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# Using interpretive structural modeling to uncover shared mental models in IS research

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# MANAGING UNCERTAINTY IN SERVICE PRODUCTION WITH MOBILE SYSTEMS – CASE WASTE MANAGEMENT COMPANY

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## Abstract

*Today's growth of the service sector as a whole has created demand for more efficient service production. Many services require interaction between customers and service personnel, whereas some can be automated into self-services. In this study, we focus on services, that are neither purely human facilitated, nor purely automated, and contain uncertainty in the production process. Based on resource centric theories of strategy and research on uncertainties in service production, we introduce a research framework to evaluate efficient solutions for service production. Our research framework looks at environmental and informational uncertainties, and how an organization can adapt to these by utilizing technology or skilled labour. Illustrated with a case company, we show how mobile information systems can be used to manage service production related uncertainties, which are also typically barriers to standardization. The case study demonstrates how informational uncertainty could be more easily controlled using the new system. The job satisfaction of the workers was increased and their turnover and training time was decreased. Additionally, customer complaints were reduced and invoicing became more efficient. These enabled the company to enhance the efficiency of the service production processes further, moving closer to standardizing and automating the service production process within an uncertain environment.*

*Keywords: Service production, Mobile systems, Resource centric theories, Uncertainties*

# 1 INTRODUCTION

Service has been characterized as something that is perishable, immediate, subjective, intangible, and inherently variable (Chen & Chien, 2008); services are consumed but not possessed (Berry, 1980). Today, the service sector comprises roughly 75 percent of the gross domestic product of developed nations and employs more people worldwide than either agriculture or manufacturing (Maglio et al, 2008). The stream of activity in western economies flows from manufacturing of goods towards service production (see e.g. Penttinen 2007). Yet, there is also an undercurrent of conceptual change in the opposite direction: service production is increasingly turning into “service manufacturing”, or standardized service production, and information and telecommunication technologies (ICT) have a salient role in this development.

Not all services will be affected alike, though. Standardized service production requires automation and current technologies apply differently to different categories of services. Many services close to the conventional services marketing paradigm, such as hairdressing, require interaction between the customer and the service personnel, and hence are ill suited for automation at the current level of technological development. At the opposite end of the continuum are those services, such as personal banking, that can be – and in many cases have been - automated into self-services. In between these two opposites lies a host of services, for example environmental management or health care services, production of which requires combining the best parts of both technology and service personnel: efficiency and predictability of technology with human skills and flexibility. The focus of our study is on these services, that are neither purely human facilitated (like hairdressing), nor purely automated and digitized (like e-banking).

Furthermore, our specific interest lies in the possibilities of mobile technologies in supporting efficient delivery of these services. These mobile business-to-employee solutions, such as wireless field force automation are used by mobile employees, remote from their base of operations, utilizing wireless technologies to perform their specific business tasks in, for example, services such as facilities maintenance and insurance claims appraisal (Barnes et al, 2006). Mobile technologies are expected to enhance business efficiency by distributing information to the workforce, as well as by offering new communication channels with customers (Leung & Antypas, 2001). For example, in an action research study on mobile technology in field customer service, Rossi et al. (2007) claimed that with a mobile information system, the case company was able to realize efficiency gains through simplified processes and at the same time the company could serve the customers better through more transparent stock and sales information.

Managing services is different from managing goods, because of uncertainties related to the characteristics of services. Intangibility implies that service cannot be inventoried or easily displayed; heterogeneity arises because service often depends on labour, which is inherently more unreliable than machines; simultaneity of production and consumption (inseparability) means that the customer participates in the transaction, and therefore service is not easily centralized, and; perishability means that for many services, once the time of potential service passes, the opportunity to sell that service perishes (Roland & Chung, 2006).

