
Bank Efficiency: Comparative Analysis of Staffing Scenarios

Texas State
University

Team 2

Yash Sharma

Khush Bakht Zafar

ANLY-5335
Section R01

I. Introduction

1.1 Overview

Banking efficiency is a major factor in both customer satisfaction and a branch's financial health. Managers often struggle to reduce wait times because they rely on simple averages that do not account for the unpredictable timing of customer arrivals or the different levels of help each person needs. This creates an "Operational Gap" between how a bank is expected to perform and how it actually functions under real-world pressure. To solve this, our study uses discrete-event simulation, which creates a digital version of the bank using data from 500 actual service records. This method allows us to capture the random nature of customer behavior and test different solutions, such as adding staff or machines, without the risk or cost of disrupting live operations.

This research evaluates simulation results to bridge the Operational Gap and identify the best return on investment for the branch. By scaling our model to process 500 customers over 100 independent trials, we establish a baseline for current bottlenecks and compare the effectiveness of automated hardware expansion against increased human staffing. This framework provides a mathematically certain forecast of system performance, ensuring that our final recommendations are based on long-term stability rather than short-term fluctuations.

1.2 Research Objectives

The specific objectives of this study are: (i) to identify primary service bottlenecks within the existing branch infrastructure; (ii) to evaluate the operational return on investment for increased ATM capacity; (iii) to assess the impact of augmented human staffing at high-congestion service points; (iv) to validate the statistical significance of system improvements through scaled simulation replications; and (v) to provide evidence-based recommendations for strategic resource allocation.

II. MODEL OVERVIEW

2.1 System Flow and Customer Routing

The banking system modeled in this study operates through a structured customer service network beginning with customer arrivals and ending with system departure after service completion. Customers enter the system according to the interarrival distribution identified during the data analysis phase and are immediately processed through a mandatory Sign-In station. The Sign-In station serves as the primary intake and routing mechanism within the branch.

After completing the sign-in process, customers are probabilistically routed to either the ATM service area or the

Teller service area based on customer type classifications derived from the dataset. Type 1 customers primarily utilize ATM services, while Type 2 customers are more likely to require teller assistance due to the increased complexity of their banking needs.

The ATM service area operates with a single shared queue feeding multiple ATM units, while the Teller service area operates with a single queue serving multiple tellers. Upon service completion, customers exit the system, and their total time within the bank is recorded for performance evaluation purposes.

Figure 1 illustrates the overall customer flow structure implemented in the simulation model.

