Restaurant Kazu
Part 2: Simulation Modeling

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9956 Simulation & Risk Analysis
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Model Setup

This simulation was developed to help management at Restaurant Kazu understand and manage congestion by explicitly quantifying how operational conditions affect customer wait times, walk-aways, revenue capture, and profitability under uncertainty. The model was built using Part 1 analysis inputs**,** translating observed operating rules, demand patterns, and service processes into a discrete-event simulation framework.

Rather than relying solely on average performance metrics, the model captures the stochastic and episodic nature of congestion, recognizing that service failures are driven by peak demand conditions rather than typical days. Customer arrivals, service times, and patience thresholds are modeled probabilistically, allowing the simulation to generate realistic variability across days and across annual replications.

The simulation explicitly represents both lunch and dinner operations, reflecting differences in arrival rates, staffing levels, and operating hours, as well as the uneven distribution of congestion across weekdays versus weekends. The baseline model reflects current operations at Kazu, including:

- Existing seating capacity (six tables plus pooled ten bar seating and two extra seat),
- Front-of-house staffing differentiated by weekday and weekend,
- Kitchen staffing (one chef with helpers, with chef-required jobs explicitly modeled),
- Current menu pricing and purchasing behavior, and
- Historical operating days and hours.
- Customers arrive according to a stochastic interarrival process **parameterized using Part 1 empirical estimates** and respond endogenously to congestion through two explicit behaviors Balking and Reneging**.**

All revenues, costs, and performance measures are computed on a per-open-day basis, ensuring internal consistency with observed operations and allowing clean aggregation to annual metrics.

Customer Abandonment Logic (Balking vs. Reneging)

To quantify “missed customers” caused by congestion, we explicitly model two distinct abandonment behaviors: **balking** and **reneging**.

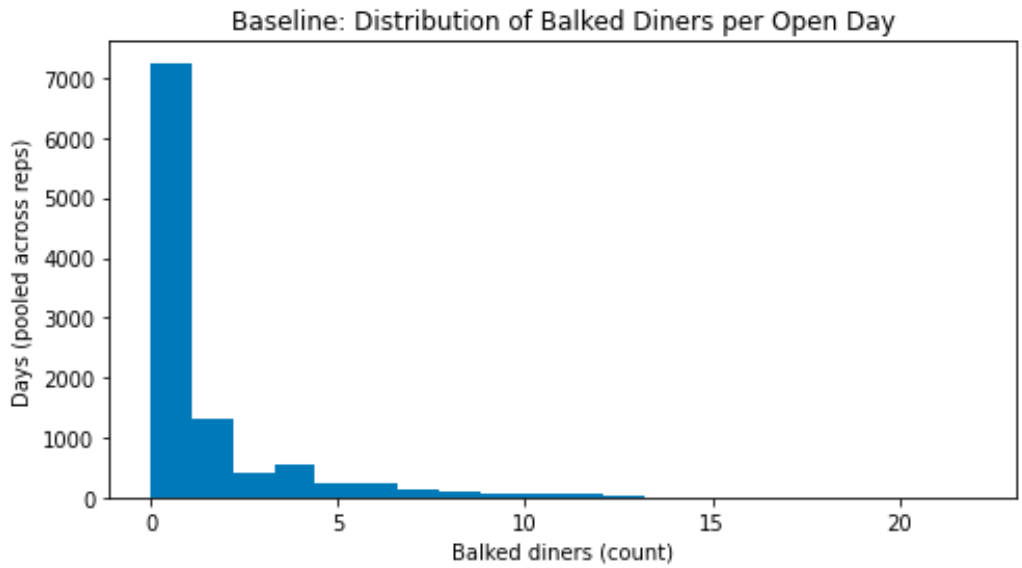

Figure 1: Distribution of Balked Diners per Open Day

Balking represents customers who **leave immediately upon arrival** when the visible line is too long; in the simulation, if the current queue exceeds a predefined threshold (measured in people), an arriving party may balk with probability P-balk, and their departure time is recorded at the arrival time.

