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The Cost Cuts and System Performance Improvements through Waiting-Line Analyses:

A Case Study to a Food-Service Company

Matthew Sage

4/6/2013

1. Introduction

In a world that experiences constantly-increasing competition, it is necessary for businesses to constantly adapt and improve if they are to survive. In the past, this has meant developing a better quality product. In other industries, a major source of competition is price; the business that can offer the lowest price wins the consumer, and in yet other industries how innovative a company is decides on how profitable they become. In the food-service industry, each of these characteristics applies, but there is one factor that “outweighs” these methods of competition: Speed of Service. In the food industry (especially so in the fast food industry), the speed of service of a restaurant can make or break the business. Customers want to order their food and receive their food with a minimal wait. Establishing a competitive speed of service, however, is more of a balancing act than one might think: if the service is too slow, customers may leave and/or the chance of customers returning decrease. If too much emphasis is put on developing the speed of service (yes, there is such a thing), customers are happy but so much money is invested in improved technologies and increased labor that profit margins decrease drastically¹. One tool that is useful for finding this “perfect balance” is called waiting line analysis.

A waiting line analysis describes the characteristics of a waiting line with six key measures: arrival rate, service rate, average number of units in the waiting line, average number

¹ This is thanks to the law of Diminishing Returns. For example, say we currently had a service level of 60% (60% of our service time was within an established acceptable range). To improve that level from 60% to 70% wouldn't cost much; probably just the labor cost of one additional employee. To go from 70% to 80% might require an *additional* two employees. To go from 80% to 90% might require five additional employees; 90% to 95% could require 10 additional employees! At some point, the cost of improving the service level *exceeds* the benefit of improving the service level.

of units in the system, average time spent in the waiting line and average time a unit spends in the system (California State University). (A table describing these measures in more detail can be found in the Appendix) The general goal is to minimize the time spent waiting in the waiting line and in the system². This is done by increasing the service rate (this can be done in several different ways – described later in this paper). A faster service rate leads to overall better performance for the system (Ashley, 2000), which can be traced to higher customer satisfaction (as far as Speed of Service is concerned), and likely, repeat business.

To demonstrate how a waiting line analysis can help a business, what it shows and how to use a business, I have performed a brief “case study” of sorts for a food-industry business. For the sake of anonymity, this company will be referred to simply as Company A. Collected data and results of analysis can be found in the Appendix at the end of this paper. After giving background information about Company A, I will explain the results of the analysis and the implications for the Company. I will then make suggestions on how to improve the performance of the system (and thus, the bottom-line) for Company A. Finally, I will finish with a brief discussion of methods to improve customer satisfaction and retention without necessarily having to improve the waiting line system.

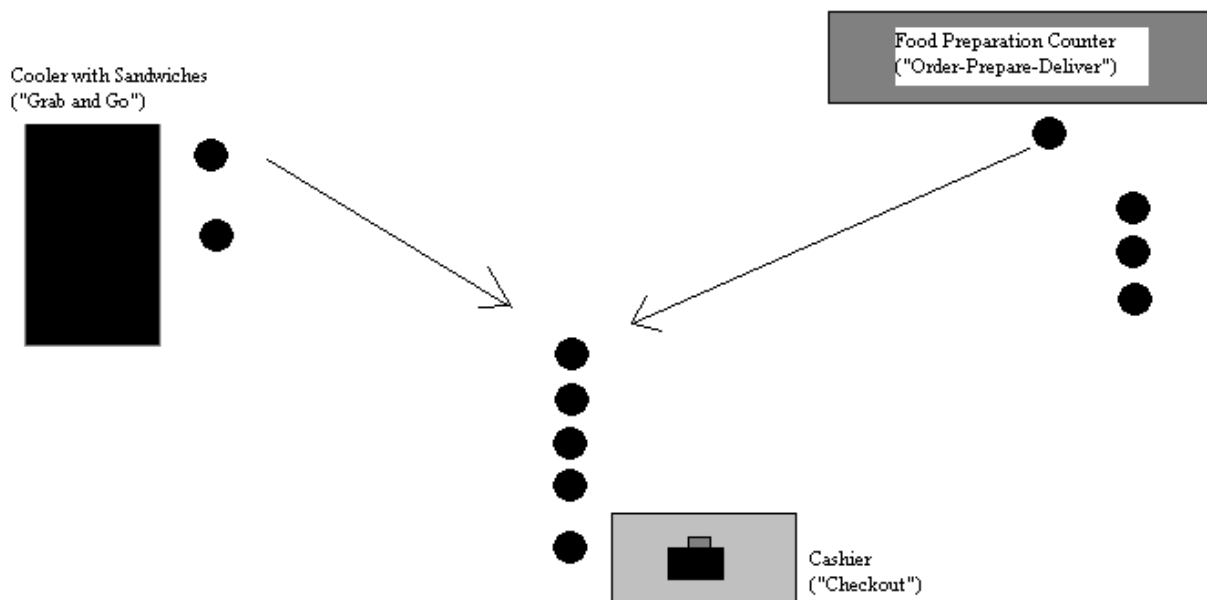
2. The Background Information of the Current Queuing System

