**Simio BBQ Smoke Pit**
**Alexander Valdman, Subhadeep Deb, and Hunter Power**
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## Executive Summary

Our simulation of the BBQ Smoke Pit restaurant shows that the current system, as modeled, is operating much more efficiently than expected. The average customer received their order in just 2.93 minutes, which is well below the 6 to 7 minute goal of the restaurant. No customers were lost due to long waiting times, either at the point of ordering (balking) or while waiting for their food (reneging).

Although these findings are promising, they likely reflect the limitations of a stylized model as much as system performance in practice. Such key operational factors as equipment bottlenecks, stockouts, overtime wage costs, and meal preparation variation were not addressed explicitly. Because of this, the model likely understates the impacts of congestion and resource constraints during peak periods.

We envision this model as a requisite beginning. It outlines the paradigm for modeling restaurant operations and establishes the foundation for elaboration. As realism is added, the model can provide far more accurate and actionable output with additional development and realistic limitations on staffing, travel time, and inventory control.

Experiment Design

To test system performance under nominal conditions, we modeled a base case scenario using actual hourly arrival data and assumed staffing levels of two customer service staff and three food production staff. Each simulation run represented a full day's operations, and 50 replications were conducted to capture variability in results.

The customer arrival to pickup average was 2.93 minutes, far ahead of the restaurant's target. Customer abandonments were zero across all runs, indicating the system did not have any serious queue buildup or delays.

While these results could point to over-capacity, they more likely reflect a lack of realism in the current model. Side preparation activity overlap, equipment availability delay, operation and staffing costs, and meat cabinet constraints were either simplified or omitted. These modeling choices allowed the model to execute without problems, but they limit the ability of the model to reflect the operational challenges the restaurant faces in practice.

## Experiment Design

To assess performance under baseline circumstances, we generated a base case scenario using true hourly arrival patterns and simulated two customer service employees and three food production employees as staffing. A single simulation run represented one operating day, and we executed 50 replications to permit result variation.

The average customer arrival-to-pickup time was 2.93 minutes, considerably ahead of the restaurant's target. Throughout all runs, no customer abandonment incidents occurred, indicating that the system experienced no extreme queue buildup or delay.
While these results may suggest the existence of excess capacity, they are actually pointing to a misrepresentation in the current model. Problems such as redundant side preparation activities, delayed equipment availability, operational and personnel expenses, and meat cabinet constraints were either sidestepped or trivialized. These simplifications facilitated easy performance by the model but limit its ability to reflect the operational problems the restaurant faces in real life.

## Results Summary

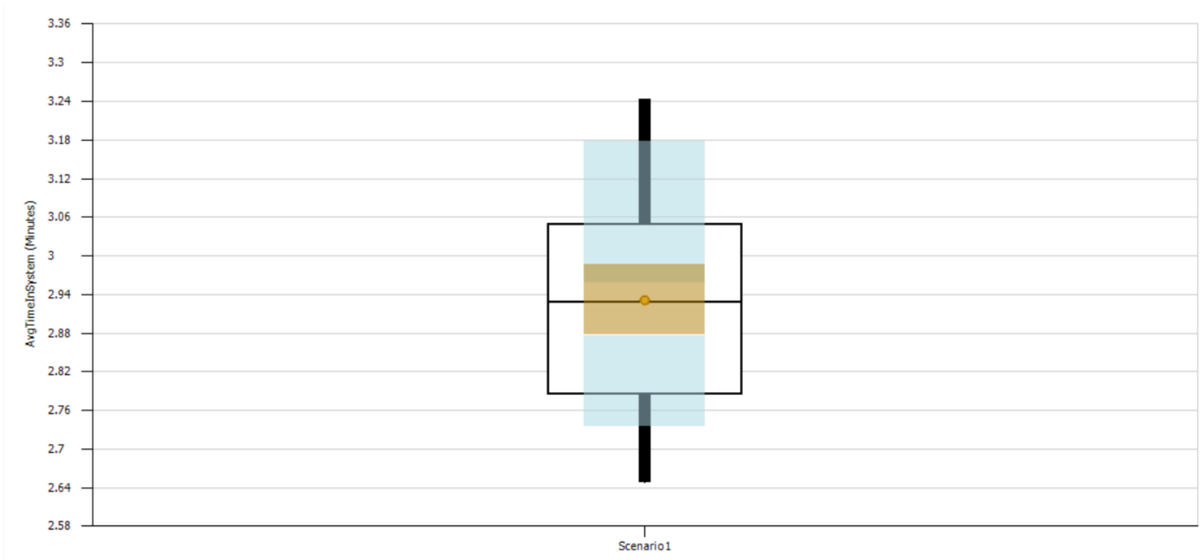


Figure 1: SMORE Plot of Average Customer Time in System

| Main Menu Breakdown | | | | |
|---|---|---|---|---|
| | Small Platters | Large Platters | Sandwiches | Total |
| Orders | 9181 | 7245 | 9486 | 25912 |
| % | 35.4315 | 27.9600 | 36.6085 | |
| Brisket | 2459 | 2057 | 4260 | |
| % | 26.7836 | 28.3920 | 44.9083 | |
| Pulled Pork | 3820 | 3234 | 5226 | |
| % | 41.6077 | 44.6377 | 55.0917 | |
| Ribs | 2902 | 1954 | 0 | |
| % | 31.6088 | 26.9703 | 0.0000 | |

| Side Menu Breakdown - By Main Menu | | | | | |
|---|---|---|---|---|---|
| | Sandwiches | Small Platter | Large Platter | | Total |
| | Side 1 | Side 1 | Side 1 | Side 2 | |
| Orders | 9486 | 9181 | 7245 | 7245 | 33157 |
| Green Beans | 453 | 1836 | 2155 | 2219 | |
| % | 4.7755 | 19.9978 | 29.7447 | 30.6280 | |
| Fries | 7597 | 2737 | 1084 | 1007 | |
| % | 80.0864 | 29.8116 | 14.9620 | 13.8992 | |
| Baked Beans | 476 | 1821 | 1823 | 1810 | |
| % | 5.0179 | 19.8344 | 25.1622 | 24.9827 | |
| Mac and Cheese | 960 | 2787 | 2183 | 2209 | |
| % | 10.1202 | 30.3562 | 30.1311 | 30.4900 | |

