaces. It is therefore unlikely that the internal governance of network operation services is more efficient than purchasing these services externally. This argument is not based on the cost advantages of outsourcing however, but rather on the lack of benefits from internal governance.

Finally, *Agency Theory* has a long tradition in analyzing situations when parties cooperate through the division of labor (Eisenhardt 1989). More precisely, it examines situations where a principal

delegates work to an agent. The focal point of analysis is how to align the interests of the agent in an efficient and cost-effective way with those of the principal.

If an agent's performance can be measured adequately, market prices provide the most effective incentives for the agent to act in accordance with the principal's interests (Poppo and Zenger 1998). If the performance of an agent, however, is difficult to measure, market contracts might be less efficient than internalizing the principal-agent relationship (Barzel 1989, p. 76). Within an organization, principals can suppress opportunistic behavior of an agent by "behavioral monitoring" (Poppo and Zenger 1998, p. 859) and the use of authority instead of incentives. In market transactions, such instruments are not available.

We now question if the performance of external network operation services can be measured accurately. If all functions related to operation services are outsourced, the focal variable is the overall quality and reliability of the network, which is crucial for the success of an operator. In practice, network operators include key performance indicators, audits and service benchmarks in their contracts with external suppliers and measure network quality via overall network coverage and the number of breakdowns (Friedrich et al. 2009, p. 14). We therefore assume that measuring network operation service performance is feasible. Hence, network operation services outsourcing will lead to reduced costs.

Summing up, we formulate our first hypothesis.

*Hypothesis 1: Outsourcing of network operation services decreases the costs of mobile network operators.*

### 3.2 Revenue effects of network operation services outsourcing

Broadly speaking, the *KBV* posits that the quality of a product or service is highest if the providing company integrates activities in which it has greater capabilities than external suppliers. Activities in which external suppliers have more production experience and higher organizational skills should be purchased on the market (Gilley and Rasheed 2000, p. 772). We ask if mobile network operators are more experienced in network operation services and are organized more appropriately for these services than specialized external providers. As mentioned earlier, external providers serve several clients. Hence, their networks are bigger than any single mobile network operators'. Considering that production experience accumulates with the absolute number of produced or served entities, external providers gather more experience in running a mobile network infrastructure than network operators. Further, external suppliers may have better organizational structures for undertaking

network operation services. Most of them run *Global Network Operation Centers*, as mentioned above. There, external service providers can employ experts for highly specific services and easily allocate them to different clients' networks depending on the demand. Hence, the quality of network operation services will improve if mobile network operators outsource these services to suppliers with more experience and better organizational structures.

*Agency Theory* also analyses the overall quality and performance (the "effort") of an agent's work. Difficulties in measuring the agent's performance decrease the quality of the agent's work, while the governance mode has no bearing on this effect (Alchian and Demsetz 1972). In contrast, if quality and performance of delegated work can be accurately measured, markets deliver high-powered incentives through prices (Poppo and Zenger 1998). Managers try to imitate this mechanism within a company by linking wages to some measurable part of an employee's performance. However, this leads to internal politics and rent-seeking, which in turn lowers performance and decouples pay from (relevant) performance measures (Milgrom and Roberts 1988). In short, market governance leads to higher relative quality of performance if output can be measured accurately. We already argued that external network operation service performance can be measured accurately. Following the logic of Agency Theory then, network operators can enhance the quality and performance of network operation services by outsourcing these services.

A third literature stream investigates the relationship between *technological dynamism* and vertical firm boundaries. Whereas TCE examines uncertainty in a broader sense, these scholars study how technological uncertainty affects the performance of vertically integrated or disintegrated companies. Here, technological uncertainty is often measured by the average lifetime of a product or process (Schilling and Steensma 2002; Walker and Weber 1984).

Some theoretical papers (e.g. Williamson 1985, 1991) argue that in an environment of high technological uncertainty, contracts need to be updated continually, leading to considerable renegotiation costs (Poppo and Zenger 1998, p. 860). Moreover, the process of renegotiation takes time during which the old contract does not reflect changed environmental conditions. That is why hierarchical governance is favourable in uncertain technological environments.

A conflicting view states that investments are related to a specific technology generation. If a new technology replaces the old one, past investment becomes obsolete (Balakrishnan and Wernerfelt 1986). Further, with rapid technological change integrated companies cannot react flexibly by purchasing the new technology externally (Poppo and Zenger 1998). Williamson (1991) argues that in the presence of technological uncertainty, the incentives of market contracts to "choose

technologies judiciously, share risks efficiently, and avert adversity will be impaired“. As market prices for an old technology decrease and the new technology becomes more valuable, this mechanism guarantees that suppliers invest in new technologies.

In hierarchies, employees within an organization who are familiar with an old technology do not have strong incentives to adapt to the new technology, and they may even try to prevent high-level managers from obtaining knowledge about the new technology. Hence, companies may adhere to outdated technologies longer than reasonable or overlook technological shifts altogether (Lacity and Hirschheim 1993). We conclude that in the presence of technological uncertainty, companies achieve the highest level of technology and quality by purchasing the services and products on the market. Several empirical studies (Balakrishnan and Wernerfeld 1986, Walker and Weber 1987 and Popo and Zenger 1998) confirm this negative relationship between vertical integration and technological dynamism.

Marshall et al. (2007) describe the telecommunications market as characterized by short product life cycles not only concerning handsets but also on the infrastructure side. Transmission technologies are revised relatively often. In the last 15 to 20 years, two major shifts (2G and 3G mobile telecommunication) took place, and a third transmission technology (Long Term Evolution) has already been piloted.<sup>4</sup> The knowledge and capabilities for operating a network are directly linked to the current technology and become more or less obsolete if this technology changes. Consequently it can be argued that by outsourcing network operation services, mobile network operators can avoid being locked in. In contrast, on the market they can match network operation services to their recent infrastructure and enhance the quality and reliability of their network.