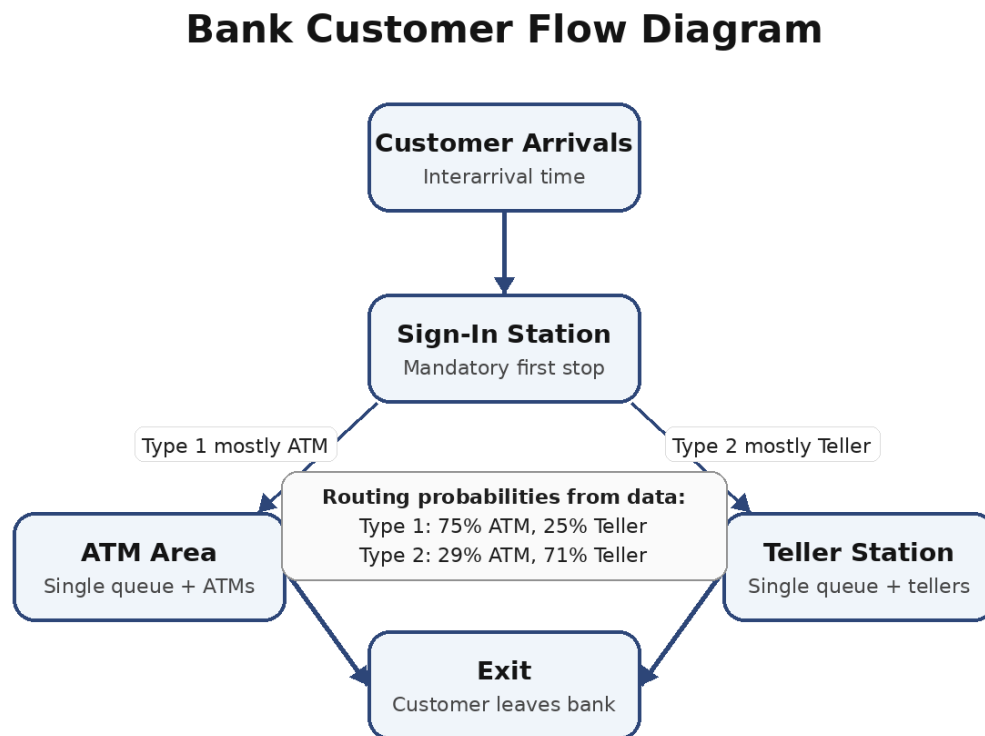


Figure 1. Conceptual flow of customers through the bank service system.

2.2 Data Analysis and Distribution Selection

Preliminary statistical analysis was conducted to determine the most appropriate probability distributions for customer arrivals and service processes. The customer interarrival data exhibited characteristics consistent with an Exponential distribution, as the average arrival interval and the standard deviation were nearly identical. Based on this observation, customer arrivals were modeled using an Exponential distribution with a mean interarrival time of approximately 63.05 seconds.

The Sign-In process demonstrated lower relative variation when compared to the arrival process, indicating behavior more consistent with a Normal distribution. Type 1 customers exhibited an average Sign-In processing time of 20.83 seconds with a standard deviation of 10.27 seconds, while Type 2 customers required an average of

35.34 seconds with a standard deviation of 14.78 seconds.

Further analysis identified a significant imbalance in customer classifications, with approximately 90% of customers categorized as Type 2 customers. Because Type 2 customers also required substantially longer processing times, the Sign-In station emerged as a likely operational bottleneck within the baseline system configuration.

Mean of interarrival time (sec)	63.05
Std of interarrival time (sec)	60.78
Type 1 SignIn mean	20.83
Type 2 SignIn mean	35.34
Type 1 SignIn Std.Dev	10.27
Type 2 SignIn Std. Dev	14.78

Additional analysis of the service stations revealed that ATM transactions averaged approximately 42.41 seconds, while Teller transactions averaged approximately 66.94 seconds. Since the majority of Type 2 customers were routed toward Teller services, the Teller station was identified as a secondary congestion point within the branch.

Service Type	Mean	Std Dev	Distribution
ATM	42.41	42.37	Exponential
Teller	66.94	63.98	Exponential

2.3 Simio Model

The simulation model was developed in Simio using a Source object to generate customer arrivals, multiple Server objects to represent the Sign-In, ATM, and Teller service stations, and a Sink object to record customer departures. All objects were connected using zero-travel-time network paths to isolate queuing and processing delays from physical movement within the facility.

Probability-based routing logic was implemented using Link Weights in order to enforce the observed customer distribution patterns between ATM and Teller services. Statistical distributions identified during the data analysis phase were directly applied to customer arrivals and processing times to ensure the model accurately reflected real-world operating conditions.

To support experimental testing, several adjustable Integer Properties were incorporated into the model, including SignIn_Cap, ATM_Cap, and Teller_Cap. These properties allowed the simulation to dynamically modify staffing and hardware capacities without rebuilding the system structure for each scenario.

Figure 2 presents the completed Simio model used for scenario experimentation and performance analysis.