Company A is a food-service business that tailors to subscription-based food plans. College campus food plans, food court locations that accept “tickets” and diners that offer “pre-paid combos” are all considered subscription-based meal options. For the sake of this analysis,

² “In the waiting line” refers to the actual wait once service has begun (i.e. from when the order was placed to when the order was received). “In the system” refers to the wait up *until* service begins (i.e. from when the customer gets in line up to the point that he/she begins placing their order)

there are two main types of check-out. The first is an “order-prepare-deliver” check-out. This means that a customer places an order with one of the kitchen attendants, the order is then forwarded onto the kitchen staff who then prepares the order. Once the food is finished being prepared it is then given to the customer, who then brings the completed meal to the check-out counter to pay. The second type of check-out is a “grab and go” check-out. In this instance, a customer grabs a pre-packaged combo (usually from a cooler containing sandwiches, salads, fruit and frozen meals), and brings it to the check-out counter to pay. Both check-out types use the same check-out counter. However, these check-outs are analyzed as if they were two separate systems³. For better understanding, reference figure 1 below:

Figure 1: Check-Out Layout



³ This is because the wait time is likely to vary significantly; For instance, it is much faster to grab a pre-made sandwich and pay than it is to place an order, wait for it to be cooked, and then pay. The resulting average of wait-times would be such that neither scenario would be accurately represented.

It is also important to note that, throughout this analysis, the number of servers (“channels”), is in reference to the number of cashiers and that the “time spent waiting” is in reference to the time in the checkout line. As a final note, understand that this study was only meant to look at the waiting time of check-out because check-out time is something that can actually be controlled. If we need to improve our service time (discussed later), we can add cashiers, find a way to streamline the process, etc. There isn’t much we can do to control the time it takes to cook food – especially since cooking temperatures and food quality is regulated on a Federal level. An analysis of wait time for food prep would be useful in seeing the degree of variance, but there is little the company could do to significantly improve its prep-time average, and thus, was not the intention of this study.

3. The Performance Analyses of the Current System

To begin the analysis, we must first understand the benchmarks for the given business in regards to the total amount of time spent waiting in the process (i.e. actually exchanging with the cashier) and the total amount of time spent waiting in the system (i.e. the line for check-out). Company A stated that its goal was to have wait-time within the process (labeled as W_q on the attached data sheet) kept to less than one minute, on average and the wait-time in the entire system (labeled as W on the attached data sheet) to be kept to less than two minutes.

Based on the data set analyzed, it would seem that these goals are largely achieved. The analysis reflects wait-time benchmarks versus actual wait-time as a probability; the probability that a customer will have to wait longer than the established benchmark. For waiting in the process, the probabilities across the dataset of that wait exceeding one minute were: 0.5%, 1.2%, 0.1%, 0.1%, 0.1%, 0.4%, 0.3%, and 0.2%. A simple average yields 0.36%, meaning the

probability of a customer waiting at the cash register for the transaction to complete for more than one minute is less than half a percent!

Results for waiting in the check-out line were also quite impressive, based on the given benchmarks. The probabilities across the dataset of the wait within the check-out line exceeding two minutes were: 7.1%, 9.3%, 6.3%, 5.6%, 9.4%, 9.6%, 10.4%, and 5.3%. A simple average yields a 7.8%. This means that the probability of a customer having to wait more than two minutes in the waiting line is only 7.8%.