Summing up, by outsourcing network operation services, mobile network operators can enhance the performance and quality of their networks. Three effects are likely to occur: i) operators can raise prices; ii) current subscribers may use an operator's services more frequently (increased intensive usage) because quality increased; and iii) as improvements in network quality and performance are known, these operators can win new subscribers (increased extensive usage). All three effects lead to an increase in revenues. We now formulate our second hypothesis:

*Hypothesis 2: Outsourcing of network operation services increases the revenues of mobile network operators.*

---

<sup>4</sup>Source: Ericsson Press Release “Ericsson to build commercial 4G network for Telia Sonera”, available online at: <http://www.ericsson.com/news/1282289> [last accessed Jan 5,2012].

### 3.3 Network operation services outsourcing and profitability

Hypothesis 1 predicts a negative relationship between network operation services outsourcing and the costs of mobile network operators, whereas Hypothesis 2 proposes an increase in revenues following the outsourcing of services. If costs decrease and/or revenues rise,<sup>5</sup> this will increase the overall profitability of mobile network operators. Thus we hypothesize:

*Hypothesis 3: Outsourcing of network operation services increases the profitability of mobile network operators.*

## **4. Data and methods**

### 4.1 Data gathering

The main dataset used for the empirical tests is *Merrill Lynch's Global Wireless Matrix*. Merrill Lynch reports amongst others the number of subscribers, the EBITDA-margin, capital expenditures and revenues of mobile network operators in 50 countries worldwide.

We matched this panel with information about contracts in regard to network operation services outsourcing. A two-step process was employed for collecting the data. The four suppliers of network operation services, namely *Ericsson*, *Nokia Siemens Network*, *Alcatel-Lucent* and *Huawei*, usually announce the signing of outsourcing contracts with mobile network operators via press releases. Hence, we first searched the press rooms of these suppliers for announcements of such contracts. In a second step, we contacted the suppliers directly to verify the deals identified, which helped us to amend several details.

By the end of 2009, 23 percent of all 213 operators in the 52 largest cellular telephony markets had outsourced at least some of the functions related to network operation services to an external supplier whereas 15 percent had fully outsourced all network operation functions.

The number of operators involved in network operation services outsourcing may be even higher. All contact persons at the suppliers' headquarters pointed out that some of their customers do not want their outsourcing decisions to be publicly announced. They could not, however, quantify the number of such "secret" deals. This is challenging as a high number of unobserved deals would distort the regression results. Most suppliers state the total number of network operation services deals

---

<sup>5</sup>Because of economies of scale, we assume that an increase in revenues caused by a higher intensive or extensive usage does not result in an over-proportional increase in costs.

achieved on their homepages. As this number refers not only to the service agreements with mobile network operators but also with fixed line telephony and broadband providers, the percentage of missing observations cannot be calculated.

To avoid miscalculations due to many unobserved outsourcing deals, we only include data from operators for which any outsourcing was reported at some point. This lets us use the observations in quarters in which our operators had not yet outsourced their network operation services as a control group. We start our analysis with the first observed outsourcing deal in 2000. Moreover, we drop negative and positive outliers.

The final dataset contains 1741 observations of 50 mobile network operators in 28 countries and covers the period from Q1 in 2000 to Q4 in 2009. The panel is unbalanced as new operators enter the markets, Merrill Lynch only reports data from 2007 onwards for some countries<sup>6</sup> and data for some other countries data is available only until Q3 in 2007.<sup>7</sup>

4.2 Measurement and descriptive statistics

Variable definitions and descriptive statistics are reported in Table 1. Our main indicator for the outsourcing of network operation services is a dummy variable ( $Out_{it}$ ) that takes value one for all quarters in which network operation services were outsourced zero otherwise.<sup>8</sup> Network operators changed their network operations partner in some cases, but no single operator reintegrated network operation services.

-----  
INSERT TABLE 1 HERE  
-----

The median operator has 10m subscribers ( $CellSub_{it}$ ). Merrill Lynch reports the EBITDA-margin ( $EBITDA_{it}$ ) as a measure for profitability. It is calculated by dividing total EBITDA by total revenues. The mean EBITDA-margin is about 30 percent. In the sample relevant for our study, total revenues ( $Revenues_{it}$ ) are reported for only about 400 observations. As this low number would complicate an adequate regression, total revenues for another 1200 observations were calculated by multiplying

---

<sup>6</sup>Countries with data reported from 2007 onwards are Bangladesh and Pakistan  
<sup>7</sup>Countries with data available only until the third quarter of 2007 are Chile, Hong Kong, Ireland and Taiwan  
<sup>8</sup>The actual starting date of an outsourcing agreement is difficult to identify as the time between contract signing and implementation are heterogeneous among different operators and suppliers. Further, the outsourcing of network operation services is a process that may last several weeks or months. We use the date of the public announcement as a proxy because it is the only reliable variable available.

average revenues per user by the number of subscribers<sup>9</sup>. On average, mobile operators in this sample have revenues of about USD 340m. Operational expenditures ( $OpEx_{it}$ ) include the costs associated with network operation services, regardless of whether these services are contracted externally or undertaken internally. As Merrill Lynch does not publish operational expenditures, we calculated this measure by subtracting capital expenditures and total EBITDA from total revenues.

#### 4.3 Modeling strategy

The actual outsourcing of network operation services is a process that takes weeks or even months and presumably does not start immediately after the public announcement of an outsourcing deal. However, the quarter of the announcement is the focal date of our study. Therefore we include the outsourcing dummy ( $Out_{it}$ ) as a distributed lag<sup>10</sup> into the regression model. Further, the benefits of outsourcing network operation services will not be observed immediately. On the contrary, we assume a long-term dynamic and persistent effect of network operation services outsourcing on operators' profitability, costs and revenues.