In this study, we look at how mobile information systems can be used to manage uncertainties in service production. Based on resource centric theories of strategy and research on uncertainties in service production, we introduce a research framework to evaluate efficient solutions to service production, in terms of environmental and informational uncertainties. Furthermore, we are interested at how the uncertainties affect the levels of standardization or flexibility in the process of producing services. To illustrate the usefulness of the framework, we present a case study in a major Finnish waste management company. Even if the industry under study may be lacking in glamour, it is one of the future growth industries in the service sector and serves as a good example of an industry where companies operate in distributed

production environments. It is also a good example for describing the opportunities mobile technology offers for services standardization.

## **2 THEORETICAL BACKGROUND**

Our study builds on resource centric theories of strategy, namely the resource based view (RBV) (Wernerfelt 1984; Barney 1986), the resource dependency theory (RDT) (Pfeffer 1981), and transaction cost economics (TCE) (Williamson 1975, 1992, 1996), focusing particularly on the treatment of uncertainty. Our perspective follows the tenets of service-dominant logic: we conceptualize service as a process, rather than a unit of output; we focus on dynamic resources, such as knowledge and skills, rather than static resources, such as natural resources; and we view value of service as a collaborative process between providers and customers, rather than what producers create and subsequently deliver to customers (Lusch et al, 2008).

Resource based view, resource dependency theory, and transaction cost economics as streams of strategic thinking, differ in their motivation: transaction cost theory has been conceived to explain the existence of different organizational structures (i.e, markets vs. hierarchies) in exchange systems. The resource dependency theory builds on research on the bases of power within organizations (Weber 1947) and seeks to explain organizational survival. The resource based view is motivated by the heterogeneity of organizations even when discounting the differences across industries.

What is common to these streams of strategic thinking is their focus on resources and, emphasis on uncertainty as the most important target of management function. Uncertainty, defined as “the degree to which future states of the world cannot be anticipated and accurately predicted” (Pfeffer & Salancik, 1978, p. 67), is a central concept in management literature for it is the ultimate source of both opportunities and risks.

RBV (Wernerfelt 1984) emphasizes uncertainty related to intra firm factors of production. Barney (1986) suggests that internal resources and the related uncertainty are more firm specific than environmental uncertainty and hold higher promise for unique, sustainable advantage. TCE is motivated by environmental uncertainty which, combined with bounded rationality (Simon 1991) of decision makers, subject the firm to opportunistic behaviour of its transaction partners. The position TCE holds on uncertainty is close to that of the RDT, which posits that organization’s success is tied to managing environmental uncertainty related to supply of strategic factors of production (Pfeffer 1981). Thus, while RBV focuses on resources and related uncertainties internal to an organization, both TCE and RDT focus on external dependencies on strategically important factors of production.

The RBV suggests that firms should examine internal resources related uncertainty in an attempt to learn how to extract unique, sustainable competitive advantage. The other two schools of strategic thinking concentrate on inter-organizational relationships in resource acquisition and, as a result, emphasize environmental uncertainties. TCE suggests that organizations are born out of desire to optimize over production and transaction costs (Williamson 1975; 1992; 1996). RDT posits that the central management function is minimization of organization’s dependence on external resources and maximization of others’ dependence on resources of its own (Pfeffer 1981).

## **3 MANAGING SERVICE PRODUCTION**

The Unified Service Theory defines a service production process as one that relies on customer inputs; customers act as suppliers for all service processes. Non-services (such as make-to-stock manufacturing) rely on customer selection of outputs, payment for outputs, and occasional feedback, but production is not dependent upon inputs from individual customers. (Sampson & Froehle, 2006) The increased service production requires more efficient ways to cope with the

variance that customers bring into service production process. From the service provider's perspective, a major element of service production is human capital. When customers introduce a high degree of variability (in other words, uncertainty) into the service production process, service organizations may be able to address this variability and successfully satisfy customer needs, when their employees are proficient at diagnosing problems, thinking creatively, developing novel solutions, and so on; that is, when they possess high levels of skill, knowledge, and expertise (i.e., human capital) (Skaggs & Youndt, 2004). Although, employees' personal skills as well as the service production environment vary every time the service is produced. Standardizing the service production process or making it more flexible can be solutions to improve the service. Nowadays technology plays an increased role in the process. Next, we will define environmental and informational uncertainties, discuss the standardization and flexibility in service production, and introduce the role of mobile technologies in this context.