“Total Cost” – in regards to waiting line analysis – refers to the cost of service (in this instance, the cost to pay the cashier), added to the cost of waiting (sales lost because of customers walking away before finishing a transaction). It was found that the total cost for the observed time period was very near \$15.30 (plus/minus 20 cents on any given day). Ideally, a company would want to find the perfect mix of cost of service and cost of waiting that yielded the lowest total cost⁴. Given that the hourly rate of a cashier is \$7.55 per hour, this total cost seems high – one would wonder if there is a way to reduce it. This will be discussed below in the “implications” section.

The final relevant piece of information from this analysis is the probability of “*n*” number of people in the system. Obviously, the data varies by day, but as a general trend it would seem that the probability of having more than two people in the system is only .9%. The probability of having more than three people is nearly zero, and the probability continues to decrease as the number of people increases. While this information will not be elaborated on further in the

⁴ This is builds on footnote 1 above; In this example, let’s say we decide to hire another cashier at \$7.55 per hour, let’s also say that this lowers our cost of waiting from \$1.16 to only \$0.85. While our “lost sales” did decrease (by 31 cents), the decrease was smaller than our service cost increase (\$7.55). We could conclude, then, that this would be a financially unwise decision; the same analysis could be performed in reverse – i.e. the benefit/risk of firing a cashier.

“implications” section, it is useful for gaining an understanding of the speed of service as well as what the waiting line “looks like” at a given time (for this case, it would be rare to see more than two people waiting to pay for their food).

While the performance of Company A’s check-out system seems quite impressive and meets the established benchmarks, this analysis brings up a few questions: are the benchmarks appropriate? Can “total cost” be reduced – and if so, what would the impact on service time be? These questions are explored in the following section.

4. Some Adjustments Suggested for the Current System

Company A performed astonishingly well compared to its established benchmarks in terms of waiting time in the system and waiting time within the waiting line. In fact, Company A performed almost too well. One could argue that such favorable results (violation of benchmark probability < 1%) could be the result of too-lenient of a benchmark. The role of checking-out an order, according to Company A, is composed of these steps:

1. Greet the customer while scanning in applicable items.
2. For items that do not have a barcode, do a manual look-up on the register.
3. When order is rung-in, hit subtotal and repeat the total to the customer.
4. When payment is given, type in the form (cash, credit card, etc.), and cash-out the order.
5. Thank the customer and hand them the receipt (when applicable).

Most experience cashiers were able to meet the one-minute benchmark with ease – in fact, in every dataset, the average time at the register was between 40 and 50 seconds. While doing these five tasks in under a minute is an acceptable goal, it is not a strenuous goal. A goal should be

attainable, but challenging – this allows it to be used as a tool for improving operational efficiency. Of course, Company A’s current customers (or at least the observed customers) did not seem to be bothered by the current service time, so there is no necessity for improvement. A more strenuous goal would simply result in an even better experience for the customers, but since there would be no value gained in doing so it should not be pursued, as doing so would only result in higher costs. It should also be noted that one Fast Food restaurant (whom also asked to remain anonymous) established their wait time benchmark at the front counter (register) to be 60 seconds or less. Even though 60 seconds may not be a difficult benchmark to achieve for Company A, it seems to be within industry standards. Whether to improve beyond these standards is a decision for upper management – based upon the intended direction for the Company, a topic well-beyond the reach of this paper.

Total Cost of Operations is the dominant area for improvement for Company A. Before delving into that, however, we shall briefly identify the source of the two costs: cost of service and cost of waiting:

The cost of service is essentially the cost of the server (the cashier) multiplied by the number of servers during the examined time. For Company A, the cost of a single server is \$7.55 – the hourly rate of the cashier. During all observed periods, there were two cashiers, so the cost of service for the examined time period (one hour) is \$15.10.