Scott, Van Reenen and Zachariadis (2010) rely on similar assumptions when empirically analyzing how the adoption of the SWIFT<sup>11</sup> transfer technology affects the profitability of banks. Therefore, we adopted their main equation for our model.

$$EBITDA_{it} = \sum_{j=0}^L \alpha_j Out_{it-j} + \beta_1 X_{it} + \eta_i + T_t + \varepsilon_{it}$$

Profitability is the central measure for overall company performance (Scott et al. 2010, p. 12). Hence, we use the EBITDA-margin ( $EBITDA_{it}$ ) as dependent variable in the basic equation. Index  $i$  refers to a specific operator and  $t$  the quarter. The sum operator  $\sum$  stands for the distributed lags of the outsourcing variable ( $Out_{it}$ ). We test several values for the lag length  $L$ .

We include operator fixed effects  $\eta_i$  to control for time-invariant unobserved heterogeneity, a set of firm-level control variables  $X_{it}$  like the number of subscribers or the share of prepaid users and time dummies ( $T_t$ ). There may however still be a number of unobserved effects so that the outsourcing coefficient could be correlated with the idiosyncratic error term  $\varepsilon_{it}$ . The fact that we analyze the joint effect of a whole bundle of lagged outsourcing coefficients decreases the probability that the

---

<sup>9</sup>Calculated and reported values for revenues are correlated with 0.94.

<sup>10</sup>We include not only the current value of the outsourcing dummy into our regression but also the values for past periods.

<sup>11</sup>SWIFT stands for the Society for Worldwide Interbank Financial Telecommunication, "a co-operative organization serving as a shared global communications link and a common language for international financial transactions" (Scott et al. 2010, p.3).

measured effects are exclusively caused by endogeneity bias. We also cluster all standard errors by operator. Moreover, we use robust standard errors to circumvent heteroscedasticity problems.

## 5. Results and interpretation

### 5.1 Overall effect of network operation services outsourcing

#### *5.1.1 Network operation services outsourcing and profitability*

Column 1 of Table 2 reports the results using the basic specification. We examine the outsourcing coefficients on a 17 quarter distributed lag after outsourcing of network operation services has taken place. As mentioned, the effect of outsourcing on profitability within single quarters is of minor interest in our study. Instead, we analyze the effect of outsourcing over a longer time period. In this context, there are several measures of specific importance.

-----  
INSERT TABLE 2 HERE  
-----

First, we test the joint significance of the outsourcing coefficients. This way, we can check the overall relevance of network operation service outsourcing on EBITDA. Second, we calculate the sum of the outsourcing coefficients over time as it measures the total effect. This sum, however, does not exhibit the extent to which the coefficients vary in single periods. Theoretically, it could be possible that the outsourcing coefficients were negative for all but the 17<sup>th</sup> quarter, in which it is highly positive. In this case, the sum of all outsourcing coefficients would still be above zero and we would assume a positive effect. We therefore analyze the arithmetic mean of cumulated outsourcing coefficients over time.

For the basic results, we use the distributed lags of four years after the quarter of implementation, i.e. 17 quarters, so that we study the effect of outsourcing on EBITDA for about four years. This lag length is appropriate since the coefficient for the 17<sup>th</sup> lagged coefficient ( $Out_{it-17}$ ) is the furthest lagged coefficient that is significant.

The outsourcing of network operation services has an impact on operator profitability as the outsourcing coefficients are jointly significant. This supports Hypothesis 3. After 17 quarters, the long-run effect counts for an improvement of the EBITDA-margin of about 7.5 percentage points. This is sizeable, taking into account that the average EBITDA-margin in the sample is approximately 30 percent.

Figure 1 shows that the cumulated effect is relatively weak in the beginning. The longer-lagged coefficients contribute comparatively more to the final sum of coefficients, which means that the effect of network operation services outsourcing on the profitability becomes stronger about three years after the outsourcing deal was publicly announced. There is no heavy fluctuation in the effect over time. The arithmetic mean of the cumulated outsourcing coefficients, reported in Figure 1 as the dotted curve, is positive but only half as high as the sum of the outsourcing coefficients. We also added a set of firm-level control variables like the number of subscribers or the share of prepaid users to the regression. They were all insignificant and thus dropped.

-----  
 INSERT FIGURE 1 HERE  
 -----

To summarize, column 1 of Table 2 suggests a positive long-run impact of network operation services outsourcing on mobile operators’ margins of between four and eight percentage points 17 quarters after the announcement of the outsourcing deal. We now analyze if this effect is driven by an increase in revenues, an improvement of the cost structure or by both.

*5.1.2 Revenue effect of network operation services outsourcing*

In column 2a of Table 2, we recalculate the main regression with the logarithm of total revenues (*Log Revenues<sub>it</sub>*) as the dependent variable. The outsourcing coefficients are also highly jointly significant. Firm-level control variables are insignificant and were dropped from the regression. The cumulated effect of the outsourcing coefficients is 24 log points. This means that operators’ revenues increase by 27 percent<sup>12</sup> over the period of 17 quarters after the outsourcing of network operation services was publicly declared. The cumulated outsourcing coefficients have an average value of 15 percent. This supports Hypothesis 2.

*5.1.3 Cost effect of network operation services outsourcing*

In Column 2b of Table 2, we use logarithmic total operational expenditures (*Log OpEx<sub>it</sub>*) as the dependent variable. The long-run effect of network operation outsourcing is negative and statistically significant. Firm-level controls are again excluded from the regression. From the sum of the outsourcing coefficients we find that operating costs decrease by about 35 percent in the 17 quarters period following the announcement of network operation services outsourcing. The arithmetic mean of the cumulated outsourcing coefficients is also negative and has a value of 16 percent. Hypothesis 1 is supported.

