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# USING SIMULATION TO ESTIMATE THE IMPACT OF SELF-SERVICE TECHNOLOGY IMPLEMENTATION ON CUSTOMER WAITING TIMES AND SYSTEM OPERATING COSTS

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by

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**Abstract**

The purpose of the present study was to examine the assumption that the implementation of self-service technology (SST) in a service delivery process could simultaneously improve service levels and decrease system operating costs, two performance measures of interest to decision makers. The context of the study was a hotel check-in process where, after SST implementation, customers would be able to choose between checking in using a self-service kiosk (SSK), or using a service employee.

First, using a sample of hotel customers, an online scenario-based survey was used to determine whether the number of customers waiting in line was a predictor of customer choice between using a service employee and using an SSK. Second, a simulation model was developed to estimate the effect of SST implementation on service levels under different supply and demand conditions. Third, as service level and operating costs are somewhat conflicting objectives, a graphical approach to solving a bi-criteria selection problem was used to compare different combinations of service employees and SSKs.

Findings of the scenario-based survey provide evidence that, in addition to their perceived usefulness, need for interaction, and anticipated quality, customers decide whether to use SST or use a service employee based on the length of the waiting line for each alternative. The results of the simulation study show that, under the assumed demand and supply conditions, SST provides satisfactory service levels at a lower operating cost. Furthermore, under high demand conditions, a service delivery process including SST outperforms a service delivery process where no SST alternative is available. When the SSK does not perform as well as expected, namely processing times and failure rates of the SSK are high, the introduction of SST has a negative impact on service levels. Implications for further research and practice are discussed.

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## Introduction

In the past thirty years, self-service technologies (SSTs) have transformed the ways in which services are delivered by allowing customers to take on a coproduction role. SSTs are technological interfaces that allow customers to produce services independently of service employees' involvement (Meuter, Ostrom, Roundtree, & Bitner, 2000). Some SSTs that have been widely accepted by customers include automated teller machines (ATMs), self-service check-in kiosks (SSKs) at airports and hospitals, online banking, supermarket self- check-outs, and online brokerage services.

Research on SSTs has focused on the antecedents of customers' use of SST in contexts where they have the choice between using an SST and using a service employee to conduct a transaction. Using an attitudinal theory framework, researchers have investigated the role that beliefs about SSTs and attitudes towards SSTs play in customers' decision to use a particular SST. Overall, studies consistently have found that attitudes towards specific SSTs positively impact both the intention to use the SST (Dabholkar, 1994, 1996) and the actual use of the SST (Weijters, Rangarajan, Falk, & Schillewaert, 2007). Several beliefs about the benefits of SSTs have been shown to positively impact customers' attitudes towards specific SSTs. These beliefs have included the perceived usefulness, the perceived ease of use, the perceived reliability, and the perceived fun/ enjoyment of the SST (Curran & Meuter, 2007; Dabholkar, 1994; Weijters et al., 2007). The results of these studies have been used to provide guidance to decision-makers on how to make SSTs more attractive to customers and increase customer usage of SST. However, while this information can help decision-makers improve the likelihood that customers will use the SST, it does not help them to estimate whether the objectives of implementing SST will be fulfilled, before incurring the cost of implementation.

Several firm objectives for implementing SST have been proposed. SSTs have been assumed to increase speed of delivery, precision, and customization (Berry, 1999; Curran et al., 2003). SSTs have also been suggested as a way to help firms reduce the heterogeneity of service in the service encounter by providing a more consistent service atmosphere, one that is not affected by service employees' moods (Weijters et al., 2007). Such benefits of SST implementation could provide valuable improvements in customer satisfaction (Bitner, Brown & Meuter, 2000; Weijters et al., 2007). Higher customer satisfaction could in turn lead to higher profits for the firm by positively impacting customer retention and re-purchase intentions (Anderson & Mittal, 2000). SSTs also could allow firms to differentiate themselves from their competitors through a technological reputation (Meuter & Bitner, 1998).

Two frequently cited potential benefits of SST implementation in service delivery processes where customers are physically present are a reduction in waiting times and a reduction in operating costs. Specifically, it has been assumed that implementing SST in a service delivery process could reduce customer waiting times. This is of interest to decision makers as longer waiting times have been linked to lower perceptions of service quality (Taylor, 1995) and customer satisfaction. SST implementation has also been proposed as a way for service firms to reduce operating costs, and increase productivity (Dabholkar, 1996; Weijters et al., 2007) as it enables firms to achieve productivity gains by shifting responsibility for production activities to customers (Lovelock & Young, 1979; Mills, Chase & Margulies, 1983; Mills & Morris, 1986). However, waiting time reduction and operating cost reduction are somewhat conflicting objectives, as a costly increase in capacity is typically needed to reduce waiting times. While it is assumed that SST implementation can improve these two performance measures simultaneously, a review of the literature found no study that concurrently examined operating costs and waiting times as performance measures of interest.

Based on the assumption that a higher rate of customer use of the SST alternative will lead to the success of the SST implementation, previous research on SST has primarily examined ways to increase usage of SST. While this assumption has intuitive appeal, a review of the literature did not find empirical support for it. It is therefore important to examine the success of an SST implementation using measurable aspects of customer satisfaction (such as reduced waiting times) and operating costs. Since these two objectives are somewhat conflicting, it is important to consider them simultaneously.

In order to develop a model of how SST implementation may impact waiting times and operating costs, it is necessary to understand the supply and demand factors that will impact waiting times and operating costs before and after the SST alternative is implemented. Demand factors include the number of customers arriving to receive service. Supply factors include the number and type of resources (service employees and SSTs) available to customers, the processing time for each resource, and the failure rate of the SST. These factors may each have a direct effect on waiting times and operating costs as well as interact amongst themselves. Consequently and due to the increasing complexity of service delivery processes, traditional cause-and-effect models of decision-making are no longer sufficient and a systems approach is required (Daellenbach, 1994). A systems approach is a theory that sees an organization as a set of interrelated and interdependent parts and therefore seeks to understand the connections and interactions between the components of the system.

**Purpose of the Study and Research Questions**

The overall objective of this study was to examine the assumption that adding an SST alternative to a service employee alternative in a service delivery process could lead to a reduction in actual waiting times and operating costs. In order to examine this assumption, several research questions need to be addressed. First, this study examines customer beliefs and situational factors that influence a customer's decision to select an SST alternative in a service context. Second, this study examines whether the number of customers waiting for each alternative can be used to predict customer choice to use SST. Third, this study examines which demand (arrival rates) and supply factors (number of service employees, number of SSTs, processing time of the SST, failure rate of the SST) have a significant impact on customer waiting times. Fourth, this study examines which combination of resources (service employees and SSTs) can provide the best service levels for the lowest cost. The focus of this study is on services for which consumers experience waiting within the facilities due to delays or queues (for instance restaurants, supermarkets, doctors' offices…) (Baker & Cameron, 1996).

**Significance of the Study**

The majority of SST research has until now focused on customer attitudes towards SST and customer evaluations of SST after the service encounter. The models developed in this research stream can primarily be classified as descriptive (Leeflang & Wittink, 2000). In this study, hospitality research and management science techniques are combined to develop a predictive model of the impact of self-service technology implementation on service levels and operating costs.

The present study further contributes to the SST literature by investigating the consequences of integrating SST into an existing process on performance measures other than the number of customers using the SST. Instead, the study focuses on the benefits that managers hope to reap when implementing SST and defines success in terms of operating costs and waiting times, two performance measures of interest to decision-makers.

This study investigates whether contextual information such as the length of the waiting lines customers encounter is a better predictor of customer use of SST than customer characteristics and attitudes towards SSTs. Previous research on SST has, in its majority, addressed either the impact of customer characteristics and/or SST characteristics on SST use, or the impact of SST use on customer satisfaction. Yet, customer characteristics such as need for interaction and technology anxiety are not visible to service providers and therefore not actionable. Instead, the present study examines the role of contextual information which is visible to decision-makers.

Finally, the present study provides practitioners with empirical information about the benefits of SST implementation for their operation. In order to implement SSTs, service operators need to convince owners and franchisees that SST implementation will add-value to their organization (Olsen and Connolly, 2000). However, a 2009 report by the publication Hospitality Technology[1] found that 38% of respondents did not feel they had sufficient information about the benefits of SST for their operation ("Hotels Acknowledge Growing Guest Demand", 2009). Furthermore, the fragmentation of ownership of hospitality firms has been identified as an impediment to technology implementation.

**Organization of the Dissertation**

This dissertation is comprised of six chapters. Chapter 1 reviews prior research relevant to the purpose of this study. Chapter 2 develops a model relating customer behavior to waiting lines in the context of hospitality/lodging operations. Chapter 3 presents the methodology and findings of a pre-test used to identify the best presentation of a scenario-based survey and to refine scales for customers' beliefs about SSTs. Chapter 4 presents the methodology, findings, and limitations of the scenario-based study. This study was used to examine the factors influencing customers' choice to use SST in a hotel check-

[1] The study was sponsored by NCR, a supplier of SST.

in context. Chapter 5 presents a simulation analysis relating customer choice to use SST, and demand and supply factors of a hotel check-in process to waiting times. Model formulation, validation, sensitivity analysis, and experimentation are discussed. Waiting times are computed for several combinations of service employees and SSKs. A spreadsheet model is used to compute operating costs for each of those combinations. Operating costs and waiting times for each combination are then compared simultaneously using a graphical approach to multiple selection problems. Chapter 6 summarizes the findings of the study, presents conclusions and implications for practice and further research.

# Chapter 1: Review of Relevant Literature

## Overview

This chapter reviews literature relevant to the development of a model to estimate how the addition of an SST alternative in a service delivery process would impact customer waiting times and system operating costs, in four sections. The first section reviews the benefits of SST implementation to customers and firms, and leads to a discussion of why customer usage is a necessary but not sufficient condition for SST success in the second section. The third section introduces a systems approach to the examination of SST implementation. The final section explains why simulation was a suitable approach to the examination of a model of SST implementation and introduces the modeling approach that was adopted in Chapter 2.

## Customer Perspective of Self-Service Technology

SSTs provide benefits to both customers and firms. For customers, SSTs provide them with more opportunities to obtain a service, outside of normal operating hour constraints (Meuter et al., 2000; Rodie & Kleine, 2000). For instance, customers have the flexibility to use ATMs at any time to withdraw cash or deposit checks. Another advantage of SSTs for customers is a reduction in transaction costs. For example, by booking a ticket online, customers can oftentimes avoid paying booking fees. SSTs also provide customers with the opportunity for customization and speedier transactions. Customers who have previously purchased at online retailers such as Amazon can take advantage of the website's recommendation function and reuse previously entered billing and shipping information. SSTs also provide psychological benefits to customers by giving them an increased sense of perceived control that can lead to personal satisfaction (Rodie & Kleine, 2000). By providing these SST-driven benefits to customers, firms have the potential to increase their satisfaction with the firm. Customer satisfaction is an important non-financial outcome for service firms as it has the potential to increase firm value.

In addition to customer satisfaction improvements, SSTs can help firms improve their productivity and reduce their operating costs (Lovelock & Young, 1979). SSTs such as online retailers and ATMs increase the availability of the service and therefore spread demand over a larger period of time. Furthermore, SSTs such as SSKs typically provide capacity at a lower cost than the equivalent work force by allowing customers to perform certain production activities (Lovelock & Young, 1979; Mills et al., 1983; Mills & Morris, 1986).

There are two opposing viewpoints on the effect of including customers in the service delivery process. According to Chase (1978), allowing customers to interact with the process increases variability in service performance. For example, when ordering by phone, customers' indecisiveness and lack of information can introduce unexpected variance in the average duration of a call. Therefore, by removing the customer from the process, variability can be reduced and performance will improve. Conversely, a more recent opinion is that productivity improvements can better be achieved by involving customers in the service delivery process. For example, banks have increased the number of transactions they can process by allowing customers to bypass the services of a teller and conduct their own transactions online. Therefore, allowing customer participation in service delivery enables firms to achieve productivity improvements.

However, participation in the production or delivery of a service requires customers to change their behavior and become co-producers of the service (Bendapudi & Leone, 2003). Customer participation has been defined as the extent to which customers are involved in the service process (Fang, 2008). It is a behavioral concept that refers to the mental, physical or emotional resources that customers provide to a production or service process (Rodie and Kleine, 2000). By providing these resources, customers take on some of the risk of the transaction from the service provider. Furthermore, since the resources they provide to the transaction have the potential to influence the quality of the output they receive, customers also become partially responsible for the quality of the service they receive, and for their satisfaction (Bitner, Faranda, Hubbert, & Zeithaml, 1997).

**Research on Customer Use**

A common assumption is that the success of SST implementation depends largely on whether customers accept to change their behavior and use the SST. Consequently, research on SST implementation has primarily focused on what drives customers to use the SST, and the factors that differentiate between frequent and infrequent users. Factors that have been examined have included technology characteristics, customer characteristics, customer attitudes towards the SST, and contextual variables. The models that have been used to examine the determinants of SST usage closely resemble those used to predict employee acceptance of new technology by arguing that technology can improve a firms' productivity only if it is used.

The first part of this section reviews the research on employee acceptance of new technologies as this is a more mature area of research that can provide valuable guidance for models of SST usage. The subsequent part examines research on customer usage of SSTs. The last two parts of this section discuss two issues common in SST and technology acceptance research, namely the (1) lack of research in the antecedents of customer beliefs, and more specifically the role of waiting time and (2) the insufficiency of customer usage as a measure of success of SST.

**Technology acceptance models.**

The Technology Acceptance Model (TAM)[2] was the first model of employee acceptance and usage of technology proposed by Davis (1989) and Davis, Bagozzi and Warshaw (1989). TAM was developed with the purpose of identifying the determinants of computer acceptance that could be used to explain user behavior across several technologies and populations (Davis et al., 1989).

TAM was an adaptation to Fishbein and Ajzen's (1975) (Ajzen & Fishbein, 1980) theory of reasoned action (Davis et al., 1989; Venkatesh, Davis & Morris, 2007). According to the theory of reasoned action, customers' behavioral intentions predict their actual behavior, and behavioral intentions are in turn predicted by two factors: attitudes towards the behavior and social norms (Sutton, 1998). Attitudes are in turned influenced by beliefs and evaluations. TAM differed from the theory of reasoned action in that it did not include the attitude construct. Furthermore, the first TAM did not include social norms as determinants of behavior intentions.

According to TAM research, the most relevant beliefs to technology users were perceived usefulness and perceived ease of use. Perceived usefulness was defined as "the prospective user's subjective probability that using a specific application system will

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[2] It is a convention in the Information Systems literature to use TAM without the article (see Silva, 2007, pg. 256).

increase his or her job performance within an organizational context" (Davis et al., 1989, pg. 985). Perceived ease of use referred "to the degree to which the prospective user expects the target system to be free of effort" (Davis et al., 1989, pg. 985). Scales for perceived usefulness and perceived ease of use were developed by Davis (1989). TAM was later enriched by the addition of subjective norms contexts where the use of the technology was mandatory. Following the theory of reasoned action and TAM, other models and theories were developed to predict usage of technology including the theory of planned behavior, the innovation diffusion theory, the social cognitive theory, and the motivational model (Venkatesh, Morris, Davis, & Davis, 2003).

**Models of customer usage of SSTs.**

Similarly to TAM research, attitudinal theory has formed the basis of inquiry into customers' willingness to use SST. Several models have been developed to explain customer behavior with respect to SSTs. Like TAM, these models have focused mainly on customer trial, adoption, and usage of SSTs and have used the theory of reasoned action and the theory of planned behavior as their basis.

Unlike TAM, models of customer usage of SSTs have adopted various forms, and have not always relied on the same structure of beliefs, attitudes, and behaviors of the theory of reasoned action. For instance, Curran, Meuter & Surprenant (2003) used customers' global attitudes towards a service firm, attitudes towards service employees, global attitudes towards SST, and attitudes towards a specific SST to examine their intention to use the service firm's SST. In a subsequent study using the same setting and the same population, Curran and Meuter (2005) examined the influence of four beliefs (ease of use, usefulness, need for interaction and risk) on attitude towards the SST and use of the SST. In a third study, using again the same context and population, Curran and Meuter (2007) developed a model that mixed the two previous studies (Curran & Meuter, 2005; Curran et al., 2003) and tested it using a series of nested structural models. However, even though the authors used variables similar to their previous studies, they used a different dependent variable, replacing intention to use SST by intention to change behavior. In a different model, Meuter, Ostrom, Bitner, and Roundtree (2003) related customers' demographics and technology anxiety to their usage of SST. In yet another model, Meuter, Bitner, Ostrom, and Brown, (2005) examined technology characteristics, customer characteristics and consumer readiness variables on customer trial of SSTs and did not examine either attitudes or beliefs.

Models that rely on the beliefs, attitudes, intentions structure have identified several beliefs that relate positively to customers' attitudes and drive their use of SST. The most commonly examined beliefs have included perceived usefulness, perceived ease of use, anticipated performance, and perceived fun/ enjoyment of the SST (Curran & Meuter, 2007; Dabholkar, 1994; Weijters et al., 2007). In the context of SST research, usefulness represents the attainment of the desired outcome while ease of use refers to the process leading to the outcome and encompasses customer concerns about the effort expended and the social risk incurred (Dabholkar, 1996; Weijters et al., 2007). Performance encompasses the reliability and accuracy of SSTs as defined by the consumer (Dabholkar & Bagozzi, 2002). Perceived fun and enjoyment reflected aspects such as novelty and play (Dabholkar, 1996; Langeard, Bateson, Lovelock & Eiglier, 1981). Other beliefs that have been shown to impact attitudes towards SSTs have included perceived risk, need for interaction, and technology anxiety. Perceived risk is a concept related to reliability and reflects the negative consequences associated with the use of SSTs (Curran & Meuter, 2005). Need for interaction was defined as the desire for personal interaction during a service encounter (Dabholkar, 1992). Technology anxiety has been defined as a potential user's fear and apprehension about general technology (Meuter et al., 2003).

The focus of SST research on finding models that explain customers' use of specific SSTs in particular contexts has resulted in a variety of models, with contradictory findings. For instance, gender was found to influence the impact of perceived usefulness on attitude towards SST in a supermarket context (Weijters et al., 2007), but did not directly impact trial of the SST in a prescription re-fill context (Meuter et al., 2005). Similarly, while the variables perceived ease of use and perceived usefulness have generally received strong support in both the SST (Dabholkar, 1994; Dabholkar & Bagozzi, 2002; Oh & Jeong, 2009; Weijters, 2007) and TAM literatures (Schepers & Wetzels, 2007; Straub & Burton-Jones, 2007; Venkatesh et al., 2003), models using these variables have shown mixed results. For instance, expected usefulness has been found to impact customers' attitudes towards ATMs and bank by phone, but not customers' attitudes towards online banking (Curran & Meuter, 2005). Similarly, expected ease of use has been found to impact customers' attitudes towards ATMs (Curran & Meuter, 2005) and fast food self-ordering (Dabholkar, 1994; Dabholkar & Bagozzi, 2002), but not their attitudes towards bank-by-phone and online banking (Curran & Meuter, 2005). This suggests that context is relevant.

**Context and the role of waiting time.**

Context could provide an explanation the mixed results obtained thus far, customers' reactions to the environment play an important role in how they behave towards the self-service technology (Dabholkar, 1996). However, previous research has not distinguished between SSTs in services for which customers experience waiting within the facilities due to delays or queues, and services for which the customer is either not physically present in the service facility or does not experience waiting (Baker & Cameron, 1996). Examples of service situations where customers are physically present include airport check-in, retail check-out and financial transactions at a bank. The equivalent service situations that do not involve customers' physical presence include online or telephone check-in, online shopping, and online or telephone banking respectively.

Customers' physical presence in the system has several implications. First, by being physically present in a service setting, customers can see how crowded the service environment is, and make a choice accordingly. For instance customers may choose differently between using a self-service check-in kiosk and a service employee to check-in for a flight at the airport, depending on the number of people ahead of them. A customer choosing between checking on the phone or online cannot see a physical waiting line and therefore the length of the line will not be relevant to his or her decision, unless informed of it (Hui & Tse, 1996).  Second, customers may suffer physical discomfort if there is a long wait associated with obtaining a service. This may impact the perceived value of each alternative. Third, by physical transporting themselves to the service system, customers have already incurred a cost and this may make them less likely to give up on the service. This suggests that customer behavior, and more specifically, customers' choice of whether or not to use SST will differ based on whether the customer is physically present in the service delivery setting and this difference will revolve around the act of waiting. It is therefore necessary to examine the role of anticipated waiting on customers' decision to use SST.

Waiting time reduction has oftentimes been cited as a motivator to use SST. Using a mixed method approach involving focus groups, in-depth interviews and surveys, Bateson (1985) reported that customers perceived services as being time consuming. Furthermore, high self-service users perceived a time difference between self-service and using a service employee and considered time an important factor in their decision to use SST. Dabholkar (1994, 1996) elicited beliefs about verbal and touch screen ordering of fast food and identified time as a salient belief in customers' choice to use the touch screen ordering. Meuter et al. (2000) examined SST satisfiers and dissatisfiers and found that thirty percent of satisfying events related to customer time savings. In a retail context, Dabholkar, Bobbitt, and Lee (2003) found that customers would be more willing to use a self-scan option to check-out if there was a line for the service employee or, conversely, if the line for the self-scan was short. Previous research has also shown that, if customers have a choice, they will pick the option with less waiting time (Clemmer & Schneider, 1989; Dabholkar, 1990).

The few studies that included waiting time found it to have a significant effect on customers' decision to use SST. Dabholkar (1996) examined waiting time in the context of customers waiting to order fast food using either verbal ordering or touch screen ordering and found it to influence customers' intentions to use the SST. Specifically, in the short wait condition, enjoyment had a direct impact on intentions to use the SST. This effect was reduced in the long wait condition, suggesting that waiting time influences the impact of hedonic benefits. Conversely, ease of use was found to be more important in the high wait condition than in the low wait condition, implying that customers were willing to exert more effort in order to benefit from a shorter waiting time. Reliability and speed of delivery also had direct effects on intentions in the high wait condition. This implied that customers were more willing to try the SST if they anticipated it to be reliable and fast to use once their turn came. In the context of customers checking in at a resort hotel, Oh and Jeong (2009) used a quasi-experiment to investigate the role of waiting (through the length of the waiting line) on customers' decision to try the SST. Other factors in the experiment were price level, star rating, and type of resort. Of these experimental factors, only waiting lines contributed to the prediction of customers' likelihood to use the SST along with perceived usefulness, perceived ease of use, desire for high touch, desire for privacy independence, and desire for efficiency.

The evidence suggests that anticipated waiting time has a strong effect on customers' choice of whether or not to use SST. However, it is unclear how this relationship is structured. The different ways in which the influence of waiting time on customers' decision to use SST has been examined suggests that there is no established way to incorporate waiting time considerations. The inclusion of waiting time in a model of customer use of SST will be further discussed in the next chapter.

**Previous experience with SST.**

Despite the anticipated time savings, it is likely that many customers will not use the SST alternative due to a lack of previous experience with SST. Conversely, as customer experience with SST increases, so does the likelihood that the customer will use SST for subsequent transactions, as his/her self-confidence increases (Gardner, Dukes & Discenza, 1993). Bentler and Speckart (1979) first tested the effect of prior behavior on future behavior and found that prior behavior contributed strongly to the occurrence of future behavior. The context of Bentler and Speckart's was drug use of young adults and therefore very different to the context of this study. However, this relationship has also been supported in the context of coupon usage (Bagozzi, Baumgartner & Yi, 1992) and class attendance (Fredricks & Dossett, 1983).

This is consistent with findings that customers have slowly, albeit reluctantly, embraced SSTs. For instance, in 1979, Lovelock and Young reported customers were reluctant to use ATMs. Yet thirty years later, the use of ATMs is widespread. In the same article, Lovelock and Young described off-peak pricing, zip codes, and pump-your-own-gas as underachieving ideas. However, in 2009, these are widely used ways to manage demand for capacity-constrained services, widely embraced by customers. Similarly, Dabholkar, et al. (2003) described self-scanners in supermarkets as initially "being met with stubborn resistance" (Dabholkar, et al., 2003, pg. 60) yet indicated that this may be changing as customers are more comfortable with the technology. Customer satisfaction with SST alternatives is related to their experience of these alternatives (Igbaria, 1990). Bobbitt and Dabholkar (2001) argued that, according to the theory of trying, the quality of customers' previous experiences with SST had the potential to impact their attitudes towards SST and hence their intention to use SST. The increase in customer usage of SST as their experience with SST increases suggest that such a learning curve effect is taking place and that customer usage with SST could vary over time.

**Measures of SST success.**

Previous research has typically focused on customer usage of SST as a measure of SST implementation success, based on the assumption that increased use of the technology will increase performance (Goodhue, 2007). This is intuitive: if no one uses the SST, the implementation of SST will not improve operational performance, and the cost of implementation will probably reduce overall financial performance.

However, basing investment decisions on the assumption that increased customer usage will lead to SST implementation may lead to adverse results. For example, it is possible to achieve100 percent customer use of the SST alternatively designing a system where there is no other alternative but to use the SST. However, this is likely to negatively impact the future performance of the firm as forcing customers to use SST will lead to negative attitudes towards the SST, towards the service provider and result in reduced behavioral intentions (Reinders, Dabholkar & Frambach, 2008).

Instead, the neoclassical economics view that economic growth depends on the productivity of resources and the quality of the output as experienced by the user (Fornell, Mithas, & Krishnan., 2006) supports the use of customer satisfaction (related to quality of the output) and operating costs (linked to productivity of the resources) as variables of interest in the study of SST implementation success. Nevertheless, customer satisfaction cannot be estimated *a priori*, and a suitable proxy needs to be found.

Waiting time is a well-documented determinant of perceived service quality and customer satisfaction. Support has been found for the relationships between actual waiting time, perceived waiting time, perceived service quality and customer satisfaction (Baker & Cameron, 1996; Bitran, Ferrer, & Rocha e Oliveira, 2008; Davis & Maggard, 1990; Hui & Tse 1996; Katz, Larson & Larson, 1991; Taylor, 1994; 1995).

Waiting time is also related to customer behavioral intentions and hence to the firm’s non-financial performance. Taylor and Fullerton (2000) reviewed this research and concluded that the impact of waiting time on customer evaluations (perceived service quality and customer satisfaction) was mediated by negative affect. In other words, a higher waiting time increased customers' anger which in turn reduced their perceived service quality and customer satisfaction.

Another advantage of waiting time as a performance measure is that it can be linked to managerial actions that have been shown to drive profits (Bitran et al., 2008). Bitran et al. suggested that the waiting time and service duration are determined by operational policies, service settings (process characteristics), and customer behavior. This suggests that not only can waiting time be determined *a priori* based on the process characteristics, it can be influenced by managerial actions. However, the relationships between process characteristics, customer behavior, and SST implementation are complex and require a systems' approach.

## Systems' Approaches

The relationships between process characteristics, customer behavior, and SST implementation are complex and require a system's approach. For example, customer behavior and process characteristics interact: customer behavior will be influenced by the process characteristics such as waiting times, yet the process characteristics will change depending on how customers behave.

These interactions imply that traditional cause-and-effect models are not sufficient. Instead, this type of process can be defined as a system. Daellenbach (1994) defined systems as being "comprised of components that have special relationships" and "each component contributes to the behavior of the system and is affected by being in the system" (Daellenbach, 1994, pg. 27). Therefore, careful consideration needs to be given to the study of the system as a whole, and not individual parts (Daellenbach, 1994). Several frameworks can be used to examine and predict the success of such systems. These include management science/operations research approaches suitable to the study of complex and multi-dimensional relationships.

### Management science.

Management science bases decisions on rational and systematic processes and uses decision models as aids to the decision-making process (Knowles, 1989). Decision models are mathematical representations of the decision environment that have been chosen for use in evaluating the available decision alternatives. Two types of decision models that are widely used in management science to provide managers with additional information are optimization and simulation models. Optimization models assist decision makers in selecting the best alternative amongst those consistent with the model representation. Simulation models, while more flexible, only show what the outcome of selecting a particular alternative would be. Therefore, a combination of simulation and optimization methods is oftentimes used to select the best decision amongst several alternatives. The use of simulation and optimization has been lauded as a way to improve process development (Luce, Trepanier, Ciochetto & Goldman., 2005) as the use of models that account for event probabilities is much more effective in predicting the success of business processes.

A particular class of models developed to study waiting lines is queuing theory (Gautam, 2008). Queuing theory is an analytical approach to system performance analysis. The purpose of queuing theory is to develop ways to compute performance metrics for systems involving waiting lines. These can take the form of formulas, expression, and algorithms. Queuing models are particularly appropriate when an analyst wants to quickly compare several what-if situations, determine the best course of action for a given set of parameters, or gain insights into the relationship between arrival and processing times. Queuing models have been developed for a variety of system configurations. These include single station and multi-station settings, single server and multiple server systems, exponential and general arrival and processing distributions. Furthermore, in the simple cases, queuing models have been developed for situations where customers are not patient and either balk or renege on service.

However, queuing models still have a number of limiting assumptions. Queuing models cannot accommodate this kind of conditional logic and interactions in a system and it may be more advantageous to use simulation (Harmonosky, 2008). Queuing models are also only useful for certain performance measures such as average waiting time, average service time, number of customers waiting in line, and number of customers waiting in the system. Queuing models are less suited to the computation of performance measures such as minimum and maximum waiting time and confidence intervals. In those situations, simulation may be more advantageous.

## Simulation

A simulation is a model of the operation of a real world system forthe purpose of evaluating that system (Goldsman, 2007). Discrete-event simulation allows one "to model an existing or proposed system, capturing key characteristics and parameters of that system, such that the model emulates the behavior and performance of the system as events take place over time" (Harmonosky, 2008, pg. 12-1). It can be used to 1) evaluate the performance of an existing system under different conditions, 2) compare the performance of alternative system designs (Law, 2007) or 3) predict whether the system design will perform in ways that meet a firms' specified goals (Harmonosky, 2008).

A key advantage of simulation is that it allows the researcher to experiment quickly and efficiently (Goldsman, 2007). In addition, simulation allows the researcher to maintain a tighter control over experimental conditions than if experimenting with the system itself (Law, 2007). Some other reasons why it might be advantageous to use simulation are lower costs, lower risks, and time compression (Law, 2007; Sánchez, 2007; Thompson and Verma, 2003).

Computer simulation is useful when analyzing systems that are too complex to be analyzed using analytical models (Law, 2007). However, simulation is a heuristic, meaning that it cannot deliver an optimal answer (Harmonosky, 2008). Instead, numerical methods are used to keep track of system changes over time. The analyst runs the simulation several times for a particular set of input parameters to obtain independent replications (Harmonosky, 2008; Law, 2007). Each replication produces estimates of the process true characteristics (observations) that are used to estimate the true characteristics.

### Simulation in hospitality.

While the principles and procedures of simulation research are similar for manufacturing and service, the processes examined and the outcomes of interest can be different. For instance, both manufacturing and service researchers have used simulation to solve resource allocation problems and queuing problems. However service researchers need to pay closer attention to issues such as timeliness (since customers get impatient), the variability of service times (since the interaction between customers and service employees can bring significant uncertainty), and labor costs (since services can be much more labor intensive than manufacturing) (Starks & Whyte, 1998). Furthermore, service research need to model human behavior. This is a challenge, since human behavior can sometimes be illogical and thus hard to model (Jaynes & Hoffman, 1994, Sterman, 1987)

In the context of services and hospitality, the majority of simulation studies have involved the re-design of either the physical system or procedures of the system or both, to improve performance measures of interest. In the context of restaurants and drive through operations, performance measures have included average time in the system, average queue length, average time to fill an order, average utilization of employees, and number of customers balking from the system (Farahmand & Garza Martinez, 1996). The most commonly examined performance measures have been labor cost and waiting time.

One of the earliest published large simulation studies was discussed by Swart and Donno (1981). Swart and Donno (1981) presented the work of the operations research department of Burger King, a U.S. fast food restaurant chain. This team initially developed several independent applications that were used to re-design restaurants in order to reduce service times and select a better set of suppliers to reduce food costs. Subsequently, in face of rising labor and food costs, Burger King instituted a continuous productivity improvement for which a general purpose restaurant simulation model was developed, that could be adapted to several Burger King restaurant designs. The simulation model was used to examine ways to improve labor schedules to reduce labor cost and was subsequently packaged for use by individual restaurant operators.

Similarly, Godward and Swart (1994) used simulation to determine the minimum amount of labor required to achieve the desired customer service level at Taco Bell, another fast food restaurant chain. They described the development of an object oriented simulation model that was part of a broader labor management system. The labor management system received the desired level of customer service as an input, combined it with projected sales, used the simulation component to determine staffing levels, and used an optimization component for scheduling. Godward and Swart indicated that Taco Bell achieved a labor saving of one hour per day, per Taco Bell store, which resulted in estimated annual savings of $2.7 million per 1,000 Taco Bell stores. Parallel to the labor management system, Taco Bell also used another simulation application, the Quick Service Restaurant Simulation (QSRS) to analyze parking lots and traffic configuration for Taco Bell sites (Jaynes & Hoffman, 1994). QSRS allowed Taco Bell to develop standard layouts for site design, communicate visually the proposed development to the community, and evaluate post-construction fixes.

Several other authors presented simulation models that could be used to analyze fast food restaurant and drive through operations with the purpose of improving utilization of resources. Whyte and Starks (1996) described ACE, a simulation based decision support tool developed for Pepsico Restaurants International. Like the Taco Bell and Burger King projects, the purpose of ACE was to help managers make labor scheduling decisions. Farahmand and Garza Martinez (1996) proposed a simulation model that could be used to simulate and animate the drive through and lobby sections of fast food restaurant. Uses for the model included the generation of recommendations to optimize labor and resource utilization, improve customer quality, and increase efficiency. While Farahmand and Garza Martinez' s simulation model did not differ much from the ones described previously, the authors demonstrated the use of simulation to compare alternate setups.

In addition to labor scheduling, another issue that has received the attention of simulation researchers is the impact of operational changes on customer waiting times and service delivery time. For instance, Chou and Liu (1999) examined a fast food restaurant queuing system. After formulating and validating a simulation model using data they observed in the restaurant, they examined the impact of an alternate line configuration or adding an extra service employee on customer waiting times. Similarly, Burger King used simulation to determine the distance between the drive-thru ordering window and pick-up window that would minimize customer waiting time (Swart & Donot, 1981).

Simulation has also been used to examine waiting times in service facilities other than fast food restaurants. For instance, Snowdon et al. (1998) used simulation to model Air Canada's ticketing and check-in operations. Amongst other performance measures, Snowdon et al. examined customer waiting times for these two processes. They identified a one hour period in the morning where waiting times for ticketing were excessively high and used simulation to study how SSKs could help reduce these waiting times. Even though, Snowdon et al. (1998) did not find any problems with customer check-in times, Snowdon et al. (2000) indicated that, according to Air Canada, SSKs could be also be used to improve throughput at baggage drop-off and check-in.

In addition to the applications described above, simulation has been used to examine several other ways to improve performance, specific to the hospitality industry. In the context of foodservice businesses, Kimes and Thompson (2004) proposed the use of simulation to enumerate and evaluate all possible table mixes for a casual dining restaurant. Using Chevy's as an example, Kimes and Thompson identified a table mix that would allow a thirty percent increase in customer volume without increases in waiting times.

In addition to solving concrete problems, such as the ones described above, simulation has also been used to test theories and assumptions involving service systems. These have included assumptions about restaurant table mixes, restaurant and hotel reservation policies and hotel overbooking policies. For example, Thompson (2002) examined whether it was more desirable - from the perspective of revenue per available seat hour (RevPASH) - to have tables dedicated to a particular party size or tables that could be combined to seat larger parties. Other studies have used simulation to examine reservations in both hotels (Lambert and Lambert, 1988a; Lambert, Lambert and Cullen, 1989) and restaurants (Lambert and Lambert, 1988b). In a more recent study, Thompson and Kwortnik (2008) examined whether it was more favorable to assign restaurant reservations to a specific table 1) at the time of reservation, or 2) in real time, after pooling the reservations.

**Summary**

Customer usage is a necessary but not sufficient condition for the success of SST implementation. Therefore, there is a need to examine how adding an SST alternative to an existing service delivery where customers are physically present and waiting will impact the performance of the process. Due to the complex nature of the relationships between customer behavior and process characteristics it is necessary to use simulation to examine these interactions and their effect on system waiting times and operating costs.

# Chapter 2: Model Development

The previous chapter proposed the use of simulation to investigate how implementing SST in a service delivery process would impact customer waiting times and system operating costs. The first section of Chapter 2 describes the context of the study in further detail. This is followed by the development of a model relating customer behavior and process characteristics for the purposes of evaluating the implementation of an SST alternative on operating costs and waiting times. The final section of this chapter describes the model of customer usage of SST that is needed to complete the simulation study.

## Research Context

The context of hospitality services was chosen as the background of the study. Specifically, this study examines the impact of implementing an SST alternative in the check-in process of a luxury resort. In the context of hotel operations, SSTs have predominantly been used to automate front office functions such as concierge functions, reservations, registrations and check-out. For example, using self-service kiosks, hotel guests can check-in, select a room based on their preferences, issue keys and print directions to their room ("IBM hotel self-service kiosk solution," 2008).

## Model Development

While the process of developing a simulation model is consistent across sources, the description of the steps can vary slightly across authors. This study adopts the steps described by Law (2006, 2007) and Harmonosky (2008). According to Law (2006, 2007) the first step of simulation model building consists of formulating the problem. Subsequently, analysts need to collect information and data, and formulate assumptions. The third and fourth steps consist of programming the model and verifying its validity. In the fifth step, the analyst designs, conducts and analyzes the experiment. The final step of the simulation is the documentation and presentation of the results. The process through which a simulation model is developed is an iterative process as oftentimes the analyst will need to go back one step in order to improve the final model.

**Problem Formulation, scope of the project and performance measures.**

While SSTs have the potential to improve process performance, the fragmentation of ownership of hospitality firms has been identified as an impediment to technology implementation. In order to implement SSTs, service operators need to convince owners and franchisees that SST implementation will be value-adding (Olsen and Connolly, 2000). This requires them to estimate the impact of adding an SST alternative to an existing process on the performance of the service delivery process.

As was discussed in Chapter 1, customer usage is a necessary but not sufficient condition to SST implementation success. However, research on SST has been limited to the study of customer usage of the technology. Therefore the purpose of this study was to examine how adding an SST alternative to an existing service delivery process would impact system waiting times and operating costs, two performance measures of interest to decision-makers.

***Scope of the project.***

The boundaries of the system to be studied extended from the arrival of the customer to the check-in process to the departure of the customer to his or her room. Extending the check-in process to customer departure to the room ensured that, if customers decided to go to the concierge or front desk clerk after check-in to ask further questions, their impact on front desk operations would be accounted for as this could, for example, result in increased waiting times for concierge services.

***Performance measures.***

The performance measures used to measure the success of SST implementation were waiting times and operating costs. Waiting times have been widely used as performance measures in the study of service systems such as call centers and fast food restaurants (Hueter & Swart, 1998). Improved waiting times positively contribute to customers' perceptions of service quality and satisfaction and hence positively impact the firm's future financial performance.

An extension to the use of waiting times as performance measures is the use of service levels. Service levels measure the proportion of customers that wait less than a pre-specified length of time. For instance, Hueter and Swart (1998) found that the balk rate of fast food customers was only 2.5% if the average waiting time remained under three minutes. Therefore, they used three minutes as the specified waiting time.

In conjunction with waiting times and service levels, the operating cost of the system should be used as a performance variable. The reduction in the operating costs of the system will result in cost savings to the firm and thus in improved financial performance.

These performance measures need to be examined simultaneously (Dickson, Ford & Laval, 2005) as there is a quantitative trade-off between operating costs and waiting times (Hueter & Swart, 1998). Waiting times can be reduced to non-existent by matching available capacity to demand. This would require managers to set their capacity to “peak demand” (Dickson et al., 2005). However, doing so generates inefficiencies in the process as servers are more likely to become idle (Lambert & Cullen, 1987). Therefore, omitting the operating costs from the analysis would render the decision-model incomplete.

**Information and data collection.**

The system of interest to this study was the process of checking a customer into a luxury resort. The current process starts with customers entering the line to check in. If there is no line, the customers moves directly to the service desk, where a front desk employee assists them. Once the front desk employee has finished checking them in, the customers either leave the service desk and go to their room or join the line to speak to the concierge. Should a SSK be introduced as an additional resource to the process, the process will start with customers’ decision of whether or not to use the SST. Once the customers have chosen their desired service delivery method, they will join the appropriate line for service. If there is no line, the customers will go directly to the desk to check-in. Customers having used a service employee to check in will leave the service desk and either go to the concierge or go to directly to their room. Customers having used the SST will either stay in the service area to see the front desk agent (for instance to change room assignments), leave the service area to go to the concierge, or to go to their room. These processes are illustrated pictorially in Figure 1and Figure 2.

Figure 1 Diagram of Current Check-In Process

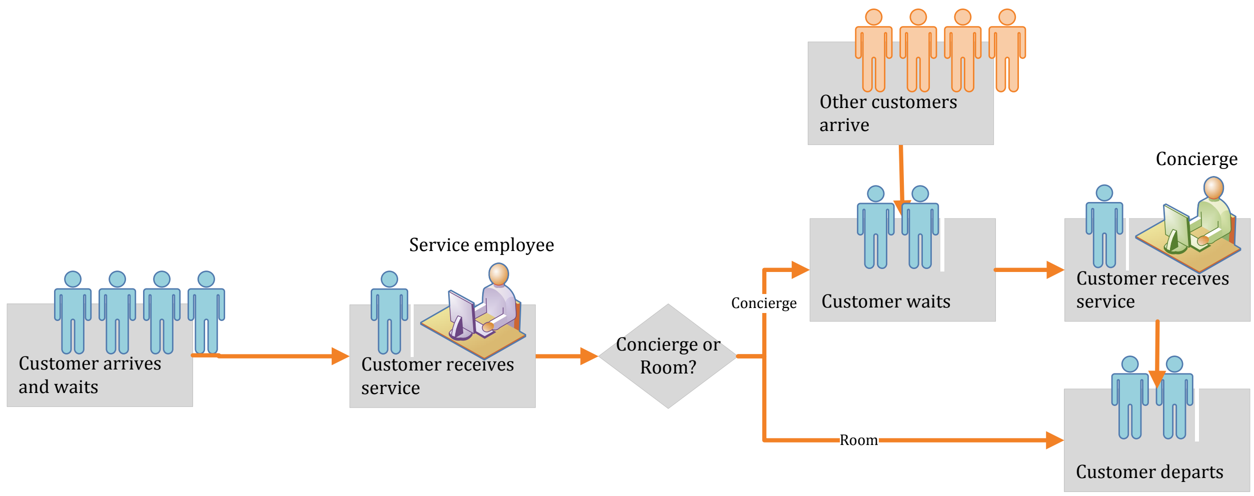
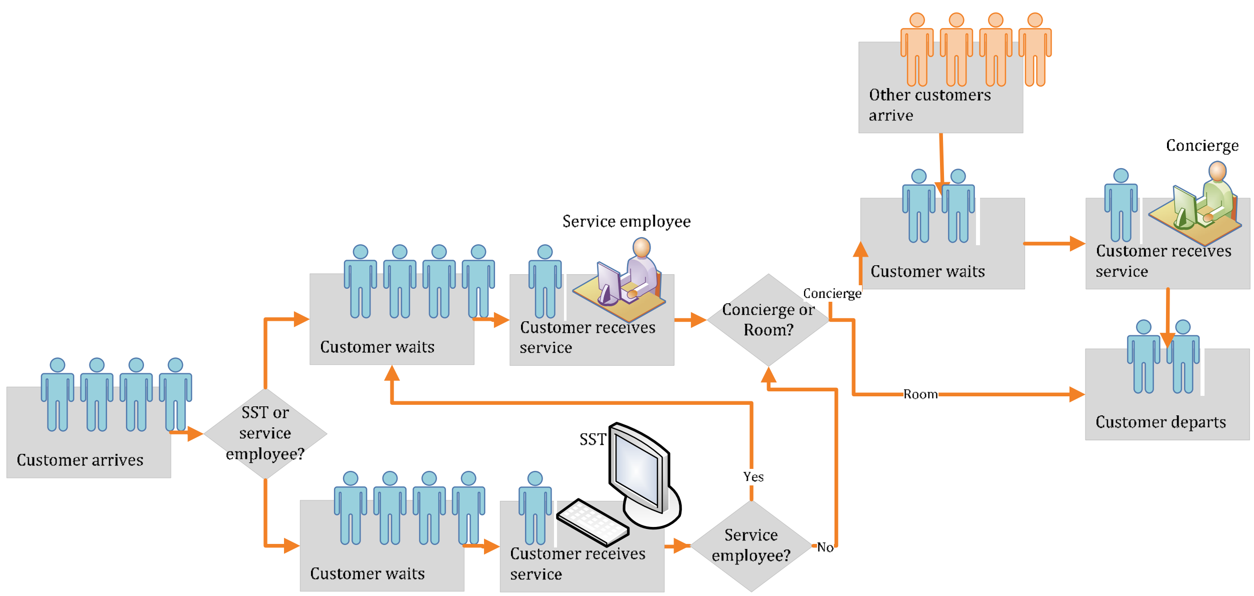



Figure 2 Diagram of Check-In Process with the Addition of a SST Alternative




The selection of input variables is an important part of model development. Decision models need to satisfy a certain number of conditions to be of practical significance. Models need to be robust, simple, complete, adaptive, easy to control and easy to communicate with (Leeflang & Wittink, 2004; Little, 1970; 2004). To satisfy the completeness requirement, models need to incorporate variables over which managers possess information and/or control. For the system under consideration, managers possess control over the number of self-service kiosks to implement, the number of service employees to employ, the waiting line priority (first come first serve or an alternative priority rule), and the waiting line structure (single line versus multiple lines). Furthermore, input variables whose variations may significantly impact the output of the system need to be incorporated in order to ascertain the riskiness of the project. For example, for a model of a process involving waiting times, it is necessary to incorporate arrival and processing rates. While managers do not always possess control over arrival and processing rates, small changes in these rates may have an important effect on the performance of the system and hence represent risk for the project.

An important requirement for the model is that it has to portray accurately human behavior. In the context of this study, this requires the analyst to understand how customers will choose between using the SSK and using the service employee to check-in. Chapter 1 proposed that customers use the relative length of lines to make decisions. The following section develops an alternative model for customer decision-making with respect to SST that incorporates the length of the waiting lines. Another aspect of the model that needs to be quantified is the proportion of customers that will choose to wait for the concierge after checking in. This proportion may differ between customers checking in using SST and customers checking in with a service employee.

**Predicting Customer Usage of SST Using Waiting Time**

The anticipated waiting time for each alternative was proposed in Chapter 1 as a predictor of customers' choice between using an SST and using a service employee to conduct a transaction. Reductions in waiting time have been cited as motivators to use SST (Bateson, 1985) and drivers of satisfaction when using SST (Meuter et al., 2000). Furthermore, waiting time has been shown to influence customers' intentions to use the SST (Dabholkar, 1996; Oh & Jeong, 2009).

Waiting time reduction could be one of the factors that determine customers' perceived usefulness (Oh and Jeong, 2009). Perceived usefulness has been consistently shown to be a strong predictor of customers' attitudes towards SST and intentions to use SST (Weijters et al., 2007). Similarly, in the context of TAM research, perceived usefulness was found to be a fundamental predictor of individuals' decision to use technology (Davis, et al., 1989; Weijters et al., 2007).

**Queue length and anticipated waiting time.**

Drawing from the above findings and TAM research, this study proposes that customers use the length of the line associated with each alternative (SST or service employee) to choose the alternative that will provide them with the shortest waiting time. According to Kumar, Kalwani and Dada (1997), customers use their observed queue length along with their beliefs about processing times to form an estimate of the likely duration of their waiting time. However, in the context of a high end resort, lines are likely to be much shorter than Kumar, Kalwani and Dada's estimated eight to twelve customers, and it will therefore be difficult for individuals to estimate the typical processing time before choosing whether to use SST. Consequently, in this study context, customers will which alternative to use based on the relative line lengths of the waiting lines.

While it is intuitive that customers will choose the shortest line, there are situations where that may not be the case. First, if a customer arrives and both the SST and the service employee are available, the service employee should acknowledge the presence of the customer and the customer will therefore go towards the service employee. Therefore:

*Hypothesis 1 When the lines for SST and for the service employee are both empty, customers will be more likely to use the service employee*

Similarly, when customers arrive to a system and see that the waiting lines for SST and for the service employee are of the same length, they will not perceive a waiting time advantage for the SSK and will choose to wait for the service employee.

*Hypothesis 2: When the lines for SST and for the service employee are both non-empty and of the same length, customers will be more likely to choose the service employee.*

In all other cases, the customer will select the waiting line with the fewer customers.

*Hypothesis 3 When the lines for SST and for the service employee are of different length, customers will be more likely to use the alternative with the shortest line*

**Customer experience.**

Customer experience with SST has been shown to impact the likelihood that customers will try a specific SST (Meuter et al., 2005). Specifically, once customers have used SST with a particular service provider, they are more likely to use SST in the same situation again as they will have more role clarity (Rodie & Kleine, 2001). In the context of this study, the SST alternative has not yet been implemented and therefore customers have not had an opportunity to use it. However, a second source of role clarity is experience in similar settings. That is, if customers have already used SST to check in another hotel, they will be more likely to use it in the focal resort. Therefore:

*Hypothesis 4 Customers that have successfully used SST to check in a hotel before will be more likely to use the SST alternative than customers that have not used SST to check in a hotel before.*

Similarly, customers new to a service setting will rely on experience with similar settings (Rodie & Kleine, 2001). For instance, customers that have used SST to check in for a flight may be more likely to use SST to check in for a hotel stay, providing support for hypothesis 5 and 6:

*Hypothesis 5 Customers that have successfully used SST to check in for a service before will be more likely to use the SST alternative than customers that have not used SST to check in before.*

*Hypothesis 6 Customers that have successfully used SST to conduct a transaction before will be more likely to use the SST alternative than customers that have not used SST to conduct a transaction before.*

**Summary**

This chapter argued that, in order to develop a model estimating the impact that adding an SST alternative will have on waiting times and system operating costs, it was necessary to improve existing models of customer choice between SST and service employee alternatives. Waiting line lengthsand customer prior experience with SST were proposed as antecedents of customers' choice to use SST.

# Chapter 3: Methodology and Results of Pilot Study

In order to model the impact of adding a SST alternative to an existing service delivery system on the system waiting times and operating costs, it was necessary to collect customer behavior information and, specifically, information on how customers checking-in in a luxury resort decide between using the SST and using the service employee. Chapter 2proposed that the length of the waiting line customers encountered when entering the service area influenced this choice, in addition to the known effects of anticipated fun, perceived usefulness, and other attitudinal variables discussed in Chapter 1. The scenario-based survey used to test this proposition required a pilot study.

The pilot study had two objectives. The first objective of the pilot study was to adapt and refine the attitudinal research scales to the research context, namely check-in at a luxury resort. The second objective of the pilot study was to examine which scenario format (image only, text only, or image and text) was most appropriate for the study.

## Overview

The pilot study investigated three ways of presenting the survey scenario to participants (shown in Appendix 1). The first presentation consisted of a short, written scenario, describing customers' arrival to the service setting, the two alternatives, and the two lines. The second presentation described customers' arrival to the service setting, the two alternatives and provided an image of the two lines. Finally, the third presentation combined the first two presentations by describing customers' arrival to the service system, the two alternatives, and the lines for each alternative and providing a visual of the two lines.

In addition to the scenario, the pilot study included forty-three measurement items from eleven known attitudinal scales that were adapted to the study context. Since these scales overlapped to a certain extent, and had not been using concurrently before, it was necessary to pre-test them, using an exploratory approach.