The cost of waiting is the potential sales that were lost from would-be customers choosing not to make a purchase (reasons can vary: food sounded unappealing, line too long, emergency came up, etc.) For the sake of waiting line analysis, we assume “walk-offs” are a result of the line being too long and a customer was unwilling to wait. Cost of waiting is:

$$(((Walk-Offs)/(Total Customers)) \times (Average Meal Price))/(Observation Time)) \times 60 mins$$

Understanding the calculations is not crucial for this analysis; just know that cost of waiting (for our purposes), is estimated lost sales within one hour. For this analysis, an average meal price of \$6.80 was used⁵.

The total cost of operations was regularly in the mid-\$15 range. This can be improved significantly. Company A should note that the service rate (81.81 customers/hour), is significantly higher than the arrival rate (27.88 customers/hour). Service capabilities are over three-time necessary capacity! A key cost-saving question should be asked, then: do we really need two cashiers? The answer is a sold “no”. A sample analysis assuming only one cashier instead of two (s = 1) yields far better economic results (see below):

Figure 2: 2 Cashiers Queuing System

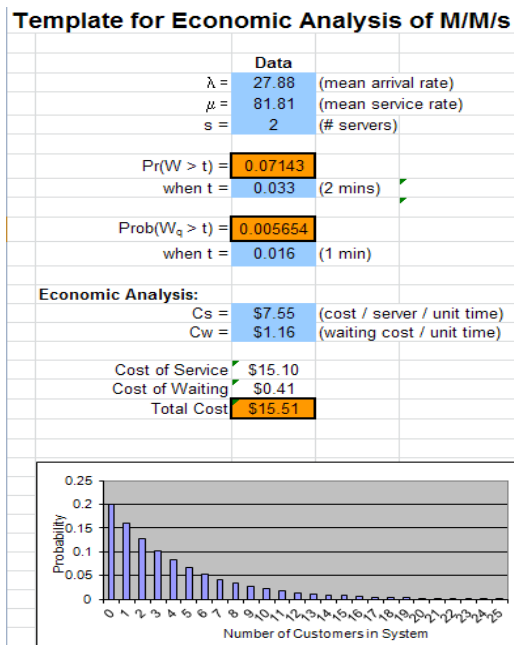
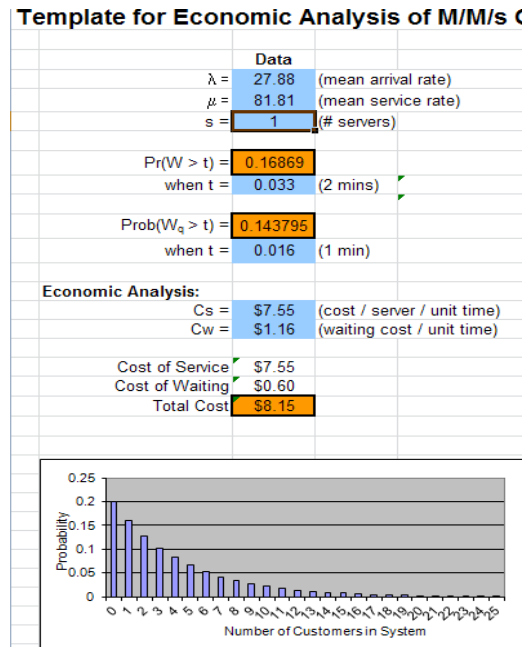


Figure 3: 1 Cashier Queuing System



⁵ Walk-offs must also include walk-offs not observed (i.e. customers that don't even walk into the food court/restaurant, etc.) For this analysis, the estimate used was an additional 10% of observed customers. So, for example, if an observation period had 40 customers, and we saw 2 walk-offs, *total* walk-offs would be 6 (For a total of 46 customers).

By decreasing the number of cashiers from two to one, we were able to reduce our cost of service by the cost of that cashier's wage: \$7.55. This did increase the cost of waiting, but only by 19 cents! Overall, Company A's total cost would decrease by \$7.36, that's a 47% reduction in cost! Granted, this would mean that the current service level would suffer (there is a tradeoff for lower costs...), but how much would it suffer? In figures 2 and 3, the probability of wait time exceeding the established benchmark ($Pr(W>t)$) does increase but is still within a reasonable level. Probability of benchmark "violation" for the waiting line ("at the register") increases to 16.8% and the probability of benchmark violation for the wait in the system increases to 14.4%. While the percentage increase is significant, in "big-picture" terms, this is still an efficient system. Less than 20% of customers have to wait longer than 1 minute at the cash register; this is still a respectable achievement, especially since it is also the result of a 47% cost reduction.