---

<sup>12</sup> $(e^{0.27}) - 1 = 0.27$

Summarizing, our results show that outsourcing of network operation services increases profitability by both reducing costs and increasing revenues, with the cost effect the stronger.

## 5.2 Differences by operator size

We now divide the sample into two subsamples of small and big mobile operators. We divide the samples based on the number of subscribers in the second quarter of 2007, which is the only quarter in which observations are reported for all operators. This allows for adequate comparison and segmentation. The sample is split at the median number of subscribers ( $CellSub_{it}$ ), which is approximately 11.5m in the second quarter of 2007.

As we report in Table 2, column 3, outsourcing network operation services has a significant effect on profitability in both sub-samples. However, the effect in the subsample of small operators (column 3a) is higher than in the whole sample (column 1) and more than twice as high as in the subsample of big operators (column 3b). If we compare the arithmetic mean of the cumulated outsourcing coefficients, the differences are smaller, but still visible. The graphs in Figure A.1 and Figure A.2 support this conclusion. Overall, this implies that small mobile operators profit more from network operation services outsourcing than big ones.

## 5.4 Robustness tests

We use several additional tests to show that the results of our main regression with EBITDA-margin as the dependent variable (column 1 of Table 3) are robust. We then demonstrate that the lag-length of 17 quarters is appropriate.

First, we include a full set of year dummies interacted with operator dummies into the model (results are reported in column 2 of Table A.1). With this modification, the positive effect of network operation services outsourcing on profitability is still significant but only at the 5% level. The sum of the outsourcing coefficients does not change sizably in comparison to our main regression, reported in column 1. The arithmetic mean of cumulated outsourcing coefficients is lower but still positive. These results suggest that the effects we show in the main regressions are not just based on a time trend and that the linear time dummies used are adequate for measuring these effects.

Second, we modify the sample. The sample we used for our robustness test (reported in column 3 Table A.1) includes only operators that outsourced all functions related to network operation services. The long-term effect of outsourcing is significant and the effect size is very similar to the one of our basic regression. We further limit our sample to operators that contracted all network operation activities to an external supplier and additionally negotiated a movement of the own

technical workforce to this supplier. Even with this modification the effect of outsourcing on profitability is significant and similar to the main regression in effect size. The arithmetic mean of the cumulated outsourcing coefficients is even considerably higher than in the basic scenario. This seems reasonable as we expect that external suppliers need more workforce for managing an additional network. Contracting past technicians of the mobile network operator for this task who already have knowledge and experience in managing a mobile network is more efficient than hiring and training new employees. Thus, external suppliers can manage the customer's network at lower costs, especially in the first quarters after the outsourcing process started. In an additional step, we enlarge the sample by including all operators reported in *Merrill Lynch's Global Wireless Matrix*. As argued before we have to expect that there are a high number of unobserved outsourcing contracts. Column 5 of Table A.1 reports the regression results for the enlarged sample of operators. The effect of operation services outsourcing on profitability is significant and positive. Looking at the sum of coefficients the effect size is about half as strong as in the basic regression. For cumulated outsourcing coefficients the effect size is even weaker. This may arise from the possibly large number of unobserved outsourcers. To summarize, our main results are robust to modifications in the underlying sample.

Third, we analyzed the effect of network operation services outsourcing on profitability in two additional models in which the length for the distributed outsourcing variable has five more and five less quarters than in the basic regression (17 quarters). According to the results in column 2 of Table A.2, the effect is significant only at the 10% level if we examine twelve quarters. This result suggests that the full effect of outsourcing appears only after a long-lasting period. It is not surprising that the sum of outsourcing coefficients is lower after 12 than after 17 quarters. However the arithmetic mean of the cumulated outsourcing coefficients is also noticeably below the one of the main regression, suggesting that the effect is comparatively stronger in the 13th to 17th quarters after the announcement of the outsourcing deal than in the previous ones. Column 3 of Table A.2 summarizes the results of the regression with a lag length of 22 quarters. As in all previous scenarios the outsourcing effect is significant. Both measures for the effect size are rather similar to the basic model: the sum of the outsourcing coefficients is slightly lower and the arithmetic mean of the outsourcing coefficients is about one percentage point higher. Thus, we can assume that the coefficients of the 18th to 22nd quarters will not contribute sizably to the overall outsourcing effect. In conclusion, the 17 quarters lag structure seems appropriate for measuring the full effect of network operation services outsourcing on the profitability of mobile network operators.

## 6. Conclusion, limitations and further research

We examine the long-term impact of network operation services outsourcing on the performance of mobile network operators using data from 50 operators over the 2000–2009 time period. We find that outsourcing network operation services raises profits, in particular for small mobile network operators. The positive effect on EBITDA is most visible in the long run and lasts up to 17 quarters after the respective outsourcing agreement was publically announced. As expected by mobile operators that opted for external contracting, the increase in profitability is primarily driven by reductions of operational expenditures. Few operators turn to outsourcing to achieve higher service levels. Our results, however, suggest that outsourcing of network operation services also has a positive effect on revenues. We argue that an improvement in quality and performance of the network boosts extensive and intensive usage and allows for an increase in service charges, which leads to higher revenues. Hence, mobile network operators should also take quality aspects into account when considering outsourcing network operation services.

The dataset used for this study poses some limitations. First, we only capture 50 of the largest operators as many companies included in *Merrill Lynch's Global Wireless Matrix* had no information available about the governance structure for network operation services. Further, revenues and operational expenditures are imperfect measures of firm performance.