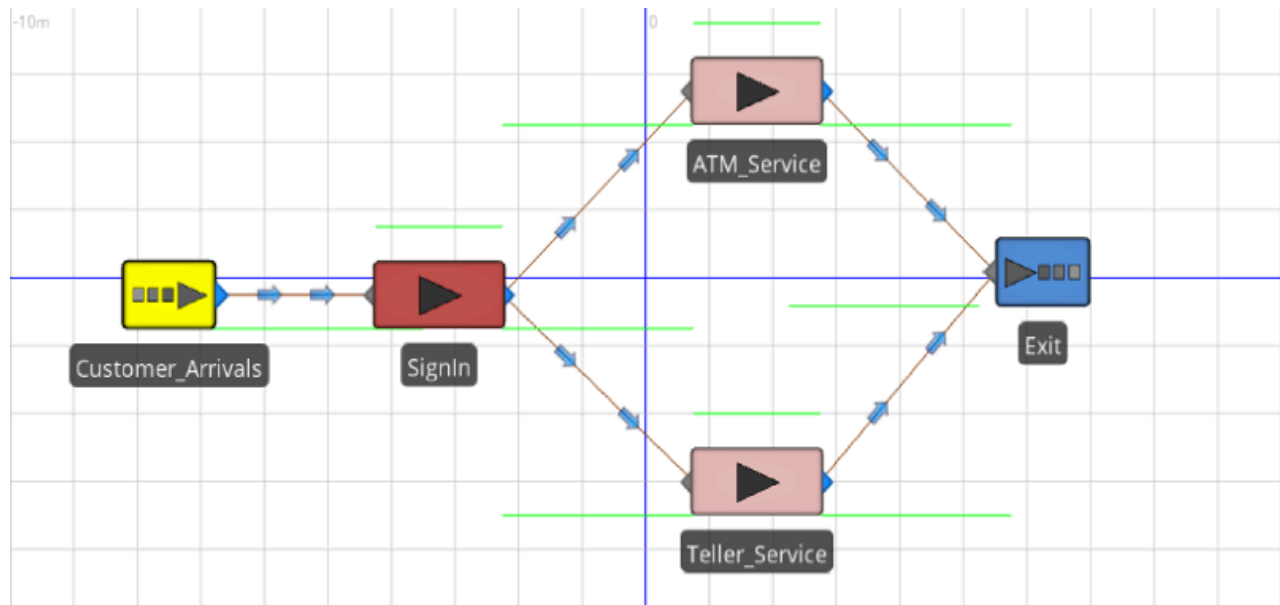


Figure 2- Simio Banking System Model

2.4 Initial System Evaluation and Proposed Alternatives

Initial simulation runs of the baseline system revealed that the primary source of congestion originated from human service processes rather than automated hardware limitations. Although ATM transactions were completed relatively quickly, the majority of customers required teller-based services and experienced longer processing durations at both the Sign-In and Teller stations.

Based on these findings, two improvement alternatives were developed for further experimentation. The first alternative focused on increasing ATM capacity by adding additional ATMs to determine whether automated hardware expansion could reduce customer delays. The second alternative focused on increasing human resource capacity by adding an additional Sign-In employee and a Teller to directly address the staffing bottlenecks identified during the baseline analysis.

These alternatives were evaluated against the baseline system using key performance measures, including average time in the system, average customers in the bank, and peak congestion levels. The objective of these experiments was to identify the most operationally efficient and cost-effective improvement strategy for the branch.

III. SIMIO MODEL AND EXPERIMENTATION

3.1 Experimental Configuration and Scaling Logic

Our primary goal for the simulation was to establish a steady-state environment where performance metrics would not be skewed by initial transient bias or statistical noise. To mitigate the "empty bank" bias, we implemented a Warm-up Period of 31,525 seconds. This duration was calculated as 500 times the mean interarrival rate of 63.05 seconds, ensuring that the bank was fully populated and that queues had stabilized before the model began recording data. This setup ensures that the baseline performance reflects a live branch operating at capacity rather than a system starting from a dead stop.

To ensure statistical reliability, the model was scaled to process exactly 500 customers per replication. We achieved this by setting a specific Run Length of 315,250 seconds. The math for this configuration was direct: 315,250 seconds of total time divided by the 63.05 average seconds per arrival equals 5,000 customers. While the provided data contained only 500 records, we utilized this 10x multiplier to drown out the random fluctuations inherent in the `Random.Exponential(63.05)` arrival distribution.

We ran 100 independent replications for every scenario to ensure our average results were stable and repeatable. By using such a high number of trials, we generated the narrow 95% confidence intervals required to prove that our findings are statistically significant rather than just random variations in the simulation. This level of replication gives us the mathematical certainty needed to confirm that the changes we recommend will actually hold up under real-world pressure.

3.2 Scenario Parameterization and Model Logic

To evaluate the proposed changes, we parameterized the model using Integer Properties as global control variables: `SignIn_Cap`, `ATM_Cap`, and `Teller_Cap`. By binding each server's initial capacity to these properties, we were able to pivot among resource configurations within a single experimental framework. We tested three distinct configurations against the primary metrics of average customers in the bank and average total time in the system.