Decisions do not have to be "black or white," either Company A could also pursue a hybrid-approach. For example, Company A could decide to run with primarily one cashier, but during the busiest periods (likely during lunch and dinner hours), could employ two. This would allow the Company to find a happy middle-ground – they could take advantage of the cost savings of having one cashier while still maintaining the benefits of having an exceptionally high service level.

One warning about waiting line analysis, however, is that it is not a complex analysis tool – so it cannot be used for analyzing all possible factors. For example, employee retention and training are not represented in the analysis, but can have a significant impact on the organization. For example, Company A may decide to cut their cashiers down to just a single-operator on a given shift. While this saves money in the short-term (cost of service), this creates unpredictability for the future: by decreasing the number of cashiers in half, the number of labor

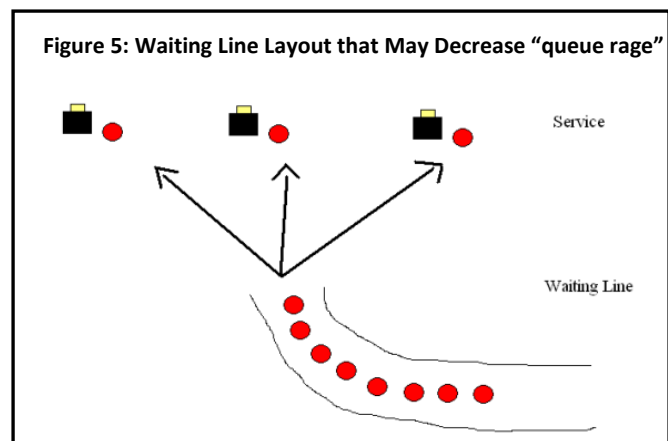
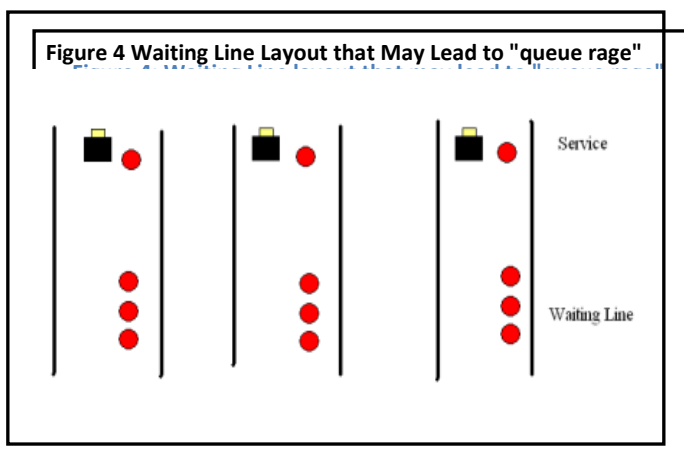
hours used is cut in half – which means a cashier’s paycheck (as an average), gets significantly reduced. This could lead to the cashier leaving the company to pursue another opportunity that will provide better pay. Repeated occurrences of this leads to a second issue: training costs. A new employee is expensive; there are the costs associated with hiring them (secretary’s time, paperwork and authorization), as well as the costs of training them: the time of the trainer, the cost of mistakes (i.e. the employee collects too much or too little from the customer), as well as the fact that a new cashier will not perform at nearly as high of a level as an experienced cashier. This means that either cost of waiting will increase significantly (due to longer wait times), or two cashiers will be needed during the new employee’s training period. Company A could side-step this issue by making “cash register proficiency” a secondary skill for another job (i.e. “food prep”) – this would allow for a stable labor force. It is always a priority to minimize costs, but how much should service levels be allowed to increase? How will these decisions affect the employees, what hidden costs are their? These things are all things that must be considered by Company A’s management. While there is never a clear-cut answer, there are always tools available; waiting line analysis is obviously very useful, and is just one of the tools available to management.