As this study is one of the first which examines cost and revenue effects of outsourcing, further evidence from other industries would be valuable. For the mobile telecommunications industry, studying the differences between mobile virtual network operators and network operators that outsource their network operation services is an important next step to gain an understanding for the strategic relevance of network ownership. It has to be analyzed in more detail why the majority of mobile network operators keeping network operation services in-house although the operators we studied successfully outsourced these services.

More generally, our study illustrates an emerging trend in outsourcing practices of firms. While initially firms outsourced peripheral activities to cut costs, firms are now much more inclined to outsource activities much closer to the core business. We find that in addition to the traditional cost-cutting effect of outsourcing, the flexibility and scale advantages of service providers to upgrade to the newest technology and the resulting increased service quality offer further reasons to outsource knowledge-intensive activities. This finding, if confirmed in other settings, would supplement theoretical approaches to outsourcing that focus predominantly on cost savings.

## References

- Alchian, A. / Demsetz, H. (1972) 'Production, Information Costs, and Economic Organization', *American Economic Review* 62(5): 777-795.
- Anderson, J. / Williams, B. (2004) 'Unbundling the mobile value chain', *Business Strategy Review* 15 (3): 51-57.
- Arrow, K. (1974) *The Limits of Organization*. New York: W.W. Norton.
- Bailey, G. / Seider, C. (2006) 'And then there were few. - how to survive the next wave of consolidation among network equipment providers', IBM, available online at: <https://www-935.ibm.com/services/us/gbs/bus/pdf/g510-7870-01-nep.pdf> [last accessed Jan 5, 2012].
- Balakrishnan, S. / Wernerfelt, B. (1986) 'Technical Change, Competition and Vertical Integration', *Strategic Management Journal* 7: 347-359.
- Barney, J. (1991) 'Firm Resources and Sustained Competitive Advantage', *Journal of Management* 17 (1): 99-120.
- Barzel, Y. (1989) *Economic Analysis of Property Rights*. New York: Cambridge University Press.
- Berggren, C. / Bengtsson, L. (2004) 'Rethinking outsourcing in manufacturing: a tale of two telecom firms', *European Management Journal* 22 (2): 211-223.
- Bharadwaj, N. / Roggeveen, A. L. (2008) 'The Impact of Offshored and Outsourced Call Service Centers on Customer Appraisals', *Marketing Letters* 19 (1): 13-23.
- Crandall, R. W. / Eisenach, J. A. / Litan, R. E. (2009) 'Vertical separation of telecommunication networks: Evidence from five countries', available online at: <http://ssrn.com/abstract=1471960> [last accessed Jan 5, 2012].
- David, R. / Han S. (2004) 'A Systematic Assessment of the Empirical Support for Transaction Cost Economics', *Strategic Management Journal* 25: 39-58.
- Davies, A. (2004) 'Moving base into high-value integrated solutions: a value stream approach', *Industrial and Corporate Change* 13 (5): 727-756.
- Eisenhardt, K. M. (1989) 'Agency Theory: an Assessment and Review', *Academy of Management Review* 14 (1): 57-74.
- Friedrich, R. / Weichsel, P. / Miles, J. / Rajvanshi, A. (2009) 'Outsourcing Network Operations - Maximizing the Potential', Booz & Company, available online at: [www.booz.com/global/home/what\\_we\\_think/reports\\_and\\_white\\_papers/ic-display/47372702](http://www.booz.com/global/home/what_we_think/reports_and_white_papers/ic-display/47372702) [last accessed Jan 5, 2012].
- Gilley, K. M. / Greer, C. R. / Rasheed, A. A. (2004) 'Human Resource Outsourcing and Organizational Performance in Manufacturing Firms', *Journal of Business Research* 57 (3): 232-240.
- Gilley, K. M. / Rasheed, A. (2000) 'Making More by Doing Less: An Analysis of Outsourcing and its Effects on Firm Performance', *Journal of Management* 26 (4): 763-790.
- Goldstein, P. (2010) 'Network outsourcing: why the U.S. is an exception', *Fierce Wireless*, available online at: <http://www.fiercewireless.com/node/73276> [last accessed Jan 5, 2012].
- Gottfredson, M. / Puryear, R. / Phillips, S. (2005) 'Strategic Sourcing – from periphery to the core', *Harvard Business Review* 83 (2): 132-139.
- Gravelle, H. / Rees, R. (1992) *Mircoeconomics*. London: Pearson Education.