### Scenario based study.

Scenario-based surveys have been widely used in the context of SST research (Dabholkar, 1994; 1996; Weijters et al., 2007). Scenario-based studies are a form of laboratory study (Surprenant & Solomon, 1987) that allow researchers control over the experimental conditions and manipulated variables while reducing random noise (Bitner, 1990). Scenario based studies also allow researchers to manipulate variables that may otherwise be difficult or very expensive to manipulate in a real setting (Bitner, 1990) with limited intrusion to the business setting (Seawright and Sampson, 2007). Time compression is also a valuable feature of scenario based studies as it can reduce the time needed for data collection (Bitner, 1990).

For the scenario based approach to work as intended, participants must be able to project themselves into a situation (Dabholkar, 1994). Furthermore, a limitation of scenario based research is the possibility of greater demand effects as participants may be able to guess the hypothesis of the study or may be inclined to provide intellectually or socially desirable responses (Surprenant & Solomon, 1987). In order to reduce demand effects, the pilot study was conducted to identify the best way to present the varying waiting line lengths.

**Attitudinal scales.**

A review of the literature did not yield measurement scales for the attitudinal variables of interest (perceived usefulness, perceived ease of use, reliability, enjoyment, expected control, expected service quality, need for interaction/need for high touch, time pressure, technology anxiety, and perceived risk) appropriate to a luxury hotel self-service check-in context. It was therefore necessary to adapt existing scales, and where necessary, supplement them with new items.

A review of the SST literature yielded a preliminary list of items that could be adapted to the SSK context. These items were primarily used in studies investigating customer attitudes towards SSTs in varying contexts such as supermarket self-scanners (Weijters et al., 2007), prescription re-fill using interactive voice recognition systems and the internet (Curran et al., 2007), and train ticket kiosks (Reinders et al., 2008). Others items were obtained from studies not directly related to SSTs (Beatty and Ferrell, 1998; Korgaonkar and Wolin, 1999). It was therefore necessary to adjust the language contained in these items to reflect the luxury check-in context. These changes made it necessary to pilot test the scales. These are summarized in Table 1.

Table 1 Measurement Items for Attitudinal Scales

| Perceived Ease of Use | Source | Abbreviation |
|---|---|---|
| Using the self-service kiosk will be *(effortless / require a lot of effort)* | (Weijters et al., 2007, Dabholkar 1996; Dabholkar & Bagozzi, 2002) | Effortless |
| Using the self-service kiosk will be *(user friendly / not be user friendly)* | (Weijters et al., 2007) | UserFriendly |
| Using the self-service kiosk will be *(complicated / not be complicated)* | (Dabholkar 1996; Dabholkar & Bagozzi, 2002) | Complicated |
| Using the self-service kiosk will *(be easy / not be easy)* | | Easy |
| Using the self-service kiosk will *(be confusing / not be confusing)* | (Dabholkar 1996; Dabholkar & Bagozzi, 2002) | Confusing |
| Using the self-service kiosk will *(require a lot of work / not require a lot of work)* | (Dabholkar 1996; Dabholkar & Bagozzi, 2002) | Work |
| **Perceived usefulness** | | |
| Using the self-service kiosk will allow me to check-in faster *(I agree/ I disagree)* | (Weijters et al., 2007) | Faster |
| Using the self-service kiosk will make me more efficient when checking-in *(I agree/ I disagree)* | (Weijters et al., 2007) | Efficient |
| Using the self-service kiosk will be more convenient *(I agree/ I disagree)* | (Curran et al., 2007) | Convenient |
| Using the self-service kiosk will save me time *(I agree/ I disagree)* | (Weijters et al., 2007) | SaveTime |
| Using the self-service kiosk would make me more productive *(I agree/ I disagree)* | (Childers, Carr, Peck &Carson, 2001) | Productive |
| **Reliability/ Performance** | | |
| Using the self-service kiosk means *(I will/ I will not get)* exactly what I want | (Dabholkar, 1996; Dabholkar & Bagozzi, 2002) | Exact |
| Using the self-service kiosk is something *(I expect/ I don't expect)* to work well | (Dabholkar, 1996, Weijters et al., 2007; Dabholkar & Bagozzi, 2002) | Well |
| Using the self-service kiosk *(will/ will not result)* in errors | (Dabholkar, 1996; Dabholkar & Bagozzi, 2002) | Errors |
| Using the self-service kiosk *(will / will not be reliable)* | (Dabholkar, 1996, ; Dabholkar & Bagozzi, 2002; Weijters et al., 2007) | Reliable |
| **Fun/Enjoyment** | | |
| Using the self-service kiosk will *(be entertaining/ not be entertaining)* | (Dabholkar, 1996; Dabholkar & Bagozzi, 2002; Weijters et al., 2007) | Entertaining |
| Using the self-service kiosk will *(be enjoyable / not be enjoyable)* | (Dabholkar, 1996; Dabholkar & Bagozzi, 2002; Weijters et al., 2007) | Enjoyable |
| Using the self-service kiosk will *(be fun/ not be* | (Dabholkar, 1996; | Fun |

| | | |
|---|---|---|
| *fun)* | Dabholkar & Bagozzi, 2002) | |
| Using the self-service kiosk will *(be interesting / not be interesting)* | (Dabholkar, 1996; Dabholkar & Bagozzi, 2002) | Interesting |
| **Expected Control/Interactive Control Motivation** | | |
| Using the self-service check-in kiosk will allow me to do things my own way (I agree/ I disagree) | (Korgaonkar and Wolin, 1999) | OwnWay |
| The self-service check-in option will give me control over checking in *(I agree/ I disagree)* | (Dabholkar ,1996 and Korgaonkar and Wolin, 1999) | Control |
| Using the service employee will not allow me to check-in the way I want to *(I agree/I disagree)* | (Korgaonkar and Wolin, 1999) | Employee |
| **Expected service quality** | | |
| Using the self-service check-in option will provide *(excellent/poor)* service | (Dabholkar 1996) | PoorQual |
| What level of quality would you receive from the self-service check-in option? *(high/low quality service)* | (Dabholkar 1996) | LowQual |
| **Need for Interaction / Desire for High Touch** | | |
| Human contact makes the process enjoyable for me *(I agree/ I disagree)* | (Dabholkar 1996; Dabholkar & Bagozzi, 2002, Reinders et al., 2008) | HumanContact |
| I like interacting WITH the person who provides the service *(I agree/ I disagree)* | (Dabholkar 1996; Dabholkar & Bagozzi, 2002, Reinders et al., 2008) | Interacting |
| Personal attention by the service employee is not very important to me (R) *(I agree/ I disagree)* | (Dabholkar 1996; Dabholkar & Bagozzi, 2002, Reinders et al., 2008) | PersonalAttention |
| It bothers me to use a machine when I could talk with a person instead *(I agree/ I disagree)* | (Dabholkar 1996; Dabholkar & Bagozzi, 2002, Reinders et al., 2008) | Bothersome |
| **Need for Speed / Time Pressure** | | |
| The amount of time pressure I feel on this occasion could be described as (none/very high) | (Beatty and Ferrell, 1998) | Pressure |
| I am not rushed for time on this occasion (I agree/ I disagree) | (Beatty and Ferrell, 1998) | Rushed |
| I have limited time available to me for this particular occasion (I agree/ I disagree) | (Beatty and Ferrell, 1998) | Limited |
| **Previous Experience with Technology** | | |
| I commonly use lots of automated systems when dealing with other businesses *(I agree/ I disagree)* | (Reinders et al., 2008) | Automated |
| I do not have much experience using the | (Reinders et al., 2008) | InternetExperience |

| | | |
|---|---|---|
| internet *(I agree/ I disagree)* | | |
| I use a lot of technologically based products and services *(I agree/ I disagree)* | (Reinders et al., 2008) | TechProducts |
| **Technology Anxiety** | | |
| I feel apprehensive about using technology *(I agree/ I disagree)* | (Meuter et al., 2005, Reinders et al., 2008) | Apprehensive |
| Technical terms sound like confusing jargon to me *(I agree/ I disagree)* | (Meuter et al., 2005, Reinders et al., 2008) | Jargon |
| I have avoided technology unfamiliar to me *(I agree/ I disagree)* | (Meuter et al., 2005, Reinders et al., 2008) | Avoidance |
| I hesitate to use most forms of technology for fear of making mistakes that I cannot correct *(I agree/ I disagree)* | (Meuter et al., 2005, Reinders et al., 2008) | Fear |
| **Perceived Risk** | | |
| I fear that using the self-service kiosk reduces the confidentiality of my transaction with the hotel *(I agree/ I disagree)* | (Meuter et al., 2005) | Confidential |
| I am unsure if the self-service kiosk will perform satisfactorily *(I agree/ I disagree)* | (Meuter et al., 2005) | Satisfactory |
| Using the self-service kiosk infringes on my privacy *(I agree/ I disagree)* | (Meuter et al., 2005) | Privacy |
| Overall, using the self-service kiosk is risky *(I agree/ I disagree)* | (Meuter et al., 2005) | Risky |
| I am sure the self-service kiosk performs as well as using the service employee (r) *(I agree/ I disagree)* | (Meuter et al., 2005) | Same |

Several other reasons warranted a pilot test to refine the scales. First, two of these scales had not previously been used in the SST context (Need for Speed and Interactive Control Motivation). Second, combining several scales in one study for the first time could result in redundant items which in turn could lead to unexpected results. Finally, the preliminary list of items was deemed too long, which could lead to a lower response rate.

**Participants & Procedures**

A student sample was used to select the scenario, and refine the scales (Richins & Dawson, 1990; 1992). One hundred and thirteen undergraduate students in hospitality management at the Pennsylvania State University participated in the pilot test. Each participant was randomly assigned to one condition: verbal description, image, or verbal description and image. The pilot test included most of the measures that would be used in the subsequent study. Therefore, after reading the written scenario, participants answered questions about their behavior in the situation described, their attitudes towards the self-service technology, and their previous experience with SST. The complete pilot test instrument is presented in Appendix 1.

Additionally, the pilot test included questions gauging participants' perceived realism of the scenario and demand effects. Measures of realism are oftentimes used to gauge whether participants perceived the scenario they read as realistic (Dabholkar, 1994). The pilot study used two items, rated on a seven-point Likert scale anchored with *strongly agree/strongly disagree*. These items were "the situation described was realistic" and "I had not difficulty imagining myself in the situation" (Dabholkar, 1994). Participants were also asked to guess the purpose of the study using an open-ended question. For each participant, the correctness of the guess was coded using a binary scale. The three presentations were then compared based on their perceived realism and the proportion of respondents that guessed the purpose of the study. The data obtained were entered into PASW Statistics 18.0 (formerly SPSS) for further analysis

## Analysis

### Scenario.

A one-way ANOVA examining whether there was a significant difference between the three presentations on participants' perceptions of realism showed no difference. Participants indicated perceiving a high degree of realism by giving the statement "the situation described was realistic" a mean rating of $M = 6.04$ and the statement "I had no difficulty imagining myself in the situation" a mean rating of $M = 5.25$. The findings of the ANOVA are shown in Table 2.

Table 2 One-Way ANOVA Results for Realism of Presentation

| | | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 1.79 | 2.00 | 1 | .318 | .729 |
| | 307.21 | 109.00 | 3 | | |
| | 309.00 | 111.00 | | | |
| Between Groups | 1.63 | 2.00 | 1 | .762 | .469 |
| | 116.23 | 109.00 | 1 | | |
| | 117.86 | 111.00 | | | |

Too few participants correctly guessed the purpose of the study for a meaningful test of the difference to be conducted. Consequently, since there did not seem to be a difference between the three presentations, the more comprehensive one was used, including both the written description and the image.

**Attitudinal scales.**

Exploratory Factor Analysis (EFA) was used to analyze the data as described by Hair, Anderson, Tatham and Black (2006). At the onset of the analysis, forty-three variables were considered as summarized in Table 1.

***Assumptions of factor analysis.***

It is important for factor analysis that variables are sufficiently inter-correlated to produce representative factors (Hair et al., 2006). Several approaches are available to ensure that this is the case. Hair et al. (2006) recommend visual inspection be used to determine whether there is a substantial number of correlations greater than 0.3. From the data above, 23.3% of correlations had an absolute value greater than 0.3.

A second test recommended by Hair et al. (2006) is the measure of sampling adequacy (MSA). The guidelines for variable-specific MSA suggest dropping variables with MSA indices scores below 0.5 and re-running the analysis. The results in Table 3 suggest dropping the following variables: UserFriendly, Employee, Rushed, and Limited. When the last variable was dropped, and the analysis run again, it appeared that the MSA index score for the variable Easy was also below 0.5 (0.483) and this variable was dropped. An overall MSA index score was also computed. Prior to dropping the five variables, the overall MSA index score was 0.757. After dropping the five variables the overall MSA index score rose to 0.809. According to Hair et al. (2006) this is a meritorious score.

Table 3 MSA Index Scores for Pilot Test Variables

| Variable | MSA | Variable | MSA | Variable | MSA |
|---|---|---|---|---|---|
| Pressure | 0.582 | SaveTime | 0.756 | Jargon | 0.812 |
| PoorQual | 0.841 | Productive | 0.786 | Avoidance | 0.828 |
| LowQual | 0.664 | OwnWay | 0.789 | Fear | 0.853 |
| Exact | 0.809 | Control | 0.784 | | |
| Well | 0.866 | Employee | 0.426 | | |
| Errors | 0.739 | Confidential | 0.718 | | |
| Complicated | 0.791 | Satisfactory | 0.824 | | |
| UserFriendly | 0.482 | Privacy | 0.793 | | |
| Easy | 0.573 | Risky | 0.805 | | |
| Confusing | 0.583 | Same | 0.770 | | |
| Effortless | 0.785 | HumanContact | 0.709 | | |
| Work | 0.798 | Interacting | 0.651 | | |
| Entertaining | 0.718 | PersonalAttention | 0.820 | | |
| Fun | 0.660 | Bothersome | 0.821 | | |
| Enjoyable | 0.681 | Rushed | 0.424 | | |
| Interesting | 0.728 | Limited | 0.467 | | |
| Reliable | 0.812 | Automated | 0.773 | | |
| Faster | 0.864 | InternetExperience | 0.623 | | |
| Efficient | 0.882 | TechProducts | 0.705 | | |
| Convenient | 0.824 | Apprehensive | 0.771 | | |

The third measure recommended by Hair et al. (2006) is Bartlett's Test of Sphericity which tests for presence of correlations amongst variables. Prior to dropping the five variables above, the test showed significance at the 0.001 level. This remained unchanged after dropping the five variables.

The above demonstrates that the data "meet the statistical requirements for a proper estimation of the factor structure" (Hair et al., 2006, pg. 115). Furthermore, the fact that the items were drawn from existing scales suggests that the set of variables also "has the conceptual foundation to support the results" (Hair et al., 2006, pg. 115).

***Preliminary factor derivation and overall fit.***

The remaining thirty-eight variables were entered into a preliminary factor analysis using principal component analysis as the extraction method. Component analysis is more appropriate to this study as the purpose of the factor analysis is to summarize most of the original information into the least number of factors possible (Hair et al., 2006). Since there are more than thirty variables, the choice of whether to use component or common factor analysis is not very consequential (Hair et al., 2006).

To determine how many factors to extract, two criteria were used: the scree test criterion and eigenvalue. The point at which the scree plot curve begins to straighten indicates the maximum number of factors to extract (Hair et al., 2006). (see Figure 3). In this preliminary analysis, the scree plot curve appeared to level off at twelve factors. Table 4shows the eigenvalues associated with each factor, before extraction, after extraction, and after rotation (Field, 2006).Since the number of variables was between twenty and fifty, only factors with eigenvalues greater than one were considered significant (Hair et al., 2006). Only ten factors had eigenvalues greater than one and were retained for further analysis.

Figure 3 Scree Plot for Preliminary Factor Analysis

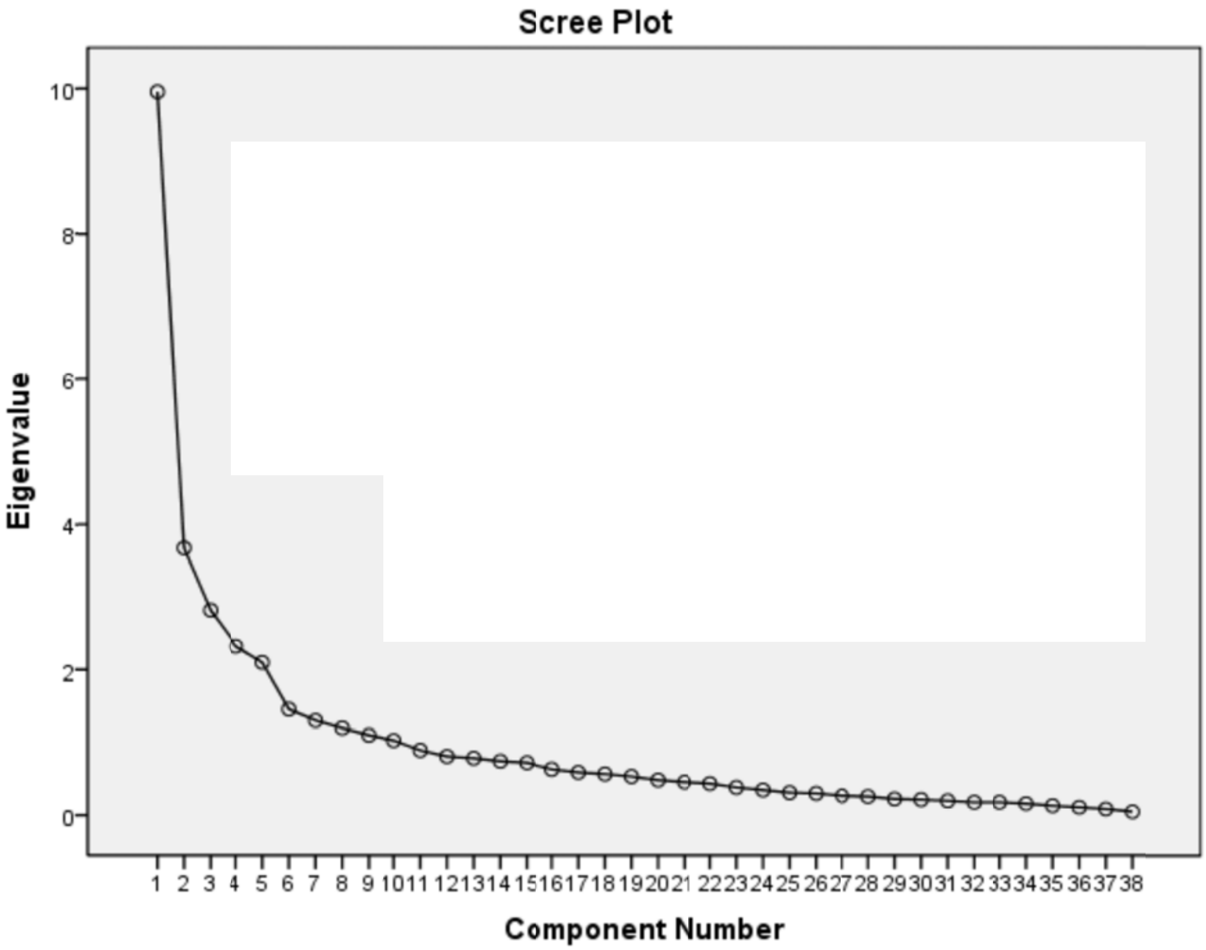



Table 4 Eigenvalues for Factors, Before and After Extraction and Rotation

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 9.955 | 26.199 | 26.199 | 9.955 | 26.199 | 26.199 | 4.411 | 11.609 | 11.609 |
| 2 | 3.673 | 9.667 | 35.866 | 3.673 | 9.667 | 35.866 | 3.677 | 9.676 | 21.285 |
| 3 | 2.819 | 7.420 | 43.285 | 2.819 | 7.420 | 43.285 | 3.508 | 9.231 | 30.516 |
| 4 | 2.320 | 6.107 | 49.392 | 2.320 | 6.107 | 49.392 | 2.933 | 7.719 | 38.235 |
| 5 | 2.099 | 5.523 | 54.915 | 2.099 | 5.523 | 54.915 | 2.873 | 7.560 | 45.795 |
| 6 | 1.456 | 3.831 | 58.745 | 1.456 | 3.831 | 58.745 | 2.786 | 7.332 | 53.126 |
| 7 | 1.301 | 3.424 | 62.169 | 1.301 | 3.424 | 62.169 | 2.028 | 5.337 | 58.463 |
| 8 | 1.197 | 3.151 | 65.320 | 1.197 | 3.151 | 65.320 | 1.912 | 5.031 | 63.495 |
| 9 | 1.098 | 2.891 | 68.211 | 1.098 | 2.891 | 68.211 | 1.618 | 4.258 | 67.752 |
| 10 | 1.028 | 2.704 | 70.915 | 1.028 | 2.704 | 70.915 | 1.202 | 3.162 | 70.915 |

In order to facilitate the interpretation of the factors, the VARIMAX orthogonal rotation was applied. The VARIMAX criterion centers on simplifying the columns of the factor matrix and seems to give a clearer separation of the factors (Hair et al., 2006). The factor loadings in Table 5 represent the correlations between the original variables and their factors (Hair et al., 2006). Factor loadings are typically assessed based on practical significance and statistical significance. For a sample size of 100 or larger, Hair et al. (2006) recommend factor loadings to exceed 0.3 for practical significance and 0.55 for statistical significance (for a sample size $n > 100$.)

A preliminary examination of the practical relevance of the factors showed that the factors generally were meaningful. The first factor (comprised of Faster, SaveTime, Efficient, Convenient, Productive, and Work) included all the variables used in the perceived usefulness scale. The variable Work was also included in the factor, with a low loading (0.428). The second factor mirrors the fun/enjoyment scale by including the variables Fun, Entertaining, Enjoyable, and Interesting. The sixth factor includes the variables Confidential, Privacy, and Risky. The combination of these three variables clearly represents a dimension of perceived risk.

Before proceeding with a complete interpretation of the factors, it was necessary to examine the statistical significance of the factor loadings. According to Hair et al. (2006), for a sample size $n > 100$, factor loadings greater than 0.55 are needed for statistical significance. However, these guidelines are quite conservative and several factor loadings in Table 5 did not achieve this level. Since the actual sample size was 113 (in the 100-200 range), and the guidelines are considered conservative, a significance level of 0.5 was used in the subsequent analysis.

Table 5 Rotated Factor Solution

| | Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Faster | .818 | | | | | | | | | |
| SaveTime | .803 | | | | | | | | | |
| Efficient | .726 | | | | | | | | | |
| Convenient | .700 | | | | | | | | | |
| Productive | .623 | | | | | | .431 | | | |
| Work | .428 | | | | .427 | | | | | |
| Fun | | .928 | | | | | | | | |
| Entertaining | | .912 | | | | | | | | |
| Enjoyable | | .893 | | | | | | | | |
| Interesting | | .830 | | | | | | | | |
| TechProducts | | | -.828 | | | | | | | |
| Jargon | | | .825 | | | | | | | |
| Avoidance | | | .725 | | | | | .314 | | |
| Fear | | | .610 | | | | | .000 | | |
| InternetExp | | | .599 | | | | | | .337 | |
| Apprehensive | | | .575 | | | | | | | |
| Interacting | | | | .884 | | | | | | |
| HumanContact | | | | .869 | | | | | | |
| PersonalAttention | | | | -.742 | | | | | | |
| Bothersome | | | | .454 | -.394 | .314 | | | | |
| Effortless | .306 | | | | .713 | | .335 | | | |
| Errors | | | | | .672 | | | | | |
| Complicated | .304 | | | | .596 | | | | | |
| Automated | | | -.367 | | .517 | | | | | |
| Well | | | | | -.498 | | | .425 | | |
| Confidential | | | | | | .863 | | | | |
| Privacy | | | | | | .794 | | | | |
| Risky | | | | | | .793 | | | | |
| OwnWay | .355 | | | | | | .690 | | | |
| Control | .326 | | | | | | .642 | | | |
| Same | .353 | | | | | | .417 | | | .342 |
| Reliable | | | | | | | | .717 | | |
| Exact | | | | | -.396 | | | .546 | | |
| Satisfactory | -.369 | | | | | | | .483 | | |
| LowQual | | | | | | | | | .779 | |
| PoorQual | -.422 | | | | | | | | .536 | |
| Confusing | | | -.310 | | | | .408 | | .462 | |
| Pressure | | | | | | | | | | .749 |

An examination of Table 5highlightedseveral variables that did not achieve statistical significance (defined as a factor loading greater than 0.5). These were Work (0.428), Bothersome (0.454), Well (-0.498), Same (0.417), Satisfactory (0.483), and Confusing (0.462). However, the communalities of all the variables exceeded the recommended level of 0.5. As suggested by Hair et al. (2006), the factor model was respecified to an 1) eight factor solution and 2) six factor solution to see whether a different factor structure would represent these variables. An eight factor solution did not improve the factor loadings for these variables. The most notable change was that the variable Pressure was added to the factor comprised of Privacy, Confidential and Risky. This did not make practical sense. Similarly, the six factor solution did not improve the factor loadings of the problem variables, while reducing the practical significance of the remaining factors.

***Model respecification.***

The subsequent step was to use an iterative approach to re-specify the model, omitting the problem variables. Several criteria were used to determine which variables to exclude. Variables with low factor loadings (lesser than 0.5), that simultaneously reduced or did not add to the meaning of a factor, and had cross loadings were identified. Furthermore factors with fewer than three items were examined since constructs represented by fewer than three items can cause specification problems in subsequent analyses using confirmatory approaches (Hair et al., 2006).Furthermore, multi-item measures decrease measurement error and reliability increases as the number of items to measure a construct is augmented (Churchill, 1979).

In the first iteration, the variable Pressure was identified as a problem variable. Pressure was originally included as part of the Need for Speed construct. However, since two of three items related to the construct were removed, Pressure loaded as a single item. In addition to its singular loading, Pressure did not add much information as time was not explicitly manipulated in the written scenario that participants were asked to read. Finally, time pressure is difficult to measure from a scenario as the experience of time is a real-time feeling. Consequently, there may not have been sufficient variation in the variables for them to be appropriate for analysis using factor analysis. The variable Pressure and the Need for Speed construct were therefore dropped from the study.

In the second iteration, the variable Work was identified as having a low factor loading (0.417) and cross-loading on a second factor (0.410) and was therefore dropped. Similarly, in the third iteration, the variable Well was identified as having a low factor loading (-0.446) and cross-loading on a second factor (0.476) which made it difficult to interpret the factors. In the fourth iteration, the variable Satisfactory was identified as having a low factor loading (0.469) and not fitting well with the other two items (Reliable and Exactly). In the fifth iteration, the variable Confusing was identified as having a relatively low factor loading (0.522) and not contributing positively to the meaning of the factor. In the sixth iteration, the variable Errors was removed. The variable Errors had multiple significant factor loadings (0.690 and -0.408 on factors 7 and 8 respectively). The final rotated component matrix is shown in Table 6. Factor loadings less than 0.4 are omitted for reading clarity.

Table 6 Rotated Component Matrix for the Final Solution

| | Component | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Fun | .931 | | | | | | | |
| Entertaining | .912 | | | | | | | |
| Enjoyable | .900 | | | | | | | |
| Interesting | .830 | | | | | | | |
| Faster | | .814 | | | | | | |
| SaveTime | | .783 | | | | | | |
| Efficient | | .699 | | | | | | |
| Convenient | | .677 | | | | | | |
| Productive | | .565 | | | | .499 | | |
| TechProducts | | | -.832 | | | | | |
| Jargon | | | .812 | | | | | |
| Avoidance | | | .706 | | | | | |
| InternetExperience | | | .649 | | | | | |
| Apprehensive | | | .628 | | | | | |
| Fear | | | .608 | | | | | |
| Interacting | | | | .888 | | | | |
| HumanContact | | | | .865 | | | | |
| PersonalAttention | | | | -.777 | | | | |
| Bothersome | | | | .484 | | | | |
| Confidential | | | | | .843 | | | |
| Privacy | | | | | .814 | | | |
| Risky | | | | | .812 | | | |
| Control | | | | | | .740 | | |
| OwnWay | | | | | | .708 | | |
| Same | | | | | | .541 | | |
| LowQual | | | | | | | .678 | |
| Exact | | | | | | | .658 | |
| Reliable | | | | | | | .645 | |
| PoorQual | | -.414 | | | | | .425 | |
| Complicated | | | | | | | | .590 |
| Effortless | | | | | | .470 | | .575 |
| Automated | | | | | | | | .443 |

The overall MSA for this model was 0.812 and Bartlett's Test for Sphericity was significant at the 0.001 level. Furthermore, no variable MSA was less than 0.5, and no communality was less than 0.5. The ten factor structure was reduced to an eight factor solution. While several variables had a factor loading less than 0.5 (Bothersome, PoorQual, and Automated), these variables contributed to the meaning of the factor on which they loaded the highest, and were necessary to ensure that each factor was represented by at least three variables.

**Factor interpretation and reliability coefficient.**

Eight factors formed the solution described above. Each factor was labeled and compared to the scales described in the literature. Reliability coefficients were computed for each factor.

***Factor 1: Fun/Enjoyment.***

Table 7 Factor Loading for Fun/Enjoyment Scale

| Variable | Items | Loadings |
|---|---|---|
| Fun | Using the self-service check-in option will *(be fun/not be fun)* | .931 |
| Entertaining | Using the self-service check-in option will *(be entertaining/ not be entertaining)* | .912 |
| Enjoyable | Using the self-service check-in option will *(be enjoyable/ not be enjoyable)* | .900 |
| Interesting | Using the self-service check-in option will *(be interesting/ not be interesting)* | .830 |

The first factor (see Table 7) was named fun/enjoyment and was composed of the same items as Dabholkar's (1996) and Dabholkar and Bagozzi's (2002) corresponding scales. The Cronbach Alpha reliability coefficient for the Fun/Enjoyment scale was 0.936 while Dabholkar and Bagozzi's reliability coefficient for the same scale was 0.84.

***Factor 2: Perceived usefulness.***

Table 8 Factor Loading for Perceived Usefulness Scale

| Variable | Items | Loadings |
|---|---|---|
| Faster | Using the self-service kiosk will allow me to check-in faster | .814 |
| SaveTime | Using the self-service kiosk will save me time | .783 |
| Efficient | Using the self-service kiosk will make me more efficient while checking-in | .699 |
| Convenient | Using the self-service kiosk will be more convenient | .677 |
| Productive | Using the self-service kiosk will make me more productive | .565 |

The second factor (see Table 8) was named perceived usefulness as it incorporates all the items typically used to represent perceived usefulness (Childers, Carr, Peck & Carson, 2001; Curran et al., 2007; Weijters et al., 2007). Perceived usefulness represents customers' perception of how the SST alternative is superior to the service employee. The Cronbach Alpha reliability coefficient for the Perceived Usefulness Scale was 0.887.

***Factor 3: Augmented technology anxiety.***

Table 9 Factor Loading for Technology Anxiety Scale

| Variable | Items | Loadings |
|---|---|---|
| TechProducts | I use a lot of technologically based products and services (REVERSE) | -.832 |
| Jargon | Technical terms sound like confusing jargon to me | .812 |
| Avoidance | I have avoided technology unfamiliar to me | .706 |
| InternetExperience | I do not have much experience using the internet | .649 |
| Mistake | I hesitate to use most forms of technology for fear of making a mistake that I cannot correct | .628 |
| Apprehensive | I feel apprehensive about using technology | .608 |

The third factor (Table 9) includes all the items from the technology anxiety scale and is supplemented by TechProducts. The Alpha Coefficient for this scale was 0.816. Reinders et al. (2008) found a reliability coefficient of 0.9 for a scale that did not include TechProducts.

#### ***Factor 4: Need for interaction.***

Table 10 Factor Loading for Need for Interaction Scale

| Variable | Items | Loadings |
|---|---|---|
| Interacting | I like interacting with the person who provides the service | .888 |
| HumanContact | Human contact makes the process enjoyable for me | .865 |
| PersonalAttention | Personal attention by the service employee is not very important to me | -.777 |
| Bothersome | It bothers me to use SST when I can use a service employee | .484 |

The fourth factor (see Table 10) was labeled need for interaction, as it included the same four items that Dabholkar (1996), Dabholkar and Bagozzi (2002), and Reinders et al. (2008) used in their need for interaction scale. Dabholkar, Dabholkar and Bagozzi, and Reinders et al. found reliabilities of 0.83, 0.83, and 0.92 respectively. The Cronbach Alpha Reliability Coefficient for this analysis was 0.811.

#### ***Factor 5: Perceived risk.***

Table 11 Factor Loading for Perceived Risk Scale

| Variable | Items | Loadings |
|---|---|---|
| Confidential | I fear that using the self-service kiosk reduces the confidentiality of my transaction with the hotel *(I agree/ I disagree)* | .843 |
| Privacy | Using the self-service kiosk infringes on my privacy (originally medical privacy) *(I agree/ I disagree)* | .814 |
| Risky | Overall, using the self-service kiosk is risky *(I agree/ I disagree)* | .812 |

The fifth factor (see Table 11) was renamed perceived risk. The original scale proposed by Meuter et al. (2005) also included the variables Same and Satisfactory.

However, in this analysis, these variables cross loaded on factors pertaining to Perceived Control and Reliability and presented poor loadings were poor, and were therefore dropped from further consideration. Three remaining items, Confidential, Privacy, and Risky, make conceptual sense. This factor therefore represents participants' perceived risk of using the SST. Cronbach Alpha for this factor was 0.813.

***Factor 6: Perceived control.***

Table 12 Factor Loading for Perceived Control Scale

| Variable | Items | Loadings |
|---|---|---|
| Control | The self-service check-in option will give me control over checking in | .740 |
| OwnWay | Using the self-service kiosk will allow me to do things my own way | .708 |
| Same | I am sure the self-service kiosk performs as well as using the service employee | .541 |

Factor six (see Table 12) was not entirely consistent with previous research. The first two items, Control and OwnWay correspond to Korgaonkar and Wolin' s (1999) scale for interactive control motivation. However, Korgaonkar and Wolin' s scale also included Employee which was dropped early in the analysis due to low MSA. Instead, the variable Same loaded on factor 6. Same was originally included in Meuter et al.'s (2005) scale for Perceived Risk. Cronbach Alpha for this factor was 0.722.

***Factor 7: Expected outcome quality.***

Table 13 Factor Loading for Expected Outcome Quality Scale

| Variable | Items | Loadings |
|---|---|---|
| LowQual | What level of quality would you receive from the self-service check-in option? *(high/low quality service)* | .678 |
| Exact | Using the self-service kiosk means *(I will/ I will not get)* exactly what I want | .658 |
| Reliable | Using the self-service kiosk *(will / will not be reliable)* | .645 |
| PoorQual | Using the self-service check-in option will provide *(excellent/poor)* service | .425 |

Factor seven (see Table 13) was also inconsistent with previous studies. It included two items from the perceived ease of use scale (Exact and Reliable) (Dabholkar, 1996 ; Dabholkar & Bagozzi, 2002; Weijters et al., 2007), and two items from the perceived service quality scale (LowQual and Poor Qual) (Dabholkar, 1996). However, all these items relate to the outcome that the customer will receive. Cronbach Alpha for this factor was 0.688.

#### ***Factor 8: Expected effort.***

Table 14 Factor Loadings for Expected Effort Scale

| Variable | Items | Loadings |
|---|---|---|
| Complicated | Using the self-service check-in option will *(be complicated/ not be complicated)* | .590 |
| Effortless | Using the self-service check-in option will *(require a lot of effort/ be effortless)* | .575 |
| Automated | I commonly use lots of automated systems when dealing with other businesses | .443 |

Factor eight (see Table 14) was similarly inconsistent with previous studies. It included two items from the perceived ease of use scale (Effortless, Complicated) (respectively Weijters et al., 2007, Dabholkar 1996; Dabholkar & Bagozzi, 2002; and Dabholkar 1996; Dabholkar & Bagozzi, 2002), and one item from the previous experience with technology scale(Automated) (Reinders et al., 2008). However, this item makes conceptual sense as it includes aspects of the service that are more closely linked to the customer. Specifically, these include the level of effort that the customer will need to exert, and his previous experiences. Cronbach Alpha for this factor was 0.677.

### Limitations.

Even though the minimum required sample size of 100 was achieved (Hair et al., 2006), the case-to-variable ratio for the pilot study was 2.65 (113 cases/ 43 variables), lower than the recommended ratio of five. Consequently, there is a danger of over-fitting the data, and that the factors derived are sample-specific, with little generalizability. However, even a cautious analysis shows that the factors derived are closely linked to previous studies' results, and have therefore face validity.

## Chapter 4: Methodology and Results of Main Study

A scenario based survey was proposed to examine customer decision to use SST in a setting where both SST and personal service alternatives were offered. Specifically, this research proposed a situational variable, waiting line information, and examined it in conjunction with the more commonly used attitudinal variables including anticipated fun, perceived usefulness, and effort. Chapter 3 described a pilot study used to refine the presentation of the scenario used to manipulate waiting line information, and the scales used to measure the attitudinal variables. This chapter describes the procedures and results of the main study.

### Overview

The model developed in chapter 2 proposed that the length of the lines customers encounter when entering the service area impacted their choice of whether to use SST or a service employee As discussed in chapter 1, research on customer choices with respect to SST has focused on customer beliefs about the benefits of SST as predictors of their use of the SST. However, these beliefs are of limited practical use to a simulation study since they are not readily observable. It was therefore necessary to examine the assumption that waiting line length can be used to predict customer choice.

### Procedures

To test hypotheses 1 through 3, a scenario based survey was used. The scenario informed participants that they were about to check-in in a luxury resort and could choose between using a SSK and using a service employee (as shown in Appendix 2). Respondents were given a description of the service setting, a description of the length of the waiting lines (which varied by condition) and asked which line they would choose.

The survey consisted of eight pages. The first page was a statement of informed consent. After reading and agreeing to this statement, participants were asked to read the scenario and answer questions about how they would behave in the situation described. The measurement items for the attitudinal variables followed on pages three to five. The third and fourth page consisted of statements anchored with (*I agree/I disagree*). The fifth page of the survey included statements anchored with sentence fragments. The sixth page of the survey asked participants about their prior experience with SST, while the seventh page requested demographic information. The last page was a thank you page that redirected participants to a separate survey where they could enter a drawing. This was set up as a second survey in order to maintain confidentiality of responses.

An online survey software and questionnaire tool (SurveyMonkey, LLC, at SurveyMonkey.com) was used to format the survey and collect data. SurveyMonkey is a website that allows investigators to create and manage online surveys that participants can self-administer (Hart, Brennan, Sym, & Larson, 2009). Online surveys have several advantages, particularly pertaining to the faster speed of data collection, the low cost to the researcher, and the instant access to a wide audience, irrespectively of their geographical location (Deutskens, de Ruyter, Wetzels, & Oosterveld, 2004; Ilieva, Baron & Healy, 2002). Furthermore, online data collection allows for the instant electronic storage of data, effectively reducing data entry duration and error (Hart, Brennan, Sym & Larson, 2009). Finally, since online surveys are self-administer, interviewer bias is eliminated (Hart, et al., 2009).

Twenty-seven different scenarios were developed. The main study was comprised of the first sixteen scenarios, following a 4 x 4 design, with each factor referring to the number of customers in each service delivery alternative. The first level of each factor referred to the situation where no customer was waiting. The second level represented the situation were a customer was being helped by the service employee (factor 1) or using the SSK (factor 2). The third and level of each factor referred to the service delivery alternative being in use and one or two more customers waiting. For example, scenario 1 described a check-in desk were no other customers were present and the participant could choose whether to receive service from the employee, or use the SSK without either alternative requiring him to wait. Conversely, in scenario sixteen, both the service employee and the SSK were in use, and two customers were waiting for each alternative.

In addition to the sixteen main study scenarios, eleven more scenarios were included for control purposes. Scenarios 17-24 presented a different number of servers (3) and line configurations (multiple server/multiple line vs. multiple server/single line) in conjunction with different waiting line lengths for the self-service kiosk. Scenarios 25-27 presented the same situation as scenario 10, which read: "Both the service employee and the SSK are currently occupied by customers. Additionally, there is one customer waiting to use the SSK. There are no other customers waiting to use the service employee". Scenario 25 was used to examine whether there were differences between early and late respondents. Scenario 26 reversed the order of the study by asking participants to first rate the attitudinal measures and then presenting the scenario. Finally, scenario 27 referred to a mid-scale resort, as opposed to a luxury resort, to determine whether context played a role.

**Main Study Independent Variables**

Hypotheses 1 through 3 posit that customers will be more or less likely to choose to use SST depending on the relative lengths of the waiting lines for the SST and for the service employee. To test these hypotheses, participants in each experimental condition were given different information with respect to the relative length of each line. Table 15 summarizes the sixteen scenarios.

Table 15 Line lengths per scenario for luxury resort context

| | SST line length | Service employee line length |
|---|---|---|
| Scenario 1 | 0 | 0 |
| Scenario 2 | 0 | 1 |
| Scenario 3 | 0 | 2 |
| Scenario 4 | 0 | 3 |
| Scenario 5 | 1 | 0 |
| Scenario 6 | 1 | 1 |
| Scenario 7 | 1 | 2 |
| Scenario 8 | 1 | 3 |
| Scenario 9 | 2 | 0 |
| Scenario 10 | 2 | 1 |
| Scenario 11 | 2 | 2 |
| Scenario 12 | 2 | 3 |
| Scenario 13 | 3 | 0 |
| Scenario 14 | 3 | 1 |
| Scenario 15 | 3 | 2 |
| Scenario 16 | 3 | 3 |

Hypotheses 4, 5, and 6 examined three types of participants' prior experiences with SST. Since a review of the literature did not find measures of experience with SSTs, several items based on work by Balasubramanian, Konana, and Menon (2003), van Beuningen, de Ruyter, Wetzels, and Streukens, (2009) and Banerjee (2009) were developed. To test hypothesis 4, three questions were developed to measure participants' prior successful experiences with hotel check-in SSTs. The first question measured the number of times participants had used the SST and was "how many times have you previously used a self-service kiosk to check-in for a hotel stay" with possible answers being *never/once/2-3 times/4 or more times*. The second question specifically asked about prior successful experiences with hotel SSKs and was "if you previously used a self-service kiosk to check-in for a hotel stay; how satisfied were you with the process of checking-in using the self-service kiosk?" Participants indicated their level of agreement on a seven-point Likert scale anchored with *very satisfied/ very dissatisfied*. One more question was used to determine whether the lack of prior experience was due to lack of opportunity or lack of desire to use SST. This question was "if a self-service kiosk is available for me to use to check-in in a hotel, I will use it" anchored with *always/never*.

Similar items were developed to measure participants' prior successful experiences with non-hotel self-service check-in (hypothesis 5) and with SSTs used to conduct transactions, such as ATMs and the internet (hypothesis 6).

**Main Study Dependent Variables**

The principle variable of interest to this study is customers' choice between using an SST and using a service employee. Customers' choice was requested by asking: "in the situation described, if you have the choice between using the SST and using a service employee to check-in, which one will you choose?". The two alternatives proposed were the SST / the service employee. This question was adapted from Dabholkar (1994).

Two more items, based on attitudinal research, were used as control variables and measured the likelihood participants will use the SST alternative. These items were adapted from Meuter et al., (2005) and Dabholkar (1994, 1996). Participants were asked to rate their answer on a seven-point Likert scale anchored with 1 (*very unlikely*) and 7 (*very likely*) to the questions: "how likely are you to use the SST alternative to check-in in this situation?" and "in the situation described, would you use the service employee to check-in?".

**Comparison to Other Models**

In order to compare the proposed model to other models of customer usage of SST, several beliefs about SST previously identified as influencing the decision to use SST were included in the study. These beliefs included anticipated fun, perceived usefulness, technology anxiety, need for interaction, perceived risk, perceived control, expected outcome quality, and expected effort. Scales for these beliefs were pre-tested in Chapter 3.

**Manipulation Checks and Control Variables**

Participants were asked to rate the acceptability of the described line length. The acceptability of the waiting line length was measured on a seven point Likert scale anchored with 1 (*unacceptable*) and 7 (*acceptable*) by asking customers: "Do you think that the length of the line for check-in using the service employee is unacceptable or acceptable?" (adapted from Chebat, Gelinas-Chebat, & Filiatrault, 1993). Furthermore, participants were asked "what do you think is an acceptable waiting time before it is your turn to check-in?" and asked to select one an appropriate time from a list showing times from 0 minutes to more than 11 minutes in increments of 20 seconds.

**Anticipated waiting time.**

The use of waiting length line as a proxy for anticipated waiting time relies on the assumption that the processing times for each alternative (service employee and SST) are similar. This assumption was verified by testing whether participants expected the waiting line for SST to move at the same speed, faster, or slower than the waiting line for the service employee. Participants were asked to rate two items on a 7-point Likert scale. These items were adapted from Dabholkar (1996) and were be anchored with 1 (*slower*) and 7 (*faster*). These were: "the line for the SST will move ______ than the line for the service employee", "it will be ___________ for customers to check-in using the SST than to check-in with the service employee".

The assumption that participants made no inferences about the speed of service was tested using a one-way ANOVA. A categorical variable with three levels was used to represent equal line lengths, the line for the SSK being longer, and the line for the service employee being longer. The findings summarized in Table 16suggest that, while statistically significant, the differences are small (as illustrated by the small effect sizes).

Table 16 ANOVA for Inferences about Speed of Service

| | | Sum of Squares | df | Mean Square | F | Sig. | Effect Size |
|---|---|---|---|---|---|---|---|
| SSTLineFaster | Between Groups | 82.86 | 2 | 41.429 | 20.256 | 0.000 | 0.198 |
| | Within Groups | 2,026.85 | 991 | 2.045 | | | |
| | Total | 2,109.71 | 993 | | | | |
| SSKioskSlower | Between Groups | 63.61 | 2 | 31.805 | 17.204 | 0.000 | 0.183 |
| | Within Groups | 1,828.34 | 989 | 1.849 | | | |
| | Total | 1,891.95 | 991 | | | | |

**Participants**

Since the research context was a check-in process at a luxury resort, it was necessary to include participants who had experience in such a setting. A local hospitality company managing several high-end hotels agreed to send out an e-mail introducing the study to their e-mail list which contained 65,579 individual e-mail addresses. Individuals interested in participating in the study were asked to contact the researchers who then forwarded them information about the study. Each participant received a link to one of the 27 versions of the study. This was done randomly.

Of the 65,579 messages sent, 15,035 were opened (22.93%), on average 18.5 hours after being received. Following this message, 2,965 individuals indicated that they would like to participate in the study. Of the2,288completed surveys, 2,239 remained after eliminating duplicate surveys, an actual response rate of 3.41%.

Table 17 Response Rate

| | Number | Percentage of Total | Percentage of Messages Opened |
|---|---|---|---|
| Messages Sent | 65,579 | | |
| Messages Opened | 15,035 | 22.93% | |
| Requested Link | 2,965 | 4.52% | 19.72% |
| Completed Survey | 2,288 | 3.49% | 15.22% |
| Completed Survey | 2,239 | 3.41% | 14.89% |

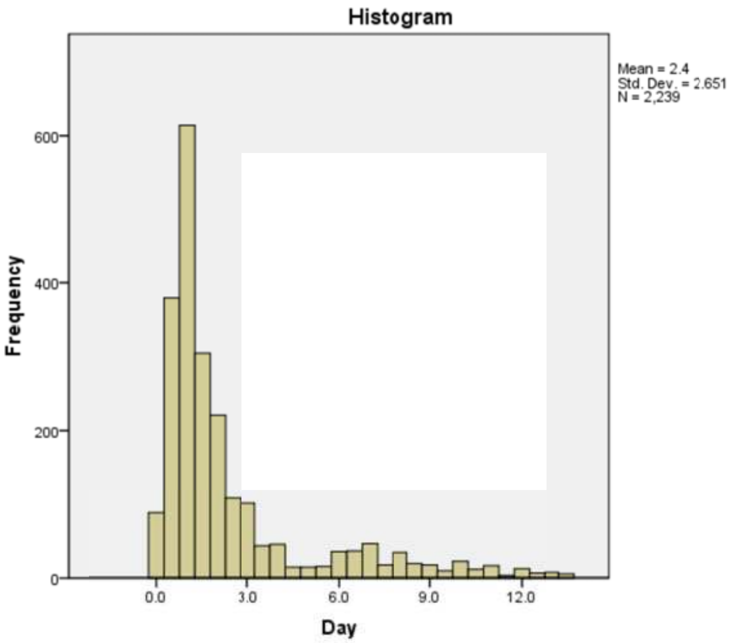
More women (66.61% $n = 1{,}464$)than men (33.39% $n = 734$)responded to the survey. More than 80% of the respondents were between 36 and 65 years old, with the largest group being respondents between 46 and 55 years old (42.53%). A large proportion of respondents (46.92%) reported incomes greater than $90,000, with the remainder being relatively equally spread between $30,000 and $90,000.

Table 18 Participant Characteristics

| | | *n* | Percent |
|---|---|---|---|
| Gender | Male | 734 | 33.39% |
| | Female | 1464 | 66.61% |
| Age | 18 to 25 | 20 | 1.89% |
| | 26 to 35 | 116 | 10.96% |
| | 36 to 45 | 214 | 20.23% |
| | 46 to 55 | 450 | 42.53% |
| | 56 to 65 | 208 | 19.66% |
| | 66 and older | 50 | 4.73% |
| Yearly Income | 14,999 or less | 5 | 0.50% |
| | 15,000 to 29,999 | 26 | 2.58% |
| | 30,000 to 44,999 | 128 | 12.72% |
| | 45,000 to 59,999 | 143 | 14.21% |
| | 60,000 to 74,999 | 123 | 12.23% |
| | 75,000 to 89,999 | 109 | 10.83% |
| | 90,000 or more | 472 | 46.92% |

The survey was available for fourteen days after the initial recruitment e-mail was sent, consistent with recommendations for web-surveys (Ilieva et al., 2002). On average, it took respondents 2.39 days to respond to the survey. More than half of the responses were received within 1.5 days after the start of the study. This is much shorter than the average number of days reported by Ilieva et al. (2002), yet consistent with predictions that average response times would decrease as individuals increased their time online.

Figure 4 Delay in Responses




## Belief Measures

Before proceeding with the test of hypotheses, it was necessary to re-examine the eight beliefs about SST identified using exploratory factor analysis(EFA) in Chapter 3. Confirmatory factor analysis (CFA) was used to provide a confirmatory test of the measurement theory (Hair et al., 2006). CFA is a multivariate technique used to test the construct validity of a pre-specified measurement theory (Hair et al., 2006). Unlike EFA where factors are derived from statistical results and do not need to be known *a priori*, CFA requires researchers to know how many factors exist within a set of variables and which factor each variable will load on highly. EFA and CFA are commonly used sequentially. Researchers use EFA to reduce the set of items and provide preliminary scales, and subsequently use CFA to test and refine the scales (Steenkamp & van Trijp, 1991) and to assess the construct validity of the measurement theory.

### Assumptions of CFA.

Before conducting the CFA it was necessary to examine research design issues and common CFA assumptions, such as sample size, and treatment of missing data, as they could influence the determination of model fit. The 1,472 responses to scenarios 1 through

16 were used to conduct CFA since only those responses would subsequently be used in hypothesis testing.

The patterns of missing data on the 32 variables that pertained to the eight factors of interest were examined. The percentage of missing data ranged between 0.8% and 3.8% per variable, and was therefore below the 10% threshold recommended by Hair et al. (2006). Since the sample size was sufficiently large, and the relationships in the data are strong so as not to be affected by any missing data process, the complete case approach to missing data (using only cases with no missing data on any variable) was deemed appropriate for conducting the CFA (Hair et al., 2006).