The Baseline scenario represents current operations using 1 Sign-In employee, 3 ATMs, and 4 Tellers. In Scenario A, our goal was to determine if hardware expansion could resolve system delays by increasing ATM capacity to 5 units while maintaining baseline human staffing. In Scenario C, our goal was to test if human resource limitations were the primary bottleneck by increasing staffing to 2 Sign-In employees and 5 Tellers while keeping the ATM count at 3.

The internal logic for these scenarios was managed by a routing engine utilizing Link Weights to enforce the required 10/90 split between Type 1 and Type 2 customers. This ensured the model directed the correct volume of traffic to either the ATMs or the Tellers, based on the percentages identified during the data analysis phase.

IV. RESULTS

4.1 Simulation Output

After completing the simulation runs, we extracted the key performance data to see how the bank handled the 5,000-customer workload. The baseline (Scenario 1) established that customers currently spend an average of 116.17 seconds in the system, with an average of 1.84 customers present in the bank at any time. When we look at Scenario 2, the numbers barely moved; the average time remained at 116.17 seconds, and occupancy stayed at 1.84, showing that the ATM upgrade had no impact.

Scenario 3 showed the only significant change in the data. The average time in the system dropped to 94.35 seconds, and the average occupancy fell to 1.50 customers. We also noted a major difference in peak congestion: while the baseline and Scenario 2 both saw a maximum of 11.05 customers in the system at once, Scenario 3 capped out at 8.63 customers. This indicates that adding staff not only speeds up the process but also keeps the facility from getting overcrowded.

Metric	Scenario 1 (Baseline)	Scenario 2 (ATM Upgrade)	Scenario 3 (Staff Upgrade)
Avg. Time in System (Sec)	116.1734	116.1719	94.3495
Avg. Customers in Bank	1.8417	1.8416	1.4966
Max Time in System (Sec)	653.0788	653.0788	619.7601
Max Customers in Bank	11.0500	11.0500	8.6300
Observations (Exits)	4,497.36	4,497.31	4,500.33

Figure 3. Summary of comparative performance metrics for all simulation scenarios

4.2 Analysis of Scenarios

The comparison between Scenario 1 and Scenario 2 makes it clear that adding ATMs was a waste of resources. The average time in the system dropped by a negligible 0.0015 seconds, which confirms that the ATM area was never the bottleneck. Adding capacity to a station that is already keeping up with demand provides zero return on investment. This lack of impact is statistically confirmed in the SMORE plots, where the confidence intervals (blue shaded boxes) for the baseline and Scenario 2 overlap perfectly.