### **3.1 Uncertainties in service production**

Environmental and informational uncertainties have an effect on the possibilities to standardize a given service or a service process. Environmental uncertainties are related to complexity and variability of the environment where the service is produced. Environmental situations and conditions cannot be fully controlled by the organization, and thus increase the uncertainty that the service provider faces. Environmental uncertainties are considerably lower for services produced and delivered at the service organization's premises than for those produced and delivered outside. Furthermore, the environmental uncertainties are lower for services produced and delivered in a single or permanent location, than services produced in multiple or varying locations.

Informational uncertainty is an internal uncertainty within the organization. In producing non-standardized services, the experience and information held by personnel plays an important role. When a customer demands customized service, the employee needs to hold enough information to be able to produce the service in the best possible way. This involves informational uncertainty for the whole organization as the information might not be distributed within the organization, while it may also flow outside of it.

### **3.2 Technology-enabled standardization or labour-enabled flexibility in service production**

To adapt to the environmental and informational uncertainties presented above, the organization has two options: either to standardize the service production process or to enable more flexible process. Levitt (1972) suggests that the standardization of a service can take three forms: (1) substitution of technology for personal contact and human effort; (2) improvement in work methods; and (3) combinations of these two methods. Standardized services do not, however, necessarily mean mechanical services, although many service tasks are routine, allowing specific rules and standards to be easily established (Järvinen et al., 2003). If the environmental and informational uncertainties are high, standardized service production process might be unrealistic, as it would require the organization to be able to control the uncertainties. Clearly an organization cannot fully control its environment. Standardization works best on routine type of services that are produced in a fixed location.

Increased flexibility in the service production process, regardless of high uncertainties, requires highly skilled labour, who can creatively adapt to changing needs. This is a solution with high environmental uncertainties. Still, the knowledge is rather personal and leaves the organization with a risk of losing some of the information along its labour.

### **3.3 Role of mobile technologies in service production**

Mobile technology offers new possibilities to overcome service production related uncertainties. The crux of employing mobile technology is that it enables companies to collect and maintain real time information about the variable production environment and to share this information on the on-demand basis to the employees going about in the distributed production environment. The environmental uncertainties can be brought under control through more complete real time information. Changes in the environment can be instantly, and often automatically, fed into the system, and they are immediately available to others in need of this information. From the resource planning point of view accumulation of production related information in the company databases diminishes the informational uncertainties caused by the stickiness or leakiness of information. Information necessary to efficient resource planning will not remain the property of individual employees, rather, it is instantly available to all employees and the mobile systems can be used to automatically feed this information to those needing it to diminish the informational delays. This information will also remain in the company even after the employee who discovered it leaves, decreasing the dependency on particular individuals' attributes.

The more dynamic the environment, the more important is timely flow of information. The more complex and idiosyncratic the service production process is, the more information is needed to properly automate or standardize the process. Especially those services produced and delivered outside of the company premises are likely to benefit from the opportunities provided by mobile technology to standardize the work flow and the service production process.

## **4 RESEARCH FRAMEWORK**

Our research framework builds on the environmental and informational uncertainties, and two extremes for an organization to adapt to the situation: standardization with technology and flexibility with highly-skilled labour (see Figure 1). As explained, typically low uncertainties in service production enable standardization as technology can easily be utilized but increased uncertainties require flexibility in the process and highly-skilled labour that can cope with varying requirements that the uncertainty creates.