An alternative to using the complete case approach is to use a model based approach. The statistical software package used to conduct CFA, AMOS, uses the maximum likelihood method to estimate missing values and subsequently uses the EM approach to estimate the mean and covariance of each mean. Following Hair et al.'s recommendation the CFA was conducted using both approaches to missing data (complete case and model based) and the results were compared.

**Measurement model and convergent validity.**

Two separate analyses were conducted, using the two approaches to missing data. For each model, four measures of Goodness-of-Fit were considered, $\chi^2$,the Comparative Fit Index (CFI), the Relative Non-centrality Index (RNI), and the Root Mean Square Error of Approximation(RMSEA). Additionally, for the complete case approach, Standardized Root Mean Residual (SRMR) was examined. SRMR cannot be computed when using the model based approach to missing data.

The $\chi^2$goodness-of-fit statistic with its associated $p$-value is commonly reported for SEM models. This measure assesses the magnitude of the discrepancy between the sample covariance matrices and the fitted covariance matrices (Hu & Bentler, 1999). The associated null hypothesis ($H_0$) postulates that this difference is null (Byrne, 2001). A limitation of the $\chi^2$ goodness-of-fit statistic is its sensitivity to sample size. Specifically, in case of large sample sizes and large numbers of indicator variables, significant $\chi^2$ ($p < 0.05$, indicating poor model fit) can be expected (Hair et al., 2006). Therefore, while this measure is usually reported, it provides limited information.

Fit indices were developed to supplement the $\chi^2$ test and address the problems associated with sample size. CFI is an absolute fit index, ranging in value from zero to 1.00, and is derived from the comparison between a hypothesized model and an independence model. RNI, an incremental fit index, compares the hypothesized model to a null model (that assumes all variables are uncorrelated) and similarly ranges in value from zero to 1.00, where 1.00 is indicative of a poor fit. RMSEA attempts to correct the $\chi^2$ test's tendency to reject models with large samples or large number of observed variables by correcting for those two parameters. SRMR is the average residual value across all standardized residuals and ranges from zero to 1.00 with 1 indicating a poor fit.

Hu and Bentler's (1999) and Hair et al.'s (2006) recommended that CFI, RNI, RMSEA, and when available, SRMR should be examined concurrently and relative to model complexity and sample size. For a sample size greater than 1,000 cases, and a model comprising more than 30 observed variables, significant $p$-values for the $\chi^2$ goodness-of-fit test were expected. For the model fit to be acceptable, values for CFI greater than 0.9 (the recommended cut-off value for sample sizes greater than 1,000), and values for RMSEA smaller than 0.07 were needed concurrently. Also, CFI needed to be greater than 0.92, and SRMR, when available, smaller than 0.08.Due to the large sample size, RNI was not considered.

For each of the two analyses, an iterative approach was used, making small adjustments to improve model fit. The changes consisted of deleting items that did not perform well with respect to model fit or construct validity. According to Hair et al. (2006), dropping up to two out of every 15 measured variables does not jeopardize the confirmatory test. The analysis for the all-complete case approach is summarized in Table 19.

Table 19 Results of CFA Iterations

| Model[3] | $\chi^2$ | CFI | RMSEA | SRMR |
|---|---|---|---|---|
| 1[a] | 2,574.6 ($p$<0.001) | 0.928 | 0.064 | 0.0764 |
| 2[b] | 2,490.5 ($p$<0.001) | 0.929 | 0.065 | 0.0781 |
| 3[c] | 2,133.5 ($p$<0.001) | 0.939 | 0.062 | 0.0696 |
| 4[d] | 1,873.2 ($p$<0.001) | 0.947 | 0.059 | 0.0650 |

The first iteration consisted of fitting the complete model, with all 32 observed variables loading on their respective factors identified in Chapter 3, using only cases with complete information. As expected, the $\chi^2$ goodness-of-fit test was significant, suggesting a poor fit. However, as discussed previously this statistic is very sensitive to sample size and model complexity. The three other measures examined, CFI, RMSEA and SRMR all suggested a good fit to the model. Specifically, CFI was greater than 0.92, while RMSEA was smaller than the recommended value of 0.07 and SRMR less than 0.08. While the combination of these statistics indicated a good fit of the model, the next step was to assess construct validity. This consisted of examining convergent validity, discriminant validity, and nomological validity.

Convergent validity refers to the extent to which indicators of a specific construct converge and consists of examining the direction and magnitude of maximum likelihood factor loading estimates. According to Hair et al. (2006) all standardized factor loadings should exceed 0.5 and preferably be greater than 0.7. InternetExperience, an item modeled to load on technology anxiety (stating "I do not have much experience using the internet") had a factor loading of 0.432 and did not meet this criterion. Since this item did not satisfy the convergent validity requirements, it was dropped the model and the CFA was repeated.

In the second iteration, the $\chi^2$ goodness-of-fit test was significant, CFI was above the recommended value of 0.92 and RMSEA and SRMR were below their recommended cut-offs (0.07 and 0.08 respectively). A review of the factor loadings indicated that while the factor loading for the reverse coded item Same ("I am sure the self-service kiosk performs as well as using the service employee ") was larger than the required value of 0.5 (0.517), it

[3a] complete model with 32 observed variables,
[b] removed Technology Anxiety item "I do not have much experience using the internet",
[c] removed item "I am sure the self-service kiosk performs as well as using the service employee",
[d] removed item "I commonly use lots of automated systems when dealing with other businesses"

was below the recommended value of 0.7. Since this item also loaded poorly onits factor in the EFA described in Chapter 3, it was dropped.

The third iteration model presented a large improvement over model 2. CFI increased from 0.929 to 0.939, RMSEA decreased from 0.065 to 0.062, and SRMR decreased from 0.0781 to 0.0696. The item Automated ("I commonly use lots of automated systems when dealing with other businesses") showed a standardized loading below 0.5. This item also had loaded poorly on the effort factor (EFA factor loading was 0.443) and was removed.

In the fourth iteration of this CFA, the fit indexes further improved. The standardized loadings that remained under the recommended 0.7 value had strong face validity and that had exhibited strong EFA loadings.

The analysis was repeated using a model based approach to missing data and similar results were found. The increase in the value of the $\chi^2$ goodness-of-fit statistic was to be expected, as the sample size for the analysis was greater. However, the values of the CFI, and RMSEA remained consistent across the two analyses. The following table summarizes the findings of this analysis. Since the two approaches to missing data yielded comparable results, the dataset with missing values was used for further analysis.

Table 20 CFA Results with Model Based Approach

| Model[4] | $\chi^2$ | CFI | RMSEA | SRMR |
|---|---|---|---|---|
| 1[a] | 2,948.5 ($p$<0.001) | 0.928 | 0.063 | N/A |
| 2[b] | 2,825.4 ($p$<0.001) | 0.930 | 0.064 | N/A |
| 3[c] | 2,424.4 ($p$<0.001) | 0.939 | 0.061 | N/A |
| 4[d] | 2.084.0 ($p$<0.001) | 0.947 | 0.058 | N/A |

The next step in the examination of convergent validity was to compute reliability scores for each factor. Table 21summarizes the CFA reliability scores for each factor, and compares them next to the EFA reliability scores.

[4a] complete model with 32 observed variables,
[b] removed Technology Anxiety item "I do not have much experience using the internet",
[c] removed item "I am sure the self-service kiosk performs as well as using the service employee",
[d] removed item "I commonly use lots of automated systems when dealing with other businesses"

Table 21 Reliability Coefficients for Belief Scales

| Factor | Abbreviation | Reliability Score | |
|---|---|---|---|
| | | Pilot Test | Main Study |
| *Fun/Enjoyment* | Fun | 0.936 | 0.939 |
| *Perceived Usefulness* | Usefulness | 0.887 | 0.953 |
| *Augmented Technology Anxiety* | Anxiety | 0.816 | 0858 |
| *Need for Interaction* | Interaction | 0.811 | 0.856 |
| *Perceived Risk* | Risk | 0.813 | 0.886 |
| *Perceived Control* | Control | 0.722 | 0.924 |
| *Expected Outcome Quality* | Quality | 0.688 | 0.863 |
| *Expected Effort* | Effort | 0.677 | 0.738 |

As the table above illustrates, all eight belief scales exhibit high reliability coefficients, and exceed the recommended 0.7 value (Hair et al., 2006). Furthermore, the Cronbach Alpha coefficients of the three scales that were modified from the analysis in Chapter 3(Augmented Technology Anxiety, Perceived Control, and Expected Effort) all increased, respectively from 0.816 to 0.858, 0.722 to 0.924, and 0.677 to 0.738.

**Discriminant validity.**

Discriminant validity refers to the extent to which a construct is truly different from other constructs. The conservative approach to determining discriminant validity consists of comparing the variance extracted estimates for each factor with the squared inter-construct correlation associated with that factor. As the table below shows, no squared inter-item correlation exceeds the variance extracted for the factor. For instance, the squared correlation of the fun and usefulness construct (0.309) is below the variance extracted for fun (0.791) and the variance extracted for usefulness (0.805).

Table 22 Squared Inter-Item Correlation and Variance Extracted

| | Fun | Usefulness | Tech Anxiety | Interaction | Risk | Control | Quality | Effort |
|---|---|---|---|---|---|---|---|---|
| Fun | | 0.309 | 0.028 | 0.201 | 0.057 | 0.370 | 0.464 | 0.163 |
| Usefulness | 0.309 | | 0.030 | 0.187 | 0.039 | 0.527 | 0.370 | 0.172 |
| Tech Anxiety | 0.028 | 0.030 | | 0.026 | 0.093 | 0.019 | 0.034 | 0.237 |
| Interaction | 0.201 | 0.187 | 0.026 | | 0.077 | 0.197 | 0.218 | 0.088 |
| Risk | 0.057 | 0.039 | 0.093 | 0.077 | | 0.033 | 0.129 | 0.129 |
| Control | 0.370 | 0.527 | 0.019 | 0.197 | 0.033 | | 0.383 | 0.135 |
| Quality | 0.464 | 0.370 | 0.034 | 0.218 | 0.129 | 0.383 | | 0.264 |
| Effort | 0.163 | 0.172 | 0.237 | 0.088 | 0.129 | 0.135 | 0.264 | |
| Variance Extracted | 0.791 | 0.805 | 0.558 | 0.487 | 0.732 | 0.859 | 0.630 | 0.587 |

Taken together, the CFA findings suggest that a model with eight belief constructs, and 29 observed variables adequately represents the data. By dropping the three observed variables included in the exploratory study in Chapter 3, better model fit and convergent validity were achieved, while yielding a more parsimonious model. The three dropped variables fall below the limit suggested by Hair et al. (2006) and therefore there was no need to conduct the exploratory analysis anew with a different sample. Furthermore, the eight belief constructs exhibit both convergent and discriminant validity.

Summated scales were computed for each belief construct to be used in further analysis. A summary of these variables is provided below.

Table 23 Summary of Observed Variables Included in Each Belief Construct

| | | |
|---|---|---|
| Fun | Enjoy | Using the self-service check-in kiosk will ____________________. (1 = NOT be enjoyable and 7 = be enjoyable) |
| | Entertain | Using the self-service check-in kiosk will ____________________. (1 = NOT be entertaining and 7 = be entertaining) |
| | Fun | Using the self-service check-in kiosk will ____________________. (1 = NOT be fun 7 = be fun) |
| | Interest | Using the self-service check-in kiosk will ____________________. (1 = NOT be interesting and 7 = be interesting) |
| Usefulness | Convenient | Using the self-service check-in kiosk will be more convenient. (1 = I disagree and 7 = I agree) |
| | Efficient | Using the self-service check-in kiosk will make me more efficient while checking-in. (1 = I disagree and 7 = I agree) |
| | Faster | Using the self-service check-in kiosk will allow me to check-in faster. |
| | Productive | Using the self-service check-in kiosk will make me more productive. |
| | Save Time | Using the self-service check-in kiosk will save me time. |
| Control | Control | The self-service check-in kiosk will give me control over checking in. |
| | Own Way | Using the self-service check-in kiosk will allow me to do things my own way. |
| | Same Employee | I am sure the self-service check-in kiosk performs as well as using the service employee. |
| Effort | Complicated | Using the self-service check-in kiosk will ____________________. (1 = NOT be complicated and 7 = be complicated) |
| | Effort | Using the self-service check-in kiosk will ____________________. (1 = NOT require a lot of effort and 7 = require a lot of effort) |
| Interaction | Human Contact | Human contact makes the process enjoyable for me. |
| | Interaction | I like interacting with the person who provides the service. |
| | Bothersome | I bothers me to use a machine when I could talk with a person instead. |
| Quality | Exactly | Using the self-service check-in kiosk means _______________ get exactly what I want. (1 = I will NOT and 7 = I will) |
| | Excellent | Using the self-service check-in kiosk will provide _________ service (1 = poor and 7 = excellent) |
| | High Quality | What quality of service would you receive from the self-service check-in kiosk? (1 = low quality service and 7 = high quality service) |
| | Reliability | Using the self-service check-in kiosk will ____________________. (1 = NOT be reliable and 7 = be reliable) |
| Risk | Confidential | I fear that using the self-service check-in kiosk reduces the confidentiality of my transaction with the hotel. |
| | Privacy | Using the self-service check-in kiosk infringes on my privacy. |
| | Risky | Overall, using the self-service check-in kiosk is risky. |
| Technology Anxiety | Apprehensive | I feel apprehensive about using technology. |
| | Avoidance | I have avoided technology unfamiliar to me. |
| | Jargon | Technical terms sound like confusing jargon to me. |
| | Mistake | I hesitate to use most forms of technology for fear of making a mistake that I cannot correct. |
| | Tech Products | I use a lot of technologically based products and services. |

A summary of descriptive statistics for the summated scales is presented in Table 24.

Table 24 Summary Statistics for Summated Scales

| | N | Range | Min | Max | Mean | St. Dev. | Skew. | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Fun | 1,369 | 6 | 1 | 7 | 3.878 | 1.495 | -0.104 | -0.446 |
| Usefulness | 1,427 | 6 | 1 | 7 | 4.375 | 1.505 | -0.138 | -0.615 |
| Tech Anxiety | 1,411 | 5.6 | 1 | 6.6 | 2.096 | 1.122 | 1.06 | 0.453 |
| Need for Interaction | 1,439 | 6 | 1 | 7 | 4.855 | 1.432 | -0.341 | -0.568 |
| Perceived Risk | 1,427 | 6 | 1 | 7 | 2.133 | 1.209 | 1.226 | 1.363 |
| Control | 1,431 | 6 | 1 | 7 | 4.181 | 1.724 | -0.066 | -0.917 |
| Quality | 1,411 | 6 | 1 | 7 | 4.683 | 1.178 | -0.288 | -0.075 |
| Effort | 1,410 | 6 | 1 | 7 | 3.004 | 1.328 | 0.312 | -0.472 |

## Previous Experience with SST

In Chapter 2, previous experience with SST, in the form of interactions with SST, was hypothesized to increase the likelihood that an individual would use SST in a particular context. Three aspects of the previous interactions were noted as relevant: how similar the previous interactions were to the current context (Rodie and Kleine, 2001), how frequently they had occurred, and whether they had been satisfactory.

### Descriptive statistics.

Consistent with Rodie and Kleine's (2002) conceptualization of role clarity, participants were asked two questions for each of three types of previous interactions with SST. They were asked how many times they had previously used SSKs to check-in in hotels (experience with a similar setting), and whether that experience was satisfactory. Similarly, participants were asked how many times they had previously used SSKs to conduct transactions other than hotel check-in (experience in a similar context), and whether that experience had been satisfactory. The final two questions asked participants about their use and satisfaction with the use of any kind of SST to conduct a transaction. For each of the frequency questions the possible answers were (*never, 1-2times, 3-4 times, more than 4 times*). For the satisfaction questions, the possible answers were (*not applicable*, and 1 *very dissatisfied* to 7 *very satisfied*).

The relationships between frequency of use of the SST and satisfaction with the SST were examined using three one-way ANOVA tests. Results showed that frequency of use of hotel self-service check-in was indeed related to satisfaction$F(2{,}319) = 6.095, p < .05$. Participants having used self-service check-in four or more times ($M = 4.835$)were more satisfied with it than participants that had only used it once ($M = 4.882$)or two or three times ($M = 5.810$). Frequency of use of self-service check-in was similarly related to satisfaction $F(2{,}1{,}276) = 57.863, p < .001$. Participants that had used self-service check-in four or more times ($M = 5.753$)were more satisfied than participants that had only used it once ($M = 4.610$)or two or more times($M = 5.018$). Also, participants that had used SSKs two or three times($M = 5.018$) were more satisfied with it than participants that had only used it once ($M = 4.610$). The same results were found for the relationship between frequency of use of SST and satisfaction with SST$F(2{,}1{,}403) = 103.693, p < .001$. Participants that had only used SST once, were significantly less satisfied ($M = 3.809$) than participants that had used SST two or three times ($M = 4.711$), and four or more times ($M = 5.615$). The difference between the latter two groups was also significant.

Finally, the correlation between satisfaction with previous SST usage and willingness to use each SST was computed (shown in Table 25). Unsurprisingly, all three correlations were positive and statistically significant at the .001 level, suggesting that the more satisfied participants were with a specific SST, the more likely they were to express an intention to use it in the future.

Table 25 Correlation between Satisfaction and Willingness to Use

| **Correlation between satisfaction with and willingness to use** | **Corr.** | **Sign.** | **n** |
|---|---|---|---|
| self-service kiosk to check-in for a hotel stay | .706 | .000 | 323 |
| self-service kiosk to check-in for a service other than a hotel stay (for instance a doctor's appointment or a flight) | .734 | .000 | 1331 |
| self-service technologies (such as a self-service kiosks and the internet) to conduct transactions | .704 | .000 | 1425 |

#### Definition of successful prior experience.

Three hypotheses were formulated, seeking to relate prior experience with SST with future behavior towards the SST. Therefore, it was necessary to identify participants that had prior successful experiences with SST. Experience variable were recoded into binary (categorical) variables where 1 indicated a participant that had previously used the focal SST and was, on average, satisfied with the experience. Zero was used to refer to all other participants that either had not previously used the SST, or where unsatisfied.

However, since using a binary variable reduced the explanatory power of satisfaction, a further distinction was made between participants that had no prior experience using the particular SSTs, participants that had prior negative experiences, and participants that had prior positive experiences with the three SSTs. Since frequency of usage and satisfaction were so strongly related, the satisfaction variables were re-coded into three categorical variables with four categories: no prior experience, dissatisfied, neutral, and satisfied. Separate analyses were conducted with the two sets of variables.

### Analysis

To test hypotheses 1 to 3, a between-subjects 4 (number of individuals waiting for self-service check-in) x 4 (number of individuals waiting for check-in using the service employee) factorial design was used.

Table 26 Proportion of Respondents Selecting the SSK, per Scenario

| Scenario | SST | Employee | N | Mean |
|---|---|---|---|---|
| 1 | 0 | 0 | 91 | 18.68% |
| 2 | 0 | 1 | 83 | 55.42% |
| 3 | 0 | 2 | 88 | 73.86% |
| 4 | 0 | 3 | 94 | 76.60% |
| 5 | 1 | 0 | 79 | 3.80% |
| 6 | 1 | 1 | 83 | 33.73% |
| 7 | 1 | 2 | 95 | 68.42% |
| 8 | 1 | 3 | 83 | 77.11% |
| 9 | 2 | 0 | 91 | 5.49% |
| 10 | 2 | 1 | 85 | 9.41% |
| 11 | 2 | 2 | 102 | 36.27% |
| 12 | 2 | 3 | 96 | 71.88% |
| 13 | 3 | 0 | 86 | 4.65% |
| 14 | 3 | 1 | 99 | 2.02% |
| 15 | 3 | 2 | 91 | 17.58% |
| 16 | 3 | 3 | 96 | 30.21% |
| | | Total | 1,442 | 36.75% |

To test hypotheses 4 to 6, three variables were introduced that represented participants' familiarity and satisfaction with three types of SST. Also, for completeness, the eight beliefs commonly examined in SST research were included, as well as demographic information.

**Logistic regression.**

Logistic regression, a specialized form of regression, was used to test the hypotheses. Logistic regression is particularly appropriate when the dependent variable is a binary categorical variable. Using PASW Statistics 18.0, five models were estimated sequentially, using the forced entry procedure. For the analysis sample, a baseline model was first developed, including only a constant. The second model included the eight beliefs, in addition to the constant. Subsequently, the waiting line information was introduced, followed by the three prior experiences variables, and finally demographic information.

***Model fit.***

Several measures of model fit are typically reported for logistic regression. These include a chi-square statistic comparing the model under study to a baseline model, several pseudo- $R^2$ measures ($R^2_{LOGIT}$, Cox & Snell $R^2$, Nagelkerke $R^2$), the Hosmer and Lemeshow goodness of fit statistic, and a measure of classification accuracy, called the hit ratio.

The three pseudo- $R^2$ measures reflect the amount of variation explained by the logistic model. $R^2_{LOGIT}$(also known as the Hosmer and Lemeshow's $R^2$) is calculated by dividing the model -2LL by the baseline model -2LL and as such, represents the proportional reduction of the log-likelihood measure (Hair et al., 2006). It is a measure of how much the badness of fit of the model is reduced by including the predictor variables. A different pseudo- $R^2$ measure, the Cox and Snell $R^2$ is based on the log-likelihood of the model, the log-likelihood of the original model, and the sample size. Since this measure cannot reach the theoretical maximum (1), a modification was proposed by Nagelkerke, the Nagelkerke $R^2$. These measures are computed differently, but jointly they can be used to determine the practical significance of the model. The Hosmer-Lemeshow goodness-of-fit statistic tests the hypothesis that the observed data are significantly different from the model's predicted values (Field, 2006), however it is sensitive to large sample sizes. A related measure is the hit ratio, measuring the percentage of cases that are correctly classified using the model.

A test for internal validity of the model consists of splitting the data set in an analysis and a holdout sample. Subsequently, the logistic regression analysis is conducted using the analysis sample, and its predictive accuracy (hit ratio) is determined using the holdout sample. The data was therefore randomly split in an analysis sample (70%) and a holdout sample (30%).

The baseline model -2 log-likelihood was 1,056.615 for the analysis sample. The introduction of the eight belief variables reduced the -2 log-likelihood to 598.484. The reduction was significant ($\chi^2 = 458.131$, $p< 0.001$), suggesting that the inclusion of the eight belief variables significantly improved the predictive ability of the model. The $R^2_{LOGIT}$ measure for this model was 0.434. Cox & Snell $R^2$ was 0.440 and Nagelkerke $R^2$ was 0.596. The classification accuracy of the model was 84.70% for the analysis sample and 82.7% for the holdout sample.

Subsequently, two variables representing the number of customers waiting for the service employee and the number of customers waiting for the SSK were introduced, in addition to the belief variables and the constant. The -2LL for the third model was 387.063. The reduction of the -2LL from the baseline model's -2LL was significant ($\chi^2 = 669.552$, $p< 0.001$). Furthermore, the reduction from model 2 was also statistically significant

($\chi^2 = 211.421$, $p < 0.001$), suggesting that the inclusion of the waiting line information significantly improved the model. The $R^2_{LOGIT}$ measure for this model was 0.634. Cox & Snell $R^2$ was 0.571 and Nagelkerke $R^2$ was 0.775. The predictive accuracy of this model was 88.60% for the analysis sample and 87.60% for the holdout sample.

The fourth model included information about participants prior experience with three types of SST: hotel self-check-in kiosk, other SSKs, and SSTs in general. These were binary variables where 1 indicated a satisfactory experience with the particular SST[5]. The -2LL for the this model was 385.356. The reduction of -2LL as compared to the baseline model was significant, ($\chi^2 = 671.256$, $p < 0.001$), however, the reduction from the previous model was not significant ($\chi^2 = 1.707$, $p = 0.635$) . There was also not a large improvement in the pseudo-$R^2$ measures. The $R^2_{LOGIT}$ measure for this model was 0.635. Cox & Snell $R^2$ was 0.572 and Nagelkerke $R^2$ was 0.776. The classification accuracy of the model also did not improve much as compared to the previous model and remained at 88.6%for the analysis sample and 87.3% for the holdout sample.

The categorical demographic variables age, gender, and income were included in the fifth model for control purposes. . The -2LL for this model was 365.987. The reduction from the previous model was not significant ($\chi^2 = 19{,}369$, $p = 0.08$), indicating that demographic information could not improve the model fit. The classification accuracy of the model increased slightly to 90.4%for the analysis sample and was reduced to 87.9% for the holdout sample. However, the slight increases in $R^2_{LOGIT}$ to 0.654. Cox & Snell $R^2$ to 0.582 and Nagelkerke $R^2$ to 0.790 suggest that the difference is of no practical significance. Taken together, these results suggest that age, gender and income are not related to participants' decision to use SST.

The above examination of model fit suggests that model 3, including a constant, the eight beliefs, and the waiting line information should be retained for further analysis. Model 3 is shown in Table 27.

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[5] Conducting the same analysis with a categorical variable where 0 = no prior experience, 1 = prior negative experience, 2 = prior neutral experience, and 3 = prior positive experience yielded similar results.

Table 27 Logistic Regression Model, DV is Choice to Use SST

| | | Unstandard. Coefficients | | Standard. Coefficients | | |
|---|---|---|---|---|---|---|
| | | B | S.E. | Beta | Wald | Sig. |
| Model 2 | Constant | -3.901 | 1.033 | .020 | 14.269 | .000 |
| | Fun | -.066 | .106 | .937 | .380 | .538 |
| | Useful | 1.419 | .127 | 4.131 | 123.963 | .000 |
| | Technology Anxiety | .335 | .102 | 1.397 | 10.806 | .001 |
| | Interaction | -.632 | .098 | .531 | 41.901 | .000 |
| | Risk | -.171 | .107 | .843 | 2.567 | .109 |
| | Control | -.183 | .089 | .832 | 4.257 | .039 |
| | Quality | .072 | .146 | 1.075 | .245 | .621 |
| | Effort | .028 | .095 | 1.029 | .090 | .764 |
| Model 3 | Constant | -5.502 | 1.312 | .004 | 17.590 | .000 |
| | Fun | -.055 | .130 | .946 | .181 | .671 |
| | Useful | 1.149 | .158 | 3.156 | 53.165 | .000 |
| | Technology Anxiety | .280 | .125 | 1.323 | 5.004 | .025 |
| | Interaction | -.812 | .128 | .444 | 40.562 | .000 |
| | Risk | -.050 | .132 | .951 | .145 | .704 |
| | Control | -.009 | .111 | .991 | .006 | .938 |
| | Quality | .551 | .181 | 1.736 | 9.238 | .002 |
| | Effort | -.050 | .118 | .952 | .177 | .674 |
| | Waiting for Service Employee | 1.460 | .156 | 4.306 | 87.640 | .000 |
| | Waiting for SSK | -1.306 | .146 | .271 | 79.519 | .000 |

An important step in the examination of the model is to look for multicollinearity (Field, 2006). The tolerance and VIF statistics for model 3 were examined. The recommended values for these statistics are above 0.1 and below 10 respectively. As the table below indicates, there does not seem to be an issue with multicollinearity for this model, as the tolerance values for all variables in the model are above 0.1, and the VIF values below the recommended cut-off of 10.

Table 28 Multicollinearity Statistics

| Model | | Unstandardized Coefficients | | Standard. Coefficients | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | S.E. | Beta | t | Sig. | Toleran ce | VIF |
| 1 | Constant | .010 | .102 | | .098 | .922 | | |
| | Fun | .008 | .010 | .026 | .836 | .403 | .511 | 1.956 |
| | Useful | .165 | .010 | .515 | 16.098 | .000 | .469 | 2.133 |
| | Technology Anxiety | .032 | .011 | .072 | 2.985 | .003 | .814 | 1.229 |
| | Interaction | -.079 | .009 | -.234 | -8.345 | .000 | .610 | 1.638 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Risk | -.003 | .010 | -.007 | -.285 | .776 | .771 | 1.297 |
| | Control | -.014 | .009 | -.050 | -1.558 | .120 | .464 | 2.153 |
| | Quality | .002 | .014 | .006 | .174 | .862 | .413 | 2.423 |
| | Effort | -.009 | .010 | -.025 | -.948 | .343 | .675 | 1.481 |
| 2 | Constant | .028 | .091 | | .311 | .756 | | |
| | Fun | .016 | .009 | .050 | 1.890 | .059 | .509 | 1.965 |
| | Useful | .093 | .010 | .288 | 9.674 | .000 | .403 | 2.479 |
| | Technology Anxiety | .028 | .009 | .064 | 3.067 | .002 | .813 | 1.230 |
| | Interaction | -.069 | .008 | -.205 | -8.430 | .000 | .606 | 1.649 |
| | Risk | -.002 | .009 | -.005 | -.248 | .804 | .769 | 1.300 |
| | Control | .001 | .008 | .005 | .176 | .860 | .460 | 2.174 |
| | Quality | .032 | .012 | .077 | 2.608 | .009 | .406 | 2.464 |
| | Effort | -.011 | .008 | -.031 | -1.351 | .177 | .675 | 1.481 |
| | Waiting for Service Employee | .139 | .009 | .320 | 15.932 | .000 | .885 | 1.130 |
| | Waiting for SSK | -.116 | .008 | -.268 | -13.678 | .000 | .930 | 1.075 |

***Coefficients.***

For each variable in the equation two coefficients were computed: a logistic coefficient and an exponentiated logistic coefficient. The logistic coefficient measures the change in the ratio of the probability (the odds), while the exponentiated logistic coefficient facilitates interpretation by taking the antilog of the logistic coefficient (Hair et al., 2006).

The Wald statistic is used to test whether a coefficient is statistically different from zero. It provides the statistical significance of each estimated logistic coefficient so that hypothesis testing can occur. In model 3, in addition to the constant, and waiting line information, four beliefs had statistically significant coefficients. The logistic coefficients for anticipated usefulness (1.149), need for interaction (-0.812), and anticipated quality (0.551) were statistically significant (respectively $p < 0.001, p < 0.001, p = 0.02$). Furthermore, the logistic coefficient for technology anxiety (0.280) was marginally significant ($p = 0.025$).

The logistic coefficients for anticipated usefulness and expected quality were positive, suggesting that anticipated usefulness and quality increased the likelihood that participants would choose to use the SST. Conversely, the negative coefficient for need for interaction suggested that an increase in need for interaction reduced the likelihood that a participant would choose to use the SST. These findings are consistent with previous research that individuals' likelihood to use SST is influenced by their beliefs. However, contrary to previous research, the positive coefficient for technology anxiety (0.280), along with the marginal significance for this variable ($p = 0.025$), would suggest that participants with greater technology anxiety were more likely to use SST. The marginal nature of this result, along with the finding that the technology anxiety variable was not normally distributed lead to the conclusion that this information should not be retained for further analysis.

Waiting line information was introduced using two continuous variables representing the number of customers waiting for each alternative. The coefficients for both variables were significant. The coefficient for the number of customers waiting for the SSK was negative (-1.306, $p < 0.001$) indicating that the longer the waiting line for the SSK, the less likely participants were to select that option. Conversely, the positive coefficient for the number of customers waiting for the service employee (-1.460, $p < 0.001$) indicating that the longer the waiting line for the service employee, the more likely participants were to select the SSK option.

**Hypotheses testing.**

Table 26 presents the proportion of participants in each scenario that selected the SST alternative. From this table, we see that, when both alternatives were available, a greater number of participants (81.32%) selected the service employee alternative. This provides support for hypothesis 1. Furthermore, the negative value of the constant suggests that, in absence of waiting line differences, the odds that participants would select the service employee alternative were greater than the odd that participants would select the SSK alternative. This provides support for both hypotheses 1 and 2.

*Hypothesis 1 When the lines for SST and for the service employee are both empty, customers will be more likely to use the service employee*

Additionally, Table 26 also shows that when the lines are equal (scenarios 6, 11 and 16) participants were more likely to select the service employee (respectively, 66.27%, 63.73%, and 69.79%) than the SSK. This is further supported by the negative sign of the constant.

*Hypothesis 2: When the lines for SST and for the service employee are both non-empty and of the same length, customers will be more likely to choose the service employee.*

Table 26 further shows that when the line for the SSK is shorter (scenarios 2 ,3, 4, 7, 8, and 12) participants were more likely to select the SSK alternative (percentages were respectively, 55.42%, 73.86%, 76.60%, 68.42%, 77.11%, and 71.88%). Conversely, when the line for the service employee was shorter, participants were less likely to select the SSK alternative (scenarios 5, 9, 10, 14, 15, and 16 with respectively 3.80%, 5.49%, 9.41%, 2.02%, 17.58%, and 30.21%). The direction and statistical significant of the coefficients for these two variables support this finding and hence hypothesis 3 is supported.

*Hypothesis 3 When the lines for SST and for the service employee are of different length, customers will be more likely to use the alternative with the shortest line*

The lack of fit improvement of the model including the three previous experience variables lead to the rejections of hypotheses 4, 5, and 6. Namely, previous successful experience with self-service hotel check-in does not increase the likelihood that a participant will choose SST to check-in to a hotel. Similarly, participants with previous satisfactory experiences with other forms of self-service check-in and were no more likely to choose the SST alternative. Finally participants that indicated being satisfied with their previous experiences using SST were also no more likely than others to choose the SST alternative.

**Summary**

A 4 (number of individuals waiting for self-service check-in) x 4 (number of individuals waiting for check-in using the service employee) between-subjects factorial design was used to examine the proposition that, in addition to the eight beliefs about SST, waiting line information influenced individuals' choice of whether or not to use SST. Confirmatory factor analysis was used to assess the measurement model for these eight beliefs. The summated scales were then used along with waiting line information in a logistic regression. Findings of this analysis included a positive effect of anticipated usefulness and anticipated quality on likelihood to use SST, and a negative effect of need for interaction. Furthermore, the direction of the coefficients associated with the number of customers waiting for to use the SSK and the service employee suggested that, a longer waiting line for one service delivery alternative increased the likelihood that participants would select the other service delivery alternative.

## Potential Limitation of the Scenario-Based Survey

While a response rate of 3.41% was consistent with other, similar, online surveys (Oh, 2009), it was important to examine whether non-response error and coverage error impacted the results of the study (Dillman, 2007). Non-response error results from "people who respond to a survey being different from sampled individuals who did not respond, in a way relevant to the study" (Dillman, 2007, pg. 11). Coverage error is the results from "not allowing all members of the survey population to have an equal or known chance of being sampled for participation in the survey" (Dillman, 2007, pg. 11).

In order to control for non-response error, two time trend extrapolation tests (Deustkens, et al., 2004) were conducted, as described by Armstrong and Overton (1977). The time-trend extrapolation test assumes that late respondents are similar to non-respondents (Armstrong & Overton, 1977). The first test consisted of a comparison between early and late respondents to scenarios 1 through 16, while the second test consisted of comparison between respondents to scenarios 10 and 25. Individuals that replied to the recruitment e-mail early (within the first three days) received links to surveys 1 through 24. Those replying later, received links to surveys 25 through 27. Therefore, respondents in scenarios 10 and 25 differed in how soon they opened the recruitment mail, whereas early and late respondents to scenarios 1 through 16 differed mainly in how long they waited after receiving the link to click on it and complete the survey.

For the first test, the sample consisting of responses to scenarios 1 to 16 was split in two groups. The first group consisted of participants that completed the survey in the first 0.8 days (40$^{th}$ percentile) after the recruitment e-mail was sent ($n = 696$), while the second group included all participants that had completed the survey after 1.1 days (60$^{th}$ percentile) ($n = 617$).

Using an independent sample t-test, the two groups were compared on their self-reported technology anxiety and their need for interaction, since those were the measures respondents and non-respondents should show the greatest difference in, for several reasons. First, the population from which the sample was drawn consisted of individuals that have access to e-mail, suggesting that on average, these individuals were more comfortable with online technology than others. Second, it could be assumed that the individuals that requested a link to, and completed the survey may, on average, be more at ease with online technology than other individuals in the same population. It has been suggested that, previous experience with the internet reduces one's technology anxiety. Higher levels of technology anxiety could lead to the avoidance of SST (Meuter et al., 2005).

The mean technology anxiety score was lower for the early responder group $(M = 1.866, SE = 0.036)$ than for the latter respondent group$(M = 2.043, SE = 0.043)$. While the difference between the two groups was statistically significant, $t(1{,}190.82) = -3.154, p = 0.02$, the effect size was very small $r = 0.091$. Similarly, the mean need for interaction was lower for the early responder group $(M = 4.725, SE = 0.055)$ than for the latter respondent group $(M = 4.957, SE = 0.057)$. While the difference between the two groups was statistically significant $t(1{,}282) = -2.916, p = 0.04$, the effect size was also small $r = 0.081$.

One disadvantage of this test was that it did not take into account the time from respondent's awareness of the study to the time they completed the study (Armstrong and Overton, 1977). Specifically, individuals that only opened this message later, and were thus not aware of the study may be different than individuals that were aware of the study early, but chose to wait to complete it. To remedy this, a second test was conducted comparing responses to the identical scenarios 10 and 25. Respondents that received a link to scenario 10 were those that had shown an interest in participating in the first three day $(n = 87)$, while respondents to scenario 25 showed their interest in the study more than three days after the initial recruitment e-mail was sent $(n = 57)$.

Similar to the previous test, the two groups were compared on their self-reported technology anxiety and need for human interaction scores. While the mean technology anxiety score was lower for respondents to scenario 10 $(M = 1.882, SE = 0.109)$ than for the latter respondent group $(M = 2.112, SE = 0.150)$, this was not statistically significant, $t(135) = -1.299, p = 0.20$, and the effect size was small $r = 0.111$. The mean need for interaction was lower for the early responder group $(M = 5.018, SE = 0.160)$ than for the latter respondent group $(M = 5.487, SE = 0.151)$. The difference between the two groups was statistically significant $t(135.076) = -2.127$, $p = 0.04$, however, the effect size was small $r = 0.180$.

Recruiting participants via e-mail does not allow individuals that do not have e-mail to be represented. This is a common critique of studies using e-mail recruitment, as it may lead to a potential source of coverage error. However, as of December 2009, 74% of U.S. adults were reported to have access to the internet, according to the Pew Research Center, with only few segments under-represented, including the over 65 years old (38%). Another critique of online surveys is that, unlike telephone surveys, there is no method to access random samples of individuals or households (Hart et al., 2004). However, 22% of US households were found not to be covered by traditional landline RDD telephone surveys (Smyth, Dillman, Christian, and O'Neill, 2010). Taken together, these observations suggest that the only advantage of telephone surveys over online surveys is that of random selection.

## Chapter 5: Simulation Analysis

### Overview

The purpose of this study was to develop a model that could help estimate whether implementing SST in an existing service delivery process could reduce both waiting times and operating costs. In Chapter 2, a simulation model that could be used to estimate the impact of SST implementation on waiting times of an existing serviced delivery was proposed. Chapters 3 and 4 examined one important assumption of this model, namely customer behavior when deciding between using the SST or the service employee. This section describes how other information necessary for the development model was collected and transformed into simulation inputs. Subsequently, a description is given of how the model was formulated, verified, and validated. As part of the model validation, a sensitivity analysis was conducted to determine which assumptions the model could be sensitive to. Critical assumptions were included the analysis. The analysis consisted of using ANOVA to identify conditions that significantly impacted the simulation results. These conditions were subsequently incorporated in a spreadsheet model that examined the somewhat conflicting objectives of reducing waiting time and reducing operating costs.

### Performance Measures

Two performance measures were of interest for the purposes of this study: waiting times and operating costs. Simulation is particularly appropriate when examining waiting times in a complex system where customers can take multiple paths through the system. An extension to the use of waiting times as performance measures is the use of service levels.

Service levels measure the proportion of customers that wait less than a pre-specified length of time (Hueter & Swart, 1998). In the context of this study, a question in the survey was used to determine what an acceptable waiting time would be for this service setting. The question read: "What do you think is an acceptable waiting time (in minutes and seconds) before it is your turn to check-in?" The possible answers ranged from 0 to more than 11 minutes in 20 second increments. The findings are shown in Table 29..

Table 29 Acceptable Waiting Times

| Time in seconds | Frequency | Percent | Valid Percent | Cumulative Percent | Cumulative Percent |
|---|---|---|---|---|---|
| 0 | 14 | 1.0 | 1.0 | 1.0 | 100.0 |
| 20 | 13 | .9 | .9 | 1.9 | 99.0 |
| 40 | 6 | .4 | .4 | 2.3 | 98.1 |
| 60 | 64 | 4.4 | 4.4 | 6.7 | 97.7 |
| 80 | 10 | .7 | .7 | 7.4 | 93.3 |
| 100 | 7 | .5 | .5 | 7.9 | 92.6 |
| 120 | 265 | 18.4 | 18.4 | 26.3 | 92.1 |
| 140 | 10 | .7 | .7 | 27.0 | 73.7 |
| 160 | 7 | .5 | .5 | 27.4 | 73.0 |
| 180 | 315 | 21.8 | 21.8 | 49.3 | 72.6 |
| 200 | 11 | .8 | .8 | 50.0 | 50.7 |
| 220 | 13 | .9 | .9 | 50.9 | 50.0 |
| 240 | 138 | 9.6 | 9.6 | 60.5 | 49.1 |
| 260 | 3 | .2 | .2 | 60.7 | 39.5 |
| 280 | 1 | .1 | .1 | 60.8 | 39.3 |
| 300 | 436 | 30.2 | 30.2 | 91.0 | 39.2 |
| 320 | 4 | .3 | .3 | 91.3 | 9.0 |
| 340 | 2 | .1 | .1 | 91.4 | 8.7 |
| 360 | 30 | 2.1 | 2.1 | 93.5 | 8.6 |
| 380 | 2 | .1 | .1 | 93.6 | 6.5 |
| 420 | 20 | 1.4 | 1.4 | 95.0 | 6.4 |
| 440 | 1 | .1 | .1 | 95.1 | 5.0 |
| 480 | 17 | 1.2 | 1.2 | 96.3 | 4.9 |
| 520 | 1 | .1 | .1 | 96.3 | 3.7 |
| 600 | 45 | 3.1 | 3.1 | 99.4 | 3.7 |
| 620 | 1 | .1 | .1 | 99.5 | .6 |
| 640 | 1 | .1 | .1 | 99.6 | .5 |
| 660 seconds or more | 6 | .4 | .4 | 100.0 | .4 |

As Table 29 shows, there are three modal responses, 300 seconds/5 minutes (30.2%), 180 seconds/3 minutes (21.8% of respondents) and 120 seconds/2 minutes (18.4% of respondents). By subtracting the cumulative percentage from 1, the percentage of individuals that would be satisfied if they had to wait less than a specified duration was obtained. For instance, from Table 29, to meet the expectations of at least 90% of customers, the wait time cannot exceed 120 seconds, or 2 minutes.

Simulation also allowed for the examination of resource utilization as a secondary performance measure. Specifically, the utilization of the SSK and the service employee could point to possible improvement in the service delivery process.

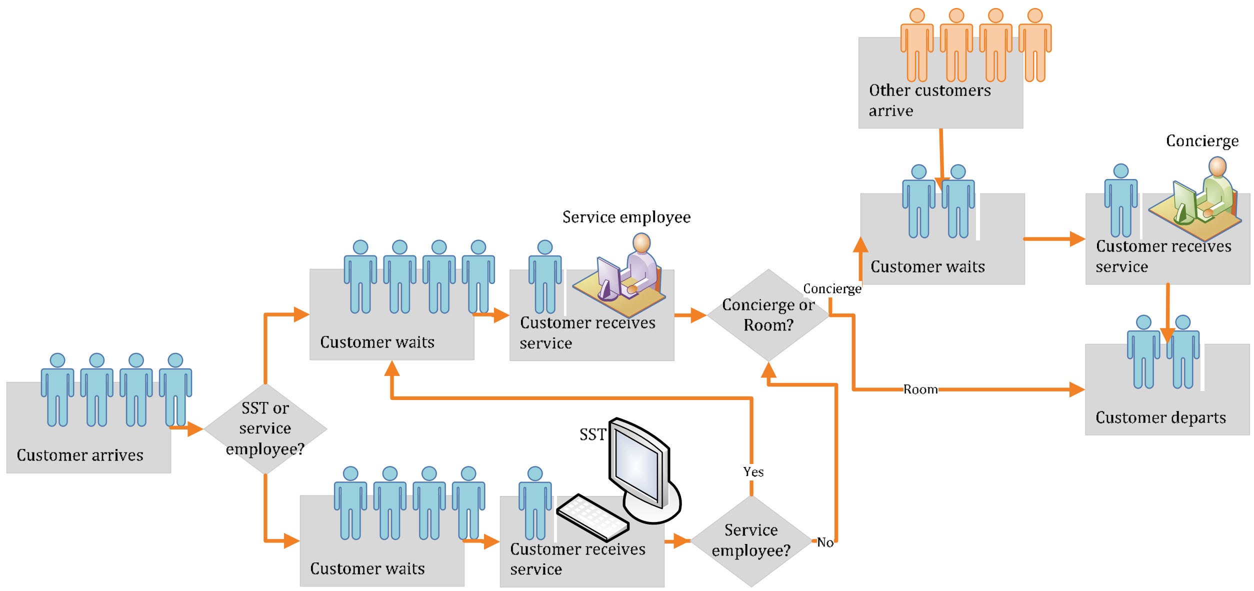
The operating costs for a system can be computed without the simulation, and were therefore analyzed separately, using a spreadsheet model.

**Input Parameters for Simulation Model**

A simulation model based on the model described in Chapter 2 was developed in ARENA (Rockwell Automation Technologies, Version 12). There were three major data components to the model: customer behavior (choice to use SST or service employee; choice to go to concierge), customer arrival times, and customer processing times.

A model representing a check-in process was developed. The model consisted of a guest's arrival to the check-in process, the services he obtains, and his departure from the system. The arrival was defined as the guest joining the waiting line. A guest could receive several services, but needed to, at a minimum, check-in using either the service employee or the SSK. In addition, after checking-in, the guest could choose to receive service from the concierge before departing to his room. Finally, after checking-in using the SSK, a guest could choose to also receive service from the service employee. This was defined as a failure. The departure of the guest from the system was defined as him or her leaving the check-in area (typically to go to the room). A schematic depiction of the process is given in Figure 5.

Figure 5 System




**Customer arrivals and processing times for service employee.**

Customer arrivals and customer processing times by the service employee represent further sources of randomness for the system and need to be quantitatively described. This is typically done by specifying input probability distributions (Law, 2007). The choice of probability distribution is an important one as it will have a large impact on the simulation output. There are several ways to specify a distribution. All include the collection of inter-arrival and processing times using the "clipboard and stopwatch method" (Starks and Whyte, 1998; page 38). These times can then either be 1) directly used in the simulation, 2) be used to define an empirical distribution, or 3) used to fit a theoretical distribution. Theoretical distributions are a compact way to represent values and are easier to change (Law, 2007). Fitting the data to a theoretical distribution is the most desirable option and was therefore used.

***Procedures.***

Customer inter-arrival times and processing time were recorded using an Excel spreadsheet. During two ninety minute periods representative of the resort's activity, 105 arrivals to the system were observed. This yielded 98 usable inter-arrival times and 96 usable processing times. These observations were then used to identify an appropriate distribution family. Identifying the appropriate distribution family and estimating the corresponding distribution parameters based on data collected using the *clipboard and stopwatch method* can be difficult (Kuhl & Lada, 2007). Graphical representations are typically used to select an appropriate theoretical distribution. Statistical goodness-of-fit tests such as the Kolmogorov-Smirnov and Chi-Squared tests of statistical fit are then used to assess the fit of the data to the distribution.

***Analysis.***

Histograms were created of the data and used to propose distribution families that could be used to model the inter-arrival and processing times. The histograms for both data sets are shown below. Figure 6 is a histogram of the inter-arrival times, while Figure 7 is a histogram of processing times.

Figure 6 Histogram of Inter-Arrival Times

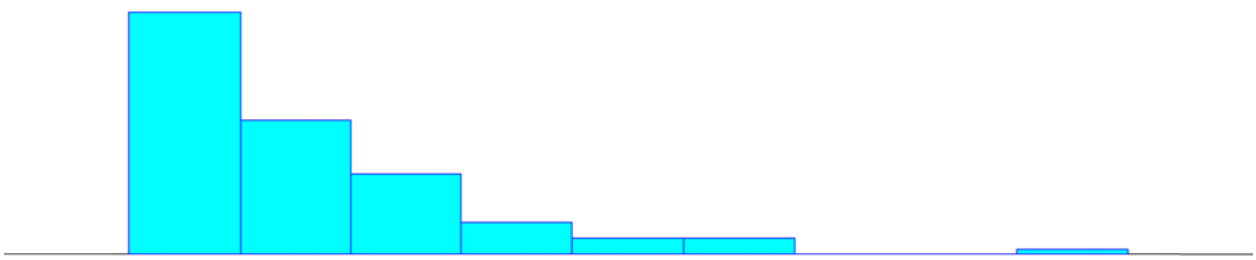
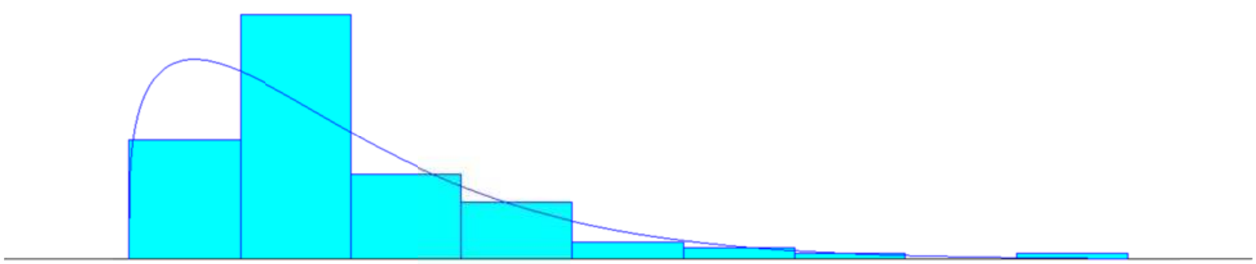


Figure 7 Histogram of Processing Times



A visual examination of the inter-arrival times histogram (Figure 6) suggests that the inter-arrival times may be best represented using an exponential distribution. However, since the minimum for these data is 4, it is likely that this is a shifted exponential distribution. Similarly, a comparison of the processing times histogram (Figure 7) to known distributions (Law, 2006; pg. 287) lead to the hypothesis that a Weibull distribution with parameter $1 < \alpha \leq 2$ would probably best summarize the data. Two tests were used to examine these hypotheses, the Kolmogorov-Smirnov and Chi-Squared tests of statistical fit. The input analyzer provided with the ARENA simulation software was used.

For the inter-arrival data, the ARENA input analyzer proposed a shifted exponential distribution (4 seconds) with mean a mean inter-arrival time of 96.9 seconds. This distribution was a good fit to the data$\chi^2(2) = 0.652, p = 0.726$. The results of the chi-square test indicated a failure to reject the null hypothesis and assumed a good fit of the exponential distribution to the data. Similarly, the Kolmogorov-Smirnov goodness-of-fitness test statistic for this data indicated a good fit. The test statistic was 0.045 with a p-value greater than 0.15. The exact formula for the distribution was 4 + EXPO(96.9). The exponential distribution is particularly well-suited to this context since it is often used to represent inter-arrival times of customers to a system. One limitation of the exponential distribution is that it is unbounded on the right. This means that it can generate infinitely large values (with a very small probability).

For the processing times, the ARENA input analyze proposed a shifted gamma distribution with parameters $\alpha = 1.29$ ,and $\beta = 109$. The exact formula was 7 + GAMM(109, 1.29). The parameter $\alpha = 1.29$ is a shape parameter, while the parameter $\beta = 109$ is a scale parameter. The statistical fit for this distribution was poor $\chi^2(1) = 16, p < 0.005$. The Kolmogorov-Smirnov test of statistical fit was similarly poor with a test statistic of 0.174, $p < 0.001$. However, according to the "fit all" option of the ARENA input analyzer, this was the best fitting distribution. Furthermore, despite a poor statistical fit, this gamma distribution was a good theoretical fit at it is oftentimes used to represent the time needed to complete a task (Kelton, Sadowski, & Sturrock,., 2007; Law, 2007).