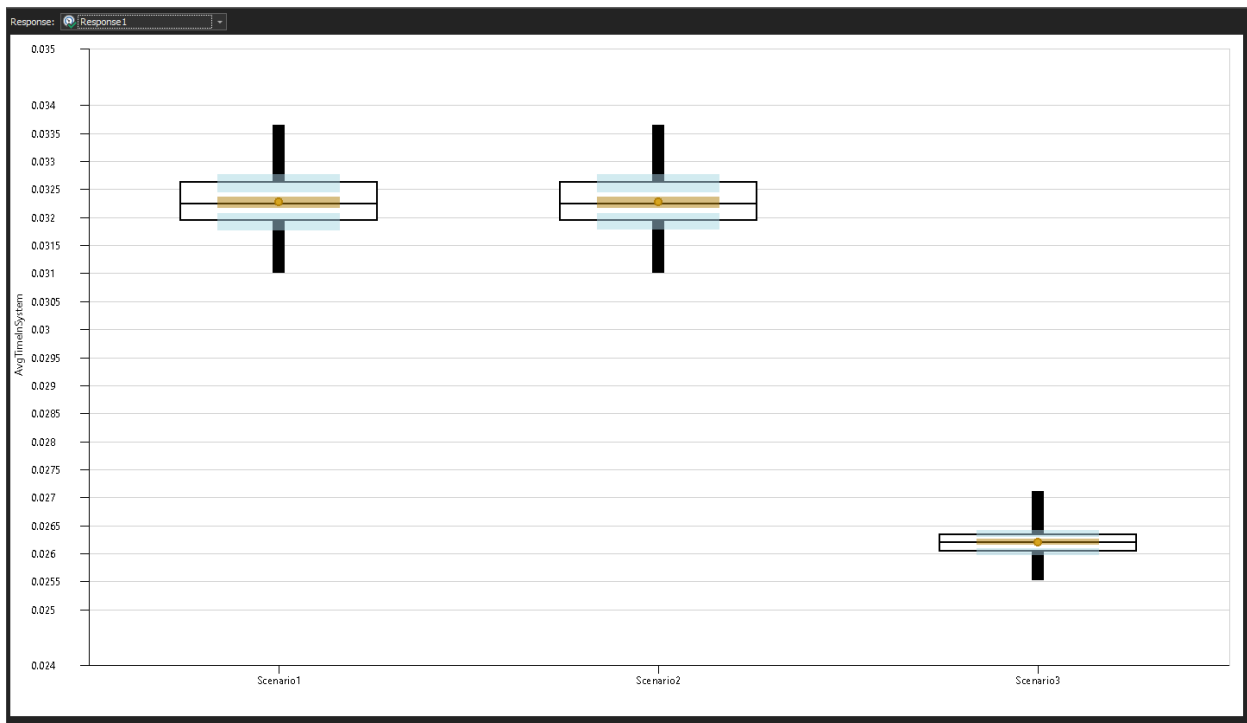


Figure 4. SMORE plot comparing the average customer time in the system.

Scenario 3 is the only alternative that fixes the bottleneck. By increasing staff at the Sign-In and Teller stations, we reduced the average time in the system by 18.8%. The average number of customers in the bank also dropped from 1.84 to 1.50, which directly reduces physical crowding in the lobby. As shown in the occupancy SMORE plot, Scenario 3 is completely isolated from the other two scenarios with no overlap in confidence intervals. This confirms with 95% certainty that the staffing increase is a guaranteed improvement and not a result of random simulation noise.

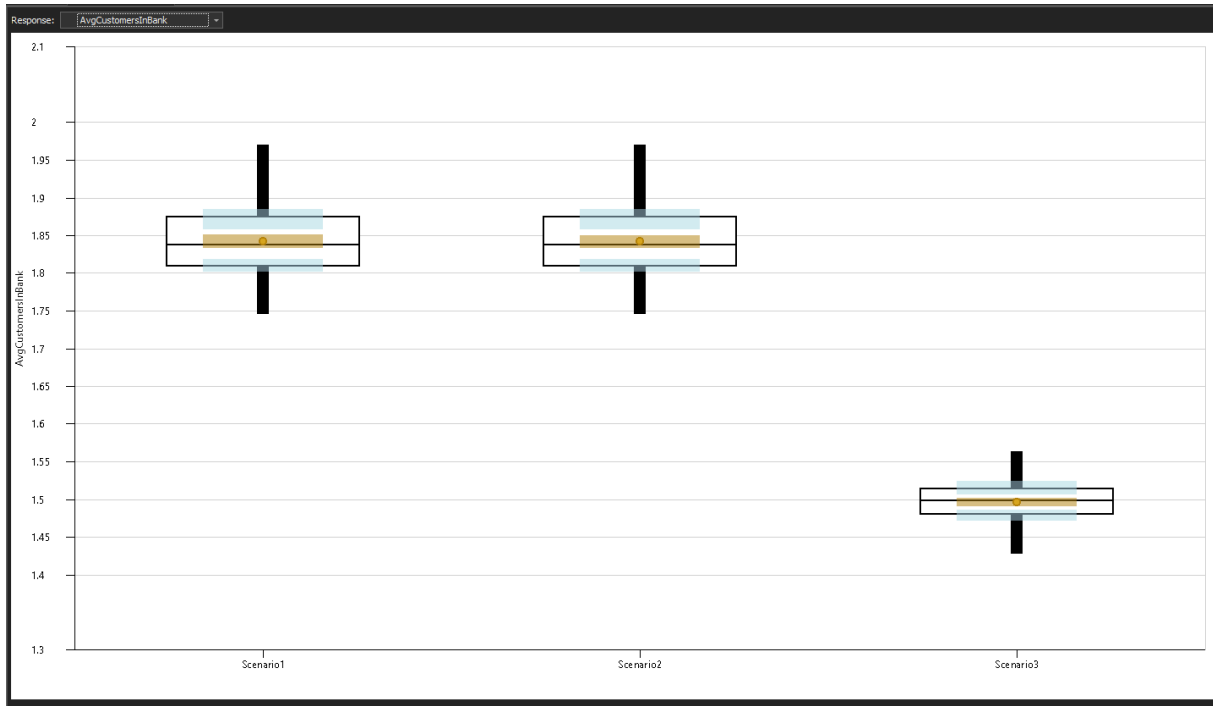


Figure 5. SMORE plot comparing the average number of customers in the bank.