- Grover, V. / Cheon, M. J. / Teng, J. T. C. (1996) 'The Effect of Service Quality and Partnership on the Outsourcing of Information Systems Functions', *Journal of Management Information Systems* 12(4): 89-116.
- Gruber, H / Verboven, F (2001) 'The evolution of markets under entry and standards regulation – the case of global mobile telecommunications', *International Journal of Industrial Organization* 19 (7): 1189-1212.
- Hecker, A / Kretschmer, T (2010) 'Outsourcing Decisions: The Effect of Scale Economies and Market Structure', *Strategic Organization* 8 (2): 155–175.
- Jiang, B. / Belohlav, J. A. / Young, S. T. (2007) 'Outsourcing Impact on Manufacturing Firms' Value: Evidence from Japan', *Journal of Operations Management* 25 (4): 885-900.
- Jiang, B. / Frazier, G. V. / Prater, E. L. (2006) 'Outsourcing effects on firms' operational performance', *International Journal of Operations & Production Management* 26 (12): 1280-1300.
- Kakabadse, A. / Kakabadse, N. (2002) 'Trends in outsourcing: Contrasting USA and Europe', *European Management Journal* 20 (2): 189-198.
- Klein, R. / Crawford, G. / Alchian A. (1978) 'Vertical integration, appropriable rents, and the competitive contracting process', *Journal of Law and Economics* 21 (2): 297-326.
- Koski, H. / Kretschmer T. (2005) 'Entry, Standards and Competition: Firm Strategies and the Diffusion of Mobile Telephony', *Review of Industrial Organization* 21(1): 89-113.
- Lacity, M. / Hirschheim, R. (1993) *Information Systems Outsourcing*. New York: Wiley.
- Laiho, J. / Wacker, A. / Novosad, T. (2006) *Radio Network Planning and Optimisation for UMTS*. London: John Wiley & Sons.
- Leiblein, M. J. / Reuer, J. J. / Dalsace, F. (2002) 'Do make or buy decisions matter? The influence of organizational governance on technological performance', *Strategic Management Journal* 23: 817–833.
- Mani, D. / Barua, A. / Whinston, A.B. (2010) 'An Empirical Analysis of the Impact of Information Capabilities Design on Business Process Outsourcing Performance', *MIS Quarterly* 34 (1): 39-62.
- Marcolin, B. L. / McLellan, K. L. (1998) 'Effective IT Outsourcing Arrangements', in *Proceedings of the 31st Annual Hawaii International Conference on System Sciences*, pp. 654-665. Los Alamitos: IEEE Computer Society Press.
- Madhok, A. (2002) 'Reassessing the fundamentals and beyond: Roland Coase, the transaction cost and resource-based theories of the firm and the institutional structure of production', *Strategic Management Journal* 23: 535-550.
- Marshall, C. / McIvor, R. / Lamming, R. (2007) 'Influences and outcomes of outsourcing: insights from the telecommunications industry', *Journal of Purchasing & Supply Management* 13 (4): 245-260.
- McNally, R. C. / Griffin, A. (2004) 'Form and individual choice drivers in make-or-buy decisions: a diminishing role for transaction cost economics?', *Journal of Supply Chain Management* 49 (1): 4-17.
- McIvor, R. (2003) 'Outsourcing: insights from the telecommunications industry', *Supply Chain Management: An International Journal* 8 (4): 380-394.
- Milgrom, P. / Roberts, J (1988) 'An Economic Approach to Influence Activities in Organizations', *American Journal of Sociology* 94: S154-S179.
- Monteverde, K. (1995) 'Technical Dialog as an Incentive for Vertical Integration in the Semiconductor Industry', *Management Science* 41 (10): 1624-1638.

- Poppo, L. / Zenger, T. (1998) 'Testing alternative theories of the firm: transaction cost, knowledge-based, and measurement explanations for make-or-buy decisions in information services', *Strategic Management Journal* 19 (9): 853-877.
- Raassens, N. (2011): *The Performance Implications of Outsourcing*. Tilburg: University of Tilburg.
- Rindfleisch, A. / Heide, J. B. (1997) 'Transaction cost economics, past, present, and future applications', *Journal of Marketing* 61 (4): 30-54.
- Schilling, M. A. / Steensma, H. K. (2002) 'Disentangling the Theories of Firm Boundaries: A Path Model and Empirical Test', *Organization Science* 13 (4): 387-401.
- Scott, S. / Van Reenen, J. / Zachariadis, M. (2010) 'The impact of the diffusion of a financial innovation on company performance: an analysis of SWIFT adoption', LSE Centre for Economic Performance, Discussion Paper No. 992.
- Sturgeon, T., Lee, J. (2001) 'Industry and co-evolution and the rise of a shared supply-base for electronics manufacturing', Massachusetts Institute of Technology, Globalisation Study Working Paper 01-002.
- Tiwana, A. (2008) 'Does Technological Modularity Substitute for Control? A Study of Alliance Performance in Software Outsourcing', *Strategic Management Journal* 29 (7): 769-780.
- Walker, G. (2007) 'The Incompleteness of Research on Firm Boundaries', *Strategic Organization* 5 (3): 227-236.
- Walker, G., & Weber, D. (1984) 'A Transaction Cost Approach to Make-or-Buy Decisions', *Administrative Science Quarterly* 29: 373-391.
- Weigelt, C. (2009) 'The Impact of Outsourcing New Technologies on Integrative Capabilities and Performance', *Strategic Management Journal* 30 (6): 595-616.
- Williamson, O. E. (1971) 'The vertical integration of production: Market failure considerations', *American Economic Review* 61: 112-123.
- Williamson, O. E. (1975) *Markets and Hierarchies*. New York: Free Press.
- Williamson, O. E. (1985) *The Economic Institutions of Capitalism*. New York: Free Press.
- Williamson, O. E. (1991) 'Strategizing, economizing, and economic organization', *Strategic Management Journal* 12: 74-94.
- Zenger, T. R. (1994) 'Explaining Organizational Diseconomies of Scale in R&D: Agency Problems and the Allocation of Engineering Talent, Ideas, and Effort by Firm Size', *Management Science* 40 (6): 708-729.