**Customer processing times for SSK.**

It was not possible to collect customer processing times for self-service check-in. This is a typical occurrence when a system does not exist or is unavailable for observation. In that situation it is common to use either a constant deterministic value (for values other than time delays) or a probability distribution (for time delays) (Kelton, et al,, 2007). Assumptions that could help select a suitable probability distribution include the fact that processing times will have a high variance and will be bounded by a minimum value on the left. It was determined that the exponential distribution probably best represented this process.

Individuals using self-service check-in will require a minimum time to complete the process, no matter how experienced they are with the process. A review of the practitioner literature yielded SSK check-in time estimates ranging from 23 seconds (Carlin, 2008) and 30 seconds ("NEXTEP SYSTEMS Debuts Self Check-In/Out Solution", 2009) to 60 seconds ("Sheraton Hotels Rolling Out New Check-In Kiosks", 2004; Mayock, 2010). A lower bound of 23 seconds was used, since this was the lowest estimate encountered in the review of the practitioner literature. Furthermore, a mean of 37 seconds was used, assuming that, on average, a transaction would take sixty seconds. The final expression was 23 + EXP(37). Finally, the impact of this assumption on the study results was controlled during experimentation (Kelton et al., 2007).

**Customer behavior.**

In the system described, two customer decisions needed to be modeled: customers' decision of whether or not to use the SSK and customers' decision of whether or not to go to the concierge after checking-in. Customers could also elect to visit the service employee after using the SSK.

***Initial selection: self-service kiosk or service employee.***

In Chapter 4, a model of customer behavior when selecting between an SST or a service employee to obtain service was presented. In addition to waiting line information, this model included several beliefs about SST that have been shown to influence individuals' choice. However, in the context of a simulation study, these beliefs are not actionable. Consequently, the logistic regression analysis was repeated using only two variables: the number of customers waiting for service by the SST, and the number of customers waiting for service by the service employee. The baseline model -2 log-likelihood was 1,324.291 for the analysis sample. The introduction of two waiting line variables reduced the -2 log-likelihood to 982.540. The reduction was significant ($\chi^2 = 341.751, p < 0.001$), suggesting that the inclusion of these two variables significantly improved the predictive ability of the model. The $R^2_{LOGIT}$ measure for this model was 0.258. Cox & Snell $R^2$ was 0.291 and Nagelkerke $R^2$ was 0.395. The value for the Hosmer &

Lemeshow goodness-of-fit statistic was $\chi^2 = 18.190$, $p$ =0.006, suggesting that the observed data were significantly different from the model's predicted values. The classification accuracy of the model was 76.50% for the analysis sample and 81.7% for the holdout sample. Taken together, these findings suggest that this model predicts customer choice better than chance alone, and only slightly worse than using customer beliefs alone. The results of the logistic regression are shown below:

Table 30 Logistic Regression with Only Waiting Time

| | B | S.E. | Wald | df | Sig. | Exp(B) | 95% C.I.for EXP(B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| PAX | 1.087 | .082 | 174.580 | 1 | .000 | 2.967 | 2.525 | 3.486 |
| SST | -.836 | .078 | 116.232 | 1 | .000 | .433 | .372 | .505 |
| Constant | -1.094 | .165 | 43.872 | 1 | .000 | .335 | | |

The logistic coefficients obtained can be used to compute the probability that a customer will select the SST alternative based on the number of individuals waiting.

Equation 1

$$P(SS) = \frac{1}{1 + e^{-(-1.087 - 0.836x_1 + 1.087x_2)}}$$

In this equation, $x_1$ is the number of individuals waiting for self-service (including the one currently using the self-service kiosk) and $x_2$ is the number of individuals waiting for service by a service employee (including the one currently talking with the service employee).

Table 31 shows, for each scenario, a comparison between the probabilities that an individual will select SST, computed using the formula above (P(SS)), and the percentage of survey respondents that indicated they would do so.

Table 31 Sample Formula Computations

| Scenario | SST | Employee | P(SS) | Survey | Difference |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 25.08% | 18.68% | 6.40% |
| 2 | 0 | 1 | 49.83% | 55.42% | -5.60% |
| 3 | 0 | 2 | 74.66% | 73.86% | 0.79% |
| 4 | 0 | 3 | 89.73% | 76.60% | 13.14% |
| 5 | 1 | 0 | 12.67% | 3.80% | 8.87% |
| 6 | 1 | 1 | 30.09% | 33.73% | -3.65% |

| | | | | | |
|---|---|---|---|---|---|
| 7 | 1 | 2 | 56.08% | 68.42% | -12.34% |
| 8 | 1 | 3 | 79.11% | 77.11% | 2.01% |
| 9 | 2 | 0 | 5.92% | 5.49% | 0.42% |
| 10 | 2 | 1 | 15.72% | 9.41% | 6.31% |
| 11 | 2 | 2 | 35.62% | 36.27% | -0.65% |
| 12 | 2 | 3 | 62.14% | 71.88% | -9.73% |
| 13 | 3 | 0 | 2.65% | 4.65% | -2.00% |
| 14 | 3 | 1 | 7.48% | 2.02% | 5.46% |
| 15 | 3 | 2 | 19.34% | 17.58% | 1.76% |
| 16 | 3 | 3 | 41.57% | 30.21% | 11.36% |

***Use of the concierge.***

In addition to the probability that customers will select SST technology based on the relative length of the lines, other measures of customer behavior in the model needed to be quantified. These included the proportion of customers that would select to go to the concierge after checking in with a service employee, and the proportion of customers that would choose to go to the concierge after checking in using the SST. These were measured using single measures in the survey described in Chapter 4.

The data showed that 14.2% of participants that had chosen to use SST, and 19.7% of those that had chosen to use the service employee, indicated they would visit the concierge desk after checking-in. A Pearson's chi-square test showed that there was a significant association between the choice to use SST and the choice to use the concierge after check-in $\chi^2(1) = 6.788, p < 0.01$. However, the effect size was very small, suggesting that the difference in behavior between individuals that use the SSK and individuals that use the concierge had no practical significance. Consequently, the concierge was not included in the simulation model.

***Jockeying.***

In real life, individuals tend to switch lines when they perceive service to be faster elsewhere. For instance, upon arrival customers may decide that the line for the service employee looks more attractive and position themselves in that line. However, the line for the SSK may move faster, and the SSK may become available. This customer may then decide to switch, and use the SSK to check-in. This behavior may impact the results of the simulation. During the course of the sensitivity analysis the performance of a model where jockeying was possible was compared to a model where jockeying was not possible. The ability to model this behavior is yet another advantage of simulation.

To model jockeying behavior, the findings the survey shown in Table 26 were used. Specifically, 25% of customers were assumed not to want to switch from the service employee to the SSK. Concretely, the first individual waiting for service by the service employee was modeled as having a 75% chance of changing lines. If that individual did not change lines, the following individual was modeled as having a similar likelihood to change. Conversely, it was assumed that 5% of customers would not want to switch from the SSK to the service employee. Therefore, if the service employee became available, and an individual was waiting to use the SSK, the individual was modeled as having a 95% of switching (approximately 100-4.51%).

***Other assumptions.***

Finally, another assumption made was the customers would not balk or renege. Customers arriving at a hotel typically have reservations. Even if the line is long, they will be slow to balk (refuse to enter the line), or renege (enter the line, change their mind, and leave the system) (Lambert & Cullen, 1987). Hotel check-in processes are special from this perspective, as customers are relatively captive.

**Self-service kiosk failure rate.**

It is likely that individuals attempting to check-in using the SSK are unable to complete the check-in process, for a variety of reasons. A common problem with SSK occurs when the information used to identify the traveler does not match the information on the reservation. One estimate of SSK failure in the context of airlines puts the failure rate at between one in seven and one in nine ("Self-Service Brings a Smile", 2007). These estimates were average and an initial estimate of 12.5% (one in eight) was used for the simulation. Again, since this was only an assumption, sensitivity analysis was performed during the validation stage to examine whether this assumption greatly impacted the results of the simulation (Kelton et al., 2007).

## Model Formulation

The simulation model was developed using an academic version of ARENA (Rockwell Automation Software, version 12.0). ARENA is a windows-based, flowchart-type simulation software. ARENA uses basic building blocks called flowchart modules to define the process to be simulated. Each flowchart module is subsequently converted to SIMAN code (Kelton et al., 2007; Lee & Lambert, 2006).. A graphical representation of the simulation is included in Appendix 4 and a complete SIMAN code is included in Appendix 5. The various components of the simulation are explained along with sample SIMAN code below. There are four main components to the simulation model; these include customer arrivals, customer behavior, processing of customers, and collection of statistics.

**Customer arrivals.**

Each customer is represented in simulation using an entity. A customer arrival to the system is therefore represented by an event, that is, the creation of an entity. Typically, in simulation, when an entity is created, the creation of the next entity is put on the simulation clock. This time is determined by taking a random sample from the arrival distribution, and adding it to the current time. So for instance, if entity 12 is created at time 120, and the random sample of the arrival distribution is 92, the next arrival is scheduled to occur at time 120+92= 212. Fortunately, the simulation analyst does not have to do this manually. Instead, arrivals to the simulation are generated using an ARENA Create module, using the distribution derived above, namely 4 + EXPO(96.9). The first arrival to the system was generated at time 4 + EXPO(96.9).

Entities can be individualized using attributes. For instance, for the purpose of statistics collection, each entity that enters the system was assigned an attribute meant to record the arrival time. This information was then used to compute how long this entity had been waiting in the system. The ARENA Assign module was used to do so.

```
Model statements for module:  BasicProcess.Create 1 (Create Customer ARRIVALS)
36$           CREATE,        1,SecondstoBaseTime(4 +
       EXPO(96.9,32)),Customer:SecondstoBaseTime(4 + EXPO(96.9,31)):NEXT(37$);
37$           ASSIGN:        Create Customer ARRIVALS.NumberOut=Create Customer
       ARRIVALS.NumberOut + 1:NEXT(1$);

Model statements for module:  BasicProcess.Assign 1 (Assign TNOW)
1$            ASSIGN:        SEYes=DISC(0.05, 0, 1.0, 1,33):
                             SSTYes=DISC(0.25, 0, 1.0, 1,34):
                             ArrivalTIME=TNOW:NEXT(2$);
```

### Customer processing.

The advanced ARENA modules Seize, Delay, and Release where used instead of the Process module to model customers (entities) receiving service (being processed). While increasing the complexity of the simulation, this added level of detail has several benefits. Specifically, by using a Seize module, followed by a Delay module, waiting time statistics can be collected for each entity after it seizes the resource. The delay for the resource representing service by the SSK was set to 23 + EXPO(37), while the delay for the resource representing service by the service employee was set to 7 + GAMM(109, 1.29).

```
Model statements for module:  AdvancedProcess.Seize 1 (Seize SST)
32$           QUEUE,         Seize SST.Queue;
              SEIZE,         2,Other:
                             SST,1:NEXT(43$);
43$           DELAY:         0.0,,VA:NEXT(7$);

Model statements for module:  AdvancedProcess.Delay 1 (Delay SST)
34$           DELAY:         23 + EXPO(37,41),,VA:NEXT(35$);

Model statements for module:  AdvancedProcess.Release 1 (Release SST)
35$           RELEASE:       SST,1:NEXT(12$);

Model statements for module:  AdvancedProcess.Seize 3 (Seize Employee)
3$            QUEUE,         Seize Employee.Queue;
              SEIZE,         2,Other:
                             Employee,1:NEXT(54$);

54$           DELAY:         0.0,,VA:NEXT(8$);
Model statements for module:  AdvancedProcess.Delay 2 (Delay Employee)
5$            DELAY:         7 + GAMM(109, 1.29,42),,VA:NEXT(6$);

Model statements for module:  AdvancedProcess.Release 2 (Release Employee)
6$            RELEASE:       Employee,1:NEXT(15$);
```

### Customer behavior.

A Decision module was used to model customers' decision of whether or not to use SST. A distribution function representing the probability that a customer would select the SSK alternative based on the number of individuals waiting in each line was developed. In Equation 1, $x_1$ was the number of individuals waiting for self-service (including the one currently using the self-service kiosk) and $x_2$ was the number of individuals waiting for service by a service employee (including the one currently talking with the service employee). Equation 1 needed to be expanded to accommodate the case where multiple service employees were serving customers and to reflect the fact that the simulation counts the number of individuals waiting for service, excluding the person currently receiving service.

***Development of the distribution function.***

In the new formula specification, $w_{\mathrm{SSK}}$ referred to the number of individuals waiting for self-service (excluding the one currently using the self-service kiosk), $w_{\mathrm{EMP}}$ referred to the number of individuals waiting for service by a service employee (excluding individuals currently receiving service), and *s* referred to the number of service employees. Furthermore, $x_{\mathrm{SSK}}$ was a binary variable where 1 indicated that the SSK was busy, and 0 that the SSK was available. Assuming no delay between customers, when $x_{\mathrm{SSK}} = 0$, $w_{\mathrm{SSK}} = 0$. In other words, the SSK can only be available when no other customers are waiting for it. Similarly, $x_{\mathrm{EMP}}$ represents the number of service employees available and can range from 0 to *s*. When $x_{\mathrm{EMP}} < s$, $w_{\mathrm{EMP}} = 0$. In other words, if one service employee is idle, no customers can be waiting for the service employee. Also, if one service employee is available, the status of the other service employees is irrelevant. Finally, the number of customers waiting for the service employee is divided by the number of servers available. For instance, if a system has an available SSK, three service employees currently busy, and six customers waiting, for the purposes of computing the probability that a customer will select the SSK, $x_{\mathrm{SSK}} = 0$, $w_{\mathrm{SSK}} = 0$, $x_{\mathrm{EMP}} = 3$, $w_{\mathrm{EMP}} = 6$, and $\mathrm{s} = 3$.

Equation 2

$$max(0, x_{EMP} - s + 1) + int\left(\frac{w_{EMP}}{s}\right) = max(0, 3 - 3 + 1) + int\left(\frac{6}{3}\right) = 1 + 2 = 3$$

Using this information, the probability that an individual will select the self-service option is then:

Equation 3

$$P(SS) = \frac{1}{1 + e^{-\left(-1.09445133 - 0.83611324(x_{SSK} + w_{SSK}) + 1.08745863\left[max(0, x_{EMP} - s + 1) + int\left(\frac{w_{EMP}}{s}\right)\right]\right)}}$$

The table below compares the results obtained using Equation 3 to the survey findings.

Table 32 Formula Computations in ARENA

| Scenario | Total SST | Total EMP | Survey | P(SS) | Difference |
|---|---|---|---|---|---|
| Scenario 1 | 0.00 | 0.00 | 18.68% | 25.08% | -6.40% |
| Scenario 2 | 0.00 | 1.00 | 55.42% | 49.83% | 5.60% |
| Scenario 3 | 0.00 | 2.00 | 73.86% | 74.66% | -0.79% |
| Scenario 4 | 0.00 | 3.00 | 76.60% | 89.73% | -13.14% |
| Scenario 5 | 1.00 | 0.00 | 3.80% | 12.67% | -8.87% |
| Scenario 6 | 1.00 | 1.00 | 33.73% | 30.09% | 3.65% |
| Scenario 7 | 1.00 | 2.00 | 68.42% | 56.08% | 12.34% |
| Scenario 8 | 1.00 | 3.00 | 77.11% | 79.11% | -2.01% |
| Scenario 9 | 2.00 | 0.00 | 5.49% | 5.92% | -0.42% |
| Scenario 10 | 2.00 | 1.00 | 9.41% | 15.72% | -6.31% |
| Scenario 11 | 2.00 | 2.00 | 36.27% | 35.62% | 0.65% |
| Scenario 12 | 2.00 | 3.00 | 71.88% | 62.14% | 9.73% |
| Scenario 13 | 3.00 | 0.00 | 4.65% | 2.65% | 2.00% |
| Scenario 14 | 3.00 | 1.00 | 2.02% | 7.48% | -5.46% |
| Scenario 15 | 3.00 | 2.00 | 17.58% | 19.34% | -1.76% |
| Scenario 16 | 3.00 | 3.00 | 30.21% | 41.57% | -11.36% |
| Scenario 21 | 0.00 | 9.00 | 86.67% | 89.73% | -3.07% |
| Scenario 22 | 1.00 | 9.00 | 77.63% | 79.11% | -1.48% |
| Scenario 23 | 2.00 | 9.00 | 82.28% | 62.14% | 20.13% |
| Scenario 24 | 3.00 | 9.00 | 49.44% | 41.57% | 7.87% |

The formula represents the probability that an individual will select the SSK option, in a service delivery process that has both a SSK and a service employee option. The number of service employees can vary.

ARENA provides the option to build the expression used to determine the probability that an entity will choose a certain path in a Decision module. The ARENA expression was

*100/(1+EP(-(-1.09445133-0.83611324*(NR(SST)+NQ(Seize SST.Queue))+1.08745863*(MX(0,NR(Employee)-MR(Employee)+1)+AINT(NQ(Seize Employee.Queue)/MR(Employee))))))*

Where *NR(SST)* is the number of SSK currently in use, *NQ(Seize SST.Queue)* is the number of individuals waiting for the SSK, is the number of service employees currently busy *NR(Employee)*, *MR(Employee)* is the total number of service employees, and *NQ(Seize Employee.Queue)*is the number of individuals waiting for service by the service employee(s). *AINT* is a truncation formula.

```
Model statements for module:  BasicProcess.Decide 1 (Decide)
2$            BRANCH,        1:
                             With,
                             (100/(1+EP(-(-1.09445133-0.83611324*(NR(SST)+NQ(Seize
                              SST.Queue))+1.08745863*(MX(0,NR(Employee)-
                              MR(Employee)+1)+AINT(NQ(Seize
                              Employee.Queue)/MR(Employee)))))))/100,
                             40$,Yes:
                             Else,41$,Yes;
40$           ASSIGN:        Decide.NumberOut True=Decide.NumberOut True +
                              1:NEXT(32$);
41$           ASSIGN:        Decide.NumberOut False=Decide.NumberOut False +
                              1:NEXT(3$);
```

***Jockeying.***

Several adjustments to the model were needed to account for jockeying. First, in the first Assign module, two attributes were assigned to each customer entity. The first attribute, SSKYes, was a binary variable ($0 = no, 1 = yes$) indicating whether the customer would be willing to switch from the service employee to the SSK. The probability was 75% that that value would be yes (1). The second attribute indicated whether the customer would be willing to switch from the SSK to the service employee. The probability that this value would be yes was 95%.

Upon release of a resource (SSK or service employee), a Decision module was used to ascertain whether 1) there were no other entities waiting for the focal resource and 2) whether there were entities waiting for the other resource. For instance, when an entity released the SSK resource, the 2-way by condition expression for the Decision module was *NQ(Seize SST.Queue) == 0 && NQ(Seize Employee.Queue) > 0.* The expression *NQ(Seize SST.Queue) == 0* ensured that there were no other entities waiting to seize the resource. *NQ(Seize Employee.Queue)* >0 was used to ensure that there were entities waiting to be processed by the service employee. If this condition was false, the entity proceeded to the next module. However, if condition was true, the entity triggering the logic was used to complete the jockeying procedure.

Two more modules, the Search module and the Remove module were then used. The Search module allowed one to search a queue to find an entity that possessed a specified attribute value. The Remove module was then used to remove this entity from its original location and re-direct it to its new destination. For example (below), when the entity leaving the SSK triggered the jockeying, a Search module was used to search the service employee waiting line for the first individual that was not averse to using SSK. If such an individual was found, the logic entity next entered the Remove module. As it name indicates the Remove module was used to remove the individual from the service employee waiting line and redirected this individual to the SSK resource.

```
Model statements for module:  BasicProcess.Assign 1 (Assign TNOW)
1$            ASSIGN:        SEYes=DISC(0.05, 0, 1.0, 1,33):
                             SSTYes=DISC(0.25, 0, 1.0, 1,34):
                             ArrivalTIME=TNOW:NEXT(2$);

Model statements for module:  BasicProcess.Decide 3 (Jockeying)
12$           BRANCH,        1:
                             If,NQ(Seize SST.Queue) == 0 && NQ(Seize Employee.Queue) >
                            0,46$,Yes:
                             Else,47$,Yes;
46$           ASSIGN:        Jockeying.NumberOut True=Jockeying.NumberOut True +
                            1:NEXT(13$);

47$           ASSIGN:        Jockeying.NumberOut False=Jockeying.NumberOut False +
                            1:NEXT(11$);

Model statements for module:  AdvancedProcess.Search 1 (Search EmployeeLine)
13$           SEARCH,        Seize Employee.Queue,1,NQ(Seize Employee.Queue):SSTYes ==
                            1;
48$           BRANCH,        1:
                             If,J<>0,49$,Yes:
                             Else,50$,Yes;
49$           DELAY:         0.0,,VA:NEXT(14$);
50$           DELAY:         0.0,,VA:NEXT(11$);

Model statements for module:  AdvancedProcess.Remove 1 (Remove from SE Line)
14$           REMOVE:        J,Seize Employee.Queue,31$:NEXT(11$);
```

***Failure rate.***

A Decision module was used to model the possibility that a customer would not succeed in checking-in using the SSK. The probability of failure was given as 12.5%. It was assumed that a customer experiencing a failure would need to wait for his turn with the service employee, and therefore there was no pre-emption rule.

```
Model statements for module:  BasicProcess.Decide 2 (SSK Failure)
11$           BRANCH,        1:
                             With,(12.5)/100,51$,Yes:
                             Else,52$,Yes;
51$           ASSIGN:        SSK Failure.NumberOut True=SSK Failure.NumberOut True +
                              1:NEXT(24$);
52$           ASSIGN:        SSK Failure.NumberOut False=SSK Failure.NumberOut False +
                              1:NEXT(27$);
```

### Statistics collection.

ARENA collects statistics for each waiting line automatically. In addition to this information, several Decision modules were used in combination with Record modules to collect other statistics of interest about the system. After the Seize module for both the SSK and the service employee resources, a Decision module was used that distinguished between customer-entities that had waiting longer than the desired service level (120 or 180 seconds) and those that had not. A Record module right after counted the number of customer-entities whose wait time was below this standard. Similarly, after the Decision module distinguishing between customer-entities that had experienced SSK failure a Record module was used to track how many SSK failures had occurred. Finally, a third combination (below) was used to record the overall service level.

```
Model statements for module:  BasicProcess.Decide 7 (Decide SLALL)
28$           BRANCH,        1:
                             If,WaitTime<=120,62$,Yes:
                             Else,63$,Yes;
62$           ASSIGN:        Decide SLALL.NumberOut True=Decide SLALL.NumberOut True +
                            1:NEXT(29$);
63$           ASSIGN:        Decide SLALL.NumberOut False=Decide SLALL.NumberOut False
                            + 1:NEXT(0$);

Model statements for module:  BasicProcess.Record 11 (CountSLALL)
29$           COUNT:         CountSLALL,1:NEXT(0$);
```

## Verification

The visual aspect of Arena facilitates model verification and validation. Verification is the process of determining whether the model is correctly constructed (Altiok & Melamed, 2007). This implies answering the question "does my simulation do what I meant it to do?" (Sánchez, 2007). Following modeling best practices, each aspect of the model was built sequentially. First the arrival process was built. Subsequently, the logic for the two resources (service employee and SSK) was built. After the two sequences of Seize, Delay, Release modules were ready, the decision rule described previously was created. To ensure that the decision rule was working correctly, the watch window in ARENA's debug bar was used to view the value of the probability expression during the simulation. The logic for jockeying was introduced subsequently. Animation was used to ensure that, when a resource became available, and a customer-entity was waiting for the other resource, the departing customer-entity triggered the jockeying-logic. The modules required for statistics collection were added last.

Verification also entails checking that the model represents the process in the detail required to fulfill the study objective. In this context it was necessary to check that the model provided sufficient information to determine waiting times for customer-entities as well as service levels. The simulation was replicated 100 times and the results were used to compute average waiting times for customers using the SSK, and customers using the service employee, service levels for customers using the SSK and service levels for customers using the service employee, and average waiting times and service levels for all customers.

**Model Validation**

Once verification of the model has been achieved, model validation can take place. Model validation consists of examining the fit of the model to empirical data (Altiok & Melamed, 2007). In other words, the validation step ensures that the model adequately represents reality. Sánchez (2007) emphasized that a modeler should expect to go through multiple iterations of verification and validation before being satisfied with his or her model. To ensure that the simulation model could represent reality adequately, the data collected was used to fit the distributions to validate a model that did not include an SST alternative. One hundred replications for a 90 minute time-period were conducted and several performance statistics were computed.

First, the number of customer-entities created by the simulation were compared to the number of arrivals observed for a similar time-period. The simulation estimate of 52 was close to the average arrivals across the two time-periods that were observed (51). Also, the maximum waiting line length observed for the process was 5, which corresponded to the maximum waiting line length for the simulation.

The results of the full model were compared to anecdotes presented by the self-service industry. For instance, it has been reported that at certain Hyatt locations, up to 40% of guests choose to use the SSK (Carlin, 2008). In 2005, Hilton reported 20 to 30% of customers at airport hotel and 10 to 15% of customers overall used SSKs to check-in

(Dragoon, 2005). A more recent estimate was 40% (Avery, 2008)[6]. The baseline model yielded a SSK usage rate of 25%.

**Sensitivity analysis.**

Since several of the inputs were based on assumptions, it was important to determine the robustness of the model to the assumptions of jockeying and SSK failure rate. Furthermore, it was necessary to examine what would happen to the model if the P(SS) (the probability distribution representing customer choice between using a SSK and using a service employee) was either over- or under-stated by 10%. The P(SS) would be over-stated if it gave a higher likelihood that a customer would use the SSK than in reality. Conversely, the P(SS) would be under-stated if it consistently gave a customer-entity a lower likelihood to select the SSK than would be the case in reality. This would be more of an issue when the utilization of the system was high.

The model was tested under two different utilization rates, the current level (3 service employees and 1 SSK) and an 85% utilization rate. The 85% rate of utilization is slightly on the higher end of what is typically sought by service managers, and therefore, the model should exhibit robustness at such a utilization rate. When utilization is high, there is a risk that the model will not behave as expected. Conversely, the model is more likely to be insensitive to variability in inputs at low levels of utilization. The service setting corresponding to an 85% utilization rate is one where only one service employee and one SSK are available to assist guests and where the arrival rate is much higher than the 4 + EXPO(96.9), namely 4 + EXPO(46.9).

This resulted in a 3 (current, over, and under estimation of probability function) x 2 (current and high utilization) x 2 (jockeying and no jockeying) x 2 (current and high SSK failure) experiment, requiring the formulation of 24 simulation models. For each model, 100 replications were obtained using ARENA, the results were exported to Excel and subsequently imported to SPSS. Two indicator variables were used to distinguish between high utilization (1) and low utilization; high (1) and low failure rate; and jockeying (1) and no jockeying. A third variable was used to indicate over-estimating (-1) the SSK decision

[6] This report was sponsored by IBM.

and under-estimating the SSK decision (1). Further analysis was conducted in PASW Statistics 18.

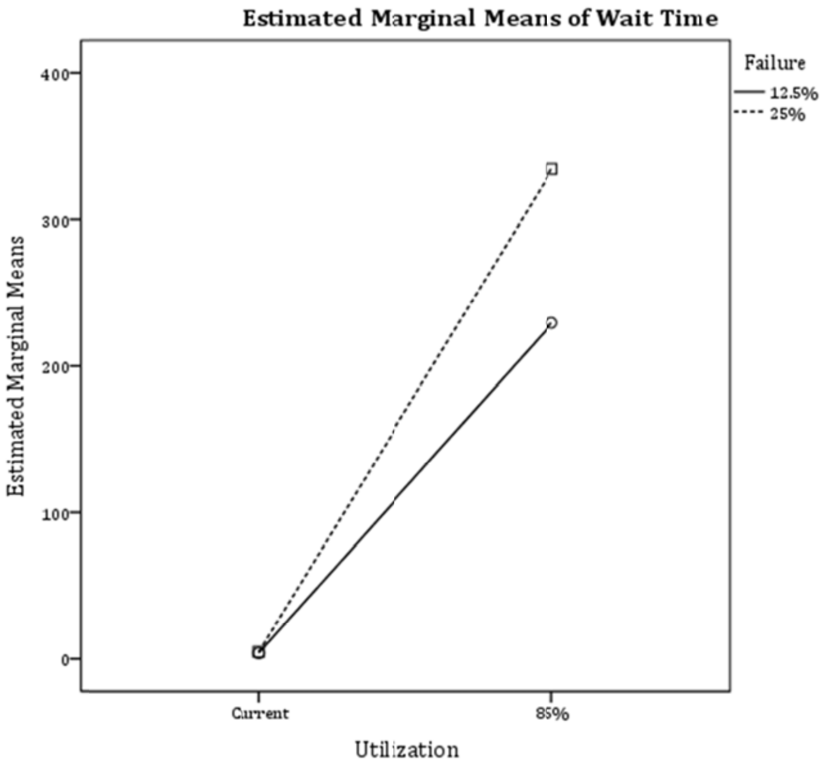
First, the impact of the four factors on the average waiting time was tested using ANOVA. The results of the analysis are shown in Table 33. From Table 33, it appears that there was a significant main effect of error in the P(SS) $F(12.430, 2376) = 12.430$, $p < 0.001$, $\eta^2 = 0.002$, utilization $F(1, 2376) = 4{,}996.33$, $p < 0.001$, $\eta^2 = 0.929$ and of failure rate $F(1, 2376) = 181.052$, $p < 0.001$, $\eta^2 = 0.034$. However, the effect sizes of failure rate and error in the P(SS) were small ($\eta^2 < 0.05$) suggesting that their effect was of no practical significance.

As predicted, the main effects of utilization and failure where qualified by a significant interaction effect $F(1, 2376) = 176.353$, $p < 0.001$, $\eta^2 = 0.033$. An examination of the interaction plot (Figure 8) indicated that at high utilization of this system, a higher failure rate would result in larger waiting time for customers ($M = 334.41, SD = 159.69$) than the current failure rate of 12.5% ($M = 229.44, SD = 109.22$). While this interaction effect is significant, the low value of $\eta^2$ ($\eta^2 = 0.033$) shows that it only explains 3.3% of the variance in waiting time in this model.

Table 33 ANOVA for Waiting Time

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Eta Squared | Observed Power |
|---|---|---|---|---|---|---|---|
| Corrected Model | 49,988,640.253 | 23 | 2,173,419.141 | 234.955 | 0.000 | | 1.000 |
| Intercept | 49,183,309.289 | 1 | 49,183,309.289 | 5,316.904 | 0.000 | | 1.000 |
| Jockeying | 2,408.156 | 1 | 2,408.156 | 0.260 | 0.610 | | 0.080 |
| Utilization | 46,217,910.384 | 1 | 46,217,910.384 | 4,996.333 | 0.000 | 0.929 | 1.000 |
| Failure | 1,674,796.388 | 1 | 1,674,796.388 | 181.052 | 0.000 | 0.034 | 1.000 |
| DM | 229,956.905 | 2 | 114,978.453 | 12.430 | 0.000 | 0.002 | 0.996 |
| Jockeying * Utilization | 1,877.366 | 1 | 1,877.366 | 0.203 | 0.652 | | 0.074 |
| Jockeying * Failure | 237.778 | 1 | 237.778 | 0.026 | 0.873 | | 0.053 |
| Jockeying * DM | 444.374 | 2 | 222.187 | 0.024 | 0.976 | | 0.054 |
| Utilization * Failure | 1,631,328.860 | 1 | 1,631,328.860 | 176.353 | 0.000 | 0.033 | 1.000 |
| Utilization * DM | 224,621.333 | 2 | 112,310.666 | 12.141 | 0.000 | 0.002 | 0.996 |
| Failure * DM | 752.482 | 2 | 376.241 | 0.041 | 0.960 | | 0.056 |
| Jockeying * Utilization * Failure | 310.478 | 1 | 310.478 | 0.034 | 0.855 | | 0.054 |
| Jockeying * Utilization * DM | 691.805 | 2 | 345.903 | 0.037 | 0.963 | | 0.056 |
| Jockeying * Failure * DM | 1,219.347 | 2 | 609.673 | 0.066 | 0.936 | | 0.060 |
| Utilization* Failure * DM | 999.217 | 2 | 499.609 | 0.054 | 0.947 | | 0.058 |
| Jockeying * Utilization * Failure * DM | 1,085.379 | 2 | 542.689 | 0.059 | 0.943 | | 0.059 |
| Error | 21,978,869.178 | 2,376 | 9,250.366 | | | | |
| Total | 121,150,818.719 | 2,400 | | | | | |
| Corrected Total | 71,967,509.431 | 2,399 | | | | | |

Figure 8 Interaction Effect of Failure and Utilization on Waiting Time




Similarly, the main effects of utilization and error in the P(SS) were qualified by a significant interaction effect $F(2{,}2376) = 12.141, p < 0.001, \eta^2 = 0.02$. Specifically, when the utilization of the system was high and the P(SS) was reduced to account for overstatement by 10%, the average waiting was greater ($M = 307.47, SD = 142.17$) than the current P(SS)($M = 278.02, SD = 144.52$). Conversely, when the P(SS) was increased by 10% to account for possible underestimation waiting times further decreased ($M = 260.29, SD = 149.13$). However, similar to the previous discussion, the effect size for the interaction was very small ($\eta^2 = 0.02$). From a practical perspective, a difference of twenty seconds is negligible when there is such a large variance in waiting times.

Figure 9 Interaction Effect of DMPF and Utilization on Waiting Time

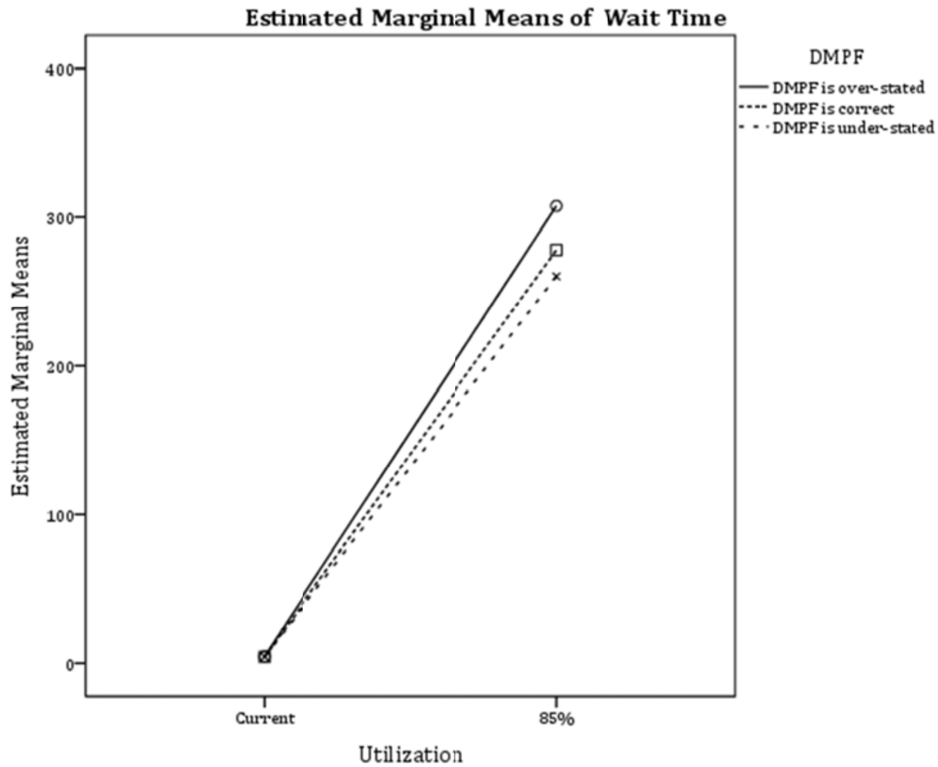


Table 34 ANOVA for Service Level

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Eta Squared | Observed Power |
|---|---|---|---|---|---|---|---|
| Corrected Model | 130.386 | 23 | 5.669 | 503.703 | 0.000 | | 1.000 |
| Intercept | 138.941 | 1 | 138.941 | 12,345.322 | 0.000 | | 1.000 |
| Jockeying | 0.005 | 1 | 0.005 | 0.454 | 0.501 | | 0.103 |
| Utilization | 129.707 | 1 | 129.707 | 11,524.853 | 0.000 | 0.995 | 1.000 |
| Failure | 0.263 | 1 | 0.263 | 23.357 | 0.000 | 0.002 | 0.998 |
| P(SS) | 0.082 | 2 | 0.041 | 3.648 | 0.026 | 0.000 | 0.674 |
| Jockeying * Utilization | 0.003 | 1 | 0.003 | 0.263 | 0.608 | | 0.081 |
| Jockeying * Failure | 0.000 | 1 | 0.000 | 0.000 | 0.984 | | 0.050 |
| Jockeying * P(SS) | 0.001 | 2 | 0.001 | 0.059 | 0.942 | | 0.059 |
| Utilization * Failure | 0.217 | 1 | 0.217 | 19.248 | 0.000 | 0.002 | 0.992 |
| Utilization * P(SS) | 0.055 | 2 | 0.027 | 2.434 | 0.088 | | 0.492 |
| Failure * P(SS) | 0.018 | 2 | 0.009 | 0.785 | 0.456 | | 0.185 |
| Jockeying * Utilization * Failure | 0.000 | 1 | 0.000 | 0.004 | 0.949 | | 0.050 |
| Jockeying * Utilization * P(SS) | 0.001 | 2 | 0.000 | 0.035 | 0.966 | | 0.055 |
| Jockeying * Failure * P(SS) | 0.005 | 2 | 0.002 | 0.211 | 0.810 | | 0.083 |
| Utilization * Failure * P(SS) | 0.025 | 2 | 0.013 | 1.127 | 0.324 | | 0.250 |
| Jockeying * Util. * Failure * P(SS) | 0.004 | 2 | 0.002 | 0.198 | 0.820 | | 0.081 |
| Error | 26.741 | 2376 | 0.011 | | | | |
| Total | 296.067 | 2400 | | | | | |
| Corrected Total | 157.126 | 2399 | | | | | |

The above analysis was repeated with a second performance measure, namely service level. The findings are shown in

Table 34.The results for this second ANOVA support the previous findings that utilization is the most important determinant of waiting time. Specifically, the analysis found significant main effects for error in the P(SS)$F(2{,}2376) = 3.648, p < 0.05, \eta^2 < 0.001$, utilization $F(1{,}2376) = 11{,}524.853, p < 0.001, \eta^2 = 0.995$ and of failure rate $F(1{,}2376) = 23.357, p < 0.001, \eta^2 = 0.002$ as well as significant interaction effects of utilization and failure $F(1{,}2376) = 19.248, p < 0.001, \eta^2 = 0.002$. Similar to the previous analysis, the effect size of the interaction between utilization and failure was very small. The error in P(SS) also explained very little variance in service level ($\eta^2 < 0.001$). Finally, similar to the previous analysis, the very large effect size of utilization ($\eta^2 = 0.995$) shows that this is the most important determinant of waiting time. Therefore, the waiting times and service levels were examined in two more cases, for a utilization of 65% and a utilization of 75%. Since jockeying did not have a significant effect on waiting times, and to facilitate this analysis, jockeying was omitted from this model.

Table 35 Performance Measures under Different Utilizations

| | Current | 40% | 70% | 85% |
|---|---|---|---|---|
| Arrivals | 53.52 | 53.52 | 88.67 | 106.09 |
| Processing of SSK | 90.00 | 90.00 | 90.00 | 90.00 |
| Processing of one SE | 36.58 | 36.58 | 36.58 | 36.58 |
| Number of SE | 3.00 | 1.00 | 1.00 | 1.00 |
| % of Customers using SSK | 25.20% | 48.60% | 60.59% | 64.82% |
| Theoretical Utilization SSK | 14.98% | 28.90% | 59.69% | 76.41% |
| Theoretical Utilization SE | 36.48% | 75.20% | 95.53% | 102.03% |
| Theoretical Utilization | 26.79% | 42.28% | 70.05% | 83.81% |
| Total Customer Capacity | 199.75 | 126.58 | 126.58 | 126.58 |
| Average Waiting Time | 3.25 | 55.82 | 102.45 | 154.01 |
| Upper 95% CI Waiting Time | 3.95 | 60.34 | 109.41 | 166.86 |
| Lower 95% CI Waiting Time | 2.55 | 51.30 | 95.49 | 141.16 |
| Service Level | 96.83% | 82.20% | 70.74% | 58.62% |

As Table 35 illustrates, utilization of the system has a very large effect on the two waiting time performance measures, namely average waiting time and service level. The correlation between utilization and average waiting time is 0.99, while the correlation between utilization and service level is -0.987. Finally, it is important to note that, even under high utilization of this system (85%), the average waiting time remained at 154 seconds (under 3 minutes).

### Summary of model validation.

The purpose of the sensitivity analysis was to determine whether the model assumptions greatly influenced the model results. The findings of the sensitivity analysis suggest that, as should be the case, the main determinant of waiting time and service levels is the utilization of the system. Since the utilization of the system is determined by the number of resources available (SSK and service employees), the processing rate of each of these resources, and the arrival rate to the system, these three factors were included in the main analysis.

The proportion of customers that select to use the SSK is important because of the assumption that check-in using the SSK takes longer than check-in using the service employee. The sensitivity analysis found that, while overstating or understating the probability that customers would select the SSK option could impact the results, the effect was small enough to be discounted, even under high utilization of the system.

The failure rate of SSK was found to be important. A higher failure rate effectively increases the utilization of the system which can result in longer waiting times. The sensitivity analysis found that the effect of the failure rate on average waiting times and service levels was small. However, since this rate is not under control of the decision maker, and could potentially impact the utilization of the system and hence the results of the analysis, it was included in the simulation analysis. Similarly, since the average SSK processing time is not under control of the service provider, this rate was included as a factor in the analysis of the simulation model.

Finally, allowing jockeying in the system did not significantly impact the results of the model. The model including jockeying was retained for further analysis, as it better represented reality.

## Simulation Analysis

Once the limitations of the model with respect to the assumptions were ascertained, several alternative scenarios were developed and simulated. The distinction was made between two types of factors: controllable factors and uncontrollable factors. Controllable factors are factors that are under the decision makers' control such as the number of service employees and the number of SSKs.  Uncontrollable factors are the failure rate of the SSK and the arrival rate to the process. One assumption that had not been included in the sensitivity analysis was also controlled for, the processing time for the SSK. The average processing time for the SSK will greatly depend on the level of experience of the customers, the design, and the option available. For example, an industry white paper quoted a Hyatt executive saying “We have been really careful that we control the amount of time at the kiosks” in order to prevent long lines forming from guests spending too much time using a kiosk (“The Business Traveler’s Best Friend”, 2005).

**Experimental design.**

The purpose of the study was to determine how implementing SST in an existing delivery process impacted waiting times and operating costs. Simulation was used to determine the impact of introducing a SSK as a second service delivery channel to customers checking-in on waiting times and service levels. Decision makers had discretion over the number of service employees and the number of SSK to be implemented. The failure rate of the SSK, the arrival rate of customers and the processing time of the SSK were varied to reflect operational uncertainty.

This resulted in a 2 (number of SSKs) x 3 (number of service employees) x 3 (arrival rate) x 2 (failure rate of SSK) x 3 (processing time of SSK) full-factorial experimental design, yielding 108 simulation models. Jockeying was possible and that the P(SS) was assumed to be a good approximation. For each model, the theoretical utilization rate was computed. That is, the utilization rate of the system, under the specified arrival rate, number of resources, and capacity of the resources. Table 36, Table 37, and Table 38 show the experimental models, along with the theoretical utilization rate. As Table 36shows, several experimental models would result in unsustainable utilization rates. For those models, the demand exceeded the available supply. Furthermore, several models were not relevant. For example, when there is not SSK, failure rate and processing rate of the SSK were not relevant. Therefore, several models were omitted from further study. This left 60 scenarios for further study.

Table 36 Experimental Scenarios (Models 1-18)

| Model | SSK | SE | AR | PR | Failure | Arrivals | Processing | Utilization |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 66.07 | 37 | 12 | 128.44 | 60.97 | 210.66% |
| | 0 | 1 | 66.07 | 37 | 25 | 128.44 | 60.97 | 210.66% |
| | 0 | 1 | 66.07 | 52 | 12 | 128.44 | 60.97 | 210.66% |
| | 0 | 1 | 66.07 | 52 | 25 | 128.44 | 60.97 | 210.66% |
| | 0 | 1 | 66.07 | 70.75 | 12 | 128.44 | 60.97 | 210.66% |
| | 0 | 1 | 66.07 | 70.75 | 25 | 128.44 | 60.97 | 210.66% |
| | 0 | 1 | 80.08 | 37 | 12 | 107.04 | 60.97 | 175.56% |
| | 0 | 1 | 80.08 | 37 | 25 | 107.04 | 60.97 | 175.56% |
| | 0 | 1 | 80.08 | 52 | 12 | 107.04 | 60.97 | 175.56% |
| | 0 | 1 | 80.08 | 52 | 25 | 107.04 | 60.97 | 175.56% |
| | 0 | 1 | 80.08 | 70.75 | 12 | 107.04 | 60.97 | 175.56% |
| | 0 | 1 | 80.08 | 70.75 | 25 | 107.04 | 60.97 | 175.56% |
| | 0 | 1 | 96 | 37 | 12 | 90.00 | 60.97 | 147.61% |
| | 0 | 1 | 96 | 37 | 25 | 90.00 | 60.97 | 147.61% |
| | 0 | 1 | 96 | 52 | 12 | 90.00 | 60.97 | 147.61% |
| | 0 | 1 | 96 | 52 | 25 | 90.00 | 60.97 | 147.61% |
| | 0 | 1 | 96 | 70.75 | 12 | 90.00 | 60.97 | 147.61% |
| | 0 | 1 | 96 | 70.75 | 25 | 90.00 | 60.97 | 147.61% |
| 1 | 0 | 2 | 66.07 | 37 | 12 | 128.44 | 121.94 | 105.33% |
| 2 | 0 | 2 | 66.07 | 37 | 25 | 128.44 | 121.94 | 105.33% |
| 3 | 0 | 2 | 66.07 | 52 | 12 | 128.44 | 121.94 | 105.33% |
| 4 | 0 | 2 | 66.07 | 52 | 25 | 128.44 | 121.94 | 105.33% |
| 5 | 0 | 2 | 66.07 | 70.75 | 12 | 128.44 | 121.94 | 105.33% |
| 6 | 0 | 2 | 66.07 | 70.75 | 25 | 128.44 | 121.94 | 105.33% |
| 7 | 0 | 2 | 80.08 | 37 | 12 | 107.04 | 121.94 | 87.78% |
| 8 | 0 | 2 | 80.08 | 37 | 25 | 107.04 | 121.94 | 87.78% |
| 9 | 0 | 2 | 80.08 | 52 | 12 | 107.04 | 121.94 | 87.78% |
| 10 | 0 | 2 | 80.08 | 52 | 25 | 107.04 | 121.94 | 87.78% |
| 11 | 0 | 2 | 80.08 | 70.75 | 12 | 107.04 | 121.94 | 87.78% |
| 12 | 0 | 2 | 80.08 | 70.75 | 25 | 107.04 | 121.94 | 87.78% |
| 13 | 0 | 2 | 96 | 37 | 12 | 90.00 | 121.94 | 73.81% |
| 14 | 0 | 2 | 96 | 37 | 25 | 90.00 | 121.94 | 73.81% |
| 15 | 0 | 2 | 96 | 52 | 12 | 90.00 | 121.94 | 73.81% |
| 16 | 0 | 2 | 96 | 52 | 25 | 90.00 | 121.94 | 73.81% |
| 17 | 0 | 2 | 96 | 70.75 | 12 | 90.00 | 121.94 | 73.81% |
| 18 | 0 | 2 | 96 | 70.75 | 25 | 90.00 | 121.94 | 73.81% |

Table 37 Experimental Scenarios (Models 19-54)

| Model | SSK | SE | AR | PR | Failure | Arrivals | Processing | Utilization |
|---|---|---|---|---|---|---|---|---|
| 19 | 0 | 3 | 66.07 | 37 | 12 | 128.44 | 182.91 | 70.22% |
| 20 | 0 | 3 | 66.07 | 37 | 25 | 128.44 | 182.91 | 70.22% |
| 21 | 0 | 3 | 66.07 | 52 | 12 | 128.44 | 182.91 | 70.22% |
| 22 | 0 | 3 | 66.07 | 52 | 25 | 128.44 | 182.91 | 70.22% |
| 23 | 0 | 3 | 66.07 | 70.75 | 12 | 128.44 | 182.91 | 70.22% |
| 24 | 0 | 3 | 66.07 | 70.75 | 25 | 128.44 | 182.91 | 70.22% |
| 25 | 0 | 3 | 80.08 | 37 | 12 | 107.04 | 182.91 | 58.52% |
| 26 | 0 | 3 | 80.08 | 37 | 25 | 107.04 | 182.91 | 58.52% |
| 27 | 0 | 3 | 80.08 | 52 | 12 | 107.04 | 182.91 | 58.52% |
| 28 | 0 | 3 | 80.08 | 52 | 25 | 107.04 | 182.91 | 58.52% |
| 29 | 0 | 3 | 80.08 | 70.75 | 12 | 107.04 | 182.91 | 58.52% |
| 30 | 0 | 3 | 80.08 | 70.75 | 25 | 107.04 | 182.91 | 58.52% |
| 31 | 0 | 3 | 96 | 37 | 12 | 90.00 | 182.91 | 49.20% |
| 32 | 0 | 3 | 96 | 37 | 25 | 90.00 | 182.91 | 49.20% |
| 33 | 0 | 3 | 96 | 52 | 12 | 90.00 | 182.91 | 49.20% |
| 34 | 0 | 3 | 96 | 52 | 25 | 90.00 | 182.91 | 49.20% |
| 35 | 0 | 3 | 96 | 70.75 | 12 | 90.00 | 182.91 | 49.20% |
| 36 | 0 | 3 | 96 | 70.75 | 25 | 90.00 | 182.91 | 49.20% |
| 37 | 1 | 1 | 66.07 | 37 | 12 | 128.44 | 210.97 | 60.88% |
| 38 | 1 | 1 | 66.07 | 37 | 25 | 128.44 | 210.97 | 60.88% |
| 39 | 1 | 1 | 66.07 | 52 | 12 | 128.44 | 180.97 | 70.97% |
| 40 | 1 | 1 | 66.07 | 52 | 25 | 128.44 | 180.97 | 70.97% |
| 41 | 1 | 1 | 66.07 | 70.75 | 12 | 128.44 | 156.97 | 81.83% |
| 42 | 1 | 1 | 66.07 | 70.75 | 25 | 128.44 | 156.97 | 81.83% |
| 43 | 1 | 1 | 80.08 | 37 | 12 | 107.04 | 210.97 | 50.74% |
| 44 | 1 | 1 | 80.08 | 37 | 25 | 107.04 | 210.97 | 50.74% |
| 45 | 1 | 1 | 80.08 | 52 | 12 | 107.04 | 180.97 | 59.15% |
| 46 | 1 | 1 | 80.08 | 52 | 25 | 107.04 | 180.97 | 59.15% |
| 47 | 1 | 1 | 80.08 | 70.75 | 12 | 107.04 | 156.97 | 68.19% |
| 48 | 1 | 1 | 80.08 | 70.75 | 25 | 107.04 | 156.97 | 68.19% |
| 49 | 1 | 1 | 96 | 37 | 12 | 90.00 | 210.97 | 42.66% |
| 50 | 1 | 1 | 96 | 37 | 25 | 90.00 | 210.97 | 42.66% |
| 51 | 1 | 1 | 96 | 52 | 12 | 90.00 | 180.97 | 49.73% |
| 52 | 1 | 1 | 96 | 52 | 25 | 90.00 | 180.97 | 49.73% |
| 53 | 1 | 1 | 96 | 70.75 | 12 | 90.00 | 156.97 | 57.34% |
| 54 | 1 | 1 | 96 | 70.75 | 25 | 90.00 | 156.97 | 57.34% |

Table 38 Experimental Scenarios (Models 55-90)

| Model | SSK | SE | AR | PR | Failure | Arrivals | Processing | Utilization |
|---|---|---|---|---|---|---|---|---|
| 55 | 1 | 2 | 66.07 | 37 | 12 | 128.44 | 271.94 | 47.23% |
| 56 | 1 | 2 | 66.07 | 37 | 25 | 128.44 | 271.94 | 47.23% |
| 57 | 1 | 2 | 66.07 | 52 | 12 | 128.44 | 241.94 | 53.09% |
| 58 | 1 | 2 | 66.07 | 52 | 25 | 128.44 | 241.94 | 53.09% |
| 59 | 1 | 2 | 66.07 | 70.75 | 12 | 128.44 | 217.94 | 58.93% |
| 60 | 1 | 2 | 66.07 | 70.75 | 25 | 128.44 | 217.94 | 58.93% |
| 61 | 1 | 2 | 80.08 | 37 | 12 | 107.04 | 271.94 | 39.36% |
| 62 | 1 | 2 | 80.08 | 37 | 25 | 107.04 | 271.94 | 39.36% |
| 63 | 1 | 2 | 80.08 | 52 | 12 | 107.04 | 241.94 | 44.24% |
| 64 | 1 | 2 | 80.08 | 52 | 25 | 107.04 | 241.94 | 44.24% |
| 65 | 1 | 2 | 80.08 | 70.75 | 12 | 107.04 | 217.94 | 49.11% |
| 66 | 1 | 2 | 80.08 | 70.75 | 25 | 107.04 | 217.94 | 49.11% |
| 67 | 1 | 2 | 96 | 37 | 12 | 90.00 | 271.94 | 33.10% |
| 68 | 1 | 2 | 96 | 37 | 25 | 90.00 | 271.94 | 33.10% |
| 69 | 1 | 2 | 96 | 52 | 12 | 90.00 | 241.94 | 37.20% |
| 70 | 1 | 2 | 96 | 52 | 25 | 90.00 | 241.94 | 37.20% |
| 71 | 1 | 2 | 96 | 70.75 | 12 | 90.00 | 217.94 | 41.30% |
| 72 | 1 | 2 | 96 | 70.75 | 25 | 90.00 | 217.94 | 41.30% |
| 73 | 1 | 3 | 66.07 | 37 | 12 | 128.44 | 332.91 | 38.58% |
| 74 | 1 | 3 | 66.07 | 37 | 25 | 128.44 | 332.91 | 38.58% |
| 75 | 1 | 3 | 66.07 | 52 | 12 | 128.44 | 302.91 | 42.40% |
| 76 | 1 | 3 | 66.07 | 52 | 25 | 128.44 | 302.91 | 42.40% |
| 77 | 1 | 3 | 66.07 | 70.75 | 12 | 128.44 | 278.91 | 46.05% |
| 78 | 1 | 3 | 66.07 | 70.75 | 25 | 128.44 | 278.91 | 46.05% |
| 79 | 1 | 3 | 80.08 | 37 | 12 | 107.04 | 332.91 | 32.15% |
| 80 | 1 | 3 | 80.08 | 37 | 25 | 107.04 | 332.91 | 32.15% |
| 81 | 1 | 3 | 80.08 | 52 | 12 | 107.04 | 302.91 | 35.34% |
| 82 | 1 | 3 | 80.08 | 52 | 25 | 107.04 | 302.91 | 35.34% |
| 83 | 1 | 3 | 80.08 | 70.75 | 12 | 107.04 | 278.91 | 38.38% |
| 84 | 1 | 3 | 80.08 | 70.75 | 25 | 107.04 | 278.91 | 38.38% |
| 85 | 1 | 3 | 96 | 37 | 12 | 90.00 | 332.91 | 27.03% |
| 86 | 1 | 3 | 96 | 37 | 25 | 90.00 | 332.91 | 27.03% |
| 87 | 1 | 3 | 96 | 52 | 12 | 90.00 | 302.91 | 29.71% |
| 88 | 1 | 3 | 96 | 52 | 25 | 90.00 | 302.91 | 29.71% |
| 89 | 1 | 3 | 96 | 70.75 | 12 | 90.00 | 278.91 | 32.27% |
| 90 | 1 | 3 | 96 | 70.75 | 25 | 90.00 | 278.91 | 32.27% |

### Procedures

Simulation was used to model the time during which a hotel front desk is at its busiest time for a hotel front desk (Danaher & Mattsson, 1994). This translated in a 9000 second runtime for the simulation (150 x 60). Similarly to the sensitivity analysis, 60 simulation models were created and 100 replications ran for each model. The results were exported to Excel and subsequently to PASW for further analysis. Before proceeding, the model's output was examined. For instance, an arrival rate that follows the distribution 4 + EXPO(66.07,32) should yield, on average, 128.44 arrivals for a 9000 second (150 minute) time period. In model 1, ARENA generated 128.47 arrivals, a deviation of 0.02%. This preliminary analysis confirmed that the simulation models were working correctly. The full results of this preliminary analysis are in Appendix 5.