The upper left corner in our framework demonstrates a situation with both low environmental uncertainty and low informational uncertainty (L,L). Both the service environment and the information related to service production are stable, making it relatively easy to standardize the service production using technology instead of labour. In fact, not standardizing it would increase service production costs since, skilful workforce would be used for tasks that do not require workers to assess each situation separately and make situational decisions. An example of this type of service could be a retail store cashier. Standardizing service production in low uncertainty situations decreases the significance of particular workers' personal learning abilities and importance of having long term loyal workers that have learned from practice and stay within the same organization to use and share the knowledge. If and when these workers leave the organization their knowledge leaves with them. However, as both uncertainties are low the necessary knowledge can be stored within the organization and share it as it is needed. This is particularly easy in routine services but also possible in some more complicated type of service, if the knowledge is such that it can be saved in a database. Then other workers can be provided with access, so they will be able to produce the service according to general guidelines without needing to assess each situation separately. This leads to increased homogenization of organizational roles at the same organizational level and tasks, but heterogeneity of the roles at the different organizational levels.

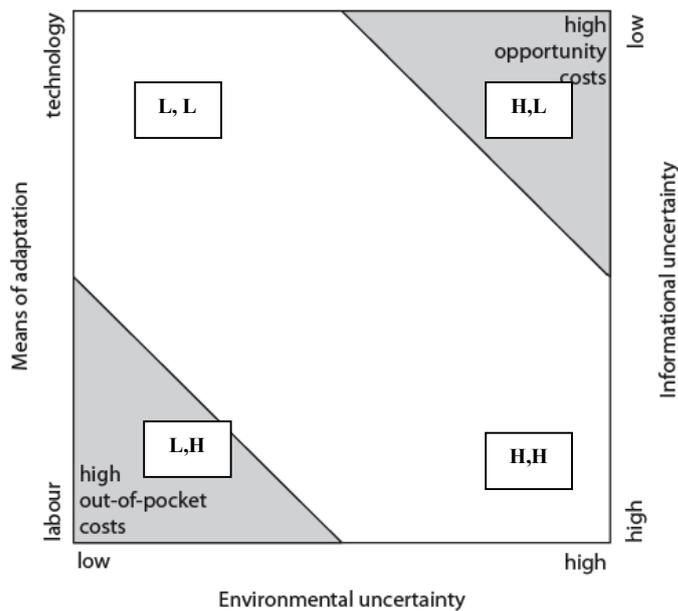


Figure 1. Service production and related uncertainties

The lower right corner shows the combination of high environmental uncertainty and high informational uncertainty (H,H). High environmental uncertainty demands high flexibility in the service production. As the service production environment and the required information varies, workers need to be flexible and skilled to assess the service production situations separately using their knowledge and decision making rights. An example of a service producer in an uncertain environment could be a travel guide. Greater flexibility that is achieved through highly trained service personnel would mean encouraging learning. Simon (1991) offers that organizational learning is profoundly influenced by the organizational roles. Distribution of decision making rights and the related expectations decree the organizational role structure. The mandate of the role is largely dependent on the variety of situations facing the employee. Clearly, if the service production process is characterized by high environmental uncertainty, the service varies highly depending on its environment, the customer, and the service producers. Thus, the workers need to be able to make quick decisions in each case. The role within an organization requires ability to learn, assess the particular situation and make a decision. As people vary on their ability to learn, wider mandates typically lead to increased heterogeneity in de facto organizational roles and produced services.

The lower left corner, on the other hand, suggests low environmental uncertainties but high informational uncertainties (L,H). In this, having highly-skilled and flexible labour handling tasks that have low environmental uncertainties basically means high costs and thus inefficient service production process. Based on the stable service production environment, the service could be automated or standardized utilizing technology, but now skilled-labour is occupied in producing this service. If the information held by the labour would be stored within an organization and the service would be automated, the production process would shift to the upper left corner making it much more efficient. The upper right corner demonstrates high environmental uncertainty but low informational uncertainty (H,L). This is not an efficient solution for service production, as high environmental uncertainty requires skilful and flexible employees. If the internal informational uncertainty would be low, it suggests that employees do not possess critical knowledge and are therefore not able to respond to the need set by the uncertain environment. Thus this means that the company has high opportunity costs as it cannot produce the service in a way that would meet the demands set by highly uncertain service production environment. Having high environmental uncertainty and need to operate efficiently, an organization must move to lower right corner and invest in skilled labour