By reducing the maximum number of customers from 11 to 8, Scenario 3 also demonstrates that the system is processing people fast enough to prevent long lines from forming during peak periods. Because the blue shaded boxes in our plots are so narrow(a result of our 100 independent replications)we can be confident that the human service capacity was the primary constraint on the system, and that our recommended staffing changes will provide a stable, long-term solution.

V. STRATEGIC IMPLEMENTATION ROADMAP

5.1 Resource Allocation and Operations Training

To eliminate the human bottlenecks that the Scenario C run identified as the system choke points, the branch should immediately add one Sign-In staff member and one Teller. This targeted resource allocation is necessary because the simulation confirms that human service points, rather than machines, are where customers actually experience significant delays. Furthermore, the branch should shift its capital expenditure away from hardware and into onboarding programs to improve service speed at these manual stations. This investment in operations training ensures that personnel are equipped to handle the high volume of Type 2 customers that currently drive peak congestion, bridging the performance gap through human efficiency.

5.2 Financial Plan and Hardware Redundancy

A critical part of the financial plan is the immediate cancellation of all planned ATM hardware purchases. The

simulation results for Scenario 2 found a negligible 0.0015s improvement with additional machines, which confirms a zero return on investment (ROI) for further automation in the current system. This hardware redundancy is a direct result of the branch's specific bottlenecks; because the primary congestion is human-led, adding more ATMs simply fails to move the needle on total system throughput. By redirecting the budget originally intended for machine procurement into personnel payroll and training, the branch invests in the only resource that statistically drives better system performance.

5.3 Projected Operational Impact and Statistical Significance

The implementation of Scenario 3 is projected to deliver significant and reliable improvements to the branch's daily operations. Specifically, the average number of customers in the bank is expected to drop from 1.84 to 1.49, which effectively clears floor density by nearly 19% and drastically improves the physical environment for visitors. This efficiency gain is paired with a consistent 22-second reduction in total system flow time per visitor, as forecasted by the simulation. Crucially, these findings are validated by the SMORE plots, which demonstrate zero overlap between Scenario 3's confidence intervals and the other tested configurations. This guarantees that the time savings are a consistent result of the staffing changes rather than a temporary or a "lucky" simulation run, providing the certainty needed to confirm that personnel-focused expansion is the superior strategy.