#### Analysis of variance.

Several performance measures for each model are listed in Appendix 6. These include the average waiting time, the maximum waiting time, the average number waiting in line for the SSK or the SE, the service level, the employee utilization, and the SSK utilization (when applicable). A preliminary examination of this table shows that when the system is working at extremely high utilization (for model 1 the theoretical utilization is greater than 100%), maximum waiting times can be very large. For example, for model 1, the maximum waiting time is 1,482.50 seconds (24.71 minutes), while the average waiting time is 523.06 seconds (8.72 minutes). However, as soon as the theoretical utilization drops below 100%, the range of waiting time estimates becomes smaller. For model 7, the theoretical utilization is 87.78%. For this model, the average waiting time is 238.80 (3.9 minutes) and the maximum waiting time is 818.48 seconds (19 minutes). The average service level for this model is still however very low (48%), while the average number in line is 2.36 individuals with a maximum of 10.54.

Since not all simulation models were representing realistic conditions, it was not possible to generate a full factorial model. Therefore two analyses were conducted. In the first analysis models where there was no SSK were examined. The second analysis examined models where SSK was an option.

***Model 1.***

Model 1 was a 2 (number of service employees) x 3 (arrival rate) experimental design, yielding 6 simulation models. First, the impact of the two factors on the average waiting time was tested using ANOVA. The results of the analysis are shown in Table 39.

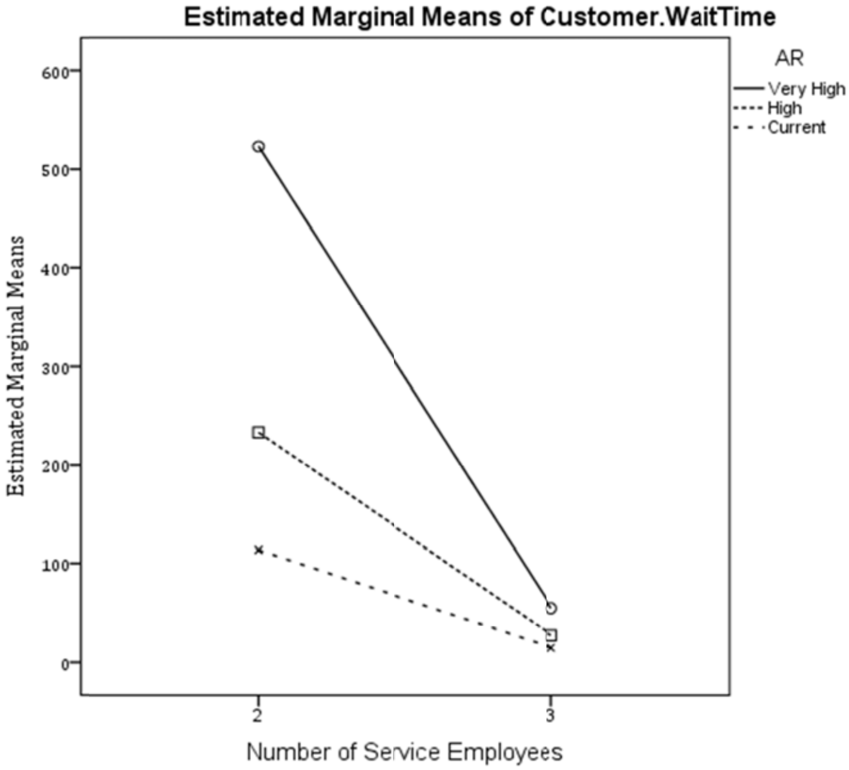
From Table 39, it appears that there was a significant main effect of the number of service employees $F(1{,}594) = 448.485, p < 0.001, \eta^2 = 0.689$, and arrival rate$F(1{,}594) = 120.011, p < 0.001, \eta^2 = 0.184$ as well as a significant interaction effect between these two variables $F(2{,}594) = 81.114, p < 0.001, \eta^2 = 0.125$. This finding was expected as the number of service employees and the arrival rate jointly determine the utilization of the system.

Table 39 ANOVA for Model 1.

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Eta Squared | Observed Power |
|---|---|---|---|---|---|---|---|
| Corrected Model | 18,899,898.69 | 5 | 3,779,979.74 | 170.147 | .000 | | 1.000 |
| Intercept | 15,601,706.48 | 1 | 15,601,706.48 | 702.275 | .000 | | 1.000 |
| AR | 5,332,306.42 | 2 | 2,666,153.21 | 120.011 | .000 | .184 | 1.000 |
| SE | 9,963,525.18 | 1 | 9,963,525.18 | 448.485 | .000 | .689 | 1.000 |
| AR * SE | 3,604,067.10 | 2 | 1,802,033.55 | 81.114 | .000 | .125 | 1.000 |
| Error | 13,196,283.59 | 594 | 22,215.97 | | | .002 | |
| Total | 47,697,888.76 | 600 | | | | | |
| Corrected Total | 32,096,182.28 | 599 | | | | | |

The interaction plot in Figure 10 shows that when there is sufficient capacity (three service employees), the arrival rate does not influence the average waiting time. However, when there is insufficient capacity to meet demand, the arrival rate greatly influences the average waiting time.

Figure 10 Interaction Between Arrival Rate and Number of Service Employees



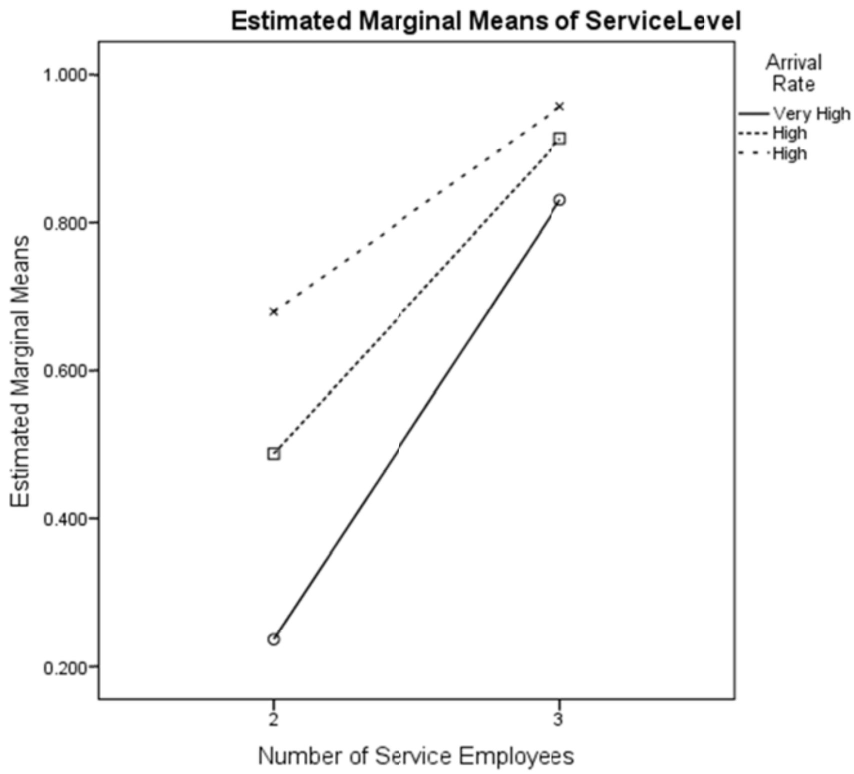

The analysis was repeated with service level as the dependent variable. The results of this ANOVA were similar. From Table 40 the main effect of the number of service employees $F(1{,}594) = 1{,}457.554, p < 0.001, \eta^2 = 839$, the main effect of arrival rate $F(1{,}594) = 213.138, p < 0.001, \eta^2 = 0.123$and the interaction effect between these two variables $F(2{,}594) = 65.039, p < 0.001, \eta^2 = 0.037$ were all statistically significant.

Table 40 ANOVA, No SSK, Service Level

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Eta Squared | Observed Powerb |
|---|---|---|---|---|---|---|---|
| Corrected Model | 38.82 | 5 | 7.76 | 402.782 | .000 | | 1.000 |
| Intercept | 281.04 | 1 | 281.04 | 14,580.615 | .000 | | 1.000 |
| AR | 8.22 | 2 | 4.11 | 213.138 | .000 | .123 | 1.000 |
| SE | 28.09 | 1 | 28.09 | 1,457.554 | .000 | .839 | 1.000 |
| AR * SE | 2.51 | 2 | 1.25 | 65.039 | .000 | .037 | 1.000 |
| Error | 11.45 | 594 | 0.02 | | | .001 | |
| Total | 331.30 | 600 | | | | | |
| Corrected Total | 50.27 | 599 | | | | | |

The interaction plot in Figure 11 showed that, for the model including three service employees, the arrival rate did not greatly influence the service level. However, in the two service employee model, the arrival rate greatly influenced the service level. For an arrival rate that was much higher than the one derived from observation, the service level could drop as low as 23.65%$(M = 0.2365, SD = 0.1630)$ when only two service employees were available to assist customers, and no SSK was available.

Figure 11 Interaction AR and SE for Service Level




***Model 2.***

Model 2 was a 3 (number of service employees) x 3 (arrival rate) x 2 (failure rate of SSK) x 3 (processing time of SSK) full-factorial experimental design, yielding 54 conditions.

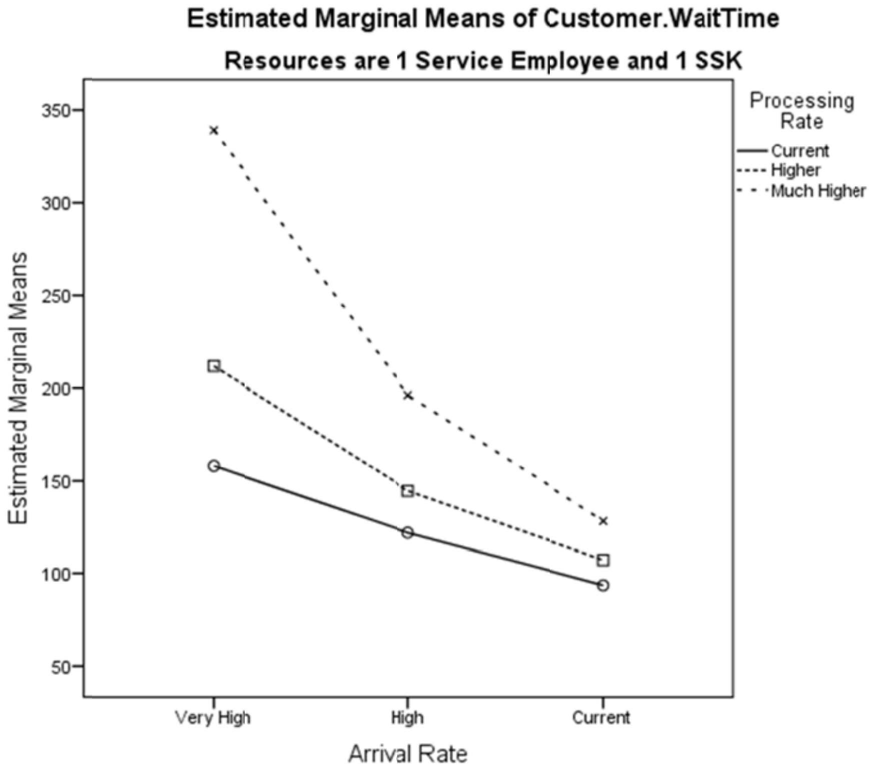
From Table 41, the main effects of the number of service employees $F(2{,}5346) = 4{,}602.389, p < 0.001, \eta^2 = 0.735$, arrival rate $F(2{,}5346) = 535.499, p < 0.001, \eta^2 = 0.086$ processing rate employees $F(2{,}5346) = 239.824, p < 0.001, \eta^2 = 0.038$, and failure rate $F(1{,}5346) = 243.772, p < 0.001, \eta^2 = 0.039$ were all statistically significant. However, these main effects were qualified by several two- and three- way interaction effects. The interactions between service employee and arrival rate, service employee and processing rate, service employee and failure rate, arrival rate and processing rate, and arrival rate and failure rate were all statistically significant, with effect sizes ranging from $\eta^2 = 0.033$ (interaction between arrival rate and failure rate)to $\eta^2 = 0.035$ (interaction between service employee and arrival rate).

Table 41 ANOVA for Model Including SSK Option, DV is Waiting Time

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Eta Squared | Observed Power |
|---|---|---|---|---|---|---|---|
| Corrected Model | 36,335,100.30 | 53 | 685,567.93 | 252.106 | .000 | | 1.000 |
| Intercept | 28,105,464.06 | 1 | 28,105,464.06 | 10,335.327 | .000 | | 1.000 |
| SE | 25,031,093.73 | 2 | 12,515,546.86 | 4,602.389 | .000 | .735 | 1.000 |
| AR | 2,912,425.38 | 2 | 1,456,212.69 | 535.499 | .000 | .086 | 1.000 |
| PR | 1,304,334.29 | 2 | 652,167.14 | 239.824 | .000 | .038 | 1.000 |
| Failure | 662,904.11 | 1 | 662,904.11 | 243.772 | .000 | .039 | 1.000 |
| SE * AR | 2,384,898.38 | 4 | 596,224.60 | 219.252 | .000 | .035 | 1.000 |
| SE * PR | 1,682,720.15 | 4 | 420,680.04 | 154.698 | .000 | .025 | 1.000 |
| SE * Failure | 778,302.65 | 2 | 389,151.33 | 143.104 | .000 | .023 | 1.000 |
| AR * PR | 501,902.04 | 4 | 125,475.51 | 46.142 | .000 | .007 | 1.000 |
| AR * Failure | 98,348.57 | 2 | 49,174.28 | 18.083 | .000 | .003 | 1.000 |
| PR * Failure | 25,597.82 | 2 | 12,798.91 | 4.707 | .009 | .001 | .790 |
| SE * AR * PR | 735,196.06 | 8 | 91,899.51 | 33.795 | .000 | .005 | 1.000 |
| SE * AR * Failure | 114,358.09 | 4 | 28,589.52 | 10.513 | .000 | .002 | 1.000 |
| SE * PR * Failure | 43,449.18 | 4 | 10,862.30 | 3.994 | .003 | .001 | .911 |
| AR * PR * Failure | 19,818.87 | 4 | 4,954.72 | 1.822 | .122 | .000 | .559 |
| SE * AR * PR * Failure | 39,750.97 | 8 | 4,968.87 | 1.827 | .067 | .000 | .786 |
| Error | 14,537,692.91 | 5346 | 2,719.36 | | | .000 | |
| Total | 78,978,257.27 | 5400 | | | | | |
| Corrected Total | 50,872,793.21 | 5399 | | | | | |

Three three-way interactions were statistically significant, however their effect sizes were small. For example, the three-way interaction with the greatest effect sizes was the interaction between the number of service employee, the arrival rate, the failure rate, and the processing rate of the SSK ($\eta^2 = 0.005$). The interaction plot (shown in) shows that the arrival rate greatly impacts the average waiting time when only one service employee is available to assist customers not using the SSK and when the processing time is much higher than anticipated.

Figure 12 Interaction of Processing Rate and Arrival Rate on Waiting Time




Since several of the interaction effect sizes were small, the analysis was limited to interactions with effect sizes greater than 0.01. This included the two-way interactions between the number of service employees and the other three variables. The interaction between number of service employees and arrival rate was statistically significant employees $F(4{,}5346) = 219.251$, $p < 0.001$, with a an effect size larger than 0.01 ($\eta^2 = 0.035$). Similarly, the interactions between number of service employees and processing rate and failure rate were also statistically significant and larger than 0.01. The interaction plots in Figure 13, Figure 15, and Figure 16, show that, the fewer the number of service employees, the more likely a greater arrival rate, a slower SSK processing rate, or a greater failure rate of the SSK was to increase waiting times.

Figure 13 Interaction of Arrival Rate and Service Employees on Waiting Time

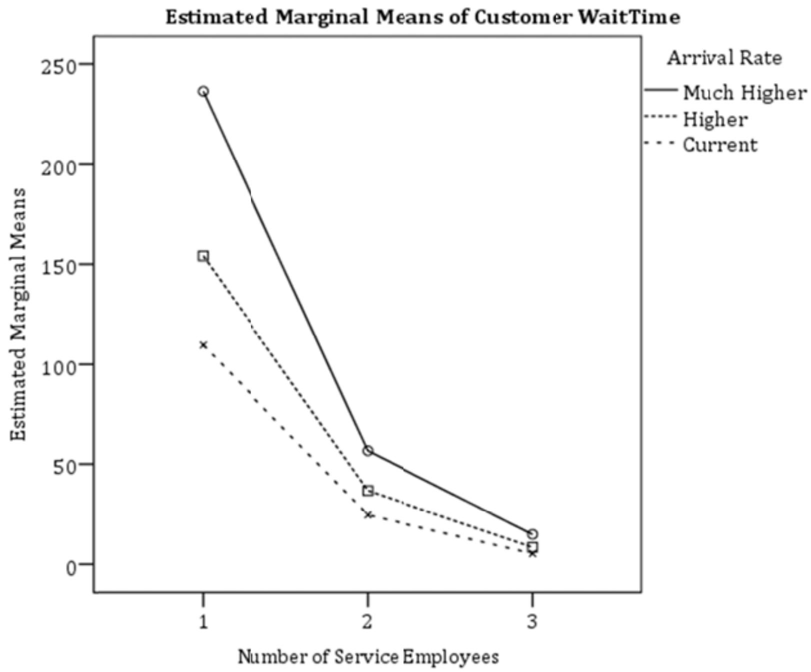



Figure 14 Interaction of Processing Time of SSK and Service Employees on Waiting Time

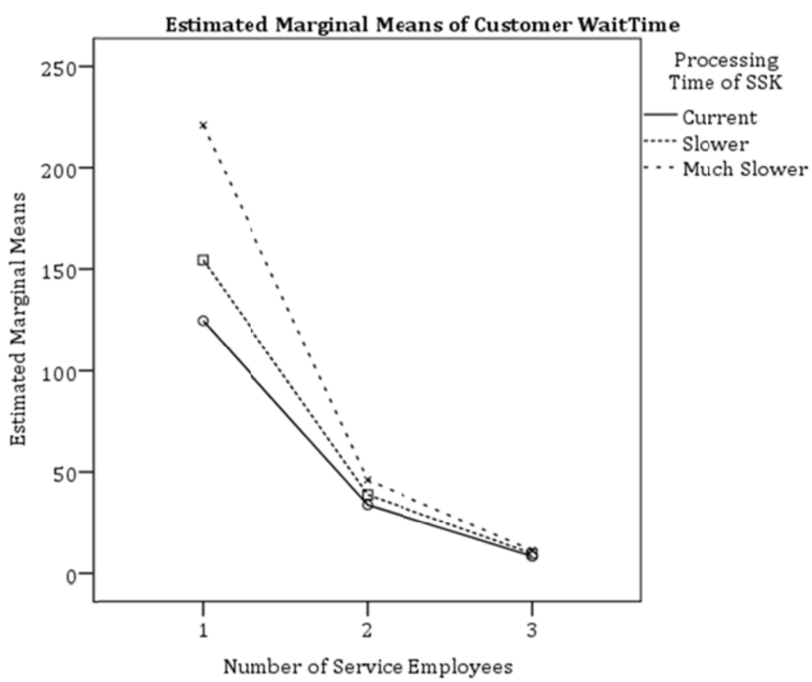
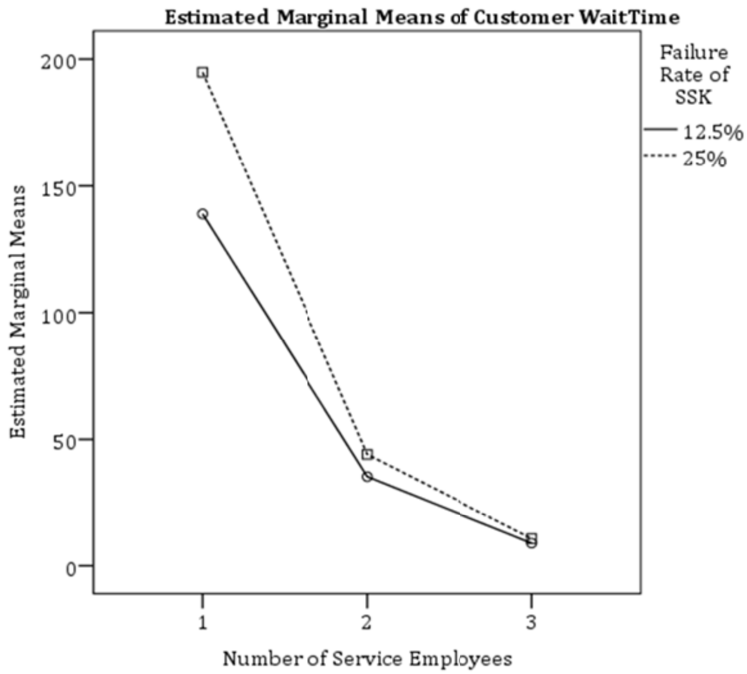


Figure 15 Interaction of SSK Failure Rate and Service Employees on Waiting Time




Repeating the analysis with service level as the dependent variable suggested very similar results. As shown in Table 42, the main effects of the number of service employees $F(2{,}5346) = 10{,}999.384$, $p < 0.001$, $\eta^2 = 0.819$, the arrival rate $F(2{,}5346) = 971.917$, $p < 0.001$, $\eta^2 = 0.072$, the SSK processing rate $F(2{,}5346) = 505.090$, $p < 0.001$, $\eta^2 = 0.038$, and the SSK failure rate $F(1{,}5346) = 307.628$, $p < 0.001$, $\eta^2 = 0.023$ were statistically significant. However, similar to the previous analysis, these main effects were qualified by interactions effects that are simultaneously statistically significant but small in effect size. Based on $\eta^2$ the three largest interaction effects were the two way interaction between the number of service employees and each of the other three variables. Interaction plots for these three interaction are shown in Figure 16, Figure 18, and Figure 19. Again, these interaction plots show that when there are fewer service employees, the more likely a greater arrival rate, a slower SSK processing rate, or a greater failure rate of the SSK was to decrease service levels.

Table 42 ANOVA Results

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Eta Squared | Observed Powerb |
|---|---|---|---|---|---|---|---|
| Corrected Model | 140.26 | 53 | 2.65 | 522.970 | .000 | | 1.000 |
| Intercept | 3,747.41 | 1 | 3,747.41 | 740,567.770 | .000 | | 1.000 |
| SE | 111.32 | 2 | 55.66 | 10,999.384 | .000 | .819 | 1.000 |
| AR | 9.84 | 2 | 4.92 | 971.917 | .000 | .072 | 1.000 |
| PR | 5.11 | 2 | 2.56 | 505.090 | .000 | .038 | 1.000 |
| Failure | 1.56 | 1 | 1.56 | 307.628 | .000 | .023 | 1.000 |
| SE * AR | 4.47 | 4 | 1.12 | 220.926 | .000 | .016 | 1.000 |
| SE * PR | 4.79 | 4 | 1.20 | 236.819 | .000 | .018 | 1.000 |
| SE * Failure | 1.15 | 2 | 0.57 | 113.379 | .000 | .008 | 1.000 |
| AR * PR | 0.94 | 4 | 0.23 | 46.269 | .000 | .003 | 1.000 |
| AR * Failure | 0.08 | 2 | 0.04 | 8.273 | .000 | .001 | .962 |
| PR * Failure | 0.02 | 2 | 0.01 | 1.795 | .166 | .000 | .377 |
| SE * AR * PR | 0.90 | 8 | 0.11 | 22.354 | .000 | .002 | 1.000 |
| SE * AR * Failure | 0.04 | 4 | 0.01 | 1.843 | .118 | .000 | .564 |
| SE * PR * Failure | 0.02 | 4 | 0.00 | 0.958 | .429 | .000 | .307 |
| AR * PR * Failure | 0.01 | 4 | 0.00 | 0.286 | .887 | .000 | .114 |
| SE * AR * PR * Failure | 0.01 | 8 | 0.00 | 0.361 | .941 | .000 | .176 |
| Error | 27.05 | 5346 | 0.01 | | | | |
| Total | 3,914.71 | 5400 | | | | | |
| Corrected Total | 167.31 | 5399 | | | | | |

Figure 16 Interaction of Arrival Rate and Service Employees on Service Level

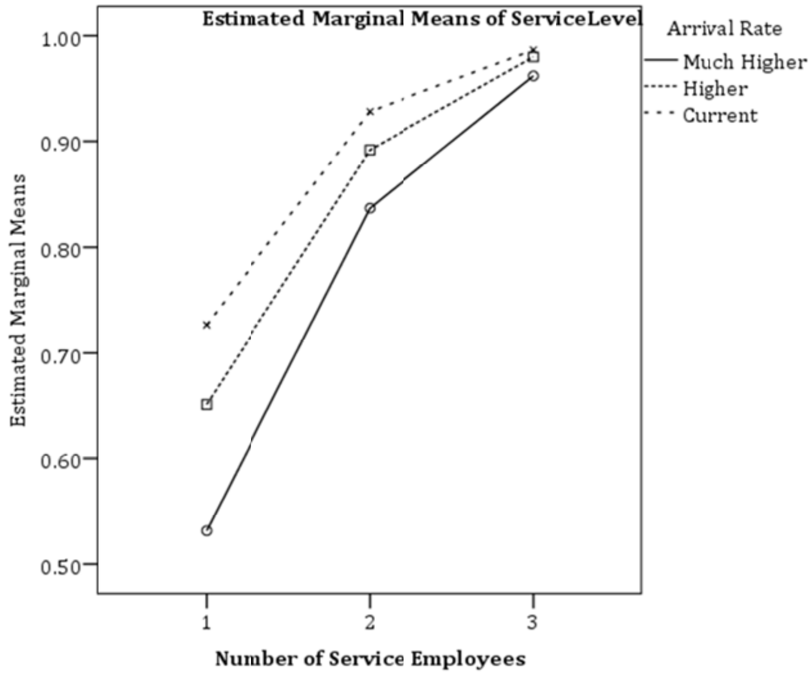



Figure 17 Interaction of Processing Time and Service Employees on Service Level

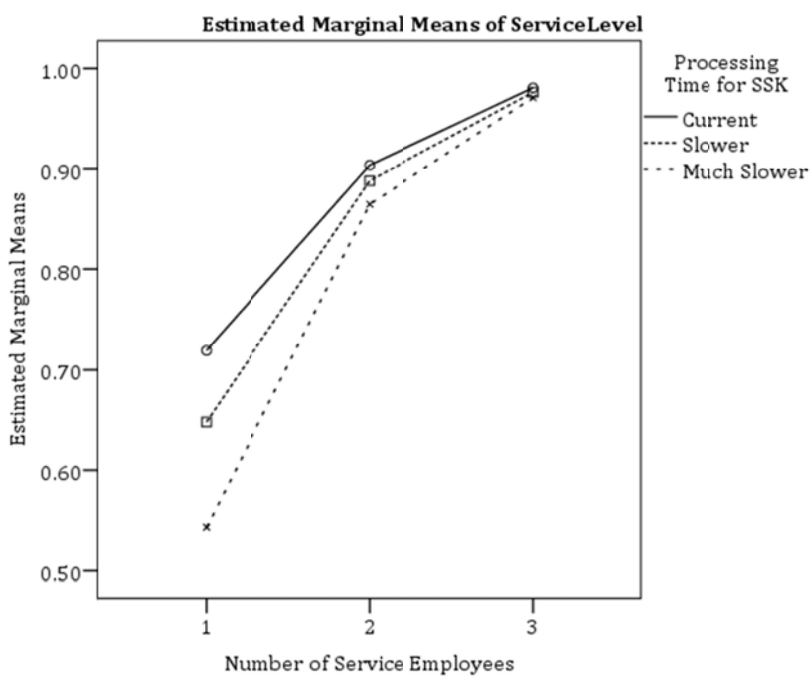


Figure 18 Interaction of Failure Rate and Service Employees on Service Level


**Conclusion of simulation analysis.**

The purpose of the simulation analysis was to examine the factors that impacted average waiting times and service levels. The sensitivity analysis showed that the simulation was sensitive to parameters that affected the utilization of the system. Since utilization could be impacted by the arrival rate of customers to the system, the number of resources (service employee, SSK), the processing time of the SSK, and the failure rate of the SSK, these factors were included in the simulation analysis. The simulation analysis showed that all of these factors had the potential to impact significantly the results of the simulation. However, waiting times and service level were influenced most (as measured by $\eta^2$) by the number of resources available (SSK and service employees). Therefore, in the next section, the focus will be on the impact of these variables on waiting times, service levels and operating costs.

## Spreadsheet Modeling

The previous analysis showed that the waiting times and service levels of the system under study are greatly influenced by the resources available. When insufficient resources are available to meet the demand and the fluctuation in demand, waiting times increase and service levels decrease. This is consistent with queuing theory and not surprising. Consequently, using a model that incorporates only waiting time and service level as performances measures would lead to the increase in resources, either through the purchase of a SSK or employment of more service employees. From this perspective, waiting times and operating costs are somewhat conflicting objectives.

In certain situations, waiting times can be reduced by increasing operating costs. For example, the simulation study showed that average waiting time when employing one service employee and using one SSK was, on average, 78.99 seconds (1.32 minutes) and reduced service level to 74% (model 49). However, under similar experimental conditions (failure rate, arrival rate, processing rate), increasing resources from one service employee to three decreased waiting times to 4.29 seconds with a service level of 95% (model 85).

However, the addition of capacity is costly and reducing waiting times by increasing capacity could potentially reduce profits (Davis & Maggard, 1990). The cost of a SSK can range from USD10,000 to USD 18,000 ("Hotel Chains Hoping Self Serve Kiosks Gain Widespread Acceptance", 2004; Avery, 2008), with maintenance costs ranging from $1,800 to $5,000 (Sojka, 2006). Similarly, the hourly wage for a receptionist can range from $7.48 (10$^{th}$ percentile) to 14.05 (90$^{th}$ percentile)[7]. Therefore, any increase in capacity needs to be carefully weighed against its cost.

Problems with multiple conflicting objectives, where the purpose is to select the best compromise solution are known as multi-criteria decision-making problems (Masud & Ravindran, 2008). A specific subset of these problems, involving finite/discrete alternatives in a deterministic context (Zeleny, 1984) are also known as multi-criteria selection problems (MCSP). MCSPs deal with selecting the best (or preferred) alternative from a finite source of alternatives that are known *a priori*.

**Model.**

Defining a MCSP necessitates defining the alternatives, the attributes, the objectives, the goals, and the evaluation criteria (Masud & Ravindran, 2008).

[7]http://www.bls.gov/oes/current/oes434081.htm

***Alternatives.***

Alternatives are the possible courses of action available to the decision maker. In this particular study, alternatives were defined as all the possible combinations of service employees and SSK. In the simulation analysis two cases were considered: SSK and no SSK. For when no SSK was available, systems with 2 and 3 service employees were examined. For when an SSK was available, systems with 1,2 and 3 service employees were examined. Consequently, there are five alternatives under consideration.

***Attributes and criteria.***

Attributes are performance parameters of the alternatives and can be used to describe the alternatives. In this study, they include the average waiting time, the service level, and operating cost. Average waiting time and service level are negatively correlated and are both proxies for customer satisfaction. Since the information they provide overlaps largely, service level were used.

In this particular study, operating costs consist of the cost of maintaining the SSK and the labor cost. Furthermore, the cost of purchasing the SSK, and the cost training service employees to provide assistance need to be incorporated in this estimate.

***Objectives and goals.***

The objective of the MDCM is the direction of improvement. In this study, operating costs need to decrease and service levels need to increase. It was therefore simpler to reason in terms of operating cost savings, which would entail a maximization objective. Therefore the objectives of the study were to maximize service levels and operating cost savings.

Goals are specific levels of attributes that are desired by decision makers. For example, a decision maker could set an upper limit for operating costs based on a budget. Another goal would be to maintain a service level of above 90%.

***Best solution.***

By definition, a MCSP cannot have a solution that possesses the optimal level for each criterion. This solution is known as the ideal solution (Masud & Ravindran, 2008). Instead, the researcher looks for the best compromise solution.

***Solution.***

There are several ways to solve a MSCP. The choice of which method is most appropriate in a particular context will depend on several considerations. In this particular context, the decision maker was not available, therefore methods such as Borda Count that require decision maker input were not appropriate. However, this problem was a simple bi-criteria problem and could therefore be solved using a graphical approach such as the NorthWest rule.

To that effect, a spreadsheet was developed to 1) compute the cost of each scenario model, to 2) summarize the performance measures obtained through simulation for the model. I compared five models. For each combination of service employee and SSK, the model for which the parameters represented the current model were used. The models that satisfied these conditions were models 13 (no SSK, two service employees), 31 (no SSK, three service employees), 49 (SSK, one service employees), 67 (SSK, two service employees), and 85 (SSK, three service employees).

***Inputs.***

The 75th percentile of hourly wage for hotel, motel, and resort clerks, $11.45[8], adjusted for benefits (25%) was used to estimate labor cost. The 75% was chosen to account for the fact that salaries at full-service high end resorts tend to be higher, on average, then salaries at motels or budget hotels. An 8 hour workday was used for several reasons. First, while only the peak check-in period was modeled using the simulation, many decision makers set their staffing levels by considering their peak demand. Furthermore, due to union constraints, front desk managers are often required to maintain this staffing level throughout the shift (so for all eight hours). Furthermore, while an SSK could enable travelers to perform other services for themselves such as checking out (reducing labor requirements for the morning shift) or printing their boarding passes (reducing labor requirements for the concierge desk), this issue was not addressed in this dissertation. Consequently, only the operating cost savings that could be achieved by adjusting staff levels for the evening shift were estimated, during which most check-in occur, for the

[8]http://www.bls.gov/oes/current/oes434081.htm#ind

majority of hotels. An average of 30.42 shifts per month (365/12) was used. The monthly cost per shift was therefore 3,482.71.

An estimated purchase cost for the SSK of $15,000 was used, at the higher end of the $10,000 to $ 18,000 range ("Hotel Chains Hoping Self Serve Kiosks Gain Widespread Acceptance", 2004; Avery, 2008), under the assumption that a more expensive SSK would also be more reliable and provide a higher quality experience to the guest. Further an additional one-time cost of $5,000 to cover possible changes to the front desk was included. The yearly operating cost was estimated to be $6,000 by using the monthly estimates of maintaining a SSK kiosk in a different industry (Sojka, 2006) and increasing it by 20% to incorporate other costs such as training of employees.  An estimated lifetime of 48 months (4 years) and a discount rate of 15% was used for the SSK.

***Net present value analysis.***

The above inputs were used to calculate the net present value (NPV) of a SSK project. First, the present value of labor costs were computed for the front desk if the current setup remained unchanged. Specifically, the present value of 48 outlays of 10,448.13 at an annual discount rate of 15% were calculated. Using this information, the present value of front desk labor expenses for four years is $375,416.60. This is the number against which all other scenarios will be compared.

The present value of maintenance costs for the SSK over the four years is $17,965.74. By adding to this number the purchase and implementation cost the SSK ($20,000), a total cost for the SSK of $37,965.74 for the four years was found. So for example, if a hotel decides to add a SSK option, without reducing front desk staffing levels, the total cost over the four years would be $413,382.34, $37,965.74 more than the current setup. Conversely, if a hotel decides to reduce the front desk by one service employee, without investing in the SSK, total front desk costs would be $250,277.74, generating savings of $125,1382.87. Five different setups and their associated savings were computed. The findings are summarized in Table 43

Table 43 NPV Analysis

| Models | SE | SSK | Operating Cost Savings | *Percentage* | Payback Periods (months) |
|---|---|---|---|---|---|
| 13 | 2 | 0 | 125,138.87 | *33%* | 3.20 |

| | | | | | |
|---|---|---|---|---|---|
| 31 | 3 | 0 | 0.00 | *0%* | No Payback |
| 49 | 1 | 1 | 212,312.00 | *57%* | 1.60 |
| 67 | 2 | 1 | 87,173.13 | *23%* | 3.20 |
| 85 | 3 | 1 | -37,965.74 | *-10%* | No Payback |

Table 43 shows that by replacing one service employee by one SSK (2 service employees and one SSK, costs could be reduced by $87,173.13. Similarly, replacing two service employees by one SSK could reduce costs by $212,312.00. The payback period for the project, when the number of service employees is reduced, is 3.20 months for a reduction of one service employee and 1.60 months for a reduction of two service employees.

Since the project lifetime and discount rate were assumed, this analysis was repeated with a shorter project duration (3 years instead of 4) and a higher discount rate (20%). The findings of this analysis (shown in Table 44) suggest that, while the cost savings of undertaking the project were smaller, they retained the same magnitude and that therefore, the model was robust to the effects of the assumptions.

Table 44 NPV Analysis With More Conservative Assumptions

| Models | SE | SSK | Operating Cost Savings | *Percentage* | Payback Periods (months) |
|---|---|---|---|---|---|
| 13 | 2 | 0 | 93,712.93 | *33%* | 3.63 |
| 31 | 3 | 0 | 0.00 | *0%* | No Payback |
| 49 | 1 | 1 | 153,971.83 | *55%* | 1.82 |
| 67 | 2 | 1 | 60,258.90 | *21%* | 3.63 |
| 85 | 3 | 1 | -33,454.03 | *-12%* | No Payback |

**Analysis**

As shown in the simulation analysis, the number of service employees had the greatest impact on waiting times and consequently service levels. Furthermore, both demand (arrival rate) and supply factors (processing time at the SSK and failure rate of the SSK) influencing the utilization rates compounded this effect. It was therefore necessary to compare the different setups under each particular situation. The five setups were compared in five different conditions: baseline, high demand, very high demand, slow SSK, very slow SSK with high failure rate, and slow SSK with high demand.

***Baseline.***

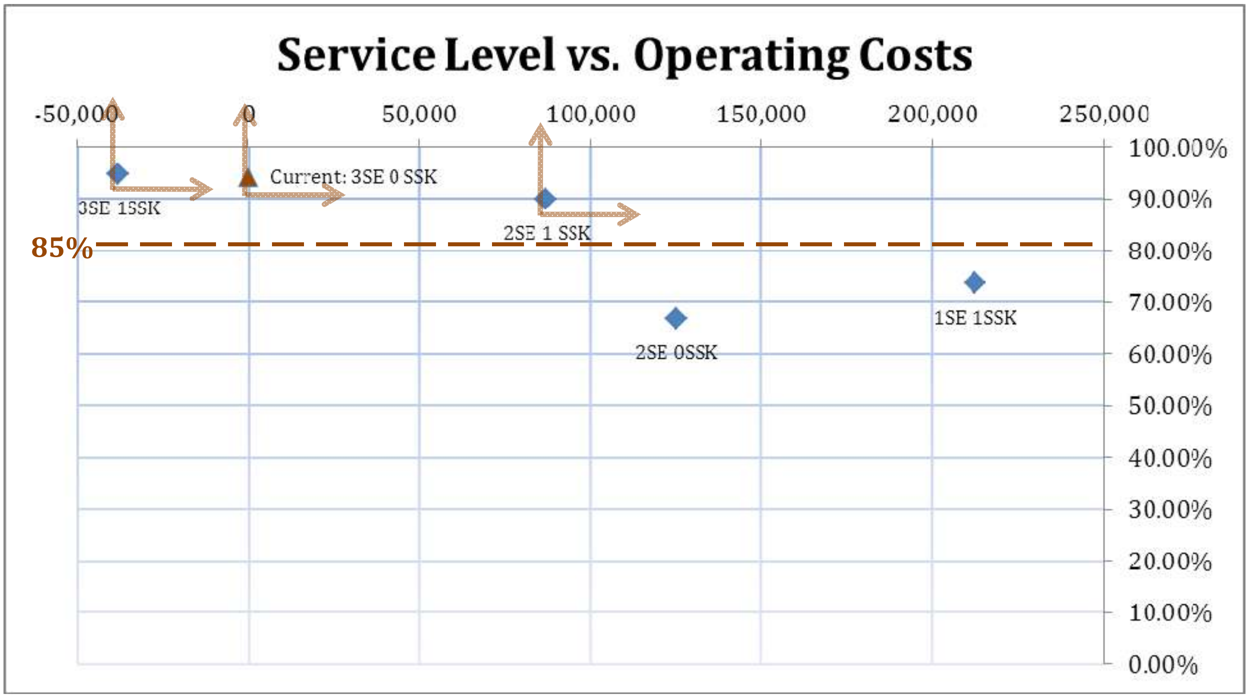
The baseline condition consisted of the observed arrival rate to the system, the processing rate derived from the practitioner literature, and the failure rate derived from the practitioner literature. For each setup, the cost of the setup as calculated in the spreadsheet and the service level as calculated using the simulation were compared. The utilization for each service option and the number of individuals waiting on average were also reported. Finally, a graph comparing service levels and operating costs for each alternative (Figure 19) was generated. On the graph, a line was added to represent the minimum service level desired. For this analysis this level was specified to be 85%, however this will be strongly influenced by the personal preferences of the decision maker.

Table 45 Comparison of Five Setups under Baseline Conditions

| Models | SE | SSK | Operating Cost Savings | Service Level | Utilization SSK | Utilization SE | Number in SSK line | Number in SE line |
|---|---|---|---|---|---|---|---|---|
| 13 | 2 | 0 | 125,138.87 | 66.82% | 0.00% | 70.49% | 0.00 | 1.15 |
| 31 | 3 | 0 | 0.00 | 94.22% | 0.00% | 47.44% | 0.00 | 0.15 |
| 49 | 1 | 1 | 212,312.00 | 73.72% | 30.97% | 75.70% | 0.09 | 0.71 |
| 67 | 2 | 1 | 87,173.13 | 89.94% | 18.68% | 51.38% | 0.02 | 0.18 |
| 85 | 3 | 1 | -37,965.74 | 94.84% | 15.33% | 36.74% | 0.01 | 0.03 |

Table 45 shows that only three setups exceed the minimum desired service level of 85%. These include the current setup (3 SE 0 SSK), the current setup supplemented by the SSK (3 SE 1 SSK), and the current setup with one service employee replaced by the SSK (2 SE 1 SSK). All three of these solutions are non-dominated. For instance, for the current setup (3 SE 0 SSK) there is no solution that improves both service levels and operating costs, hence this is a non-dominated solution. Since all three solutions are non-dominated, it is up to the decision maker to evaluate the trade-offs. If a decision maker is satisfied with an 85% service level (at least 85% of guests wait less than 2 minutes), the setup with two service employees and no SSK may be chosen as it generates the greatest cost savings ($87,173.13 from Table 43). However, another decision maker may think that the additional 4.27% service level may well be worth the $87,173.13 over four years. A third decision maker may even decide that a 94.84% service level (and giving guests an extra choice of service delivery option) may well be worth investing an additional $37,965.74.

Figure 19 Graphical Solution for Baseline Conditions Analysis



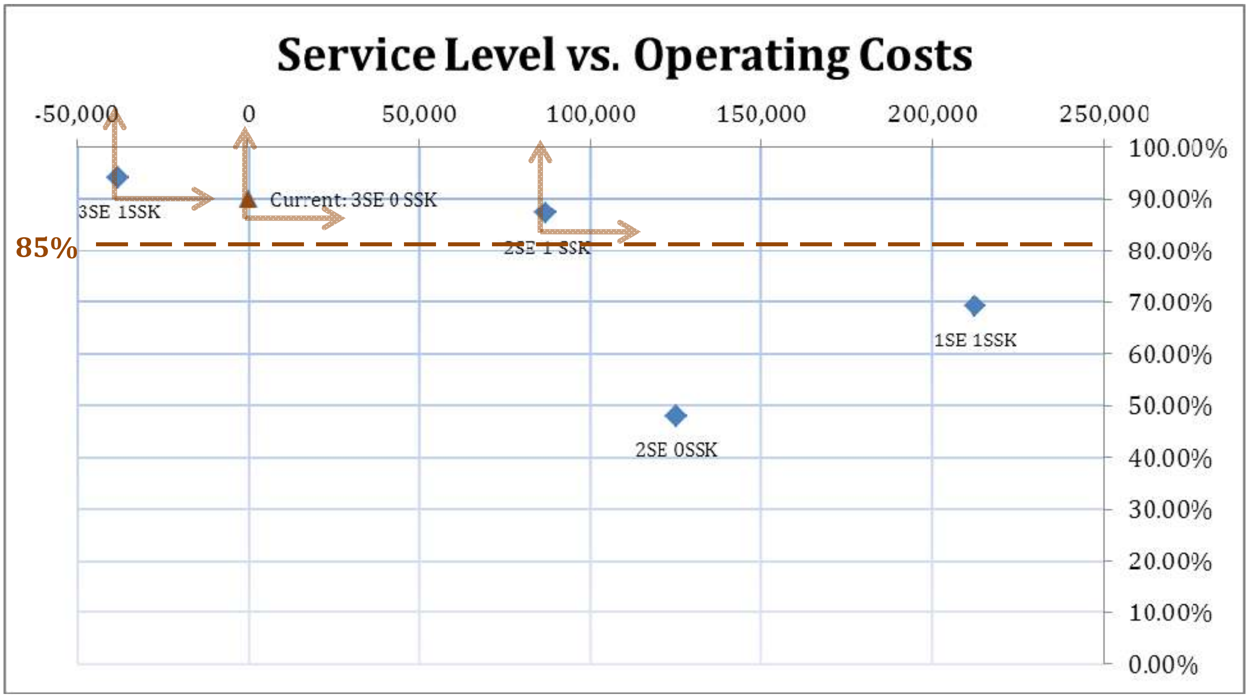

***Demand conditions.***

The above analysis assumes that the demand that was observed was representative of year round demand. However, demand levels may change. As the simulation analysis showed, a higher level of demand will increase the utilization of the system, and increase waiting times. This in turn reduces service levels. However, the service levels for different setups will be impacted differently. The above analysis was repeated under two conditions: a higher demand than observed (18%) and a much higher demand than observed (42%).