Tables 1 and 2: Main Menu and Sides Breakdown Based on Historical Orders

| Group Distributions | | |
|---|---|---|
| Total Group Orders | 12720 | |
| Group Size | Group Orders | Frequency |
| 1 | 4393 | 34.536% |
| 2 | 5736 | 45.094% |
| 3 | 1299 | 10.212% |
| 4 | 638 | 5.016% |
| 5 | 326 | 2.563% |
| 6 | 328 | 2.579% |

Table 3: Combined Group Size Distribution

**Analysis**

The SMORE plot of Figure 1 shows the distribution of average customer time in the system across 50 replications of the base case. Average time is approximately 2.93 minutes, with relatively low variability from run to run. Both the interquartile range and confidence interval are narrow, suggesting that the system performs consistently under the conditions being modelled. However, this consistency is likely due to the simplicity of the model, which does not deal with certain operational realities such as resource contention, multitasking, or conflicting demands on staff. For example, the side prep and packing process can have conflicts or delays in a real kitchen, particularly when it is busy, that are not reflected in the present model. Therefore, the short and consistent order-to-delivery times likely reflect the model's idealized version rather than actual restaurant performance.

To learn more about ordering habits from consumers, we analyzed the raw data and broke down the primary meal and side orders. As Table 1 shows, sandwiches accounted for the largest share of overall orders at 36.6%, with small platters (35.4%) and large platters (28.0%) following closely. Pulled pork was the most ordered meat overall, with a strong showing in sandwiches, where it was included in over 55% of cases. Brisket and ribs were more evenly divided among the platter categories, with ribs being exclusive to platters.

Side choice pattern is also shown in Table 2, which captures the frequency of every side dish by main menu category and side location. Fries were the most ordered side, especially as the 1st side with small platters and sandwiches, followed by mac and cheese, the most popular second side, which complemented large platters well. Green beans and baked beans were less frequent but significant, particularly as seconds on platters. These distinctions were used to direct the logic in our model for determining side dishes and entrees to ensure that model-driven customer movement and station use realistically represented actual menu selection. This measurement-oriented strategy enhanced the validity of assumptions in the model and enabled more realistic use of resources within the system.

We also looked at four weeks of history to see what group size distributions were ordering. As Table 3 illustrates, two-person groups were most frequent at 45.1% of total orders, followed by 34.5% for individual diners. Three-or-more-size groups were much less frequent, and each of the larger sizes made up a relatively small percentage of total orders. This distribution was used to establish group sizes in the model and influenced how items break up into divisible meals. While the current model only speculates that everyone in a group orders simultaneously and separately, additional advancements would be facilitated by advanced logic to account for shared waiting times or group-level decisions such as collective balking. While in the process, this analysis calibrated the simulation's arrival dynamics and assisted in providing an anchored point of departure to simulate order complexity and volume

**Verification & Validation**

We compared its outcome to a basic expectation of how long customers would wait on average, given known service steps, to evaluate the validity of the simulation. The restaurant's target of 6 to 7 minutes from arrival to pickup is compared to the simulation's average of 2.93 minutes, which shows a significant discrepancy.

This incompatibility is one of the causes since, as we realistically applied simple reasoning in side cooking through the fryer and stove, other delay causes such as mixed use of equipment, simultaneous side preparatory activities, and last-in-line bottlenecks in building were simplified or left out. Above these, the model also accepts orders to be supplied without food waste or full production capacity and its employees working fully efficiently without worker exhaustion, error, or task disruption caused by multitasking.

This version of the model always executes the expected order sequence and records significant preparation activities, but it likely underestimates the net effect of coordination, queuing, and resource conflict that occurs in practice. Additional iterations will be necessary to compare model output with observed performance data and build greater confidence in the predictive capability of the simulation.

**Model Risk**

There are some limitations in the current model that affect the validity of its conclusions. Firstly, the simulation is relatively insensitive to changes in demand or staffing in the current configuration. Despite the utilization of real hourly arrival patterns, the average customer time in the system was consistently low, and there was no balking or reneging on the part of any customers in any of the replications. This means that the model is not capturing the types of congestion or variability in service that would occur in practice.

A second concern is the absence of cost accounting, particularly as it relates to labor (including overtime), food disposal, and lost sales due to stockouts. In the absence of these factors, the model cannot currently be used to examine profit-based performance.

To further increase the model's utility and credibility for future analysis, we recommend the following next steps. Then, more logic to capture task sequencing, worker utilization, and shared equipment contention must be added. Meat inventory depletion and food availability constraints must be added to allow analysis of stockouts and lost revenue. Then, conducting targeted sensitivity analysis on staffing, arrival intensity, and preparation times would work to determine where the system is most vulnerable and which levers have the most impact on customer experience and profitability.