Utilizing technology to automate or standardize service production process in a situation of both low environmental uncertainty and low informational uncertainty or investing in highly-skilled and flexible labour in high environmental uncertainty and high informational uncertainty are thus both applicable and sustainable solutions for an organization. This area is demonstrated with white colour in our framework. However, having a situation where environmental uncertainty is low but informational uncertainty is high, as in the lower left corner of the framework, means high service production costs: if the service production environment is stable, investments made on flexibility and ability to adapt to environmental uncertainty are needless. On the other hand, if environmental uncertainty is high but informational uncertainty is low, as in the upper right corner of the framework, the changing environment requires flexibility and adaptation to new situations but the organization does not meet these requirements lacking the required information and flexibility.

Thus, when facing a situation of high environmental and informational uncertainty, the service production requires flexibility created and information produced by skilled labour. To adapt to this situation an organization might gain greater control over the informational uncertainty if technology can be utilized to maintain more up-to-date information about the service production environment and other service production related issues, and distribute it on a need-to-know basis. As mentioned having highly trained service production personnel increases organizations dependency on them which increases informational uncertainty. The solution is to have more up-to-date information stored within the organization databases that is shared in service production. The stored information makes it possible to decrease the impact of environmental and informational uncertainties that the service producer is facing and move the production process closer to automation also within an uncertain environment. In terms of our framework, this would mean that moving from lower right corner closer to upper right corner is still efficient, as the required information or environment has not objectively changed. This requires an extensive use of mobile technologies to be able to share the information to service producer living within an uncertain service production environment.

## **5 EMPIRICAL STUDY**

In the empirical part of our study, we look at the presented ways to manage service production related uncertainties in a company specializing in environmental management. In particular, we focus on a new mobile system introduced to facilitate the field work of the service personnel in waste management, and the ways the system has helped to adapt to both environmental and informational uncertainties. Furthermore, in order to illustrate the usefulness of our framework, we discuss the case company solution in terms of informational and environmental uncertainties.

### **5.1 Research methodology**

We chose to look into one case to be able to acquire more in-depth understanding of the phenomenon. The empirical material was collected through in-depth, semi-structured interviews with four employees of the case company. In order to get as multifaceted view of the phenomenon as possible, the interviewees were at different levels and different positions in the company: the development director, the Auvo system developer, the project manager, and finally a field worker. All of them have been closely involved in the development and introduction of the mobile logistics system. The interviewed field worker uses the system on a daily basis, and he has been with the company long enough to know both the earlier system as well as the new mobile system.

Each semi-structured interview, lasting from half an hour to one hour, was conducted by two researchers. All the discussions were recorded and transcribed for analyzes. The topics covered the old service process, the new system, and its implications. Of particular interest was how the new system has changed the work process, what kinds of benefits had been created by it, and

the impacts the new system has had on the processes and the company. In addition to the interviews, publicly available information related to the organization and its services was collected and analyzed.

## 5.2 The Case Company: Lassila & Tikanoja

The case company, Lassila & Tikanoja (L&T) specializes in environmental management and support services for properties and plants. L&T has business operations in Finland, Sweden, Latvia, Russia and Norway. L&T's net sales in 2006 amounted to EUR 436.0 million and it employed 8.328 people at the end of the year. The company's shares are quoted on the Helsinki Stock Exchange. L&T's services are split into three divisions: Environmental Services, Property and Office Support Services, and Industrial Services.