Table 46 Comparison of Five Setups Under High Demand (18%)

| Models | SE | SSK | Operating Cost Savings | Service Level | Utilization SSK | Utilization SE | Number in SSK line | Number in SE line |
|---|---|---|---|---|---|---|---|---|
| 7 | 2 | 0 | 125,138.87 | 48.02% | 0.00% | 82.77% | 0.00 | 2.83 |
| 25 | 3 | 0 | 0.00 | 90.05% | 0.00% | 56.81% | 0.00 | 0.33 |
| 43 | 1 | 1 | 212,312.00 | 69.26% | 40.66% | 83.28% | 0.17 | 1.06 |
| 61 | 2 | 1 | 87,173.13 | 87.21% | 24.13% | 59.61% | 0.03 | 0.31 |
| 79 | 3 | 1 | -37,965.74 | 94.12% | 18.85% | 43.50% | 0.02 | 0.07 |

Figure 20 Graphical Solution for High Demand (+18%) analysis

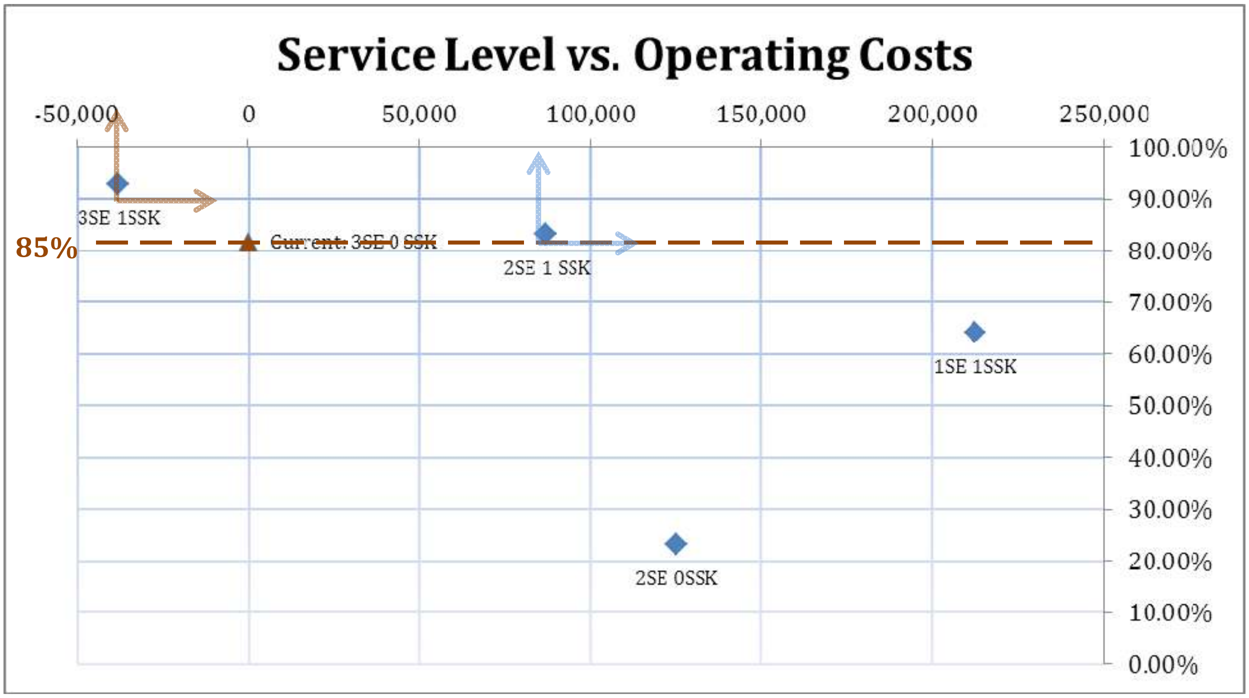



From Figure 20, when demand is 18% higher than observed, the same three solutions (3 SE 1 SSK), (3 SE 0 SSK) and(2 SE 1 SSK) are still non-dominated. The (SE 3 SSK 1) setup maintains a very high service level (94.12% vs. 94.84% for the observed demand. However, the two other setups, (3 SE 0 SSK) and (2 SE 1 SSK) both lose several percentage points for service level (4.17% and 2.74% respectively).

Table 47 Comparison of  Five Setups Under Very High Demand (42%)

| Models | SE | SSK | Operating Cost Savings | Service Level | Utilization SSK | Utilization SE | Number in SSK line | Number in SE line |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 0 | 125,138.87 | 23.26% | 0.00% | 93.07% | 0.00 | 7.77 |
| 19 | 3 | 0 | 0.00 | 81.68% | 0.00% | 68.74% | 0.00 | 0.82 |
| 37 | 1 | 1 | 212,312.00 | 64.23% | 53.80% | 90.08% | 0.37 | 1.56 |
| 55 | 2 | 1 | 87,173.13 | 83.17% | 31.09% | 69.99% | 0.06 | 0.54 |
| 73 | 3 | 1 | -37,965.74 | 92.85% | 23.63% | 52.30% | 0.03 | 0.14 |

Figure 21 Graphical Solution for Very High Demand Condition (+42%)




When demand is 42% higher than expected (Figure 21), only one setup (3 SE 1 SSK) achieves an acceptable service level (92.85%). This option would require incurring an additional $37,965.64 over four years. Even though the other two setups (3 SE 0 SSK) and (2 SE 1 SSK) do not achieve an acceptable service level (respectively 81.68% and 83.17%), it is interesting to note that the setup providing a SSK alternative (2 SE 1 SSK) dominates the current setup (3 SE 0 SSK). As shown in Table 47, the (2 SE 1 SSK) setup provides a higher service level at a lower cost, making it a more attractive option.

The fact that, under very high demand conditions, replacing a service employee with an SSK improves service level is due to the assumption that checking-in using the SSK is faster than checking-in using the service employee. While industry sponsored literature suggests that this is case, without direct observation this is only an assumption. Furthermore, as the simulation analysis showed, service levels are sensitive to the assumptions about processing time of the SSK.

***Supply conditions .***

The check-in time for guests using a SSK was not directly observed during this study. Industry reports estimates range from 30 seconds ("Nextep Systems Debuts Self Check-In/Out Solution", 2009) to 1 to 2 minutes ("Hotel Chains Hoping Self Serve Kiosks

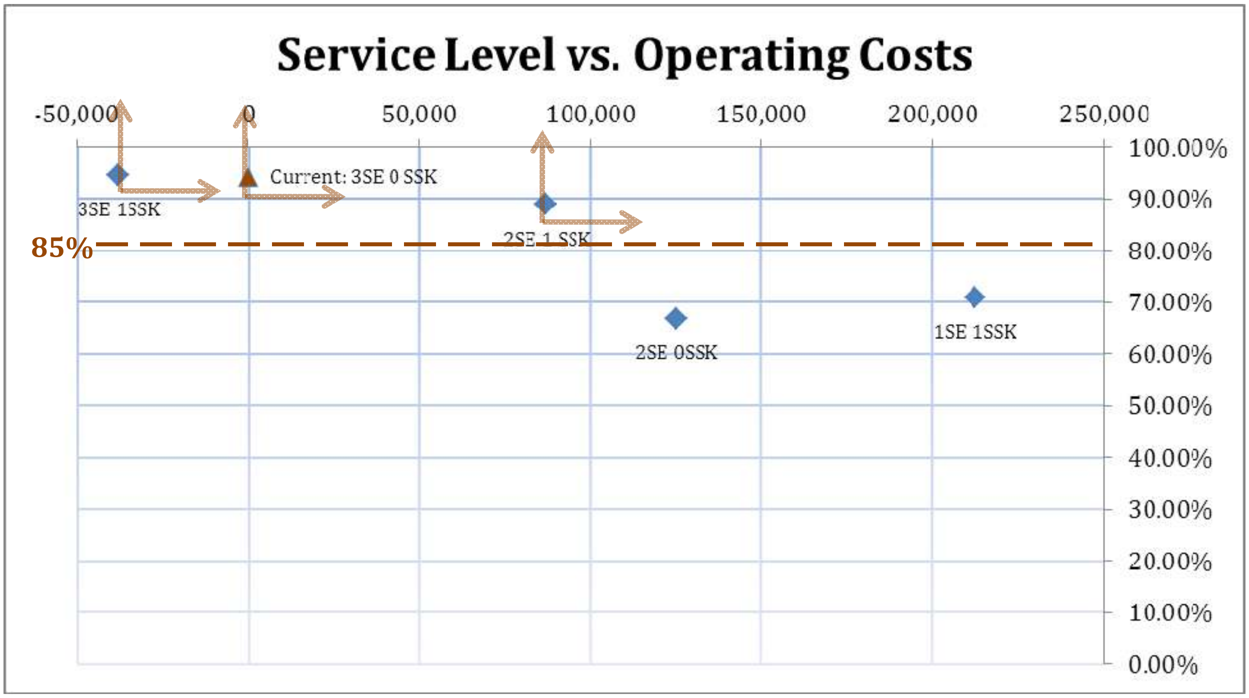
Gain Widespread Acceptance", 2004). The actual SSK processing time will depend on several factors, including customer experience, clarity of presentation, and choices available. Specifically, the more choices a guest has, the longer checking-in using the SSK will take. For instance, the 1 to 2 minute estimate ("Hotel Chains Hoping Self Serve Kiosks Gain Widespread Acceptance", 2004) involved a check-in kiosk where, in addition to confirming a room choice and printing a room key, guests could check their messages, get coupons for food and beverage, and update their frequent traveler accounts. The previous conditions used a mean time of 60 seconds (23 + EXPO(37)) to model the delay that customers checking in using a SSK incurred. While this is in line with industry estimates, there is reason to believe these could be optimistic estimates, and actual processing times may be higher. Since processing times for the SSK significantly impacted service levels, as found in the simulation analysis, it was necessary to re-examine the MCSP under low processing time conditions. Table 48 and Figure 22 show the analysis for when the processing time is 20% longer, while Table 49 and Figure 23 show the analysis for when the processing times are 42% longer and the service rate is double the estimate (25% instead of 12.5%).

From Figure 22, the three non-dominated solutions from the baseline analysis remain non-dominated. Specifically, setups (3 SE 1 SSK), (3 SE 0 SSK) and (2 SE 1 SSK) all retain service levels greater than 85% (respectively 94.49%, 94.22% and 88.92%). Furthermore, all three setups are the most cost-effective setup to satisfy the specified service level, hence they are non-dominated. This suggests that the analysis is robust to a slight variation from the processing time assumption (up to 20%). Similar to the baseline analysis, the selection of the best alternative will greatly depend on the decision maker.

Table 48 Slow SSK (20% Longer Processing Time)

| Models | SE | SSK | Operating Cost Savings | Service Level | Utilization SSK | Utilization SE | Number in SSK line | Number in SE line |
|---|---|---|---|---|---|---|---|---|
| 13 | 2 | 0 | 125,138.87 | 66.82% | 0.00% | 70.49% | 0.00 | 1.15 |
| 31 | 3 | 0 | 0.00 | 94.22% | 0.00% | 47.44% | 0.00 | 0.15 |
| 51 | 1 | 1 | 212,312.00 | 70.88% | 37.66% | 76.66% | 0.15 | 0.77 |
| 69 | 2 | 1 | 87,173.13 | 88.92% | 22.69% | 51.88% | 0.03 | 0.20 |
| 87 | 3 | 1 | -37,965.74 | 94.49% | 18.75% | 37.02% | 0.02 | 0.03 |

Figure 22 Slow SSK (20% Longer Processing Time)

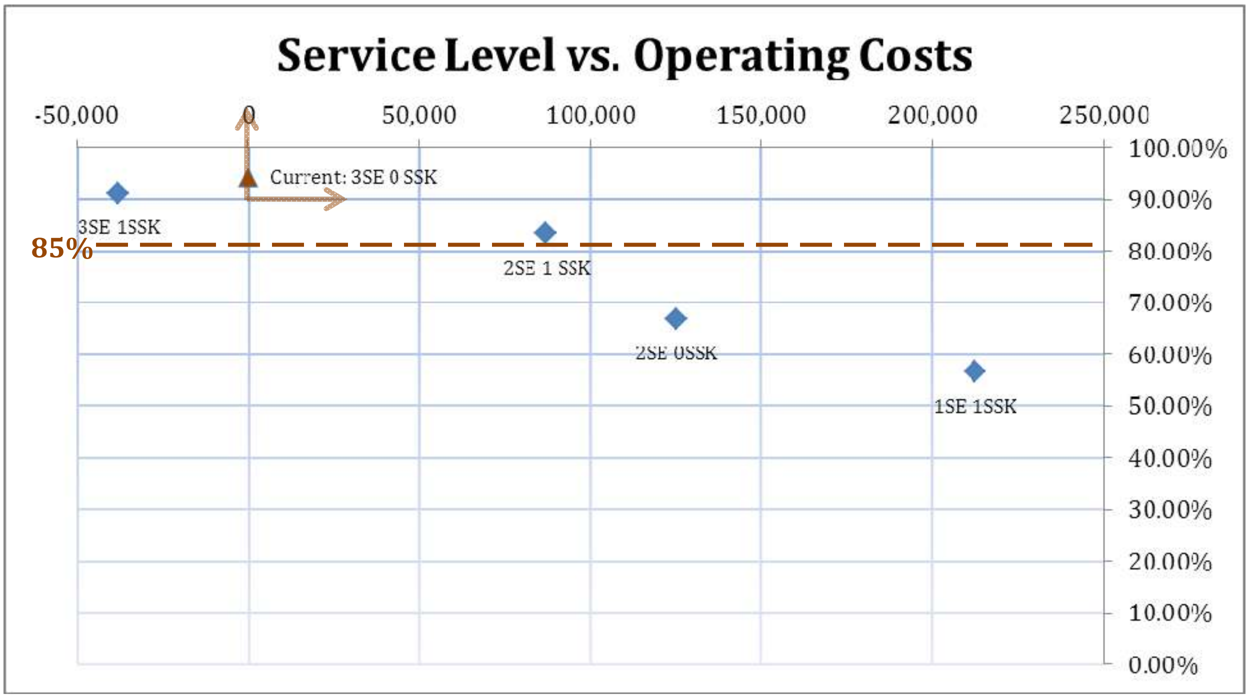



However, it is important to examine what would happen if the assumptions about SSK processing times and failure rates were significantly off. The situation where SSK processing times were 42% slower and the failure rate was much higher than currently reported in the industry literature (25% instead of 12.5%) was therefore examined. Under these conditions, assuming the observed level of demand, only the two setups involving 3 employees remain above the desired 85% service level. As shown in Figure 23, the service level for the (2 SE 1 SSK) is slightly below this level (83.34%) and is therefore no longer an option. Furthermore, from Figure 23 it is also clear that the current setup (3 SE 0 SSK) dominates the (3 SE 1 SSK), suggesting that in this case, adding a resources both decreases service level and increases operating costs. While this seems counter-intuitive, it is due to the fact that, under an increased failure rate, more customers will use the service employee as they fail to complete their transaction using the SSK. Furthermore, this is more likely to occur when the service employees are already busy helping customers, which prompted to select the SSK in the first place. This in turn will increase the demand for the service employee at times where they are already busy.

Table 49 Very Slow SSK (+44%) with Very High Failure Rate (25%)

| Models | SE | SSK | Operating Cost Savings | Service Level | Utilization SSK | Utilization SE | Number in SSK line | Number in SE line |
|---|---|---|---|---|---|---|---|---|
| 13 | 2 | 0 | 125,138.87 | 66.82% | 0.00% | 70.49% | 0.00 | 1.15 |
| 31 | 3 | 0 | 0.00 | 94.22% | 0.00% | 47.44% | 0.00 | 0.15 |
| 54 | 1 | 1 | 212,312.00 | 56.60% | 49.87% | 81.82% | 0.34 | 1.14 |
| 72 | 2 | 1 | 87,173.13 | 83.34% | 28.58% | 54.42% | 0.06 | 0.25 |
| 90 | 3 | 1 | -37,965.74 | 91.20% | 23.06% | 38.59% | 0.03 | 0.05 |

Figure 23 Very Slow SSK (+44%) with Very High Failure Rate (25%)




***Conclusion.***

The use of a MCSP technique to examine the simulation analysis results yielded several interesting observations. First, when considering the trade-offs between service level and waiting time, it is not possible to find a "best solution" as it will greatly depend on the decision maker's subjective preference. Instead, it is possible to determine a set of non-dominated solutions, that is, solutions that provide the best cost savings for a given service level. This reduced set can then be presented to the decision maker.

Second, the baseline analysis, consisting of examining five setups under the conditions observed in an existing hotel and using assumptions derived from industry reports, suggested that three of the five setups should be retained for consideration. These setups consisted of the current setup (3 SE 0 SSK), the current setup augmented by a SSK (3 SE 1 SSK), and a setup where one service employee was replaced by a SSK (2 SE 1 SSK). This solution was found to be robust to small variations in the assumptions (an increase of 18% in demand, or a 20% slower processing time for the SSK). However, when demand was much higher than expected, only a setup that increased the number of resources available to meet this demand was acceptable. If additional expenditures were not an option, a setup with 2 service employees and 1 SSK was found to outperform the current setup both in service level and costs. This result is mostly due to the fact that SSK processing times are assumed to be lower than service employee processing times.

When SSK processing times and failure rates were assumed to be much larger than reported by the industry, the best solution was to maintain the current setup. Replacing a service employee by a SSK would yield a service level lower than the minimum required.

**Limitations of the Simulation Analysis**

While great care was taken to examine the impact that assumptions would have on the simulation results, and to control for these, it was not possible to examine all assumptions. As such, there are several limitations to this analysis that need to be considered. These include the type of hotel that was observed, the cost approximations, and other factors.

**Context.**

The front desk that was observed to formulate this model belonged to a mid-sized hotel (300 rooms). The size of the hotel is likely to impact the arrival rate and the number of resources that should be available. Also, a resort hotel may have different arrival patterns than a conference, casino or airport hotel or resort. For instance, the arrival rates of an airport hotel check-in desk could be tied to flight arrival times, which would require a very different modeling approach (Snowdon et al., 1998). In addition to day seasonality, hotels experience weekly, and yearly seasonality which was not accounted for. Finally, as mentioned previously, only the evening shift was considered. While a SSK may be used by guests to perform services such as checking their messages, order food and beverage, print boarding passes, that would be performed by front desk employees or a hotel concierge, the analysis was based solely on the check-in process.

**Financial analysis.**

The numbers used for the financial analysis of the SSK project were not specific to a particular hotel. Specifically, government data were used for average hourly wages to estimate payroll cost, and mostly industry reports were used to estimate costs for SST. The SST industry is highly competitive, and prices for SST are usually only available through formal requests for proposals. Several of the SST suppliers contacted refused to provide this information. To remedy this, estimates on the higher end of the range provided in industry reports were used. However, it is possible that these reports greatly underestimate the true costs of a SSK.

Similarly, the appropriate discount rate for a particular hospitality organization will depend on the organization itself. Again, the proprietary nature of this information made it difficult to obtain an accurate estimates. However, as the financial analysis show, the cost savings achieved by reducing the evening shift by one individual are so large, that changes in the discount rate have very little effect.

# Chapter 6: Summary, Conclusions, and Implications

The purpose of this dissertation was to develop a model that could estimate whether adding an SST alternative to a service employee alternative in a service delivery process could lead to a reduction in actual waiting times and operating costs. Specifically, a model of a hotel check-in process was developed and used to examine the impact that adding a self-service kiosk (SSK) would have on service levels and costs. This chapter summarizes the study findings, conclusions, and the implications for theory, practice, and future research.

## Summary of Findings

### Customer decision-making.

In order to develop a model that could estimate the impact of adding a SSK alternative to a hotel check-in process, it was necessary to understand the factors that influence customers' decision to use the SST instead of using the service employee. Previous research had identified several customer beliefs about SST that influenced customers' intention to use the SST. Depending on the context, these beliefs have included the perceived usefulness of the SST, its perceived ease of use, its anticipated performance, and the anticipated fun of using the SST (Curran & Meuter, 2007; Dabholkar, 1994; Weijters et al., 2007). However, in addition to these beliefs, customers make decisions based on contextual information. It was hypothesized that customers used the length of the waiting line as a proxy when deciding whether to use the SST.

To test this, a 4 (number of individuals waiting for self-service check-in) x 4 (number of individuals waiting for check-in using the service employee) between-subjects factorial design was used. Logistic regression showed that the waiting line information customers had available greatly influenced their choice of whether or not to use SST.

In addition to waiting line information, eight beliefs about SSST that were previously mentioned in the SST literature were included. Since these beliefs were context specific, and no measurement model for the particular context was found, it was necessary to pre-test the measurement model. The measurement model was pretested using an undergraduate student sample and exploratory factor analysis was used to identify factors and eliminate un-necessary variables. After using confirmatory factor analysis to assess the main study measurement model, summated scales were computed and used in the logistic regression.

Three beliefs were found to influence participants' likelihood to use SST, in the particular context of a hotel check-in. The three beliefs that influenced participants' likelihood to use SST were anticipated usefulness, anticipated quality, and need for interaction. Specifically, anticipated usefulness and anticipated quality had a positive effect on choice, whereas need for interaction decreased the likelihood a participant would select the SST alternative.

In order to determine whether waiting line information could be used to predict the impact that SST would have on service levels of a service process, logistic regression was used to fit a model including only the two waiting line manipulations. This model predicted between 76.5 and 81.7% of participant response correctly. While this hit ratio was lower than the model including the beliefs, it did suggest that it is possible to predict customer choice using waiting time information. This information was subsequently converted in a probability function that could be used to estimate how likely an individual was to use SST based on the length of the waiting lines for each alternative.

#### Service levels and operating costs.

Developing the probability function modeling customer behavior was a necessary step before developing a simulation model that could estimate the impact of implementing SST on service levels and operating costs. The simulation model was developed after observing a hotel check-in desk. This allowed the estimation of arrival rates and processing rates for the current system. This information was used, along with assumptions based on SST industry publications, to create a simulation model of the check-in desk with a SSK alternative. Sensitivity analysis was used to determine whether the model assumptions greatly influenced the model results. Specifically, the effect of over- or under- estimating the distribution function, the utilization of the system, and jockeying were examined. Since the utilization of the system influenced the service levels, the three determinants of utilization were incorporated in the main analysis (the number of resources available (SSK and service employees), the processing rate of the SSK, and the arrival rate to the system). This resulted in 60 simulation models.

First, ANOVA was used to determine which of these factors had the greatest influence on service levels and found the main effect of each factor to be important. In the context of this study, service levels were impacted by the number of resources (service employee, SSK), the processing time of the SSK, and the failure rate of the SSK, with the greatest influence coming from the number of resources.

Findings of the simulation, along with financial calculations were used to estimate which combination of service employees and SST provided the best service levels for the lowest cost. The problem was therefore setup as a dual objective multiple criteria selection problem and a graphical approach was used to solve it. Several model formulations were used to compare five possible front desk setups under different assumptions. Under limited deviations from the assumptions, the analysis generated a consistent set of non-dominated solutions. In this context, non-dominated solutions were front desk setups that provided the best cost savings for a given service level. The costs considered for this analysis included payroll costs, maintenance costs of the SSK, and the costs of purchasing the SSK.

When conditions varied greatly from the assumptions, that is when arrival rates were much larger than the observed arrival rates, or when processing times for the SSK were much slower than reported by industry publications, the set of non-dominated changed. When demand was much larger than observed, the only setup that resulted in a service level greater than 85% was a setup that included three service employees and one SSK, suggesting that the current setup would have been insufficient. Furthermore, a setup involving two service employees and one SSK would have performed better than the current setup. However, this finding relied on the assumption that SSK processing times were much faster than service employee processing times. Conversely, when SSK processing times were much larger than those predicted by the industry literature, SSK was no longer an appealing option.

**Discussion and Contributions to Theory**

Previous research on SST has focused on customer usage of the SST as an outcome of interest. This has been based on the assumption that customer usage is necessary for the success of SST. The present study nuanced this result by showing that customer usage is not sufficient for SST success when the performance measures used to measure success are service levels and operating costs, and showed that demand and supply factors can also influence success. The study also extended the SST literature by examining the influence of context on customer intention to use SST and by adapting the measurement scales used to measure beliefs about SST to a hotel check-in context. Methodological contributions included the use of binary variable to measure customer intention, the use of logistic regression and the use of simulation.

**Service level and operating cost.**

Prior research on SST focused on customer usage of SST as a dependent variable (Curran et al., 2003; Curran & Meuter. 2005; Curran & Meuter, 2007; Dabholkar, 1994; Weijters et al., 2007). This stems from the early days of the Technology Acceptance Model, when technology was new and slow to be adopted in the workplace (Davis, 1989; Davis et al., 1989). Therefore, the assumption was that, for the technology to be successful, it had to be used and efforts were focused on increasing usage of the SST. However, the relationship between increased use and performance is unclear. Furthermore,  usage lacks practical use as a dependent variable (Burton-Jones & Straub, 2006; Goodhue, 2007).

The present study used two performance measures, service level and operating cost, to evaluate the impact of SST. Service level (a measure of whether customers were served in a timely fashion) and operating cost are two somewhat contradictory objectives that service managers strive to balance (Mehrotra & Fama, 2003). Considering these two objectives simultaneously is therefore more realistic than only focusing on customer usage. The present study showed, using simulation, that customer usage is a necessary, but not sufficient condition for the success of SST when success is measured as an increase in service levels and reduction in operating costs. Specifically, in this study, customer usage of SST was investigated as an antecedent of success of the SST. Using a survey, the probability that customers would choose to use a SSK to check-in when a service employee was available was determined. This information was then used to estimate the impact of implementing a SSK, either to supplement or replace service employees, on service levels and operating costs. Findings showed that the success of SST implementation depended on demand factors other than customer usage, and on supply factors such as the SST.

**Supply and demand factors.,**

In this context, the success of SST was jointly determined by demand factors (arrival rates) and supply factors (processing rate of the SSK and failure rate of the SSK). Previous research has shown that customers' beliefs about the SST impact their likelihood to use the SST, and that consequently the design of the SST will greatly influence its success (Curran & Meuter, 2007; Dabholkar, 1994; Weijters et al., 2007). Specifically, perceived ease of use of the SST was found to influence customer intention to use it (Dabholkar, 1996; Weijters et al., 2007). This study augments this by arguing that two additional necessary conditions for the success of the SST, in the particular setting studied, are the reliability of the SST (with low failure rates) and the speed at which a guest can check-in using the SST. Taken together, these findings suggest that, not only will the SST design influence how many customers will use it, but also whether higher customer usage will translate in improved service levels. These findings are nevertheless specific to the managerial objectives of waiting time reduction and operating cost reduction (Bitner et al., 2002). For example, another managerial objective for implementing SST is customization (Berry, 1999; Curran et al., 2003). However, customization in a hotel self-service check-in process may increase the processing time for check-in using the SSK, risking a decrease in service levels. One study finding was that the processing time and failure rate of the SSK greatly influence service levels. Specifically, a much longer processing time could result in lower service levels, even if capacity is increased.

An important contribution of this research was to show that SST can, under certain circumstances, provide greater capacity and/or handle demand fluctuations at a lower cost (Curran et al., 2003; Weijters et al., 2007). This is an important objective of firms seeking to implement SST in their service delivery processes (Dabholkar, 1996). By shifting responsibility for certain production activities to customers, firms can improve productivity (Lovelock & Young, 1979; Mills, Chase & Margulies, 1983; Mills & Morris, 1986). Involving customers in the production process allows firms to handle demand fluctuations without the high cost of adjusting employee levels.

**Intention to use SST in a hotel check-in situation.**

Customers' intentions to use SST have been examined in a variety of contexts, including fast food restaurants (Dabholkar, 1994; 1996), online and ATM banking (Curran & Meuter, 2005), supermarket shopping (Weijters et al., 2007), and transportation (Reinders et al., 2009). However, until recently (Oh & Jeong, 2009), the intention to use SST to check-in into a luxury resort had not been examined. This context is somewhat different from other SST research contexts. First, hotel check-in implies a somewhat captive audience. Customers checking-in to a resort typically hold reservations subject to a non-show penalty clause and therefore have to incur the burdens of waiting. Even when waiting lines are long, they will be reluctant to not enter the waiting line (Lambert & Cullen, 1987). Second, these customers are more likely to have hedonic objectives than customers examined in different settings such as supermarket purchases. Therefore, the context of hotel check-in was an interesting context in which to examine customers' intention to use SST and the role that customer beliefs about SST played, as it could provide new information on why customers decide to use SST.

Customer beliefs about SST are very context specific. During the course of this study, a measurement model was developed to measure customer beliefs about SST in the context of hotel check-in that could be used in subsequent research. One interesting observation was, that not only was the measurement model context specific, it was also study specific. Since the study was administered using an online survey, certain variables exhibited very little variation and contributed little to the research model. When examining customer beliefs about SST in the context of check-in in a high end resort, three beliefs were found to be important. These included anticipated usefulness, anticipated quality, and need for interaction. Anticipated usefulness is a belief that has been found to be important across contexts. Need for interaction and anticipated quality have received mixed support, suggesting that there may be a contextual component to their importance.

Another important contribution of this study was that individuals are willing to use SST to perform their own services even in service contexts where personal service is considered part of the service experience. Until now, researchers had mostly examined service contexts such as supermarkets (Weijters et al., 2007, online prescription refills (Meuter et al., 2005), online and ATM banking (Curran & Meuter, 2005; 2007), railway transportation (Reinders et al., 2008), and online trading (van Beuningen et al., 2010) where customers had mostly utilitarian goals. However, the present study showed that, even in a luxury resort, where most guests' purposes can be assumed to be at least somewhat hedonic, individuals were willing to use SSK, even when doing so would not save them time.

The present study also found that, without a doubt, customers' decision to use SSK is greatly influenced by whether they anticipate waiting a long time to receive service. Specifically, using logistic regression, the study found that it was possible to predict customer choice based on the relative waiting line lengths for using each alternative. While the importance of waiting line information had been touched upon by other researchers, this was the first study that manipulated waiting line length so extensively. Previous research has mostly used adjectives such as "longer" to describe the relative waiting line length to participants (Dabholkar, 1996; Oh & Jeong, 2009) . Instead, this study described the waiting lines in term of absolute numbers and represented the setting schematically.

The study did not find previous experience with SST to predict future usage. Previous research has suggested that, as customer experience with SST increases, so does the likelihood that the customer will use SST for subsequent transactions, (Gardner et al., 1993). Bobbitt and Dabholkar (2001) further hypothesized that the quality of these previous experiences may be relevant to whether customers will use the SST again. Neither hypothesis was found to be true in the context of this study. Specifically, including information about prior participant successful usage of the SST did not improve the predictive ability of the model. There are several possible explanations for this. First, prior experience with SST and prior successful experience may not have been appropriately operationalized. For example, it may be that the levels of prior experience were poorly defined. Second, a cross-sectional study may be insufficient in distinguishing between levels of usage and a longitudinal study design may be more appropriate. .

**Methodological contributions.**

***Binary dependent variable and logistic regression.***

A review of the literature did not find any study to have used a binary variable to measure participants' intention to use the SSK. While the use of a binary variable may lead to the loss of nuance (is a person more or less likely to use the SST), it makes the findings of the research more actionable. In other words, when the answer to the question "how likely are you to use the SST" is measure on a scale from 1 (very unlikely) to 7 (very likely), (Dabholkar, 1994, 1996; Meuter et al., 2005), it is not possible to predict whether the respondent will or will not use the SST. If a respondent answers 5, does that mean that given the choice, he or she would use the SST? Or should the cut-off be 3.5? By using a binary variable, this subjectivity is removed. A consequence of using a binary dependent variable, is that analysis requires the use of logistic regression (Hair et al., 2006), a technique seldom used in the context of SST research, where the majority of research uses structural equation models (Dabholkar, 1996; Curran & Meuter, 2005; Weijters et al., 2007) or regression (Oh & Jeong, 2009). Consequently, it was not feasible to compare the results of this analysis directly to previous research findings.

***Simulation.***

Simulation is a management science technique occasionally used in the context of hospitality research (Feinstein & Parks, 2002; Thompson & Verma 2003). One difficulty in using simulation to conduct hospitality research is that hospitality research oftentimes deals with customers, and customer behavior is difficult to model (Sterman, 1987). Furthermore, the assumptions made in the context of simulation can be simplistic, and not express the nuances of reality. This can generate heated discussions about the merit of a simulation's assumptions, and consequently the merit of its results (Law, 2007). However, through the present, several approaches to data collection were using (observation, survey, industry reports), showing that it was possible to formulate a simulation model with realistic assumptions. Furthermore, as long as the influence of the assumptions on the results of the simulation was controlled for, the results, and not the assumptions should be the focus of the analysis.

## Contributions to Practice

Decision makers considering SST implementation have increasingly been asked to anticipate whether the objectives of SST implementation could be achieved *a priori*. This is especially relevant to decision maker who are faced with high initial investments (Bitner et al., 2000; Weijters et al., 2007). The present study showed that it is possible to create a model to estimate the impact of SSK implementation on an existing service delivery process *a priori* using simulation. Simulation was used to examine how implementing a SSK in an existing hotel check-in desk would impact the process's operating costs and service levels. In the process, information was gathered about the current check-in process, the customer requirements for the process, and the SSK alternative that could be implemented. This analysis showed that there is no straightforward answer to the question "will implementing SST reduce operating costs and improve service levels?" To the contrary, the analysis showed that, while SSK seems to be attractive option as it could reduce operating costs while maintaining satisfactory service levels, the exact answer will depend on the context, on the decision maker, and on the technology. Therefore, decision makers need to consider their options carefully when deciding whether to invest in SST. The present study showed that it is possible to gather information to reduce the uncertainty of the decision, enabling decision makers to make better decisions.

The present study showed that it is possible to estimate the impact of implementing SSK on waiting times and operating costs, prior to implementing an SSK alternative, opening the way for improved decision-making for hospitality operators. Furthermore, the study showed that under certain assumptions, the implementation of SSK will always belong to the set of non-dominated solutions. However, the process used to achieve this conclusion may not seem to be accessible to all hospitality decision makers, since it requires specific skills, such as simulation. The lack of these skills should not be an impediment to the use of data-driven approaches to decision-making. It is possible to simplify this process and create a black-box application where decision makers would only need to be able to use an Excel spreadsheet.

The results of the study also point to recommendations as to characteristics of the SST that should be considered. From the analysis, it appears that the purchase cost of SST is a fraction of the cost savings that could be realized. However, the success of the SST in improving, or at least maintaining service levels depends on the time it takes a customer to complete the transaction and on the failure rate of the SST. The study showed that, in the context of hotel check-in, a SSK can only help maintain or reduce service levels if the time to check-in remains short. This is especially important when the SST has a high failure rate (in this context a high failure rate was 25%). However, this finding is specific to the stated objectives, which in this study were expressed in terms of service levels and operating costs (Bitner et al., 2002). Other objectives for SST implementation include giving customers greater flexibility and autonomy (for instance to print boarding passes, food and beverage vouchers, look up weather information). However, great care should be taken to design the SST to fit the process, in order to ensure that the objectives of the implementation will be fulfilled.

**Implications for Future Research**

This dissertation examined whether, in contexts where waiting in the physical facility was involved, customers made decisions (for example to use SSK) based on the information they had available, such as the number of individuals waiting ahead of them. The study demonstrated that customers did indeed make decisions based on the number of customers waiting ahead of them. However, in real life settings, participants may observe the speed at which the waiting line is moving, update their expected waiting time, and make decisions accordingly. Consequently, future research should examine the role of processing times as a supplement to waiting line information on customers' decision of whether or not to use SST.

A second limitation of the study was that it examined a single configuration of waiting line (one service employee, one SSK).While this is consistent with how previous studies presented the choice between using a service employee or using SSK (Dabholkar, 1994; 1996) Oh & Jeong, 2009), this may not be realistic. Further research should further examine this assumption.

Like others, the present study used an online data collection method (surveymonkey.com). This method has several advantages with respect to cost and speed of data collection. However, it seems plausible that individuals able and willing to use the internet may be different from participants that either are not willing or able to do so. Further research should investigate whether findings derived through online studies regarding customer use of SST can be generalized.

The study focused on operating costs and waiting times as important performance measures, mirroring the oftentimes cited managerial objectives for implementing SST. However, SST can be used to fulfill other objectives, such as increasing customization

(Berry, 1999; Curran et al., 2003), reducing the heterogeneity of service encounters due to server moods (Weijters et al., 2007), and providing customers more choice with respect to service delivery alternatives. Further research should therefore investigate performance measures better suited to these different objectives.

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## Appendix A: Pilot Study Instruments

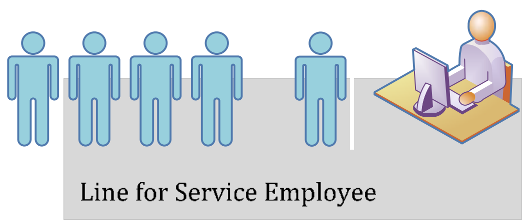
Three alternative presentations were developed for the pilot study. The first format is shown completely on the next page (including questions). The alternate formats are shown thereafter.

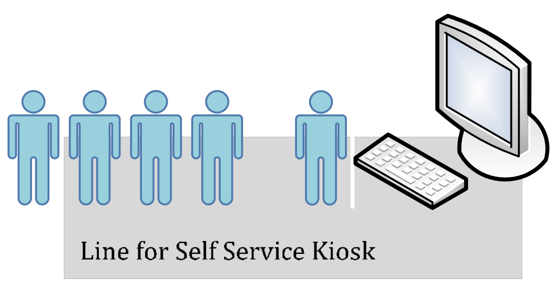
# Format 1

You are in the lobby of a luxurious resort, about to check in. Approaching the counter, you find that you have two check-in options. You may check-in with the employee or you may check-in using the self-service check-in kiosk. The self-service kiosk is located next to the counter, has instructions for use and the same options as you would have checking in with the service employee. Check-in is done by touching the appropriate boxes on the screen. If you make a mistake or change your mind, information can be re-entered.

Both options (employee and self-service kiosk) have the same options at the same prices and allow you to personalize your experience (e.g. queen size bed, non-smoking room, etc.) and receive a room key. In each case, after you have finished checking-in, you can proceed directly to your room.

You now have to choose which line you will join. Both the service employee and the self-service kiosk are currently in use. Additionally, there are currently four customers waiting for the service employee and six customers waiting in line to use the self-service kiosk. Here is how the lobby looks like.




Which line will you join?
*(Check the appropriate answer)*
____ self-service ____ service employee

1. What do you think is an acceptable waiting time before it is your turn to check-in?

| *Minutes* | *0* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *More than 10* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Seconds* | *0* | *5* | *10* | *15* | *20* | *25* | *30* | *35* | *40* | *45* | *50* | *55* |

# Questions

2. The line for the self-service touch screen will move _________ than the line for the service employee
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Slower* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Faster* |

3. Customers will take __________ to order using the touch screen than to order using the service employee
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Longer* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Shorter* |

4. The amount of pressure I feel in the situation described could be described as ________
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *None* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Very High* |

5. Using the self-service kiosk will provide __________________ service
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Excellent* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Poor* |

6. What quality of service would you received from the self-service check-in option?
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *High Quality Service* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Low Quality Service* |

7. Using the self-service kiosk means ________________ exactly what I want
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *I Will Get* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *I Will Not Get* |

8. Using the self-service kiosk is something _________________ to work well
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *I Expect* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *I Do Not Expect* |

9. Using the self-service kiosk ___________ in errors
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Will Result* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Will Not Result* |

10. Using the self-service check-in option will ______________________
*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Be Complicated* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be Complicated* |
| *Be User Friendly* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be User Friendly* |
| *Be Easy* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be Easy* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Be Confusing* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be Confusing* |
| *Require a Lot of Effort* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Be Effortless* |
| *Require a Lot of Work* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Require a Lot of Work* |
| *Be Entertaining* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be Entertaining* |
| *Be Fun* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be Fun* |
| *Be Enjoyable* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be Enjoyable* |
| *Be Interesting* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be Interesting* |
| *Be Reliable* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Not Be Reliable* |

11. Please rate the following statements

a. Using the self-service kiosk will allow me to check-in faster

*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

b. Using the self-service kiosk will make me more efficient while checking-in

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

c. Using the self-service kiosk will be more convenient

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

d. Using the self-service kiosk will save me time

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

e. Using the self-service kiosk will make me more productive

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

f. Using the self-service kiosk will allow me to do things my own way

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

g. The self-service check-in option will give me control over checking in

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

h. Using the service employee will not allow me to check-in the way I want to

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

i. I fear that using the self-service kiosk reduces the confidentiality of my transaction with the hotel

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

j. I am unsure if the self-service kiosk will perform satisfactorily

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

k. Using the self-service kiosk infringes on my privacy

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

l. Overall, using the self-service kiosk is risky

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

m. I am sure the self-service kiosk performs as well as using the service employee

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

n. Human contact makes the process enjoyable for me

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

o. I like interacting *with* the person who provides the service

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

p. Personal attention by the service employee is *not* very important to me

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

q. It bothers me to use a machine when I could talk with a person instead

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

r. In the situation described, I am not rushed for time

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

s. In the situation described, I have limited time available to me

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

t. I commonly use lots of automated systems when dealing with other businesses

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

u. I do not have much experience using the internet

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

v. I use a lot of technologically based products and services

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

w. I feel apprehensive about using technology

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

x. Technical terms sound like confusing jargon to me

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

y. I have avoided technology unfamiliar to me

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

z. I hesitate to use most forms of technology for fear of making a mistake that I cannot correct

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

12. Please answer the following questions by checking the appropriate answer

a. How many times have you previously used self-service kiosk to check-in for a hotel stay

[ ] *Never* [ ] *Once* [ ] *2-3 times* [ ] *4 or more times*

b. If you previously used a self-service kiosk to check-in for a hotel stay; how satisfied were you with the process of checking-in using the self-service kiosk?

[ ] *Not Applicable*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Very Dissatisfied* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Very Satisfied* |

c. If a self-service kiosk is available for me to use to check-in in a hotel, I will ______ use it

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Never* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Always* |

d. How many times have you previously used self-service kiosk to check-in for a service other than a hotel stay (for instance a doctor's appointment or a flight)

[ ] *Never* [ ] *Once* [ ] *2-3 times* [ ] *4 or more times*

e. If you previously used a self-service kiosk to check-in for a service other than a hotel stay (for instance a doctor's appointment or a flight); how satisfied were you with the process of checking-in using the self-service kiosk?

[ ] *Not Applicable*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Very Dissatisfied* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Very Satisfied* |

f. If a self-service kiosk is available for me to use to check-in for a service other than a hotel stay (for instance a doctor's appointment or a flight), I will ______ use it

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Never* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Always* |

g. How many times have you previously used self-service technologies (such as a self-service kiosks and the internet) to conduct transactions?

| |
|---|
| [ ] *Never* [ ] *Once* [ ] *2-3 times* [ ] *4 or more times* |

h. If you have previously used self-service technologies (such as a self-service kiosks and the internet) to conduct a transaction, how satisfied were you with the process of conducting the transaction using the self-service technology?

[ ] *Not Applicable*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Very Dissatisfied* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Very Satisfied* |

i. If a self-service technology (such as a self-service kiosks and the internet) is available for me to use to conduct a transaction, I will ______ use it

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Never* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Always* |

13. I had not difficulty imagining myself in the situation

*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

14. The situation described was realistic

*(Circle the appropriate number)*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Completely Disagree* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | *Completely Agree* |

15. In your own words, what do think was the purpose of the study?

*(Please be as descriptive as possible)*

# Format 2

You are in the lobby of a luxurious resort, about to check in. Approaching the counter, you find that you have two check-in options. You may check-in with the employee or you may check-in using the self-service check-in kiosk. The self-service kiosk is located next to the counter, has instructions for use and the same options as you would have checking in with the service employee. Check-in is done by touching the appropriate boxes on the screen. If you make a mistake or change your mind, information can be re-entered.

Both options (employee and self-service kiosk) have the same options at the same prices and allow you to personalize your experience (e.g. queen size bed, non-smoking room, etc.) and receive a room key. In each case, after you have finished checking-in, you can proceed directly to your room.

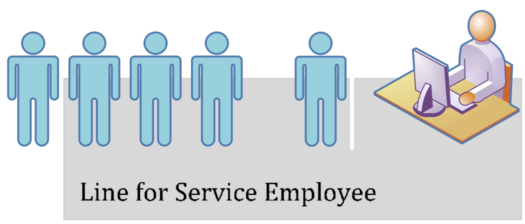
You now have to choose which line you will join. Both the service employee and the self-service kiosk are currently in use. Additionally, there are currently four customers waiting for the service employee and six customers waiting in line to use the self-service kiosk.

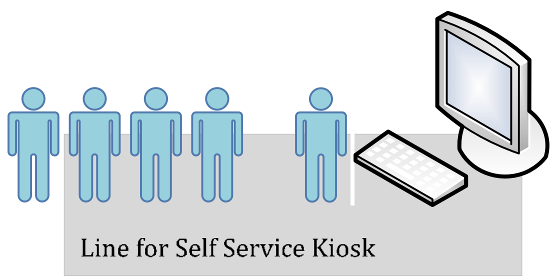
# Format 3

You are in the lobby of a luxurious resort, about to check in. Approaching the counter, you find that you have two check-in options. You may check-in with the employee or you may check-in using the self-service check-in kiosk. The self-service kiosk is located next to the counter, has instructions for use and the same options as you would have checking in with the service employee. Check-in is done by touching the appropriate boxes on the screen. If you make a mistake or change your mind, information can be re-entered.

Both options (employee and self-service kiosk) have the same options at the same prices and allow you to personalize your experience (e.g. queen size bed, non-smoking room, etc.) and receive a room key. In each case, after you have finished checking-in, you can proceed directly to your room.

You now have to choose which line you will join. Here is how the lobby looks like.



## Appendix B: Main Study Instruments

## Self-service technology in resorts 10 SAMPLE

### 1. Statement of Consent

Title of Project:Using Simulation to Predict the Impact of Self-Service Technology Implementation on Customer Waiting Times and System Operating Costs

Principal Investigators: Alinda Kokkinou
201 Mateer Building
University Park, PA 16802
(814)221-9314; axk953@psu.edu

Dr. David A. Cranage
218 Mateer Building
University Park, PA 16802
(814)863-0296; dac2@psu.edu

1. Purpose of the Study: The purpose of this research study is to understand people's decision to use a self-service technology or use a service employee when conducting a transaction.

2. Procedures to be followed: You will be asked to read a short description of a situation and picture yourself in that situation. You will then be asked to answer questions pertaining to your behavior in such a situation. You will be asked for demographic information.

3. Duration: It will take about 10 to 15 minutes to complete the survey.

4. Statement of Confidentiality: Your participation in this research is confidential. Your responses to the survey will in no way be linked to your e-mail address.
Your confidentiality will be kept to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.
In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared because your name is in no way linked to your responses.

5. Right to Ask Questions: Please contact Alinda Kokkinou at (814)221-9314 or Dr. David A. Cranage at (814)863-0296 with questions or concerns about this study.

# Self-service technology in resorts 10 SAMPLE

6. Payment for Participation: to thank you for your participation, you may choose to be entered in a drawing to win one of 10 $75 gift cards. Upon completion of this survey, you will be re-directed to a separate survey to enter your e-mail address or telephone number. This information cannot be linked to your responses to this survey. This is for the sole purpose of contacting you, if you are one of the ten gift card winners. After the drawing, this information will be deleted. If you are one of the ten winners, we will contact you to arrange for the gift card to be sent to you.

7. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Clicking on the yes button below implies that you have read the information in this form and consent to take part in the research. If you would like to keep this form for your records or future reference, please print it now.

*** 1. Would you like to take the survey?**

- ○ Yes
- ○ No

# Self-service technology in resorts 10 SAMPLE

## 2. Context

You are in the lobby of a luxurious resort, about to check in. Approaching the counter, you find that you have two check-in options. You may check-in with the employee or you may check-in using the self-service check-in kiosk. The self-service check-in kiosk is located next to the counter, has instructions for use, and offers the same options as you would have checking in with the service employee. Check-in is done by touching the appropriate boxes on the screen. If you make a mistake or change your mind, information can be re-entered.

Both options (employee and self-service check-in kiosk) have the same options at the same prices and allow you to personalize your experience (e.g. queen size bed, non-smoking room, etc.) and receive a room key. In each case, after you have finished checking-in, you can proceed directly to your room.

You now have to choose which line you will join. Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, there is one customer waiting to use the self-service check-in kiosk. There are no other customers waiting to use the service employee.

Here is how the lobby looks.

## Self-service technology in resorts 10 SAMPLE

**1. Which line will you join/enter?**

- ◯ Self-service check-in kiosk
- ◯ Service employee

**2. In THIS situation, how likely are you to use the self-service check-in KIOSK to check-in?**

◯ 1 Very Unlikely ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Very Likely

**3. In THIS situation, how likely are you to use the service EMPLOYEE to check-in?**

◯ 1 Very Unlikely ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Very Likely

**4. Do you think that the length of the line for check-in using the service employee is unacceptable or acceptable?**

◯ 1 Unacceptable ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Acceptable

## Self-service technology in resorts 10 SAMPLE

**5. What do you think is an acceptable waiting time (in minutes and seconds) before it is your turn to check-in?**

| | | |
|---|---|---|
| ◯ 0:00 | ◯ 4:00 | ◯ 8:00 |
| ◯ 0:20 | ◯ 4:20 | ◯ 8:20 |
| ◯ 0:40 | ◯ 4:40 | ◯ 8:40 |
| ◯ 1:00 | ◯ 5:00 | ◯ 9:00 |
| ◯ 1:20 | ◯ 5:20 | ◯ 9:20 |
| ◯ 1:40 | ◯ 5:40 | ◯ 9:40 |
| ◯ 2:00 | ◯ 6:00 | ◯ 10:00 |
| ◯ 2:20 | ◯ 6:20 | ◯ 10:20 |
| ◯ 2:40 | ◯ 6:40 | ◯ 10:40 |
| ◯ 3:00 | ◯ 7:00 | ◯ 11 minutes or more |
| ◯ 3:20 | ◯ 7:20 | |
| ◯ 3:40 | ◯ 7:40 | |

**6. After checking-in, would you go to the concierge desk?**

◯ Yes ◯ No

Optional Explanation

**7. If the self-service check-in kiosk ALSO offered you a concierge option (for instance for making or changing a restaurant or spa reservation), how likely would you be to use the self-service check-in kiosk to check-in?**

◯ 1 Very Unlikely ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Very Likely

## Self-service technology in resorts 10 SAMPLE

**8. If a SEPARATE self-service concierge kiosk offering ONLY concierge services (for instance making or changing a restaurant or spa reservation) was available, how likely would you be to use the self-service CONCIERGE kiosk?**

○ 1 Very Unlikely ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very Likely

## Self-service technology in resorts 10 SAMPLE

### 3. Statements

Please indicate your level of agreement with the following statements.

**1. Using the self-service check-in kiosk will allow me to check-in faster.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

**2. Using the self-service check-in kiosk will make me more efficient while checking-in.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

**3. Using the self-service check-in kiosk will be more convenient.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

**4. Using the self-service check-in kiosk will save me time.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

**5. Using the self-service check-in kiosk will make me more productive.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

## Self-service technology in resorts 10 SAMPLE

6. Using the self-service check-in kiosk will allow me to do things my own way.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

7. The self-service check-in kiosk will give me control over checking in.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

8. I fear that using the self-service check-in kiosk reduces the confidentiality of my transaction with the hotel.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

9. Using the self-service check-in kiosk infringes on my privacy.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

10. Overall, using the self-service check-in kiosk is risky.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

11. I am sure the self-service check-in kiosk performs as well as using the service employee.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

## Self-service technology in resorts 10 SAMPLE

### 4. Statements (cont)

Please indicate your level of agreement with the following statements.

**1. Human contact makes the process enjoyable for me.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

**2. I like interacting with the person who provides the service.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

**3. Personal attention by the service employee is not very important to me.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

**4. It bothers me to use a machine when I could talk with a person instead.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

**5. I commonly use lots of automated systems when dealing with other businesses.**

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

## Self-service technology in resorts 10 SAMPLE

6. I do not have much experience using the internet.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

7. I use a lot of technologically based products and services.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

8. I feel apprehensive about using technology.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

9. Technical terms sound like confusing jargon to me.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

10. I have avoided technology unfamiliar to me.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

11. I hesitate to use most forms of technology for fear of making a mistake that I cannot correct.

○ 1 Completely Disagree ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Completely Agree

## Self-service technology in resorts 10 SAMPLE

### 5. Questions

Please select the most appropriate answer.