## Figure and Tables

**Table 1:** Variable definitions and descriptive statistics.

Variable	Definition	Obs.	Mean	Std. Dev.	Min	Max
$Out_{it}$	Adoption dummy, set “one” in the quarter when the outsourcing of network operation services was announced and in all the following quarters	-	-	-	-	-
$CellSub_{it}$	Subscribers to a given operator (000’s)	1724	10116	13999	1.00	118860
$EBITDA_{it}$	Earnings before interest, taxes, depreciation and amortization to revenues-margin  Calculated by dividing total EBITDA by total revenues	1561	0.2916	0.2147	- 0.8800	0.7700
$Revenues_{it}$	Total Revenues (m. US dollars)  1,153 observations are roughly calculated by multiplying average revenue per user by CellSub; in the regression used as total number	1582	343.80	464.57	0.30	2754.01
$OpEx_{it}$	Operational Expenditures (m. US dollars)  Roughly calculated by subtracting capital expenditures and total EBITDA from revenues; in the regression used as total number	532	305.86	374.76	0.38	1078.04

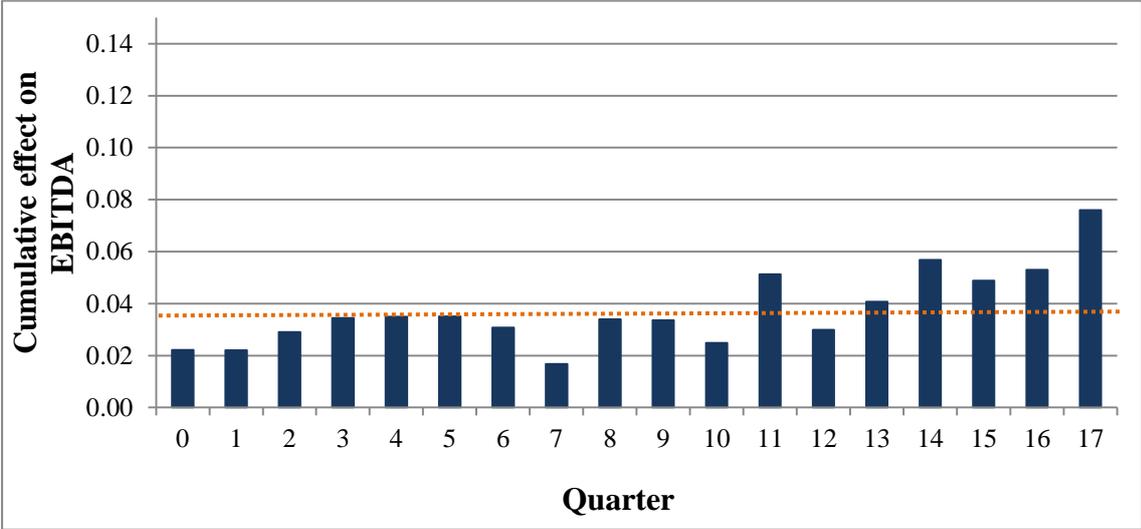
*Notes:* The time period of the presented sample is 2000-2009 (40 quarters). The sample includes observations of all operators that at least partly outsourced network operation services in this period.

**Table 2: Main regression results.**

	(1)	(2)		(3)	
		(a)	(b)	(a)	(b)
Sample operators	All	All		Small CellSub <sub>2007/2</sub> ≤ 11.5 mio	Big CellSub <sub>2007/2</sub> > 11.5 mio
Dependent variable	EBITDA <sub>it</sub>	Log Revenues <sub>it</sub>	Log OpEx <sub>it</sub>	EBITDA <sub>it</sub>	
<b>Joint significance</b> (Prob>F) of out coefficients (out <sub>it</sub> – out <sub>it-17</sub> )	0.0021	0.0000	0.0000	0.0000	0.0000
<b>Sum</b> of out coefficients (out <sub>it</sub> – out <sub>it-17</sub> )	0.0760	0.2369	-0.4320	0.0801	0.0332
<b>Arithmetic mean</b> of <u>over time</u> <u>cumulated</u> out coefficients (out <sub>it</sub> – out <sub>it-17</sub> )	0.0375	0.1303	-0.1667	0.0459	0.0286
Number of operators	40	41	21	20	20
Number of observations	837	878	223	404	433
R <sup>2</sup>	0.8325	0.7757	0.9023	0.7654	0.8781

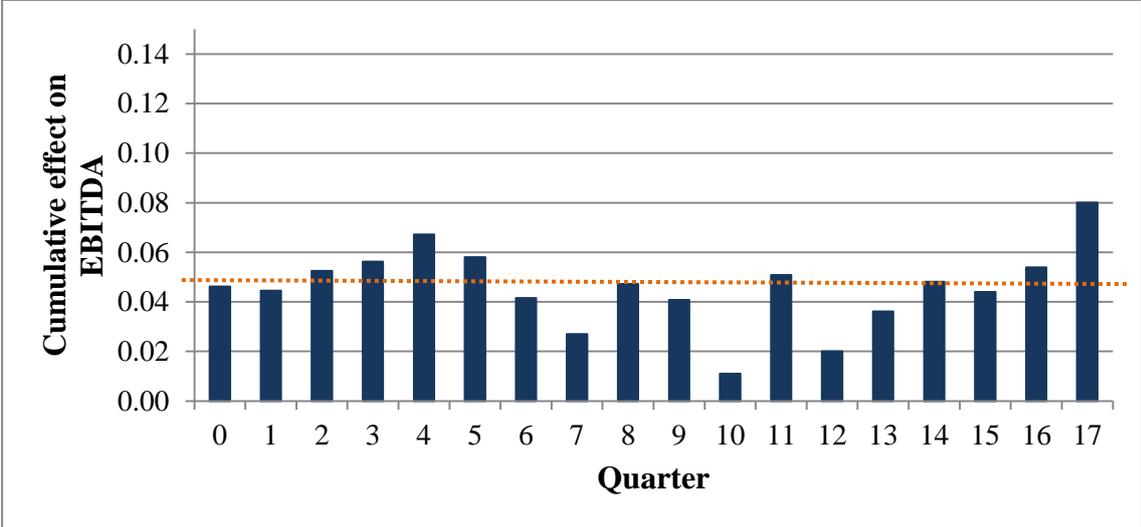
*Notes: All equations include operator and time fixed-effects. A 17-quarters lag structure is used to test the long-term effect of network operation services outsourcing on the operators' profitability (columns 1, 3, 4, 5), revenues (column 2a) and costs (column 2b). Firm-level control variables are dropped as they were insignificant in all regressions. Standard errors are robust and clustered by operators. The time period of the sample is 2000-2009 (40 quarters). The sample includes observations of all operators that at least partly outsourced network operation services in this period.*

**Figure 1:** Cumulative effect of network operation services outsourcing on the EBITDA-margin in the whole sample (graphical representation of column 1 in Table 3).