L&T employs a vast number of maintenance personnel and similar, whose work consist of a collection of maintenance and support tasks in customers' premises. Previously each worker received a list of work tasks and their planned schedule as they arrived to the office. They got all the needed information, tasks, schedules, and maps on paper format, with which they started their work day. After accomplishing the tasks, they returned to the office to report the finished work tasks and to receive a new set of instructions. Changes to the schedule were possible only as the workers physically visited the office. This process involved a lot of driving, causing high fuel as well as car maintenance costs. Salaries and fuel and car maintenance costs account for the top three costs for the company. Furthermore, in the old paper based system, the field workers had to learn the routes and tasks, which took a considerable amount of time for new workers.

## 5.3 The Mobile System: Auvo

L&T launched the mobile logistics control system, named *Auvo*, to improve its efficiency. *Auvo* collects information related to service production and distributes it on demand see Figure 2.). For waste management field workers, whose job includes a lot of driving, the information related to the locations and the routes is crucial.

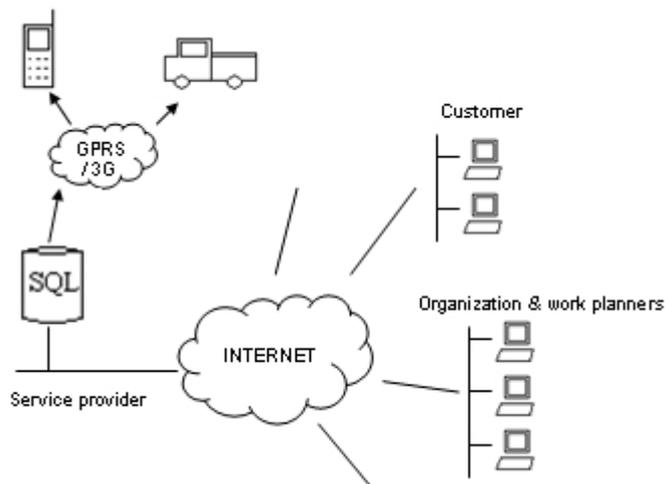


Figure 2. The new mobile system: Auvo

Each maintenance worker has a mobile device with him, providing the work tasks, schedules, as well as maps that were all previously delivered on paper format. Workers do not need to return to the office to sign for new tasks, but the updates and changes are delivered automatically on their mobile devices. As the maps and routes are provided directly to the devices, the routes do not need to be learned. As a task is completed, the worker signs it by pressing *Enter* on the device, possibly adding some other information, if needed. The process moves from the

customer order to the service production and finally to billing without manual paper handling. The field workers have their mobile devices with which they operate, and office workers and customers can access the systems using a web browser.

#### 5.4 Benefits of the new system

According to the development director and the developer of Auvo, the new mobile system has had a significant effect for the company in form of reduction of production costs, consisting of salaries, fuel costs, and the maintenance of special vehicles. Fuel consumption has decreased, since there is less unnecessary driving back and forth to the office, and the field workers know exactly where the target customer sites are. Maintenance of the vehicles is now cheaper because the control system lowers driving speed, causing less damage to the vehicles. Also the shortening of the entire production process from order to invoice from earlier 30 days to only 3 days with Auvo is seen as a significant advantage.

<b>Benefits</b>	<b>Director</b>	<b>Developer</b>	<b>Project Manager</b>	<b>Field worker</b>
Large <b>savings</b> from less driving to and from the office.	+	+		
Entire <b>production process</b> from order to invoicing has become faster.	+	+		
<b>Decreased production costs</b> , as the field workers can serve more customers in the same time.	+	+		
<b>GPS positioning</b> in vehicles making it possible for the supervisor to know in real time where the vehicles are.	+	+		
<b>New customer</b> orders relayed directly to field	+	+		
Waste management <b>production life cycle</b> shortened from 1,5 to 1 day.	+	+	+	
<b>Availability of real time information</b> on production.	+	+	+	
<b>Automation of invoicing</b> has decreased manual work from 100 to 4 invoices.	+	+	+	
<b>Fuel</b> consumption has decreased.	+	+	+	
Maintenance of <b>vehicles</b> is cheaper.	+	+	+	
<b>Invoicing</b> increased 10 %, because there is less unforgotten invoices.			+	
<b>The quality of customer service</b> has risen, because of less mistakes by the field workers.			+	+
<b>The number of customers</b> has increased.			+	
<b>GPS maps and work lists in cars</b> , letting the field worker know exactly where the customer site is and how to drive next.	+	+	+	+
<b>Field workers' duties</b> are easier than before.				+
<b>Less mistakes</b> with customer orders by the field workers.			+	+
<b>Acknowledgement</b> of customer order/target is easier-	+	+	+	+
It is quick and easy to <b>train a new field worker</b> .	+	+	+	+
<b>Field workers job satisfaction</b> has increased, and <b>worker turnover</b> has decreased from 60% to 4,5%.			+	+