**1. The line for the self-service check-in kiosk will move __________ than the line for the service employee**
**(1 = slower and 7 = faster)**

◯ 1 Slower ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Faster

**2. It will be __________ for customers to check-in using the self-service check-in kiosk than to check-in with the service employee**
**(1 = slower and 7 = faster)**

◯ 1 Slower ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Faster

**3. Customers will take __________ to check-in using the self-service check-in kiosk than to check-in using the service employee**
**(1 = shorter and 7 = longer)**

◯ 1 Shorter ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Longer

**4. Using the self-service check-in kiosk will provide __________ service**
**(1 = poor and 7 = excellent)**

◯ 1 Poor ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Excellent

**5. What quality of service would you receive from the self-service check-in kiosk?**
**(1 = low quality service and 7 = high quality service)**

◯ 1 Low Quality ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 High Quality

**6. Using the self-service check-in kiosk means _______________ get exactly what I want.**
**(1 = I will NOT and 7 = I will)**

◯ 1 I Will NOT ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 I Will

## Self-service technology in resorts 10 SAMPLE

**7. Using the self-service check-in kiosk will ____________________.**
**(1 = NOT be complicated and 7 = be complicated)**

◯ 1 NOT Be Complicated ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Be Complicated

**8. Using the self-service check-in kiosk will ____________________.**
**(1 = NOT be fun 7 = be fun)**

◯ 1 NOT Be Fun ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Be Fun

**9. Using the self-service check-in kiosk will ____________________.**
**(1 = NOT be entertaining and 7 = be entertaining)**

◯ 1 NOT Be Entertaining ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Be Entertaining

**10. Using the self-service check-in kiosk will ____________________.**
**(1 = NOT be interesting and 7 = be interesting)**

◯ 1 NOT Be Interesting ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Be Interesting

**11. Using the self-service check-in kiosk will ____________________.**
**(1 = NOT require a lot of effort and 7 = require a lot of effort)**

◯ 1 NOT Require a lot of Effort ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Require a lot of Effort

**12. Using the self-service check-in kiosk will ____________________.**
**(1 = NOT be reliable and 7 = be reliable)**

◯ 1 NOT Be Reliable ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Be Reliable

13. Using the self-service check-in kiosk will ____________________.
(1 = NOT be enjoyable and 7 = be enjoyable)

○ 1 NOT Be Enjoyable ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Be Enjoyable

## Self-service technology in resorts 10 SAMPLE

### 6. Previous Experiences

1. How many times have you previously used a self-service check-in kiosk to check-in for a hotel stay?

◯ Never ◯ 1-2 times ◯ 3-4 times ◯ 5 or more times

2. If you previously used a self-service check-in kiosk to check-in for a hotel stay; how satisfied were you with the process of checking-in using the self-service kiosk?
(0 = Not Applicable, 1 = Very Dissatisfied and 7 = Very Satisfied)

◯ Not Applicable ◯ 1 Very Dissatisfied ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Very Satisfied

3. If a self-service check-in kiosk is available for me to use to check-in in a hotel, I will _____ use it
(1 = Never and 7 = Always)

◯ 1 Never ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Always

4. How many times have you previously used a self-service kiosk to check-in for a service other than a hotel stay (for instance a doctor's appointment or a flight)?

◯ Never ◯ 1-2 times ◯ 3-4 times ◯ 5 or more times

5. If you previously used a self-service kiosk to check-in for a service other than a hotel stay (for instance a doctor's appointment or a flight); how satisfied were you with the process of checking-in using the self-service kiosk?
(0 = Not Applicable, 1 = Very Dissatisfied and 7 = Very Satisfied)

◯ Not Applicable ◯ 1 Very Dissatisfied ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Very Satisfied

6. If a self-service kiosk is available for me to use to check-in for a service other than a hotel stay (for instance a doctor's appointment or a flight), I will _____ use it
(1 = Never and 7 = Always)

◯ 1 Never ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 Always

## Self-service technology in resorts 10 SAMPLE

**7. How many times have you previously used self-service technologies (such as an internet retailer, or a self-service kiosk at a hotel, airport, medical practice, or grocery store) to conduct transactions?**

- ◯ Never
- ◯ 1-2 times
- ◯ 3-4 times
- ◯ 5 or more times

**8. If you have previously used self-service technologies (such as an internet retailer, or a self-service kiosk at a hotel, airport, medical practice, or grocery store) to conduct a transaction, how satisfied were you with the process of conducting the transaction using the self-service technology?**
**(0 = Not Applicable, 1 = Very Dissatisfied and 7 = Very Satisfied)**

- ◯ Not Applicable
- ◯ 1 Very Dissatisfied
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7 Very Satisfied

**9. If a self-service technology (such as an internet retailer, or a self-service kiosk at a hotel, airport, medical practice, or grocery store) is available for me to use to conduct a transaction, I will ______ use it**
**(1 = Never and 7 = Always)**

- ◯ 1 Never
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7 Always

## Self-service technology in resorts 10 SAMPLE

### 7. Demographic Information

This is the last page of questions.

**1. Please indicate your gender:**

- ◯ Male
- ◯ Female
- ◯ Other

**2. Please indicate your age:**

- ◯ 18 to 25 years old
- ◯ 26 to 35 years old
- ◯ 36 to 45 years old
- ◯ 46 to 55 years old
- ◯ 56 to 65 years old
- ◯ 66 and older

## Self-service technology in resorts 10 SAMPLE

**3. Please indicate your income:**

- ◯ Less than $14,999 per year
- ◯ $15,000 to $29,999 per year
- ◯ $30,000 to $44,999 per year
- ◯ $45,000 to $59,999 per year
- ◯ $60,000 to $74,999 per year
- ◯ $75,000 to $89,999 per year
- ◯ More than $90,000 per year

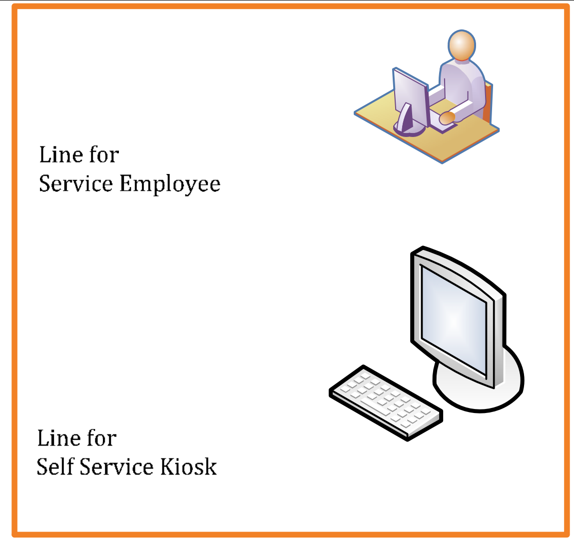
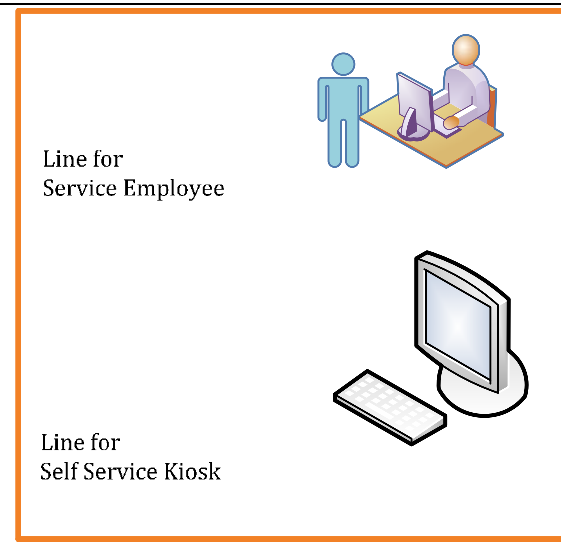
## Self-service technology in resorts 10 SAMPLE

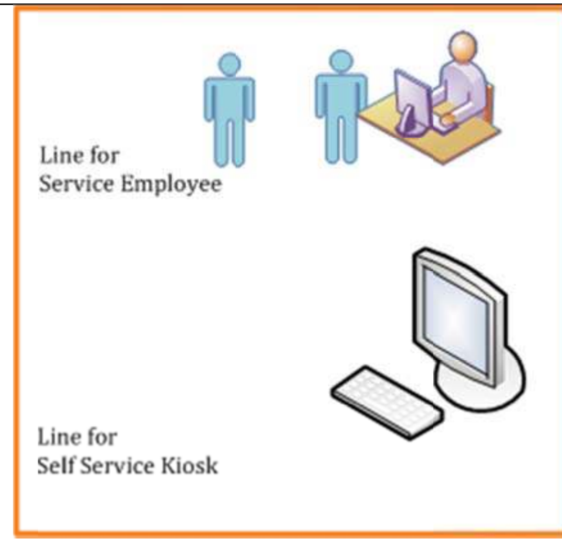
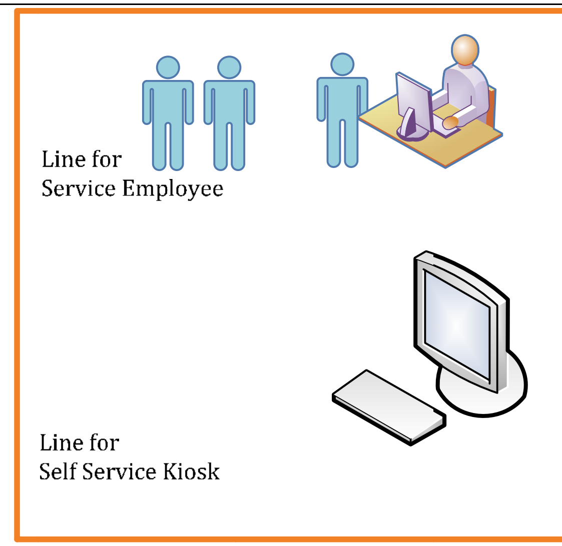
### 8. Thank You

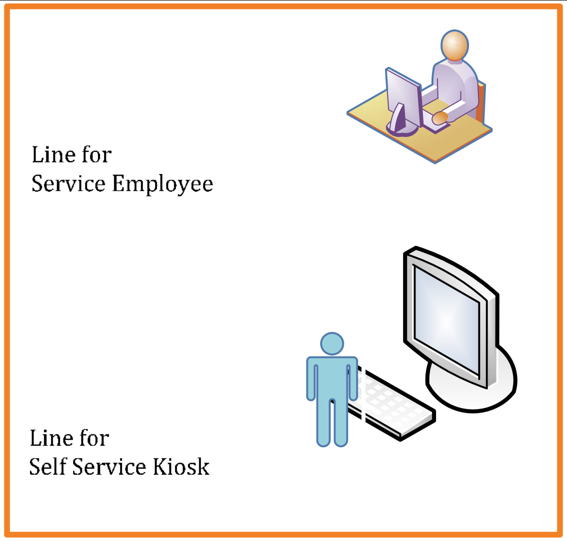
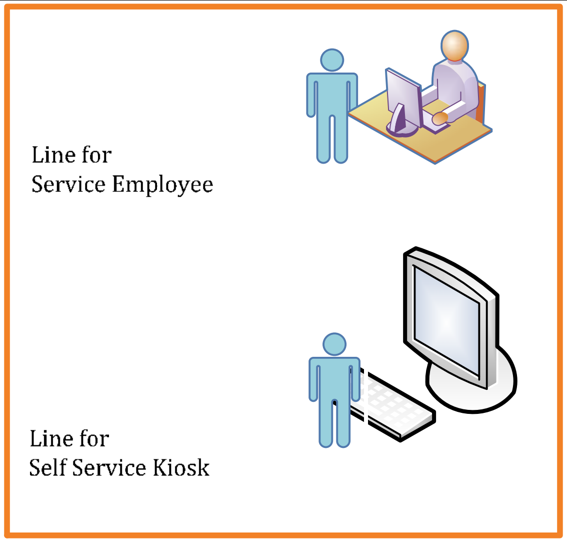
Thank you for helping us with this study. If you have any questions, comments, or concerns, you may contact us at axk953@psu.edu.

To be entered in the drawing to win one of ten $75 gift cards, please click on the "Done" button at the bottom of this page.

**Appendix C: Scenarios**

| | Service employee line length | SST line length | Scenario Description | Image |
|---|---|---|---|---|
| Scenario 1 | 0 | 0 | Both the service employee and the self-service check-in kiosk are currently available. There are no other customers waiting for either the service employee or the self-service check-in kiosk. |  |
| Scenario 2 | 1 | 0 | The service employee is currently occupied with a customer. The self-service check-in kiosk is available. There are no other customers waiting for either the service employee or the self-service check-in kiosk. |  |

| | | | | |
|---|---|---|---|---|
| Scenario 3 | 2 | 0 | The service employee is currently occupied with a customer. The self-service check-in kiosk is available. Additionally, there is one customer waiting to use the service employee. There are no other customers waiting to use the self-service check-in kiosk. |  |
| Scenario 4 | 3 | 0 | The service employee is currently occupied with a customer. The self-service check-in kiosk is available. Additionally, there are two customers waiting to use the service employee. There are no other customers waiting to use the self-service check-in kiosk. |  |

| | | | | |
|---|---|---|---|---|
| Scenario 5 | 0 | 1 | The service employee is currently available. The self-service kiosk check-in is occupied by a customer. There are no other customers waiting for either the service employee or the self-service check-in kiosk. |   |
| Scenario 6 | 1 | 1 | Both the service employee and the self-service kiosk check-in are currently occupied by customers. There are no other customers waiting for either the service employee or the self-service check-in kiosk. |   |

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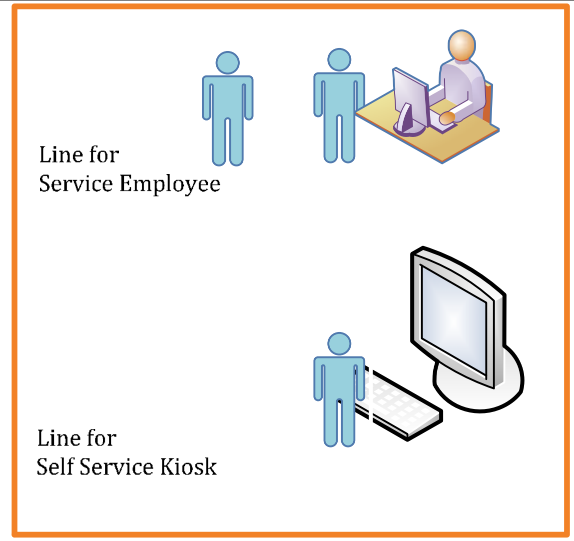
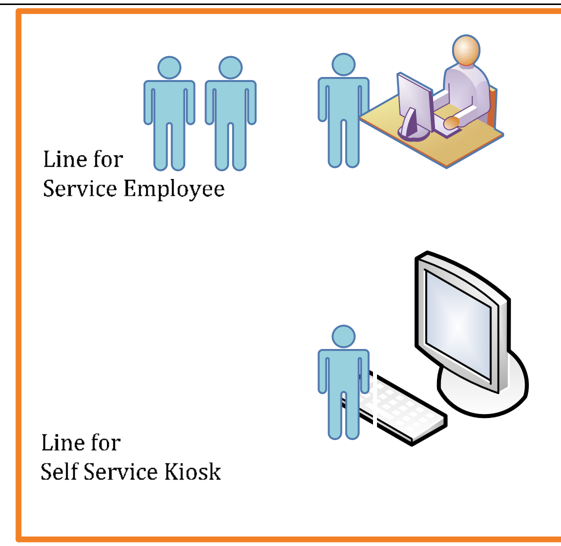
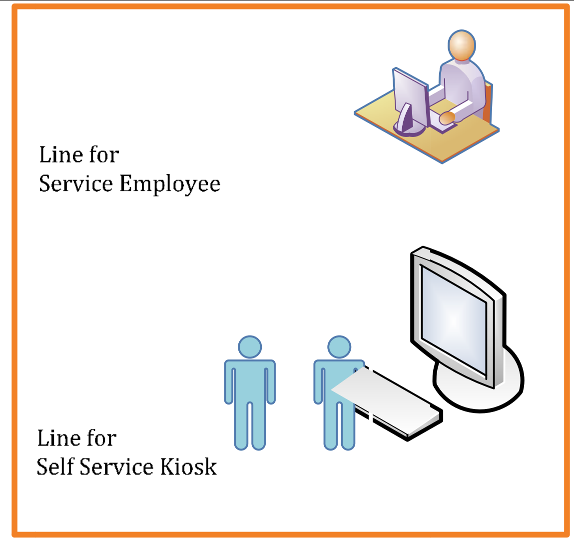
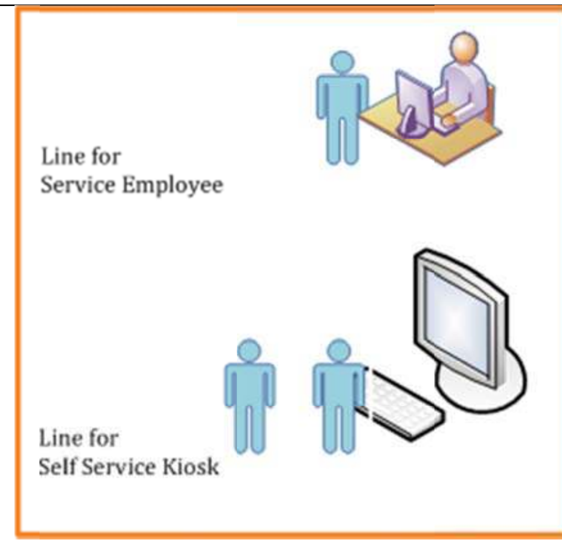
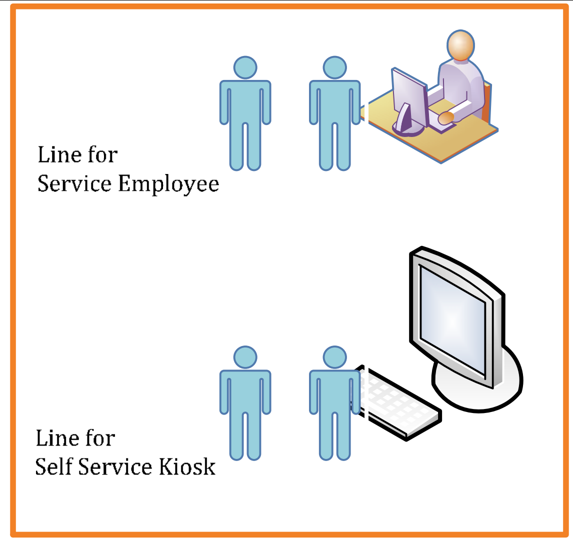
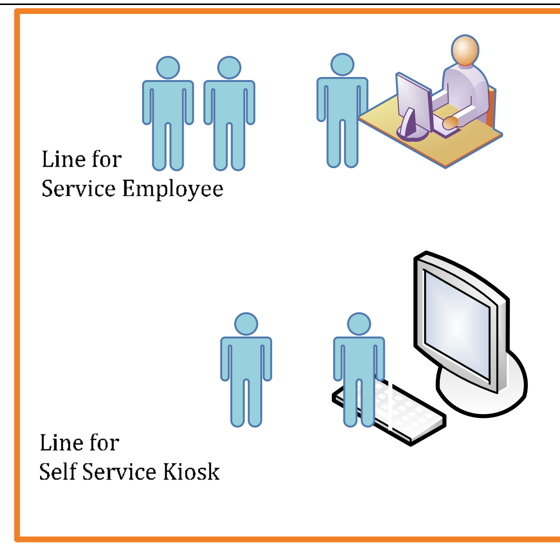
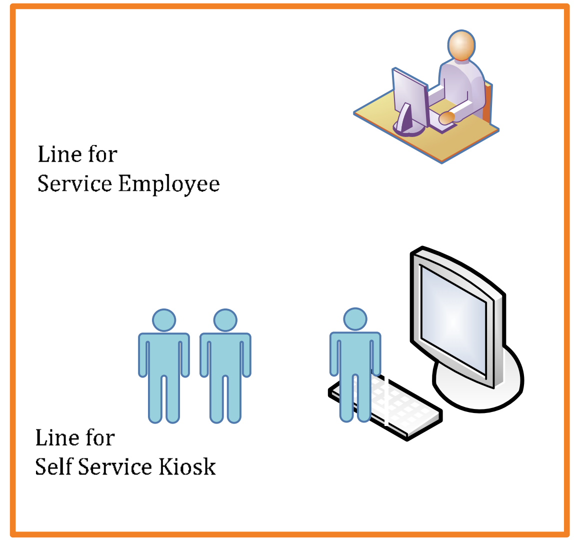
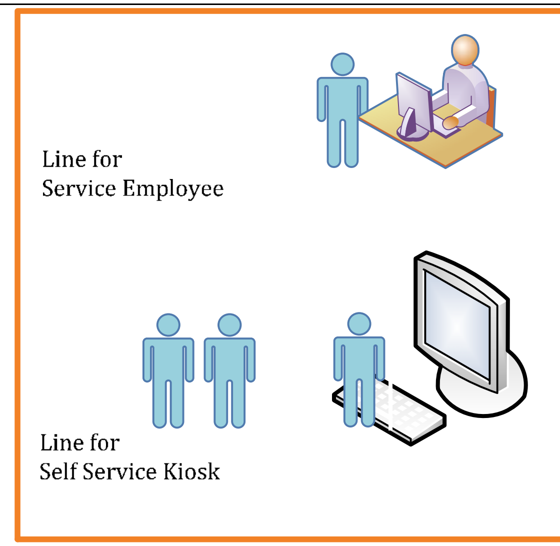
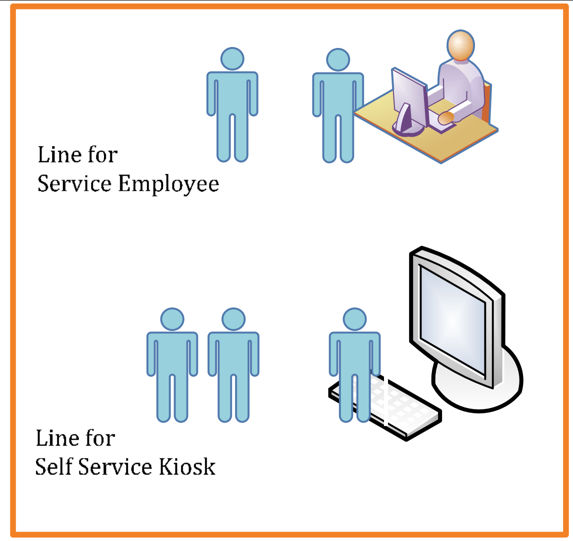
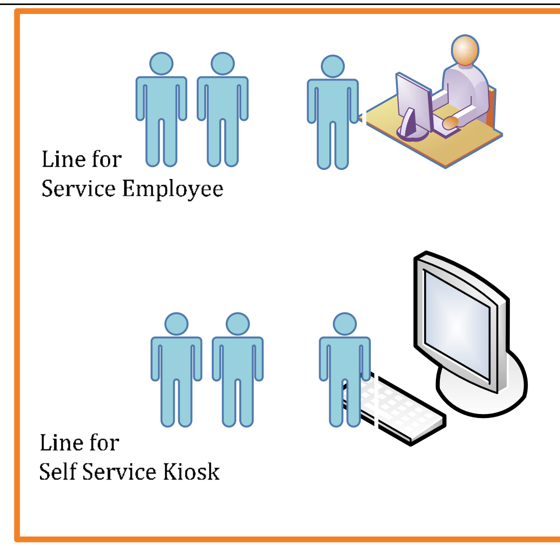
|---|---|---|---|---|
| Scenario 7 | 2 | 1 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, there is one customer waiting to use the service employee. There are no other customers waiting to use the self-service check-in kiosk. |  |
| Scenario 8 | 3 | 1 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, there are two customers waiting to use the service employee. There are no other customers waiting to use the self-service check-in kiosk. |  |

| | | | | |
|---|---|---|---|---|
| Scenario 9 | 0 | 2 | The service employee is currently available. The self-service kiosk check-in is occupied by a customer. Additionally, there is one customer waiting to use the self-service check-in kiosk. There are no other customers waiting to use the service employee. |   |
| Scenario 10 | 1 | 2 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, there is one customer waiting to use the self-service check-in kiosk. There are no other customers waiting to use the service employee. |   |

| | | | | |
|---|---|---|---|---|
| Scenario 11 | 2 | 2 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, one customer is waiting to use the service employee and one customer is waiting to use the self-service check-in kiosk. |   |
| Scenario 12 | 3 | 2 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, two customers are waiting to use the service employee and one customer is waiting to use the self-service check-in kiosk. |   |

| | | | | |
|---|---|---|---|---|
| Scenario 13 | 0 | 3 | The service employee is currently available. The self-service check-in kiosk is occupied by a customer. Additionally, there are two customers waiting to use the self-service check-in kiosk. There are no other customers waiting to use the service employee. |   |
| Scenario 14 | 1 | 3 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, there are two customers waiting to use the self-service check-in kiosk. There are no other customers waiting to use the service employee. |   |

| | | | | |
|---|---|---|---|---|
| Scenario 15 | 2 | 3 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, one customer is waiting to use the service employee and two customers are waiting to use the self-service check-in kiosk. |  |
| Scenario 16 | 3 | 3 | Both the service employee and the self-service kiosk are currently occupied by customers. Additionally, two customers are waiting to use the service employee and two customers are waiting to use the self-service check-in kiosk. |  |

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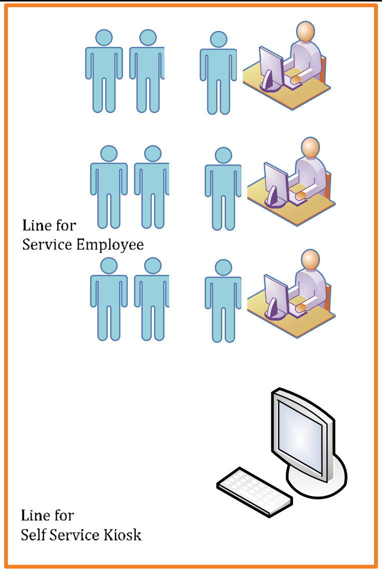
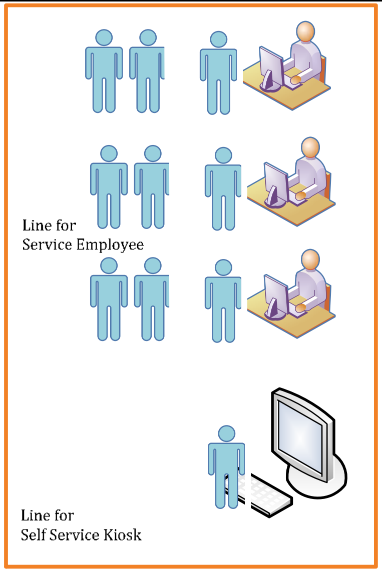
|---|---|---|---|---|
| Scenario 17 | 3 x 3 | 0 | The three service employees are currently occupied with customers The self-service check-in kiosk is available. Two customers are waiting for each service employee. There are no customers waiting for the self-service check-in kiosk. |   |
| Scenario 18 | 3 x 3 | 1 | The three service employees are currently occupied with customers The self-service kiosk check-in is occupied by a customer. Two customers are waiting for each service employee. There are no customers waiting for the self-service check-in kiosk. |   |

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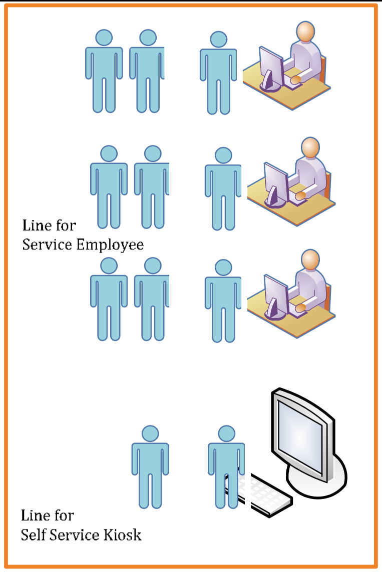
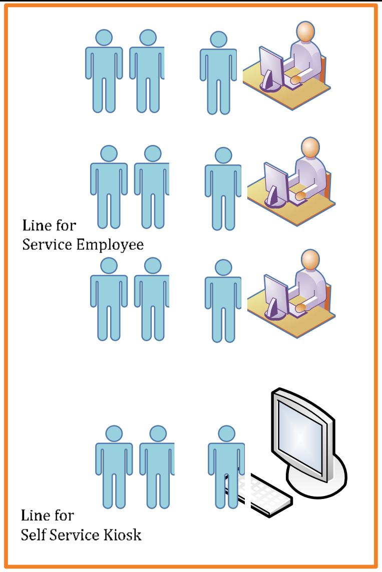
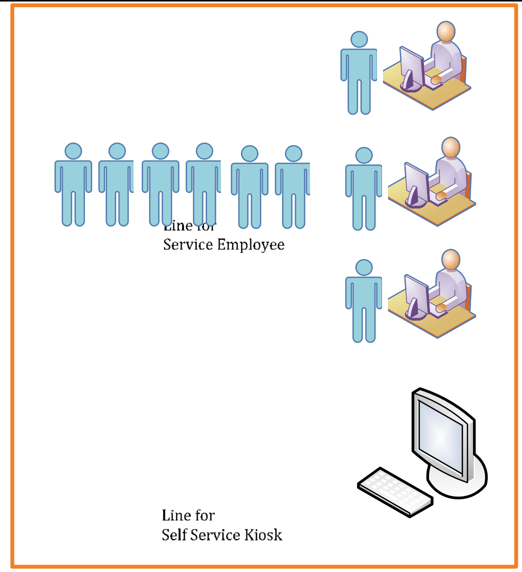
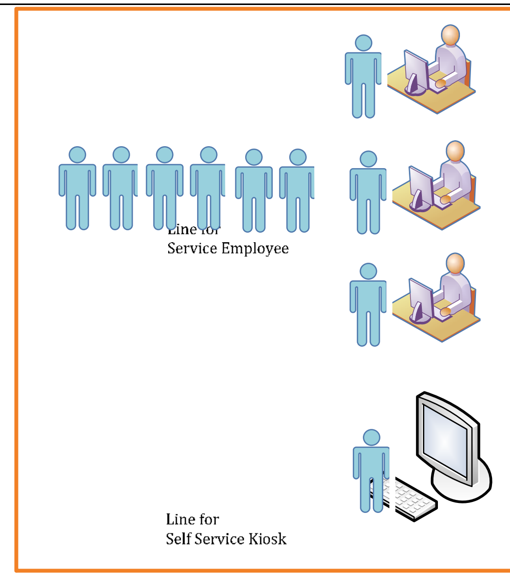
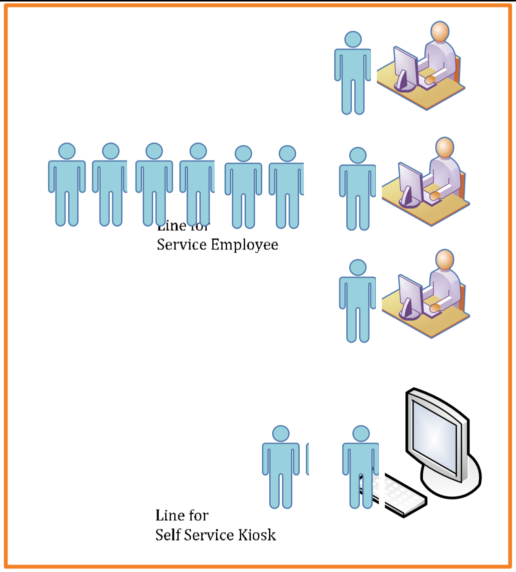
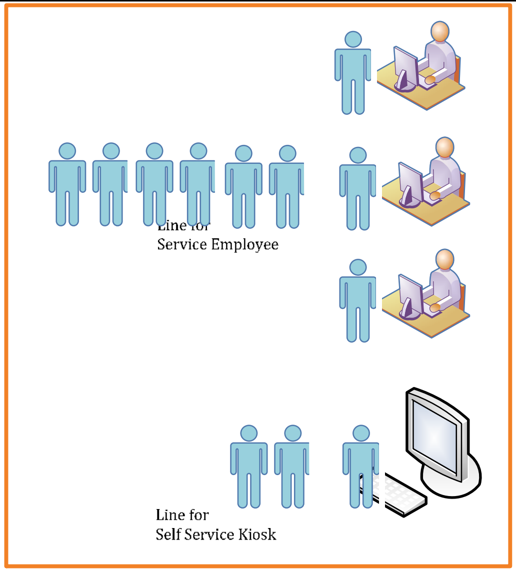
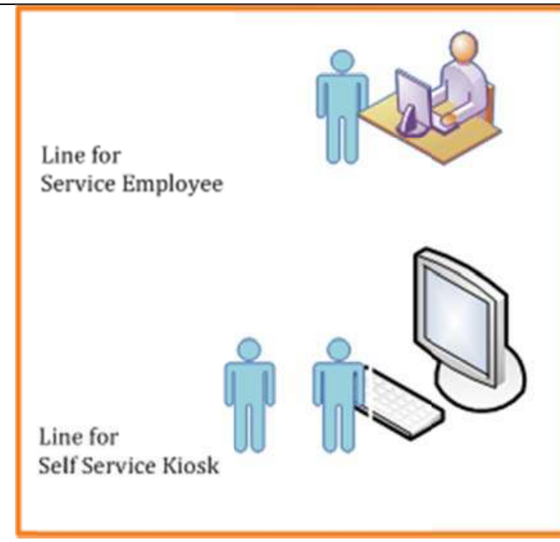
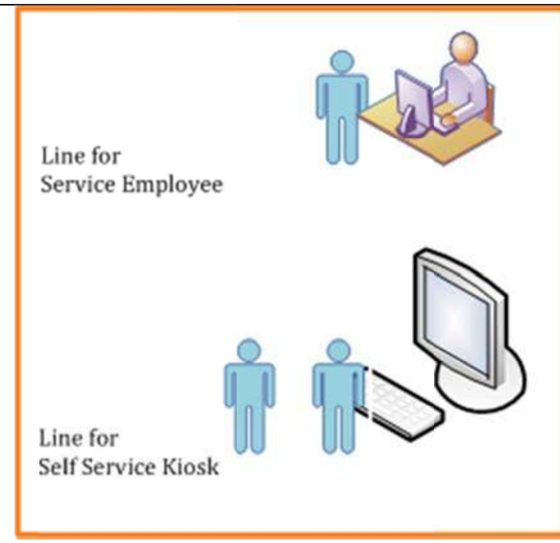
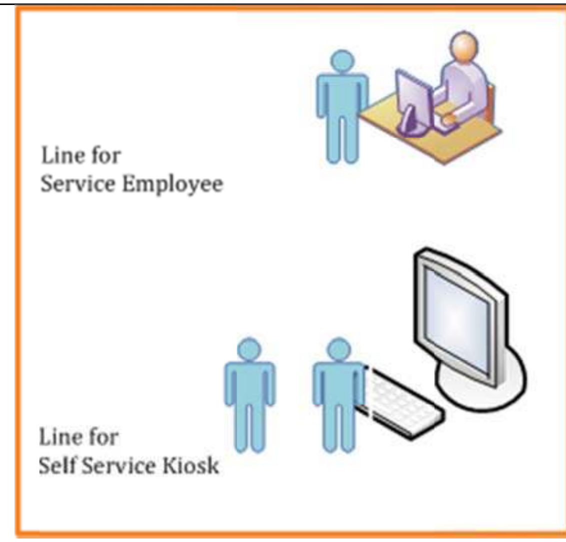
|---|---|---|---|---|
| Scenario 19 | 3 x 3 | 2 | The three service employees are currently occupied with customers The self-service kiosk check-in is occupied by a customer. Two customers are waiting for each service employee. One customer is waiting for the self-service check-in kiosk. |   |
| Scenario 20 | 3 x 3 | 3 | The three service employees are currently occupied with customers The self-service kiosk check-in is occupied by a customer. Two customers are waiting for each service employee. Two customers are waiting for the self-service check-in kiosk. |   |

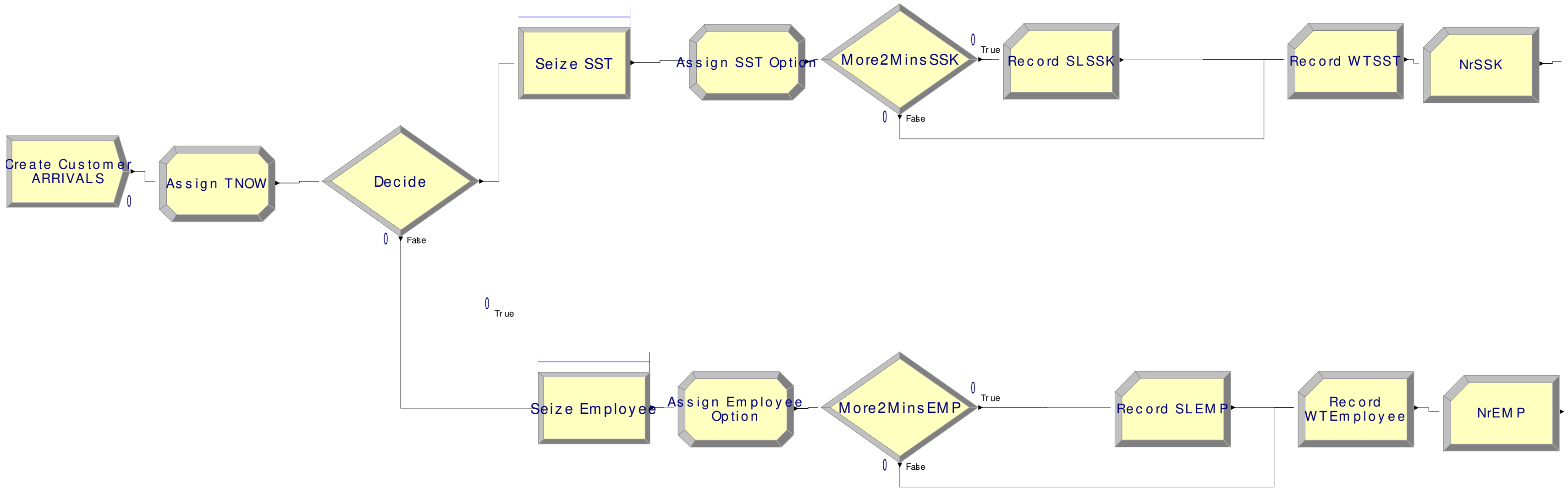
| | | | | |
|---|---|---|---|---|
| Scenario 21 | 3 + 6 | 0 | The three service employees are currently occupied with customers The self-service check-in kiosk is available. Six customers are waiting for the service employees. There are no customers waiting for the self-service check-in kiosk. |   |
| Scenario 22 | 3 + 6 | 1 | The three service employees are currently occupied with customers The self-service kiosk check-in is occupied by a customer. Six customers are waiting for the service employees.  There are no customers waiting for the self-service check-in kiosk. |   |

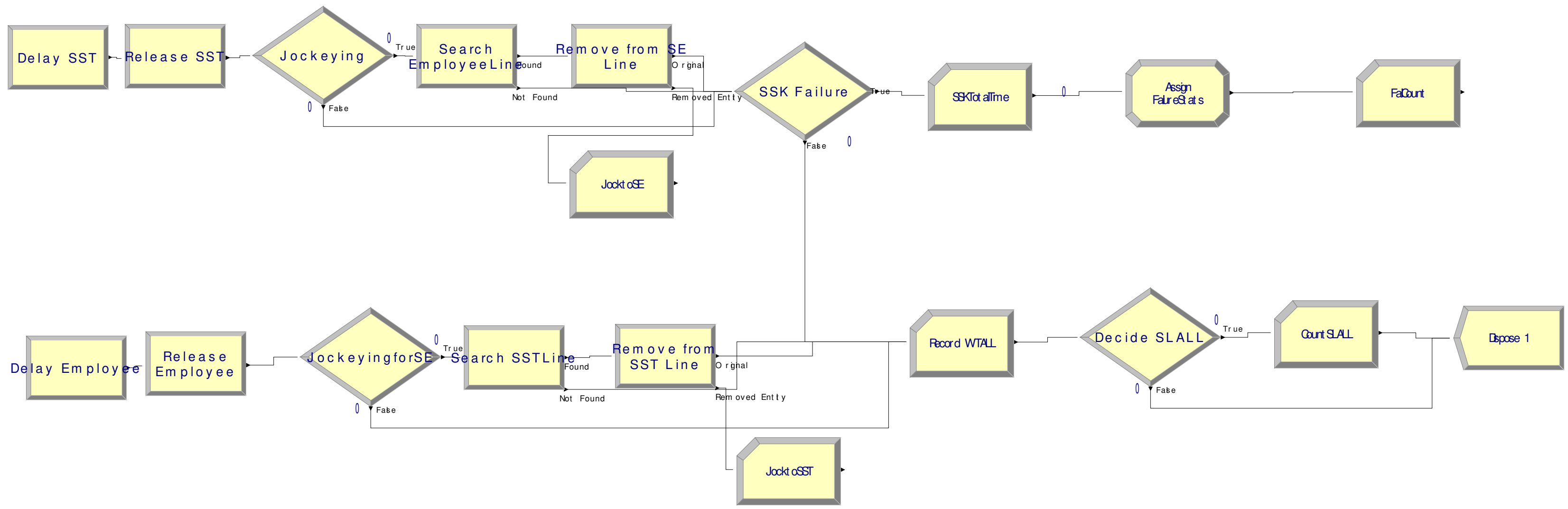
| | | | | |
|---|---|---|---|---|
| Scenario 23 | 3 + 6 | 2 | The three service employees are currently occupied with customers The self-service kiosk check-in is occupied by a customer. Six customers are waiting for the service employees. One customer is waiting for the self-service check-in kiosk. |   |
| Scenario 24 | 3 + 6 | 3 | The three service employees are currently occupied with customers The self-service kiosk check-in is occupied by a customer. Six customers are waiting for the service employees. Two customers are waiting for the self-service check-in kiosk. |   |

| | | | | |
|---|---|---|---|---|
| Scenario 25/ (Copy of Scenario 10) | 1 | 2 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, there is one customer waiting to use the self-service check-in kiosk. There are no other customers waiting to use the service employee. |   |
| Scenario 26 (reverse of Scenario 10, first measures, then scenario) | 1 | 2 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, there is one customer waiting to use the self-service check-in kiosk. There are no other customers waiting to use the service employee. |   |

| | | | | |
|---|---|---|---|---|
| Scenario 27 (Scenario 10 with MID-SCALE) | 1 | 2 | Both the service employee and the self-service check-in kiosk are currently occupied by customers. Additionally, there is one customer waiting to use the self-service check-in kiosk. There are no other customers waiting to use the service employee. |   |

## Appendix D:Sample Simulation Model


Create Customer ARRIVALS
Assign TNOW
Decide
True
False
Seize SST
Assign SST Option
More2MinsSSK
True
False
Record SLSSK
Record WTSST
NrSSK
Seize Employee
Assign Employee Option
More2MinsEMP
True
False
Record SLEMP
Record WTEmployee
NrEMP


Delay SST
Release SST
Jockeying
True
False
Search EmployeeLine
Found
Not Found
Remove from SE Line
Original
Removed Entity
SSK Failure
True
False
SSKTotalTime
Assign FailureStats
FailCount
JocktoSE
Delay Employee
Release Employee
JockeyingforSE
True
False
Search SSTLine
Found
Not Found
Remove from SST Line
Original
Removed Entity
JocktoSST
Record WTALL
Decide SLALL
True
False
CountSLALL
Dispose 1

# Appendix E: Sample SIMAN Code

```
PROJECT,       "Model 1","Alinda Kokkinou",,,No,Yes,Yes,Yes,No,No,No,No,No,No;

ATTRIBUTES:    SSTYes:
               SSKFail:
               WaitingTimeFail:
               ArrivalTIME:
               SEYes:
               Service:
               WaitTime;

VARIABLES:     Decide.NumberOut True,CLEAR(Statistics),CATEGORY("Exclude"):
               Jockeying.NumberOut True,CLEAR(Statistics),CATEGORY("Exclude"):
               SSK Failure.NumberOut True,CLEAR(Statistics),CATEGORY("Exclude"):
               Decide.NumberOut False,CLEAR(Statistics),CATEGORY("Exclude"):
               Create Customer
ARRIVALS.NumberOut,CLEAR(Statistics),CATEGORY("Exclude"):
               SSK Failure.NumberOut False,CLEAR(Statistics),CATEGORY("Exclude"):
               JockeyingforSE.NumberOut True,CLEAR(Statistics),CATEGORY("Exclude"):
               Decide SLALL.NumberOut False,CLEAR(Statistics),CATEGORY("Exclude"):
               More2MinsSSK.NumberOut True,CLEAR(Statistics),CATEGORY("Exclude"):
               Decide SLALL.NumberOut True,CLEAR(Statistics),CATEGORY("Exclude"):
               Dispose 1.NumberOut,CLEAR(Statistics),CATEGORY("Exclude"):
               More2MinsEMP.NumberOut False,CLEAR(Statistics),CATEGORY("Exclude"):
               More2MinsSSK.NumberOut False,CLEAR(Statistics),CATEGORY("Exclude"):
               More2MinsEMP.NumberOut True,CLEAR(Statistics),CATEGORY("Exclude"):
               JockeyingforSE.NumberOut False,CLEAR(Statistics),CATEGORY("Exclude"):
               Jockeying.NumberOut False,CLEAR(Statistics),CATEGORY("Exclude");

QUEUES:        Seize SST.Queue,FIFO,,AUTOSTATS(Yes,,):
               Seize Employee.Queue,FIFO,,AUTOSTATS(Yes,,);

PICTURES:      Picture.Airplane:
               Picture.Green Ball:
               Picture.Blue Page:
               Picture.Telephone:
               Picture.Blue Ball:
               Picture.Yellow Page:
               Picture.EMail:
               Picture.Yellow Ball:
               Picture.Bike:
               Picture.Report:
               Picture.Van:
               Picture.Widgets:
               Picture.Envelope:
               Picture.Fax:
               Picture.Truck:
               Picture.Person:
               Picture.Letter:
               Picture.Box:
               Picture.Woman:
               Picture.Package:
               Picture.Man:
               Picture.Diskette:
               Picture.Boat:
               Picture.Red Page:
               Picture.Ball:
               Picture.Green Page:
               Picture.Red Ball;
```

```
RESOURCES:
Employee,Capacity(3),,,COST(0.0,0.0,0.0),CATEGORY(Resources),,AUTOSTATS(Yes,,):

SST,Capacity(1),,,COST(0.0,0.0,0.0),CATEGORY(Resources),,AUTOSTATS(Yes,,);

COUNTERS:      CountSLALL,,,,DATABASE(,"Count","User Specified","CountSLALL"):
               Record SLSSK,,,,DATABASE(,"Count","User Specified","Record SLSSK"):
               Record SLEMP,,,,DATABASE(,"Count","User Specified","Record SLEMP"):
               NrSSK,,,,DATABASE(,"Count","User Specified","NrSSK"):
               NrEMP,,,,DATABASE(,"Count","User Specified","NrEMP"):
               FailCount,,,,DATABASE(,"Count","User Specified","FailCount"):
               JocktoSE,,,,DATABASE(,"Count","User Specified","JocktoSE"):
               JocktoSST,,,,DATABASE(,"Count","User Specified","JocktoSST");

TALLIES:       Record WTSST,,DATABASE(,"Interval","User Specified","Record WTSST"):
               Record WTALL,,DATABASE(,"Expression","User Specified","Record WTALL"):
               Record WTEmployee,,DATABASE(,"Interval","User Specified","Record
WTEmployee"):
               SSKTotalTime,,DATABASE(,"Interval","User Specified","SSKTotalTime");

REPLICATE,     100,,SecondsToBaseTime(9000),Yes,Yes,,,,24,Seconds,No,No,,,Yes,No;

ENTITIES:      Customer,Picture.Report,0.0,0.0,0.0,0.0,0.0,0.0,AUTOSTATS(Yes,,);
```

```
;
;
;     Model statements for module:  BasicProcess.Create 1 (Create Customer ARRIVALS)
;

36$            CREATE,        1,SecondstoBaseTime(4 + EXPO(96.9,32)),Customer:SecondstoBaseTime(4 +
EXPO(96.9,31)):NEXT(37$);

37$            ASSIGN:        Create Customer ARRIVALS.NumberOut=Create Customer ARRIVALS.NumberOut + 1:NEXT(1$);


;
;
;     Model statements for module:  BasicProcess.Assign 1 (Assign TNOW)
;
1$             ASSIGN:        SEYes=DISC(0.05, 0, 1.0, 1,33):
                              SSTYes=DISC(0.25, 0, 1.0, 1,34):
                              ArrivalTIME=TNOW:NEXT(2$);


;
;
;     Model statements for module:  BasicProcess.Decide 1 (Decide)
;
2$             BRANCH,        1:
                              With,
                              (100/(1+EP(-(-1.09445133-0.83611324*(NR(SST)+NQ(Seize
SST.Queue))+1.08745863*(MX(0,NR(Employee)-MR(Employee)+1)+AINT(NQ(Seize Employee.Queue)/MR(Employee)))))))/100,
                              40$,Yes:
                              Else,41$,Yes;
40$            ASSIGN:        Decide.NumberOut True=Decide.NumberOut True + 1:NEXT(32$);

41$            ASSIGN:        Decide.NumberOut False=Decide.NumberOut False + 1:NEXT(3$);


;
;
;     Model statements for module:  AdvancedProcess.Seize 1 (Seize SST)
;
32$            QUEUE,         Seize SST.Queue;
               SEIZE,         2,Other:
                              SST,1:NEXT(43$);

43$            DELAY:         0.0,,VA:NEXT(7$);
```

```
;
;
;     Model statements for module:  BasicProcess.Assign 2 (Assign SST Option)
;
7$            ASSIGN:        Service=SST:
                             WaitTime=TNOW-ArrivalTime:NEXT(18$);


;
;
;     Model statements for module:  BasicProcess.Decide 5 (More2MinsSSK)
;
18$           BRANCH,        1:
                             If,WaitTime<=120,44$,Yes:
                             Else,45$,Yes;
44$           ASSIGN:        More2MinsSSK.NumberOut True=More2MinsSSK.NumberOut True + 1:NEXT(19$);

45$           ASSIGN:        More2MinsSSK.NumberOut False=More2MinsSSK.NumberOut False + 1:NEXT(9$);


;
;
;     Model statements for module:  BasicProcess.Record 3 (Record SLSSK)
;
19$           COUNT:         Record SLSSK,1:NEXT(9$);


;
;
;     Model statements for module:  BasicProcess.Record 1 (Record WTSST)
;
9$            TALLY:         Record WTSST,INT(ArrivalTIME),1:NEXT(26$);


;
;
;     Model statements for module:  BasicProcess.Record 9 (NrSSK)
;
26$           COUNT:         NrSSK,1:NEXT(34$);


;
;
;     Model statements for module:  AdvancedProcess.Delay 1 (Delay SST)
```

```
;
34$          DELAY:         23 + EXPO(37,41),,VA:NEXT(35$);


;
;
;     Model statements for module:  AdvancedProcess.Release 1 (Release SST)
;
35$          RELEASE:       SST,1:NEXT(12$);


;
;
;     Model statements for module:  BasicProcess.Decide 3 (Jockeying)
;
12$          BRANCH,        1:
                            If,NQ(Seize SST.Queue) == 0 && NQ(Seize Employee.Queue) > 0,46$,Yes:
                            Else,47$,Yes;
46$          ASSIGN:        Jockeying.NumberOut True=Jockeying.NumberOut True + 1:NEXT(13$);

47$          ASSIGN:        Jockeying.NumberOut False=Jockeying.NumberOut False + 1:NEXT(11$);


;
;
;     Model statements for module:  AdvancedProcess.Search 1 (Search EmployeeLine)
;
13$          SEARCH,        Seize Employee.Queue,1,NQ(Seize Employee.Queue):SSTYes == 1;
48$          BRANCH,        1:
                            If,J<>0,49$,Yes:
                            Else,50$,Yes;
49$          DELAY:         0.0,,VA:NEXT(14$);

50$          DELAY:         0.0,,VA:NEXT(11$);


;
;
;     Model statements for module:  AdvancedProcess.Remove 1 (Remove from SE Line)
;
14$          REMOVE:        J,Seize Employee.Queue,31$:NEXT(11$);


;
;
```

```
;     Model statements for module:  BasicProcess.Decide 2 (SSK Failure)
;
11$          BRANCH,        1:
                            With,(12.5)/100,51$,Yes:
                            Else,52$,Yes;
51$          ASSIGN:        SSK Failure.NumberOut True=SSK Failure.NumberOut True + 1:NEXT(24$);

52$          ASSIGN:        SSK Failure.NumberOut False=SSK Failure.NumberOut False + 1:NEXT(27$);


;
;
;     Model statements for module:  BasicProcess.Record 7 (SSKTotalTime)
;
24$          TALLY:         SSKTotalTime,INT(ArrivalTIME),1:NEXT(22$);


;
;
;     Model statements for module:  BasicProcess.Assign 4 (Assign FailureStats)
;
22$          ASSIGN:        SSKFail=1:
                            WaitingTimeFail=WaitTime:
                            ArrivalTIME=TNOW:NEXT(23$);


;
;
;     Model statements for module:  BasicProcess.Record 6 (FailCount)
;
23$          COUNT:         FailCount,1:NEXT(3$);


;
;
;     Model statements for module:  AdvancedProcess.Seize 3 (Seize Employee)
;
3$           QUEUE,         Seize Employee.Queue;
             SEIZE,         2,Other:
                            Employee,1:NEXT(54$);

54$          DELAY:         0.0,,VA:NEXT(8$);


;
```

```
;
;     Model statements for module:  BasicProcess.Assign 3 (Assign Employee Option)
;
8$            ASSIGN:        Service=Employee:
                             WaitTime=TNOW-ArrivalTime+WaitingTimeFail:NEXT(20$);


;
;
;     Model statements for module:  BasicProcess.Decide 6 (More2MinsEMP)
;
20$           BRANCH,        1:
                             If,WaitTime<=120,55$,Yes:
                             Else,56$,Yes;
55$           ASSIGN:        More2MinsEMP.NumberOut True=More2MinsEMP.NumberOut True + 1:NEXT(21$);

56$           ASSIGN:        More2MinsEMP.NumberOut False=More2MinsEMP.NumberOut False + 1:NEXT(10$);


;
;
;     Model statements for module:  BasicProcess.Record 4 (Record SLEMP)
;
21$           COUNT:         Record SLEMP,1:NEXT(10$);


;
;
;     Model statements for module:  BasicProcess.Record 2 (Record WTEmployee)
;
10$           TALLY:         Record WTEmployee,INT(ArrivalTIME),1:NEXT(25$);


;
;
;     Model statements for module:  BasicProcess.Record 8 (NrEMP)
;
25$           COUNT:         NrEMP,1:NEXT(5$);


;
;
;     Model statements for module:  AdvancedProcess.Delay 2 (Delay Employee)
;
5$            DELAY:         7 + GAMM(109, 1.29,42),,VA:NEXT(6$);
```

```
;
;
;     Model statements for module:  AdvancedProcess.Release 2 (Release Employee)
;
6$            RELEASE:       Employee,1:NEXT(15$);


;
;
;     Model statements for module:  BasicProcess.Decide 4 (JockeyingforSE)
;
15$           BRANCH,        1:
                             If,NQ(Seize Employee.Queue) == 0 && NQ(Seize SST.Queue)>0,57$,Yes:
                             Else,58$,Yes;
57$           ASSIGN:        JockeyingforSE.NumberOut True=JockeyingforSE.NumberOut True + 1:NEXT(16$);

58$           ASSIGN:        JockeyingforSE.NumberOut False=JockeyingforSE.NumberOut False + 1:NEXT(27$);


;
;
;     Model statements for module:  AdvancedProcess.Search 2 (Search SSTLine)
;
16$           SEARCH,        Seize SST.Queue,1,NQ(Seize SST.Queue):SEYes == 1;
59$           BRANCH,        1:
                             If,J<>0,60$,Yes:
                             Else,61$,Yes;
60$           DELAY:         0.0,,VA:NEXT(17$);

61$           DELAY:         0.0,,VA:NEXT(27$);


;
;
;     Model statements for module:  AdvancedProcess.Remove 2 (Remove from SST Line)
;
17$           REMOVE:        J,Seize SST.Queue,30$:NEXT(27$);


;
;
;     Model statements for module:  BasicProcess.Record 10 (Record WTALL)
;
```

```
27$          TALLY:         Record WTALL,WaitTime,1:NEXT(28$);


;
;
;     Model statements for module:  BasicProcess.Decide 7 (Decide SLALL)
;
28$          BRANCH,        1:
                            If,WaitTime<=120,62$,Yes:
                            Else,63$,Yes;
62$          ASSIGN:        Decide SLALL.NumberOut True=Decide SLALL.NumberOut True + 1:NEXT(29$);

63$          ASSIGN:        Decide SLALL.NumberOut False=Decide SLALL.NumberOut False + 1:NEXT(0$);


;
;
;     Model statements for module:  BasicProcess.Record 11 (CountSLALL)
;
29$          COUNT:         CountSLALL,1:NEXT(0$);


;
;
;     Model statements for module:  BasicProcess.Dispose 1 (Dispose 1)
;
0$           ASSIGN:        Dispose 1.NumberOut=Dispose 1.NumberOut + 1;
64$          DISPOSE:       Yes;


;
;
;     Model statements for module:  BasicProcess.Record 12 (JocktoSST)
;
30$          COUNT:         JocktoSST,1:NEXT(32$);


;
;
;     Model statements for module:  BasicProcess.Record 13 (JocktoSE)
;
31$          COUNT:         JocktoSE,1:NEXT(3$);
```