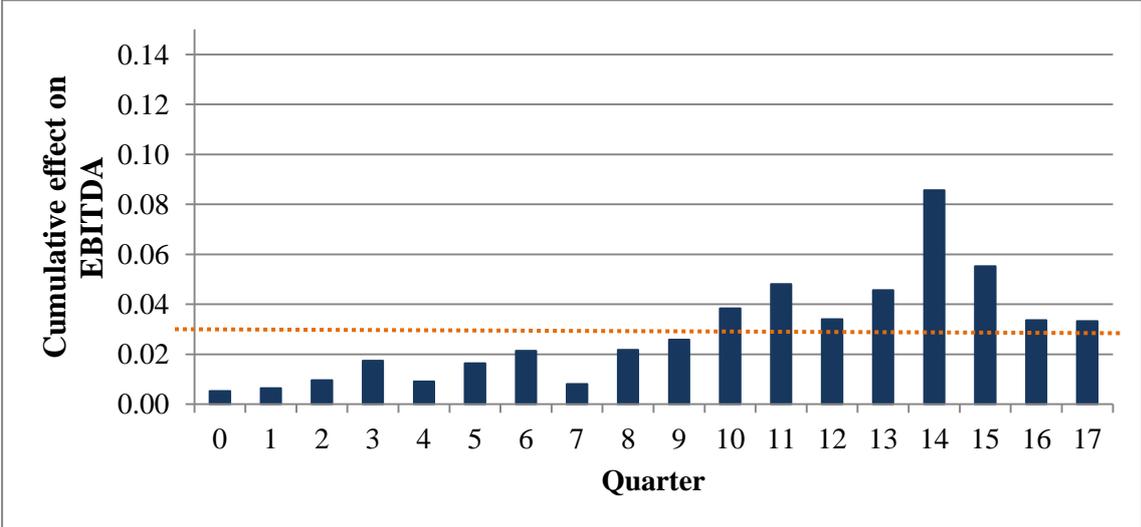


Appendix

**Figure A. 1:** Cumulative effect of network operation services outsourcing on the EBITDA margin in the sub-sample of **small operators** (graphical representation of column 3a in Table 3).



**Figure A. 2:** Cumulative effect of network operation services outsourcing on the EBITDA-margin in the sub sample of **big operators** (graphical representation of column 3b in Table 3).



**Table A. 1: Robustness tests for the main regression.**

	(1)	(2)	(3)	(4)	(5)
Sample operators	<b>Network operation services outsourced</b>	Network operation services outsourced*  *year dummies interacted with country dummies are included	<b>Network operation services fully outsourced</b>	<b>Network operation services fully outsourced &amp; movement of employees</b>	<b>All</b>
Dependent variable	EBITDA <sub>it</sub>	EBITDA <sub>it</sub>	EBITDA <sub>it</sub>	EBITDA <sub>it</sub>	EBITDA <sub>it</sub>
<b>Joint significance</b> (Prob>F) of out coefficients (out <sub>it</sub> – out <sub>it-17</sub> )	0.0021	0.0123	0.000	0.0000	0.0088
<b>Sum</b> of out coefficients (out <sub>it</sub> – out <sub>it-17</sub> )	0.0760	0.0641	0.0915	0.0942	0.0309
<b>Arithmetic mean</b> of <u>over time cumulated</u> out coefficients (out <sub>it</sub> – out <sub>it-17</sub> )	0.0375	0.0094	0.0306	0.0811	0.0113
Number of operators	40	40	23	14	162
Number of observations	837	837	452	267	2957
R <sup>2</sup>	0.8325	0.9120	0.8734	0.7036	0.8237

*Notes: The main regression is presented in column 1. All equations include operator and time fixed-effects. In column 2, year dummies interacted with operator dummies are additionally included. In all equations, a 17-quarters lag structure is used to test the long-term effect of network operation services outsourcing on the operators' profitability. Firm-level control variables are dropped as they were insignificant. Standard errors are robust and clustered by operators. The time period of the sample is 2000-2009 (40 quarters).*

**Table A. 2: Tests for the appropriate lag length.**

	(1)	(2)	(3)
<b>Lag length L</b>	<b>17</b>	<b>12</b>	<b>22</b>
Dependent variable	EBITDA <sub>it</sub>	EBITDA <sub>it</sub>	EBITDA <sub>it</sub>
<b>Joint significance</b> (Prob>F) of out coefficients (out <sub>it</sub> – out <sub>it-L</sub> )	0.0021	0.0877	0.0000
<b>Sum</b> of out coefficients (out <sub>it</sub> – out <sub>it-L</sub> )	0.0760	0.0471	0.0659
<b>Arithmetic mean</b> of <u>over time</u> <u>cumulated</u> out coefficients (out <sub>it</sub> – out <sub>it-L</sub> )	0.0375	0.0191	0.0490
Number of operators	40	42	40
Number of observations	837	1030	641
R <sup>2</sup>	0.8325	0.8033	0.8638

*Notes: The main equation is represented in column 1. All equations include an operator and time fixed-effects estimator. In all equations, a lag structure of L lag lengths is used to test the long-term effect of network operation services outsourcing on the operators' profitability Firm-level control variables are dropped as they were insignificant. Standard errors are robust and clustered by operators The time period of the sample is 2000-2009 (40 quarters). The sample includes observations of all operators that at least partly outsourced network operation services in this period.*