5. Psychological Methods in Improving Waiting Experiences

Sometimes there is little that can be done in improving the performance of the waiting line, but what is a company to do in this situation – they still want to please their customers! In instances like these, it’s best to shift attention away from the performance of the waiting line and focus on the experience of the waiting line (Martin, Grahn, Pankoff, & Madeo, 1992). How

happy a customer is within the waiting-line can be a huge determinant in their overall experience (just ask a Disney World employee), as well as how long (or short) they perceive the line to be.

One way to keep the experience of the waiting line positive is to make sure the customers view the waiting line as in compliance with “social justice.” What this refers to is the “fairness” of the line (Pawlowski, 2008). There is a social expectation that the first person to arrive is the first person to be served (we’ve all experienced a violation of “social justice” when we choose a check-out line at a grocery store and the line next to us serves three people in the time our line serves one). Thus, it can be beneficial to the experience of the line if the waiting line is condensed to just a single line (however, multiple channels can still be used; see figures 4 & 5). This will avoid “queue rage” – or anxiousness/anger that results from the perception of unfair treatment to all parties within a waiting line.



Another way to improve the experience of a waiting line is to keep the customer “in the know” with regards to how long they will likely be waiting. Researchers have found that customers that had an idea of how long the wait was going to be before they joined the waiting line were far less anxious than customers who did not know the estimated time in the waiting line (Stevenson, 2012). In a system that works on a “take a ticket” basis (i.e. “take a number” and

numbers are called in order), it would be fairly easy to integrate IT with the ticket system and calculate the average service time per customer. This info could then be used to display a “benchmark” wait estimate. For example, if you had ticket number “15” there might be a screen in the waiting area that says: “Now serving: #5. Approximate wait for #10: 15 minutes.” This would allow a customer to approximate their wait time, and thus, they will be far-less anxious.

To build-on to the idea of wait approximations is over-estimation of wait times. At first this seems counter-intuitive: “why would I tell a customer there is a 20 minute wait, if it’s likely only going to be 15 minutes?” Because a “reduction” (or appearance thereof) in waiting time is perceived positively to the customer, a customer that ends up waiting less than they had planned on is happy because they’ve “saved time” and are now “ahead of schedule” (Maister, 1985). This will contribute to overall customer satisfaction with the entire experience – and will likely contribute to their returned business.

It is also fairly well-known that an active mind perceives time more quickly than an inactive -or rather, an un-engaged-mind (Norman, 2008). Many fast food chains have applied this concept in their waiting area by installing televisions. Sometimes the televisions display commercials, other times news – the content is not as important as the fact that the customer is not thinking about the line, how long they’ve been in the line, or critiques of the employees working, but are focused on whatever is on the television (Stone, 2012). They perceive their wait to be far shorter than someone who is bitterly waiting in line trying to figure out “why it’s taking so long.”

A final aspect to keep in mind for creating a good experience is that the final moments of the experience determine how a customer views the entire experience. For example, if a wait is

relatively long and painful but ends with quick service, friendly staff, and the customer leaves with a smile on his/her face – they will likely think back on the entire experience and classify this experience as positive. The inverse is also true; if a customer has a relatively painless wait but is greeted with poor customer service and a frustrating service experience, they will view the overall experience as negative. So, the lesson learned is fairly obvious: above all, make sure that the actual service is always a positive experience; this may mean having an overly-friendly staff, easy-to-use machinery, or the service should go above-and-beyond expectations. These steps would ensure that a customer always leaves satisfied, and thus, will bring repeat-business.

6. Conclusions

As if running a successful business was not hard enough, managing an effective waiting-line is a significant and sizeable task in of itself. In the case study we saw that Company A performed exceptionally well in relation to its set benchmarks (fewer than 10% of customers had to wait longer than the benchmark time). Because of the high performance against this benchmark, Company A should look into how this benchmark compares to other similar food-service industries. For the time being, however, Company A can be proud of the performance of their queuing system. This performance, however, came at a cost: employing an extra cashier. A cost analysis showed that the cost of service was \$15.10 with the cost of waiting being only \$0.41. Reducing the number of cashiers from two to one decreased the cost of service by 50% (down to \$7.55), while only increasing the cost of waiting by \$0.19 (up to \$0.60). Thus, it is recommended that Company A restructure their waiting line so that only one cashier is working at a time – though scheduling a second cashier during the “peak hours” may prove beneficial.