## Appendix F: Simulation Model Output Validation

| | Inputs | | | | | | Theoretical | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | SSK | SE | AR | PR | AvgPR | Failure | Arrivals | Processing | Util. SE | Util. SSK | Util. |
| 1 | 0 | 2 | 66.07 | 37 | 60 | 12 | 128.44 | 121.94 | 1.00 | 0.00 | 105.33% |
| 7 | 0 | 2 | 80.08 | 37 | 60 | 12 | 107.04 | 121.94 | 0.83 | 0.00 | 87.78% |
| 13 | 0 | 2 | 96 | 37 | 60 | 12 | 90.00 | 121.94 | 0.69 | 0.00 | 73.81% |
| 19 | 0 | 3 | 66.07 | 37 | 60 | 12 | 128.44 | 182.91 | 0.67 | 0.00 | 70.22% |
| 25 | 0 | 3 | 80.08 | 37 | 60 | 12 | 107.04 | 182.91 | 0.55 | 0.00 | 58.52% |
| 31 | 0 | 3 | 96 | 37 | 60 | 12 | 90.00 | 182.91 | 0.46 | 0.00 | 49.20% |
| 37 | 1 | 1 | 66.07 | 37 | 60 | 12 | 128.44 | 210.97 | 0.89 | 0.54 | 60.88% |
| 38 | 1 | 1 | 66.07 | 37 | 60 | 25 | 128.44 | 210.97 | 0.95 | 0.60 | 60.88% |
| 39 | 1 | 1 | 66.07 | 52 | 75 | 12 | 128.44 | 180.97 | 0.92 | 0.66 | 70.97% |
| 40 | 1 | 1 | 66.07 | 52 | 75 | 25 | 128.44 | 180.97 | 1.00 | 0.72 | 70.97% |
| 41 | 1 | 1 | 66.07 | 70.75 | 93.75 | 12 | 128.44 | 156.97 | 0.98 | 0.78 | 81.83% |
| 42 | 1 | 1 | 66.07 | 70.75 | 93.75 | 25 | 128.44 | 156.97 | 1.07 | 0.84 | 81.83% |
| 43 | 1 | 1 | 80.08 | 37 | 60 | 12 | 107.04 | 210.97 | 0.82 | 0.41 | 50.74% |
| 44 | 1 | 1 | 80.08 | 37 | 60 | 25 | 107.04 | 210.97 | 0.88 | 0.46 | 50.74% |
| 45 | 1 | 1 | 80.08 | 52 | 75 | 12 | 107.04 | 180.97 | 0.84 | 0.51 | 59.15% |
| 46 | 1 | 1 | 80.08 | 52 | 75 | 25 | 107.04 | 180.97 | 0.90 | 0.55 | 59.15% |
| 47 | 1 | 1 | 80.08 | 70.75 | 93.75 | 12 | 107.04 | 156.97 | 0.86 | 0.62 | 68.19% |
| 48 | 1 | 1 | 80.08 | 70.75 | 93.75 | 25 | 107.04 | 156.97 | 0.93 | 0.66 | 68.19% |
| 49 | 1 | 1 | 96 | 37 | 60 | 12 | 90.00 | 210.97 | 0.74 | 0.31 | 42.66% |
| 50 | 1 | 1 | 96 | 37 | 60 | 25 | 90.00 | 210.97 | 0.79 | 0.34 | 42.66% |
| 51 | 1 | 1 | 96 | 52 | 75 | 12 | 90.00 | 180.97 | 0.76 | 0.38 | 49.73% |
| 52 | 1 | 1 | 96 | 52 | 75 | 25 | 90.00 | 180.97 | 0.80 | 0.42 | 49.73% |
| 53 | 1 | 1 | 96 | 70.75 | 93.75 | 12 | 90.00 | 156.97 | 0.77 | 0.46 | 57.34% |
| 54 | 1 | 1 | 96 | 70.75 | 93.75 | 25 | 90.00 | 156.97 | 0.82 | 0.50 | 57.34% |
| 55 | 1 | 2 | 66.07 | 37 | 60 | 12 | 128.44 | 271.94 | 0.68 | 0.31 | 47.23% |
| 56 | 1 | 2 | 66.07 | 37 | 60 | 25 | 128.44 | 271.94 | 0.71 | 0.33 | 47.23% |
| 57 | 1 | 2 | 66.07 | 52 | 75 | 12 | 128.44 | 241.94 | 0.69 | 0.38 | 53.09% |
| 58 | 1 | 2 | 66.07 | 52 | 75 | 25 | 128.44 | 241.94 | 0.72 | 0.40 | 53.09% |
| 59 | 1 | 2 | 66.07 | 70.75 | 93.75 | 12 | 128.44 | 217.94 | 0.70 | 0.46 | 58.93% |
| 60 | 1 | 2 | 66.07 | 70.75 | 93.75 | 25 | 128.44 | 217.94 | 0.73 | 0.48 | 58.93% |
| 61 | 1 | 2 | 80.08 | 37 | 60 | 12 | 107.04 | 271.94 | 0.58 | 0.24 | 39.36% |
| 62 | 1 | 2 | 80.08 | 37 | 60 | 25 | 107.04 | 271.94 | 0.62 | 0.25 | 39.36% |
| 63 | 1 | 2 | 80.08 | 52 | 75 | 12 | 107.04 | 241.94 | 0.59 | 0.30 | 44.24% |
| 64 | 1 | 2 | 80.08 | 52 | 75 | 25 | 107.04 | 241.94 | 0.62 | 0.31 | 44.24% |
| 65 | 1 | 2 | 80.08 | 70.75 | 93.75 | 12 | 107.04 | 217.94 | 0.60 | 0.36 | 49.11% |
| 66 | 1 | 2 | 80.08 | 70.75 | 93.75 | 25 | 107.04 | 217.94 | 0.63 | 0.37 | 49.11% |
| 67 | 1 | 2 | 96 | 37 | 60 | 12 | 90.00 | 271.94 | 0.50 | 0.19 | 33.10% |

| | Inputs | | | | | | Theoretical | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model** | **SSK** | **SE** | **AR** | **PR** | **AvgPR** | **Failure** | **Arrivals** | **Processing** | **Util. SE** | **Util. SSK** | **Util.** |
| 68 | 1 | 2 | 96 | 37 | 60 | 25 | 90.00 | 271.94 | 0.52 | 0.19 | 33.10% |
| 69 | 1 | 2 | 96 | 52 | 75 | 12 | 90.00 | 241.94 | 0.50 | 0.23 | 37.20% |
| 70 | 1 | 2 | 96 | 52 | 75 | 25 | 90.00 | 241.94 | 0.53 | 0.23 | 37.20% |
| 71 | 1 | 2 | 96 | 70.75 | 93.75 | 12 | 90.00 | 217.94 | 0.51 | 0.28 | 41.30% |
| 72 | 1 | 2 | 96 | 70.75 | 93.75 | 25 | 90.00 | 217.94 | 0.53 | 0.29 | 41.30% |
| 73 | 1 | 3 | 66.07 | 37 | 60 | 12 | 128.44 | 332.91 | 0.51 | 0.24 | 38.58% |
| 74 | 1 | 3 | 66.07 | 37 | 60 | 25 | 128.44 | 332.91 | 0.53 | 0.24 | 38.58% |
| 75 | 1 | 3 | 66.07 | 52 | 75 | 12 | 128.44 | 302.91 | 0.51 | 0.29 | 42.40% |
| 76 | 1 | 3 | 66.07 | 52 | 75 | 25 | 128.44 | 302.91 | 0.53 | 0.29 | 42.40% |
| 77 | 1 | 3 | 66.07 | 70.75 | 93.75 | 12 | 128.44 | 278.91 | 0.52 | 0.34 | 46.05% |
| 78 | 1 | 3 | 66.07 | 70.75 | 93.75 | 25 | 128.44 | 278.91 | 0.54 | 0.35 | 46.05% |
| 79 | 1 | 3 | 80.08 | 37 | 60 | 12 | 107.04 | 332.91 | 0.42 | 0.19 | 32.15% |
| 80 | 1 | 3 | 80.08 | 37 | 60 | 25 | 107.04 | 332.91 | 0.45 | 0.19 | 32.15% |
| 81 | 1 | 3 | 80.08 | 52 | 75 | 12 | 107.04 | 302.91 | 0.43 | 0.23 | 35.34% |
| 82 | 1 | 3 | 80.08 | 52 | 75 | 25 | 107.04 | 302.91 | 0.45 | 0.23 | 35.34% |
| 83 | 1 | 3 | 80.08 | 70.75 | 93.75 | 12 | 107.04 | 278.91 | 0.43 | 0.28 | 38.38% |
| 84 | 1 | 3 | 80.08 | 70.75 | 93.75 | 25 | 107.04 | 278.91 | 0.45 | 0.29 | 38.38% |
| 85 | 1 | 3 | 96 | 37 | 60 | 12 | 90.00 | 332.91 | 0.36 | 0.15 | 27.03% |
| 86 | 1 | 3 | 96 | 37 | 60 | 25 | 90.00 | 332.91 | 0.37 | 0.16 | 27.03% |
| 87 | 1 | 3 | 96 | 52 | 75 | 12 | 90.00 | 302.91 | 0.36 | 0.19 | 29.71% |
| 88 | 1 | 3 | 96 | 52 | 75 | 25 | 90.00 | 302.91 | 0.37 | 0.19 | 29.71% |
| 89 | 1 | 3 | 96 | 70.75 | 93.75 | 12 | 90.00 | 278.91 | 0.36 | 0.23 | 32.27% |
| 90 | 1 | 3 | 96 | 70.75 | 93.75 | 25 | 90.00 | 278.91 | 0.37 | 0.23 | 32.27% |

| | ARENA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Arrivals** | ***Dev*** | **Selecting SSK** | **Actual for SE** | ***Dev*** | **Utilization SE** | ***Dev*** | **Utilization SSK** | ***Dev*** |
| 1 | 128.47 | *-0.02%* | 0.00% | 128.47 | *-0.02%* | 93.07% | *7.26%* | | |
| 7 | 106.03 | *0.94%* | 0.00% | 106.03 | *0.94%* | 82.77% | *0.07%* | | |
| 13 | 88.42 | *1.76%* | 0.00% | 88.42 | *1.76%* | 70.49% | *-2.05%* | | |
| 19 | 128.47 | *-0.02%* | 0.00% | 128.47 | *-0.02%* | 68.74% | *-2.74%* | | |
| 25 | 106.03 | *0.94%* | 0.00% | 106.03 | *0.94%* | 56.81% | *-2.87%* | | |
| 31 | 88.42 | *1.76%* | 0.00% | 88.42 | *1.76%* | 47.44% | *-3.02%* | | |
| 37 | 128.47 | *-0.02%* | 63.14% | 57.08 | *-0.02%* | 90.08% | *-1.00%* | 53.80% | *0.51%* |
| 38 | 128.47 | *-0.02%* | 70.04% | 60.98 | *-0.02%* | 92.63% | *2.78%* | 59.90% | *0.14%* |
| 39 | 128.47 | *-0.02%* | 61.45% | 59.00 | *-0.02%* | 91.17% | *1.10%* | 65.37% | *0.62%* |
| 40 | 128.47 | *-0.02%* | 66.96% | 63.95 | *-0.02%* | 93.58% | *6.34%* | 71.35% | *0.47%* |

| | ARENA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Arrivals** | ***Dev*** | **Selecting SSK** | **Actual for SE** | ***Dev*** | **Utilizatio n SE** | ***Dev*** | **Utilizatio n SSK** | ***Dev*** |
| 41 | 128.47 | *-0.02%* | 58.15% | 62.73 | *-0.02%* | 92.74% | *5.37%* | 77.13% | *0.87%* |
| 42 | 128.47 | *-0.02%* | 62.41% | 68.34 | *-0.02%* | 95.08% | *10.95%* | 82.89% | *0.75%* |
| 43 | 106.03 | *0.94%* | 57.62% | 52.27 | *0.94%* | 83.28% | *-1.98%* | 40.66% | *0.16%* |
| 44 | 107.26 | *-0.20%* | 63.66% | 56.05 | *-0.20%* | 87.67% | *-0.11%* | 45.18% | *0.75%* |
| 45 | 107.26 | *-0.20%* | 56.54% | 53.90 | *-0.20%* | 84.71% | *-0.59%* | 50.12% | *0.82%* |
| 46 | 107.26 | *-0.20%* | 61.83% | 57.52 | *-0.20%* | 88.10% | *1.97%* | 54.82% | *0.82%* |
| 47 | 107.26 | *-0.20%* | 55.19% | 55.16 | *-0.20%* | 86.16% | *0.03%* | 60.87% | *1.29%* |
| 48 | 107.26 | *-0.20%* | 59.47% | 59.42 | *-0.20%* | 89.68% | *3.39%* | 65.69% | *1.14%* |
| 49 | 88.42 | *1.76%* | 52.88% | 47.27 | *1.76%* | 75.70% | *-2.50%* | 30.97% | *0.66%* |
| 50 | 88.42 | *1.76%* | 57.33% | 50.40 | *1.76%* | 79.85% | *-1.41%* | 33.73% | *0.20%* |
| 51 | 88.42 | *1.76%* | 51.47% | 48.37 | *1.76%* | 76.66% | *-1.45%* | 37.66% | *0.69%* |
| 52 | 88.42 | *1.76%* | 56.42% | 51.00 | *1.76%* | 80.48% | *-1.00%* | 41.42% | *0.38%* |
| 53 | 88.42 | *1.76%* | 50.29% | 49.29 | *1.76%* | 77.82% | *-1.07%* | 46.11% | *0.46%* |
| 54 | 88.42 | *1.76%* | 54.43% | 52.32 | *1.76%* | 81.82% | *-0.09%* | 49.87% | *0.53%* |
| 55 | 128.47 | *-0.02%* | 36.75% | 86.93 | *-0.02%* | 69.99% | *-3.07%* | 31.09% | *1.22%* |
| 56 | 128.47 | *-0.02%* | 38.87% | 91.02 | *-0.02%* | 72.97% | *-2.63%* | 32.93% | *1.09%* |
| 57 | 128.47 | *-0.02%* | 35.79% | 88.01 | *-0.02%* | 70.76% | *-2.92%* | 37.83% | *1.28%* |
| 58 | 128.47 | *-0.02%* | 37.58% | 92.26 | *-0.02%* | 74.00% | *-2.67%* | 39.67% | *1.40%* |
| 59 | 128.47 | *-0.02%* | 34.49% | 89.48 | *-0.02%* | 71.83% | *-2.76%* | 45.54% | *1.34%* |
| 60 | 128.47 | *-0.02%* | 36.18% | 93.61 | *-0.02%* | 74.61% | *-2.03%* | 47.76% | *1.35%* |
| 61 | 106.03 | *0.94%* | 34.08% | 74.23 | *0.94%* | 59.61% | *-2.80%* | 24.13% | *-0.14%* |
| 62 | 107.26 | *-0.20%* | 35.38% | 78.80 | *-0.20%* | 63.23% | *-2.72%* | 25.23% | *0.29%* |
| 63 | 107.26 | *-0.20%* | 33.16% | 75.96 | *-0.20%* | 61.33% | *-3.36%* | 29.42% | *0.73%* |
| 64 | 107.26 | *-0.20%* | 34.60% | 79.43 | *-0.20%* | 63.43% | *-2.22%* | 30.73% | *0.62%* |
| 65 | 107.26 | *-0.20%* | 32.04% | 77.01 | *-0.20%* | 61.94% | *-2.95%* | 35.63% | *0.48%* |
| 66 | 107.26 | *-0.20%* | 33.20% | 80.55 | *-0.20%* | 64.39% | *-2.33%* | 37.04% | *0.15%* |
| 67 | 88.42 | *1.76%* | 31.75% | 63.72 | *1.76%* | 51.38% | *-3.22%* | 18.68% | *0.18%* |
| 68 | 88.42 | *1.76%* | 32.39% | 66.94 | *1.76%* | 54.01% | *-3.29%* | 19.04% | *0.26%* |
| 69 | 88.42 | *1.76%* | 30.90% | 64.38 | *1.76%* | 51.88% | *-3.15%* | 22.69% | *0.34%* |
| 70 | 88.42 | *1.76%* | 31.72% | 67.38 | *1.76%* | 54.31% | *-3.18%* | 23.40% | *-0.11%* |
| 71 | 88.42 | *1.76%* | 30.22% | 64.91 | *1.76%* | 52.23% | *-3.02%* | 27.81% | *0.09%* |
| 72 | 88.42 | *1.76%* | 31.10% | 67.80 | *1.76%* | 54.42% | *-2.76%* | 28.58% | *0.24%* |
| 73 | 128.47 | *-0.02%* | 27.58% | 97.29 | *-0.02%* | 52.30% | *-3.21%* | 23.63% | *-0.03%* |
| 74 | 128.47 | *-0.02%* | 28.22% | 101.28 | *-0.02%* | 54.35% | *-3.06%* | 24.11% | *0.28%* |
| 75 | 128.47 | *-0.02%* | 26.86% | 98.10 | *-0.02%* | 52.73% | *-3.21%* | 28.75% | *0.01%* |
| 76 | 128.47 | *-0.02%* | 27.20% | 102.27 | *-0.02%* | 54.99% | *-3.26%* | 29.11% | *0.02%* |
| 77 | 128.47 | *-0.02%* | 25.74% | 99.37 | *-0.02%* | 53.30% | *-2.99%* | 34.26% | *0.56%* |
| 78 | 128.47 | *-0.02%* | 26.03% | 103.39 | *-0.02%* | 55.41% | *-2.91%* | 34.66% | *0.50%* |
| 79 | 106.03 | *0.94%* | 26.82% | 81.00 | *0.94%* | 43.50% | *-3.12%* | 18.85% | *0.56%* |

| | ARENA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Arrivals** | ***Dev*** | **Selecting SSK** | **Actual for SE** | ***Dev*** | **Utilizatio n SE** | ***Dev*** | **Utilizatio n SSK** | ***Dev*** |
| 80 | 107.26 | *-0.20%* | 26.59% | 85.87 | *-0.20%* | 46.11% | *-3.11%* | 18.96% | *0.28%* |
| 81 | 107.26 | *-0.20%* | 25.72% | 82.98 | *-0.20%* | 44.52% | *-3.02%* | 22.83% | *0.69%* |
| 82 | 107.26 | *-0.20%* | 26.03% | 86.32 | *-0.20%* | 46.46% | *-3.35%* | 23.17% | *0.41%* |
| 83 | 107.26 | *-0.20%* | 25.19% | 83.48 | *-0.20%* | 44.81% | *-3.08%* | 27.89% | *0.91%* |
| 84 | 107.26 | *-0.20%* | 25.61% | 86.66 | *-0.20%* | 46.38% | *-2.77%* | 28.44% | *0.59%* |
| 85 | 88.42 | *1.76%* | 25.94% | 68.23 | *1.76%* | 36.74% | *-3.39%* | 15.33% | *-0.23%* |
| 86 | 88.42 | *1.76%* | 26.34% | 70.95 | *1.76%* | 38.12% | *-3.16%* | 15.57% | *-0.25%* |
| 87 | 88.42 | *1.76%* | 25.36% | 68.69 | *1.76%* | 37.02% | *-3.50%* | 18.75% | *-0.35%* |
| 88 | 88.42 | *1.76%* | 25.64% | 71.42 | *1.76%* | 38.35% | *-3.12%* | 18.93% | *-0.19%* |
| 89 | 88.42 | *1.76%* | 24.73% | 69.17 | *1.76%* | 37.32% | *-3.61%* | 22.92% | *-0.62%* |
| 90 | 88.42 | *1.76%* | 24.98% | 71.85 | *1.76%* | 38.59% | *-3.12%* | 23.06% | *-0.19%* |

## Appendix G: Simulation Analysis Output

| | Service Level | | | Waiting Time | | | Waiting Time for SSK | | | Waiting Time for SE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** |
| 1 | 0.23 | 0.03 | 0.69 | 523.06 | 97,774.44 | 1,470.59 | 0.00 | 0.00 | 0.00 | 529.71 | 99,470.32 | 1,482.50 |
| 7 | 0.48 | 0.04 | 0.88 | 233.34 | 26,827.17 | 810.94 | 0.00 | 0.00 | 0.00 | 233.84 | 26,620.70 | 818.48 |
| 13 | 0.67 | 0.03 | 0.97 | 113.95 | 6,921.17 | 439.22 | 0.00 | 0.00 | 0.00 | 113.62 | 6,758.49 | 432.85 |
| 19 | 0.82 | 0.01 | 0.99 | 54.99 | 1,269.02 | 205.31 | 0.00 | 0.00 | 0.00 | 55.17 | 1,269.40 | 207.64 |
| 25 | 0.90 | 0.01 | 1.00 | 27.34 | 353.40 | 86.19 | 0.00 | 0.00 | 0.00 | 27.21 | 344.35 | 83.92 |
| 31 | 0.94 | 0.00 | 1.00 | 14.84 | 150.60 | 60.04 | 0.00 | 0.00 | 0.00 | 14.86 | 148.62 | 59.35 |
| 37 | 0.64 | 0.01 | 0.80 | 129.52 | 1,695.16 | 296.29 | 38.16 | 468.48 | 150.34 | 134.77 | 1,640.53 | 304.06 |
| 38 | 0.53 | 0.01 | 0.72 | 186.78 | 5,330.74 | 405.73 | 50.78 | 1,092.52 | 197.73 | 181.56 | 5,062.78 | 455.36 |
| 39 | 0.54 | 0.01 | 0.78 | 175.72 | 5,361.52 | 484.11 | 79.57 | 2,728.68 | 339.95 | 173.48 | 5,282.42 | 474.91 |
| 40 | 0.43 | 0.02 | 0.65 | 248.21 | 13,783.96 | 597.96 | 106.89 | 5,589.69 | 398.71 | 243.07 | 17,269.92 | 753.50 |
| 41 | 0.41 | 0.02 | 0.72 | 277.83 | 24,074.32 | 752.07 | 172.27 | 15,817.97 | 545.53 | 271.32 | 29,621.59 | 929.58 |
| 42 | 0.28 | 0.02 | 0.63 | 400.80 | 45,843.82 | 1,109.13 | 242.02 | 28,003.16 | 783.31 | 389.33 | 55,660.94 | 1,254.40 |
| 43 | 0.69 | 0.00 | 0.87 | 101.46 | 907.50 | 174.40 | 23.11 | 228.45 | 74.39 | 109.93 | 850.68 | 218.60 |
| 44 | 0.59 | 0.01 | 0.75 | 142.58 | 2,353.33 | 284.41 | 27.17 | 203.20 | 84.89 | 139.25 | 1,909.86 | 279.01 |
| 45 | 0.65 | 0.01 | 0.80 | 118.86 | 1,861.25 | 299.96 | 40.11 | 536.87 | 136.88 | 123.32 | 1,801.94 | 290.43 |
| 46 | 0.54 | 0.01 | 0.73 | 170.35 | 4,712.11 | 408.63 | 53.57 | 1,378.61 | 209.48 | 161.54 | 3,661.56 | 354.56 |
| 47 | 0.55 | 0.01 | 0.78 | 166.03 | 6,359.49 | 486.81 | 83.76 | 3,436.93 | 336.22 | 155.74 | 4,698.54 | 451.22 |
| 48 | 0.45 | 0.01 | 0.65 | 226.65 | 11,854.44 | 642.51 | 107.75 | 5,499.72 | 435.07 | 205.72 | 10,083.64 | 572.97 |
| 49 | 0.74 | 0.00 | 0.90 | 78.99 | 813.25 | 177.13 | 14.85 | 89.90 | 54.40 | 89.84 | 789.43 | 181.03 |
| 50 | 0.64 | 0.01 | 0.83 | 108.59 | 1,676.52 | 250.90 | 17.92 | 155.13 | 77.22 | 111.38 | 1,310.15 | 219.66 |
| 51 | 0.71 | 0.01 | 0.89 | 90.51 | 1,542.44 | 240.36 | 25.73 | 339.51 | 96.80 | 98.53 | 1,387.90 | 247.75 |
| 52 | 0.61 | 0.01 | 0.75 | 124.20 | 3,119.23 | 421.55 | 30.84 | 451.68 | 106.86 | 123.66 | 2,798.79 | 445.92 |
| 53 | 0.66 | 0.01 | 0.86 | 111.49 | 2,585.82 | 293.01 | 47.04 | 1,117.81 | 198.26 | 111.78 | 2,136.22 | 294.92 |
| 54 | 0.57 | 0.01 | 0.80 | 145.14 | 4,323.41 | 351.16 | 55.39 | 1,390.07 | 184.25 | 137.03 | 3,591.53 | 376.63 |
| 55 | 0.83 | 0.00 | 0.95 | 41.27 | 261.41 | 87.51 | 10.46 | 42.55 | 38.50 | 45.83 | 271.72 | 94.91 |
| 56 | 0.76 | 0.00 | 0.93 | 53.95 | 513.72 | 127.93 | 12.13 | 69.20 | 43.50 | 55.64 | 425.81 | 115.71 |
| 57 | 0.81 | 0.00 | 0.94 | 49.11 | 408.10 | 113.10 | 19.01 | 170.60 | 82.82 | 51.03 | 376.53 | 102.96 |

| | Service Level | | | Waiting Time | | | Waiting Time for SSK | | | Waiting Time for SE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** |
| 58 | 0.74 | 0.01 | 0.91 | 62.23 | 709.98 | 131.09 | 21.49 | 193.50 | 88.29 | 61.32 | 575.52 | 119.34 |
| 59 | 0.78 | 0.01 | 0.93 | 61.04 | 890.09 | 164.84 | 32.14 | 557.28 | 140.72 | 59.08 | 706.86 | 161.11 |
| 60 | 0.71 | 0.01 | 0.90 | 74.60 | 1,544.87 | 209.34 | 37.33 | 621.34 | 161.78 | 69.05 | 1,175.89 | 186.35 |
| 61 | 0.87 | 0.00 | 0.96 | 28.51 | 199.18 | 85.83 | 7.54 | 27.34 | 30.02 | 32.74 | 242.19 | 90.33 |
| 62 | 0.81 | 0.00 | 0.94 | 35.67 | 302.23 | 88.30 | 7.91 | 39.90 | 37.53 | 38.70 | 295.84 | 86.87 |
| 63 | 0.86 | 0.00 | 0.94 | 32.26 | 210.86 | 82.09 | 12.79 | 79.81 | 58.80 | 34.64 | 209.19 | 82.42 |
| 64 | 0.81 | 0.00 | 0.94 | 39.98 | 402.74 | 124.90 | 14.49 | 128.39 | 60.42 | 41.00 | 352.73 | 116.98 |
| 65 | 0.84 | 0.00 | 0.94 | 38.19 | 346.03 | 100.08 | 20.82 | 211.29 | 85.29 | 38.19 | 319.81 | 111.18 |
| 66 | 0.78 | 0.00 | 0.90 | 47.88 | 597.71 | 147.50 | 23.41 | 230.46 | 80.02 | 45.90 | 492.18 | 137.98 |
| 67 | 0.90 | 0.00 | 0.98 | 19.90 | 157.09 | 63.03 | 5.31 | 20.98 | 27.80 | 23.45 | 200.52 | 69.08 |
| 68 | 0.85 | 0.00 | 0.95 | 24.30 | 208.93 | 84.65 | 5.39 | 18.06 | 22.75 | 27.25 | 226.82 | 88.34 |
| 69 | 0.89 | 0.00 | 0.98 | 22.30 | 189.67 | 98.82 | 8.71 | 51.97 | 40.77 | 24.67 | 214.49 | 101.53 |
| 70 | 0.84 | 0.00 | 0.95 | 27.66 | 344.02 | 110.71 | 9.60 | 58.66 | 36.89 | 29.08 | 332.05 | 97.68 |
| 71 | 0.88 | 0.00 | 0.98 | 25.24 | 210.77 | 84.88 | 14.58 | 116.63 | 45.91 | 25.56 | 208.07 | 83.99 |
| 72 | 0.83 | 0.00 | 0.96 | 30.61 | 370.25 | 121.91 | 15.89 | 158.04 | 79.19 | 29.87 | 317.15 | 108.72 |
| 73 | 0.93 | 0.00 | 0.99 | 11.85 | 43.96 | 34.76 | 6.34 | 19.04 | 19.79 | 12.36 | 52.30 | 38.28 |
| 74 | 0.89 | 0.00 | 0.96 | 14.31 | 67.94 | 48.37 | 5.99 | 16.59 | 18.04 | 14.83 | 76.60 | 52.62 |
| 75 | 0.92 | 0.00 | 0.98 | 13.64 | 60.77 | 43.62 | 9.76 | 41.11 | 28.81 | 13.29 | 64.81 | 45.02 |
| 76 | 0.88 | 0.00 | 0.96 | 16.72 | 86.37 | 54.75 | 9.83 | 41.81 | 31.71 | 16.19 | 87.81 | 53.57 |
| 77 | 0.91 | 0.00 | 0.98 | 15.80 | 72.56 | 44.35 | 15.00 | 67.53 | 37.04 | 13.90 | 71.87 | 45.13 |
| 78 | 0.88 | 0.00 | 0.97 | 18.99 | 112.08 | 63.16 | 16.03 | 84.28 | 44.16 | 16.32 | 97.90 | 57.74 |
| 79 | 0.94 | 0.00 | 0.99 | 6.81 | 27.88 | 30.05 | 4.66 | 15.92 | 16.93 | 6.90 | 34.35 | 32.55 |
| 80 | 0.90 | 0.00 | 0.97 | 8.36 | 31.99 | 31.07 | 4.37 | 16.16 | 18.83 | 8.57 | 34.93 | 29.73 |
| 81 | 0.94 | 0.00 | 0.99 | 7.66 | 28.42 | 33.26 | 7.03 | 35.65 | 28.52 | 6.99 | 29.73 | 32.03 |
| 82 | 0.90 | 0.00 | 0.96 | 9.51 | 44.12 | 41.06 | 6.66 | 34.33 | 28.52 | 9.07 | 42.17 | 40.65 |
| 83 | 0.93 | 0.00 | 0.99 | 9.36 | 36.37 | 33.49 | 11.16 | 65.27 | 39.63 | 7.78 | 33.96 | 31.98 |
| 84 | 0.90 | 0.00 | 0.99 | 10.73 | 46.28 | 43.30 | 11.68 | 70.63 | 38.63 | 8.68 | 41.61 | 40.81 |

| | Service Level | | | Waiting Time | | | Waiting Time for SSK | | | Waiting Time for SE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** |
| 85 | 0.95 | 0.00 | 1.00 | 4.29 | 12.52 | 16.40 | 3.47 | 14.13 | 19.61 | 4.19 | 16.07 | 16.17 |
| 86 | 0.92 | 0.00 | 0.99 | 5.06 | 17.89 | 20.39 | 3.63 | 12.29 | 17.54 | 5.00 | 24.59 | 21.74 |
| 87 | 0.94 | 0.00 | 1.00 | 4.96 | 14.70 | 19.23 | 5.90 | 31.11 | 28.83 | 4.21 | 18.13 | 21.29 |
| 88 | 0.91 | 0.00 | 0.98 | 5.95 | 23.40 | 31.16 | 5.79 | 27.96 | 28.83 | 5.32 | 29.65 | 31.55 |
| 89 | 0.94 | 0.00 | 1.00 | 6.11 | 21.69 | 24.95 | 9.51 | 59.67 | 37.00 | 4.36 | 21.72 | 27.14 |
| 90 | 0.91 | 0.00 | 0.97 | 7.21 | 30.51 | 29.47 | 9.54 | 57.65 | 37.00 | 5.52 | 31.88 | 32.51 |

| | Number in SSK Line | | | Number in SE line | | | SSK Utilization | | | SE Utilization | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** |
| 1 | 0.00 | 0.00 | 0.00 | 7.765 | 24.118 | 22.160 | 0.00% | 0.00% | 0.00% | 93.07% | 0.31% | 99.59% |
| 7 | 0.00 | 0.00 | 0.00 | 2.834 | 4.135 | 10.536 | 0.00% | 0.00% | 0.00% | 82.77% | 0.70% | 98.75% |
| 13 | 0.00 | 0.00 | 0.00 | 1.153 | 0.741 | 4.037 | 0.00% | 0.00% | 0.00% | 70.49% | 0.81% | 93.47% |
| 19 | 0.00 | 0.00 | 0.00 | 0.818 | 0.342 | 3.701 | 0.00% | 0.00% | 0.00% | 68.74% | 0.55% | 87.06% |
| 25 | 0.00 | 0.00 | 0.00 | 0.331 | 0.054 | 1.035 | 0.00% | 0.00% | 0.00% | 56.81% | 0.43% | 71.64% |
| 31 | 0.00 | 0.00 | 0.00 | 0.151 | 0.016 | 0.574 | 0.00% | 0.00% | 0.00% | 47.44% | 0.38% | 63.01% |
| 37 | 0.37 | 0.07 | 1.95 | 1.555 | 0.236 | 3.410 | 53.80% | 0.63% | 80.03% | 90.08% | 0.20% | 99.68% |
| 38 | 0.56 | 0.19 | 2.71 | 2.258 | 0.742 | 4.773 | 59.90% | 0.86% | 82.62% | 92.63% | 0.20% | 99.66% |
| 39 | 0.77 | 0.36 | 4.11 | 1.847 | 0.484 | 4.873 | 65.37% | 0.78% | 86.59% | 91.17% | 0.21% | 99.83% |
| 40 | 1.14 | 0.85 | 5.05 | 2.601 | 1.220 | 6.043 | 71.35% | 1.00% | 96.35% | 93.58% | 0.18% | 99.88% |
| 41 | 1.65 | 1.82 | 6.59 | 2.509 | 1.643 | 6.873 | 77.13% | 0.91% | 97.11% | 92.74% | 0.21% | 99.71% |
| 42 | 2.48 | 3.59 | 8.44 | 3.556 | 2.904 | 8.523 | 82.89% | 0.78% | 99.25% | 95.08% | 0.12% | 99.88% |
| 43 | 0.17 | 0.02 | 0.57 | 1.063 | 0.109 | 1.949 | 40.66% | 0.60% | 59.04% | 83.28% | 0.34% | 96.32% |
| 44 | 0.22 | 0.02 | 0.86 | 1.530 | 0.305 | 3.008 | 45.18% | 0.59% | 64.83% | 87.67% | 0.41% | 99.30% |
| 45 | 0.30 | 0.05 | 1.26 | 1.165 | 0.174 | 2.711 | 50.12% | 0.62% | 73.26% | 84.71% | 0.41% | 97.84% |
| 46 | 0.44 | 0.12 | 2.01 | 1.673 | 0.428 | 3.613 | 54.82% | 0.84% | 78.18% | 88.10% | 0.34% | 98.85% |
| 47 | 0.63 | 0.25 | 2.84 | 1.412 | 0.387 | 3.896 | 60.87% | 0.86% | 84.51% | 86.16% | 0.42% | 97.91% |
| 48 | 0.87 | 0.52 | 4.25 | 1.942 | 0.775 | 5.131 | 65.69% | 1.06% | 91.72% | 89.68% | 0.32% | 99.66% |
| 49 | 0.09 | 0.00 | 0.34 | 0.710 | 0.081 | 1.652 | 30.97% | 0.47% | 44.33% | 75.70% | 0.45% | 91.45% |
| 50 | 0.11 | 0.01 | 0.49 | 0.990 | 0.171 | 2.472 | 33.73% | 0.56% | 51.89% | 79.85% | 0.53% | 96.63% |
| 51 | 0.15 | 0.01 | 0.56 | 0.774 | 0.119 | 1.844 | 37.66% | 0.71% | 60.38% | 76.66% | 0.48% | 91.45% |
| 52 | 0.19 | 0.02 | 0.85 | 1.084 | 0.289 | 4.263 | 41.42% | 0.81% | 65.81% | 80.48% | 0.44% | 95.52% |
| 53 | 0.27 | 0.05 | 1.10 | 0.865 | 0.152 | 2.466 | 46.11% | 1.04% | 67.20% | 77.82% | 0.50% | 93.64% |
| 54 | 0.34 | 0.07 | 1.21 | 1.144 | 0.284 | 3.313 | 49.87% | 1.26% | 75.19% | 81.82% | 0.45% | 97.19% |
| 55 | 0.06 | 0.00 | 0.20 | 0.538 | 0.053 | 1.231 | 31.09% | 0.30% | 47.54% | 69.99% | 0.42% | 86.41% |

| | Number in SSK Line | | | Number in SE line | | | SSK Utilization | | | SE Utilization | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** |
| 56 | 0.08 | 0.00 | 0.33 | 0.709 | 0.105 | 2.004 | 32.93% | 0.37% | 50.25% | 72.97% | 0.41% | 89.25% |
| 57 | 0.11 | 0.01 | 0.45 | 0.604 | 0.068 | 1.366 | 37.83% | 0.45% | 56.56% | 70.76% | 0.45% | 86.38% |
| 58 | 0.13 | 0.01 | 0.43 | 0.778 | 0.122 | 1.935 | 39.67% | 0.53% | 62.27% | 74.00% | 0.43% | 91.96% |
| 59 | 0.19 | 0.02 | 0.92 | 0.701 | 0.121 | 2.112 | 45.54% | 0.73% | 65.78% | 71.83% | 0.46% | 88.20% |
| 60 | 0.23 | 0.03 | 0.97 | 0.867 | 0.238 | 2.754 | 47.76% | 0.77% | 72.84% | 74.61% | 0.46% | 90.44% |
| 61 | 0.03 | 0.00 | 0.18 | 0.310 | 0.027 | 0.923 | 24.13% | 0.29% | 35.87% | 59.61% | 0.32% | 75.58% |
| 62 | 0.04 | 0.00 | 0.17 | 0.399 | 0.043 | 1.031 | 25.23% | 0.24% | 37.34% | 63.23% | 0.47% | 79.14% |
| 63 | 0.06 | 0.00 | 0.24 | 0.337 | 0.027 | 0.870 | 29.42% | 0.31% | 41.24% | 61.33% | 0.43% | 78.17% |
| 64 | 0.07 | 0.00 | 0.32 | 0.419 | 0.052 | 1.313 | 30.73% | 0.37% | 45.49% | 63.43% | 0.49% | 80.52% |
| 65 | 0.10 | 0.01 | 0.33 | 0.375 | 0.042 | 1.260 | 35.63% | 0.52% | 51.59% | 61.94% | 0.51% | 79.04% |
| 66 | 0.11 | 0.01 | 0.37 | 0.475 | 0.070 | 1.686 | 37.04% | 0.56% | 53.69% | 64.39% | 0.48% | 81.34% |
| 67 | 0.02 | 0.00 | 0.11 | 0.185 | 0.015 | 0.614 | 18.68% | 0.22% | 28.98% | 51.38% | 0.40% | 64.42% |
| 68 | 0.02 | 0.00 | 0.11 | 0.230 | 0.021 | 0.775 | 19.04% | 0.23% | 29.82% | 54.01% | 0.52% | 73.95% |
| 69 | 0.03 | 0.00 | 0.19 | 0.197 | 0.017 | 0.857 | 22.69% | 0.32% | 37.40% | 51.88% | 0.45% | 66.29% |
| 70 | 0.03 | 0.00 | 0.17 | 0.248 | 0.034 | 1.085 | 23.40% | 0.36% | 36.15% | 54.31% | 0.55% | 75.97% |
| 71 | 0.05 | 0.00 | 0.19 | 0.205 | 0.017 | 0.709 | 27.81% | 0.50% | 45.29% | 52.23% | 0.50% | 67.21% |
| 72 | 0.06 | 0.00 | 0.34 | 0.253 | 0.028 | 0.930 | 28.58% | 0.53% | 46.06% | 54.42% | 0.53% | 72.78% |
| 73 | 0.03 | 0.00 | 0.10 | 0.143 | 0.008 | 0.489 | 23.63% | 0.16% | 32.49% | 52.30% | 0.33% | 66.81% |
| 74 | 0.03 | 0.00 | 0.10 | 0.180 | 0.013 | 0.693 | 24.11% | 0.18% | 33.44% | 54.35% | 0.35% | 69.39% |
| 75 | 0.04 | 0.00 | 0.15 | 0.155 | 0.010 | 0.578 | 28.75% | 0.26% | 41.71% | 52.73% | 0.32% | 66.13% |
| 76 | 0.04 | 0.00 | 0.15 | 0.198 | 0.015 | 0.661 | 29.11% | 0.25% | 41.25% | 54.99% | 0.36% | 70.38% |
| 77 | 0.07 | 0.00 | 0.21 | 0.164 | 0.011 | 0.486 | 34.26% | 0.32% | 48.76% | 53.30% | 0.34% | 67.99% |
| 78 | 0.08 | 0.00 | 0.24 | 0.203 | 0.017 | 0.736 | 34.66% | 0.38% | 48.76% | 55.41% | 0.36% | 72.39% |
| 79 | 0.02 | 0.00 | 0.07 | 0.066 | 0.003 | 0.329 | 18.85% | 0.17% | 28.91% | 43.50% | 0.28% | 57.61% |
| 80 | 0.02 | 0.00 | 0.08 | 0.086 | 0.004 | 0.305 | 18.96% | 0.13% | 27.55% | 46.11% | 0.31% | 60.75% |
| 81 | 0.02 | 0.00 | 0.12 | 0.068 | 0.003 | 0.327 | 22.83% | 0.21% | 33.83% | 44.52% | 0.29% | 56.43% |
| 82 | 0.02 | 0.00 | 0.13 | 0.093 | 0.005 | 0.411 | 23.17% | 0.22% | 34.08% | 46.46% | 0.33% | 59.42% |

| | Number in SSK Line | | | Number in SE line | | | SSK Utilization | | | SE Utilization | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** | **Mean** | ***Var.*** | ***Max*** |
| 83 | 0.04 | 0.00 | 0.19 | 0.076 | 0.004 | 0.281 | 27.89% | 0.33% | 42.12% | 44.81% | 0.33% | 58.87% |
| 84 | 0.04 | 0.00 | 0.18 | 0.088 | 0.005 | 0.408 | 28.44% | 0.38% | 42.26% | 46.38% | 0.35% | 58.65% |
| 85 | 0.01 | 0.00 | 0.04 | 0.034 | 0.001 | 0.133 | 15.33% | 0.14% | 22.57% | 36.74% | 0.27% | 49.18% |
| 86 | 0.01 | 0.00 | 0.04 | 0.042 | 0.002 | 0.189 | 15.57% | 0.14% | 23.53% | 38.12% | 0.28% | 51.72% |
| 87 | 0.02 | 0.00 | 0.07 | 0.034 | 0.001 | 0.175 | 18.75% | 0.21% | 28.26% | 37.02% | 0.29% | 48.36% |
| 88 | 0.02 | 0.00 | 0.07 | 0.044 | 0.002 | 0.263 | 18.93% | 0.23% | 29.44% | 38.35% | 0.26% | 51.72% |
| 89 | 0.03 | 0.00 | 0.11 | 0.036 | 0.002 | 0.253 | 22.92% | 0.35% | 35.87% | 37.32% | 0.29% | 48.98% |
| 90 | 0.03 | 0.00 | 0.11 | 0.047 | 0.003 | 0.318 | 23.06% | 0.35% | 36.05% | 38.59% | 0.28% | 51.72% |

## Vita

**Alinda Kokkinou** (Born 1980, Athens, Greece)

### Education

Bachelor of European Hospitality Management and Bachelor of Business Administration
Hotelschool The Hague, The Netherlands (June 2003)
Master of Business Administration in Hospitality Management
Institut de Management Hotelier International, ESSEC-Cornell University, France (June 2005)
Doctor of Philosophy in Hotel, Restaurant and Institutional Management and Operations Research
Pennsylvania State University, University Park, PA, USA (anticipated graduation December 2010)

### Teaching

HRIM 350 Hospitality Decision Making and Information Systems (Spring 2009, Fall 2009),
HRIM 480 Advanced Hotel Management (Fall 2009)
HRIM 350 Hospitality Decision Making and Information Systems (Assistant Fall 2006, Spring 2007, Spring 2008, Fall 2009),
HRIM 497 Revenue Management (Assistant Spring 2007, Spring 2008)
HRIM 430 Financial Management for Hospitality Operations (Assistant Fall 2007)

### Refereed Conference Presentations

Kokkinou, A., & Noone, B. M. (2009). Self Service Technology and Staffing Decisions Using Simulation in the Hospitality Industry*. Paper presented at the 14th Annual Graduate Student Research Conference in Hospitality and Tourism*, Las Vegas, NV, USA. 4 - 6 January 2009 ***(Best Paper Award)***

Kokkinou, A., & Noone, B. M. (2008). Reference Price Formation in the Context of Revenue Management. *Paper presented at the 17th Annual Frontiers in Service Conference*, Center for Excellence in Service, Robert H. Smith School of Business, University of Maryland, USA. October 2-5, 2008

Kokkinou, A., & Noone, B. M. (2008). The Formation of Reference Price in the Context of Demand-based Pricing Practices and its Role in Consumer Perceptions of Price Fairness*. Paper presented at the 3rd International Conference on Services Management*, University Park, PA. May 9 - 10, 2008

### Posters

Kokkinou, A., & Cranage, D. A. (2010). Modeling Customers' Decision to Use Self-Service Technology, *2010 CHRIE Conference*, San Juan, Puerto Rico. 28-31 July 2010

Kokkinou, A., Cranage, D. A, Mitas, O., & Kim, Y. (2010). Customers' Motivations to Use Self-Service Technology in a Resort Context, *2010 CHRIE Conference*, San Juan, Puerto Rico. 28-31 July 2010

Kokkinou, A., & Cranage, D. A. (2009). The Decision to Implement Self-Service Technology and its Impact on Service Performance and Operating Costs, *Graduate Exhibition*. The Pennsylvania State University. 29 March 2009

Kokkinou, A., & Noone, B. M. (2008). Simulation as a Planning and Decision-Making Tool in the Context of Hospitality Operations Management*. 2008 Winter Simulation Conference*, Miami, FL. 7 - 10 December 2008

Kokkinou, A., & Noone, B. M. (2008). The Effect of Demand-Based Pricing Practices on Reference Price in the Hospitality Industry*. 13th Annual Graduate Education and Graduate Research Conference in Hospitality and Tourism*, Orlando, FL. January 3 - 5, 2008