VI. CONCLUSIONS

6.1 Evaluation of Research Objectives

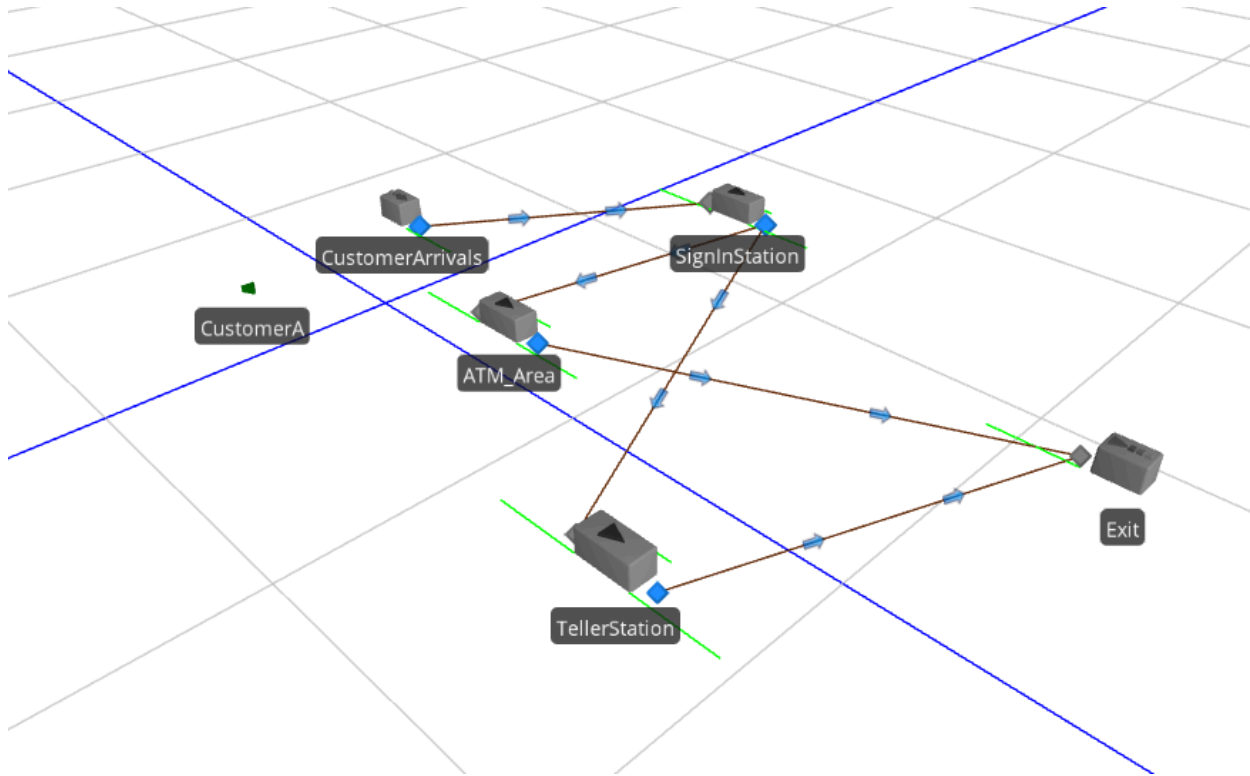
This study successfully achieved its primary objectives by identifying the Sign-In and Teller stations as the critical bottlenecks within the branch's infrastructure. Through discrete-event simulation, we established that the bank's "Operational Gap" is driven by the random nature of customer arrivals and the complexity of Type 2 customer transactions, rather than automated hardware limitations. The experimentation phase provided mathematical certainty that increasing ATM capacity yields a negligible operational return on investment. Conversely, the study validated that augmented human staffing is the only statistically reliable method for reducing congestion and processing times at the branch's primary service points.

6.2 Final Verdict and Strategic Outlook

The final verdict of this comparative analysis is that the branch must prioritize human capital expansion to achieve long-term stability and efficiency. By processing 5,000 customers across 100 independent trials, we have confirmed with high statistical reliability that adding one Sign-In staff member and one Teller will reduce total system flow time by 18.8% and facility occupancy by nearly 19%. The isolation of Scenario 3 in the SMORE plots confirms that these results are not temporary fluctuations but consistent, repeatable outcomes. We recommend the immediate cancellation of planned ATM hardware purchases to redirect funds toward personnel

training and payroll, ensuring the branch is optimized for high-impact human service rather than redundant technology.

VII. APPENDIX



3-D View of Simio-Model post final run

Scenario ▲													
Statistic ▲ ▼	Scenario1				Scenario2				Scenario3				
	Average	Minimum	Maximum	Half Width	Average	Minimum	Maximum	Half Width	Average	Minimum	Maximum	Half Width	
Average	1.8417	1.7452	1.9704	0.0089	1.8416	1.7451	1.9698	0.0089	1.4966	1.4271	1.5636	0.0056	
Maximum	11.0500	8.0000	16.0000	0.2805	11.0500	8.0000	16.0000	0.2805	8.6300	7.0000	13.0000	0.1753	
Average (Sec...)	116.1734	111.604	121.1438	0.3562	116.1719	111.602	121.1402	0.3556	94.3495	91.8572	97.6045	0.1957	
Maximum (Sec...)	653.0788	500.783	976.9543	19.1447	653.0788	500.783	976.9543	19.1447	619.7601	487.854	938.7364	18.1754	
Minimum (Sec...)	1.8051	0.0028	4.9945	0.2795	1.8051	0.0028	4.9945	0.2795	1.0885	0.0028	4.6643	0.1890	
Observations	4,497.3600	4,373.00	4,641.00	11.5128	4,497.3100	4,373.00	4,641.00	11.5022	4,500.3300	4,372.00	4,676.00	13.0327	

Output Statistics of Scenarios via PivotGrid