Table1. The benefits of AUVO system according to the interviewees (+ denotes a mention by an interviewee)

For the project manager, the biggest benefits of Auvo are created by GPS positioning, shorter production life cycle, and automation of invoicing and customer orders. Waste management production life cycle has shortened from 1,5 days to 1 day, because now the management can reschedule orders and change the order of customer sites to be visited, if needed. The field workers can serve more customers in the same time, and there is no more waiting for the next assignment at the office. New customer orders are relayed directly to the field workers' task lists and to the electronic maps, reducing the number of mistakes made. GPS positioning in vehicles makes it possible for the supervisors to know in real time where each vehicle is driving. Automation of invoicing has decreased manual work from 100 to 4 invoices, as there are no

more paper orders to handle. Furthermore, invoicing has increased for 10 %, because there are fewer orders and invoices forgotten. The decreased number of mistakes has also increased the level of customer satisfaction. Also the number of customers has risen lately.

In the point of view of the field workers, the biggest advantage is that the work is, in general, easier than before, and there are less risks of making mistakes. GPS maps and work lists in cars allow the field workers to know exactly where the next customer site is and how to drive there. The field worker we interviewed also valued the fact that acknowledgement of orders and customer sites target is easy and swift. The job satisfaction of field workers has increased, and worker turnover has decreased dramatically from 60% to 4,5 %. A significant advantage is also that it is quick and easy to train new field workers. Our interviewee has already trained 100 workers to use the new Auvo system.

Summary of all the benefits mentioned by the interviewees is presented in Table 1.

### 5.5 Discussion

Service production that requires high flexibility has conventionally been labour-intensive and more costly than standardized service production. Being able to standardize the production process enables the company to decrease production costs, in our case through simultaneous management of environmental and informational uncertainties.

The service production environment involves uncertainties as the service is produced in customer premises. The routes can change and it is crucial for new employees to learn the environment related information. Conventionally, the employees have been the data depositories possessing the idiosyncratic information needed to efficiently navigate the distributed production environment. This makes the informational uncertainty also relevant for the service production. Ownership of production related information commands increased influence. The knowledgeable employees have been a valuable asset to the company and, hence, enjoyed considerable negotiating power over the terms of employment. Information uncertainty is most clearly reflected in the inability of the employer to prevent information from leaking outside the company as employees change their employment. The mobile logistics control system enabled the collection of service production related information and its distribution on demand decreasing informational uncertainties that the company is facing in its service production process.