The experience of a waiting line was also discussed; in fact, the experience of a waiting line is often what determines if a customer is willing to return (note that waiting-line performance is an attribute of experience). The basic principles of creating a “pleasurable” waiting line can be summed up by the following:

1. Waiting lines should be in-line with “social justice” to avoid “queue rage.”
2. Knowledge of the wait time will decrease waiting anxiety.
3. An active mind perceives time more quickly than an inactive mind.
4. The final experience shapes the memory of the entire experience.

For Company A this can mean having a single waiting line that feeds into multiple service channels (1). Letting customers know about how long the wait usually is (via signs or electronic screen) would help customers be less anxious while waiting in line (2). Installing TVs in the waiting-area or hanging up posters with interesting and related information (i.e. the food pyramid, or the effects of various vitamins/substances on the body), would help customers perceive time faster and thus make the wait feel less long (3). Lastly, having a friendly wait-staff with a fast service time (fast check-out), will create a positive end experience which means the customer will likely perceive the entire experience as positive – and will bring repeat business (4).

Competition demands that a business develop a product or a service that has high demand, and even then, a strong business strategy is needed to even compete in such a market. The benefits from doing a waiting-line analysis are immense: it can identify bottlenecks, it can help cut costs and it creates a standard for which companies can compare performance to similar businesses. While optimizing a waiting-line is not likely to be a service-based company's competitive advantage, it may be enough to give them the edge they need.

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Appendix

Description of Waiting Line Analysis Key Measures		
<u>Variable</u>	<u>Measure/Description</u>	<u>Equation</u>
λ	Arrival Rate per unit of time	—
μ	Service rate per unit of time	—
σ	Standard deviation of the service time	—
L_q	Average number of units in the waiting line	$(\lambda^2\sigma^2 + (\lambda/\mu)^2) / (2(1 - \lambda/\mu))$
L	Average number of units in the system	$L_q + (\lambda/\mu)$
W_q	Average <i>time</i> a unit spends in the waiting line	L_q / λ
W	Average <i>time</i> a unit spends in the system	$W_q + (1/\mu)$

Table information gathered from:

“An Introduction to Management Science” (Anderson, Sweeney, & Williams, 2010)

Example of Analysis Sheet (1 sitting):

Template for Economic Analysis of M/M/s Queuing Model						
Data			Results			Range Na Cells
$\lambda =$	27.88	(mean arrival rate)	$L =$	0.35098		CostOfSer C18
$\mu =$	81.81	(mean service rate)	$L_q =$	0.01019		CostOfWai C19
$s =$	2	(# servers)	$W =$	0.012589		Cs C15
			$W_q =$	0.000366		Cw C16
$Pr(W > t) =$	0.07143		$\rho =$	0.170395		L G4
when t =	0.033	(2 mins)				Lambda C4
$Prob(W_q > t) =$	0.005654		n	P_n	$P_{\leq n}$	Lq G5
when t =	0.016	(1 min)	0	0.708825	0.708825	Mu C5
Economic Analysis:			1	0.24156	0.950385	n F13:F38
$C_s =$	\$7.55	(cost / server / unit tin)	2	0.041161	0.991546	P0 G13
$C_w =$	\$1.16	(waiting cost / unit tir)	3	0.007014	0.998559	Pn G13:G38
Cost of Service	\$15.10		4	0.001195	0.999755	Rho G10
Cost of Waiting	\$0.41		5	0.000204	0.999958	s C6
Total Cost	\$15.51		6	3.47E-05	0.999993	Time1 C9
			7	5.91E-06	0.999999	Time2 C12
			8	1.01E-06	1	TotalCost C20
			9	1.72E-07	1	W G7
			10	2.93E-08	1	Wq G8
			11	4.98E-09	1	
			12	8.49E-10	1	
			13	1.45E-10	1	
			14	2.47E-11	1	
			15	4.2E-12	1	
			16	7.16E-13	1	
			17	1.22E-13	1	
			18	2.08E-14	1	
			19	3.54E-15	1	
			20	6.04E-16	1	
			21	1.03E-16	1	
			22	1.75E-17	1	
			23	2.99E-18	1	
			24	5.09E-19	1	
			25	8.67E-20	1	

Number of Customers in System