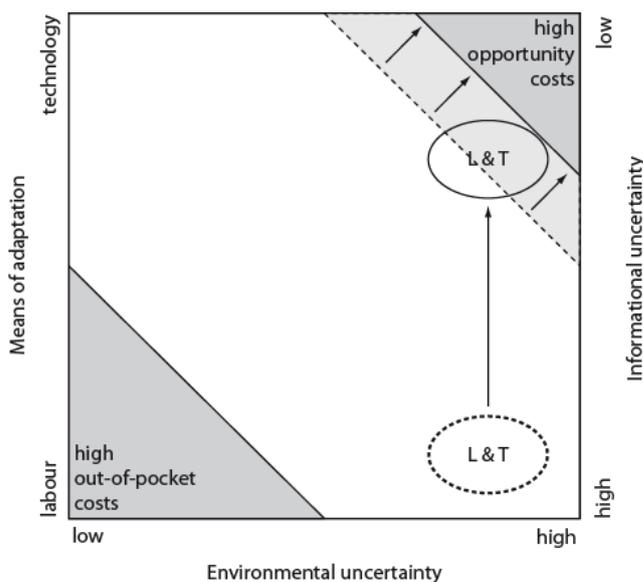


Figure 3. Service production and related uncertainties in L&T

With the old paper based system, the company was situated in the lower right hand corner of our research framework, having high environmental and informational uncertainties. Before the emergence of mobile location aware information systems environmental uncertainty could only be combated with specialized labour, as technology fell short of meeting the requirements of the work and its employment would have led to high opportunity costs in the guise of low service quality. The mobile production system allows simultaneous combating of both environmental and informational uncertainty. Even if the environment cannot be changed its idiosyncrasies can be tracked real time. This information ends up being stored in the company instead of being in the possession of the employees only, which decreases informational uncertainty. This decrease in informational uncertainty is depicted in our framework (see Figure 3) as a move closer to the upper right corner. The mobile system thus has changed the preferred organization for efficient service production: the upper right corner had previously been an inefficient solution but utilization of mobile technology has pushed back the frontier of efficient service production, increasing the ability to automate service production within an uncertain environment.

The mobile logistics control system also adds value for the workers. All the necessary information is stored in a database and accessible on demand. Especially the electronic maps and routing makes the work easier and less stressful. Previously having all the information on paper was risky in the sense that losing some of the papers, or ordering the papers enabled more mistakes from the workers. Now, it is easier and quicker to train new workers, and the work in general is easier. Initially, when the system was introduced, change resistance occurred, as the workers could not see the added value. However, after its launch the system has been constantly updated and improved, the workers have been encouraged to put forward any wishes concerning its improvement. After the adoption, job satisfaction has clearly increased and consequently, the turnover of workers has fallen considerably.

The impact of the system in an organizational level is easy to recognize. Customer service quality has been improved as the number of mistakes has fallen. This can be seen from the radically decreased amount of customer complaints. The invoicing is more accurate as the system does not lose orders or forget to send invoices. Previously the financial department used to go through approximately 100 orders, in comparison to 4 nowadays, as 96 are invoiced automatically. This improvement is dramatic. Also, unnecessary driving back and forth is minimized which decreases fuel consumption. Overall, the lifecycle of the production process has fallen from 1.5 days to one day.

## **6 SUMMARY AND CONCLUSIONS**

In this study, we looked at how a mobile information system can be used to manage uncertainties in service production process. We introduced a research framework based on resource centric theories of strategy and literature on uncertainties in service production. The research framework looks at environmental and informational uncertainties, and the efficient ways of service production within the framework. The framework was illustrated with a case company in the field of waste management. The case company had previously used a paper based system in distributing work tasks, which has now been replaced with a mobile information system to improve and rationalize the information flow within the service production process.

The efficiencies gained with the new mobile system are clear, as the length of the service production life cycle as well as the invoicing life cycle have fallen together with the number of customer complaints and lost orders. The improved information handling and its on-demand delivery were not possible before the launch of the new mobile system. This efficient information processing and sharing are required to enable production of standardized services. Thus, with soundly implemented mobile system service production can be standardized to an activity reminiscent of goods manufacturing. Standardization of service production process

improves cost efficiency, as the company does not have to train and support highly diverse and skilled workforce, and some parts of the process can be automated.

This case study also demonstrates how ICT changes the composition of the efficient solutions. Utilizing ICT applications companies can change their service production processes from highly flexible to standardization, which would not be possible with the traditional paper based systems. The next step in our research is to further evaluate the framework with other companies in different industries and environments, with different informational and environmental uncertainties.

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