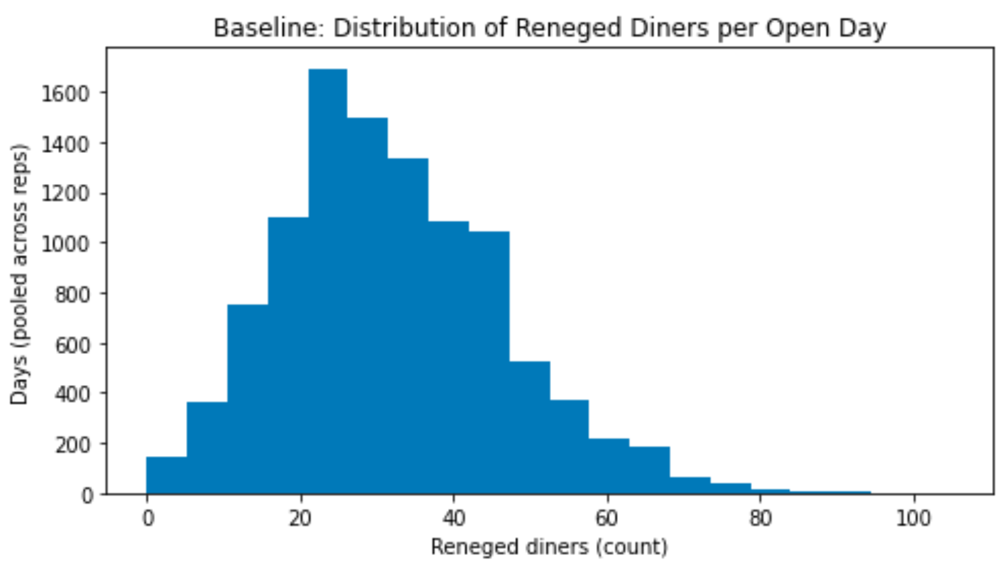

Figure 2: Distribution of Reneged Diners per Open Day

Reneging represents customers who **initially join the queue but leave after waiting too long;** for each arriving party we draw an individual patience time from a specified distribution (with an optional cap), and if the party is not seated before their patience expires, they renege and leave the system. We report walk-aways as Balked + Reneged diners (weighted by party size rather than party count), and we also track the split between balking vs. reneging because the two mechanisms imply different operational causes and different strategic levers (e.g., reducing visible queue vs. reducing actual wait).

Model Verification & Validation

Step A: Verification (Trace Log).

To verify that the simulation is "built right," we generated an event-level trace log from a short run (e.g., the first 60 minutes of service). The trace records each entity's key transitions step-by-step—arrival, queue entry, balk decision, patience countdown, seat assignment, service progression, and departure—together with resource seize/release actions (tables, bar seats, servers, chef/helpers). This forensic log confirms that (i) customers are never seated after closing time, (ii) **balking** occurs only when the visible queue exceeds the defined threshold (immediate walk-away), (iii) **reneging** occurs only when an individual's patience expires while waiting in queue (delayed abandonment), and (iv) resources are acquired and released in the intended sequence without deadlocks or impossible states. These checks provide confidence that the DES logic and conditional triggers execute exactly as designed before using the model for experiments and financial impact analysis (See the Validation Log attached).

Step B: Validation

We validated the model by running 100 replications of Saturday dinner (17:00–21:30) and comparing the simulated KPIs to the historical values in *Kazu_data.xlsx*. KPIs include served diners, left diners, left/served, and average stage times (wait, order, cook, pay, depart), weighted by party size. "Left diners" combines **balking** (walk-away when the visible line is too long) and **reneging** (leaving after waiting longer than a patience limit). We report the mean and 95% CI across replications to show output stability. Across all service stages (wait, order, cook, pay, and departure), simulated timing results fall within **–0.3% to –7.7% of historical values**, which is considered acceptable given natural day-to-day variability and unobserved behavioral factors. In addition to stage times, we also validated demand outcomes (served diners, left diners, and left/served) to ensure the model matches both timing dynamics and congestion-driven abandonment at the system level.

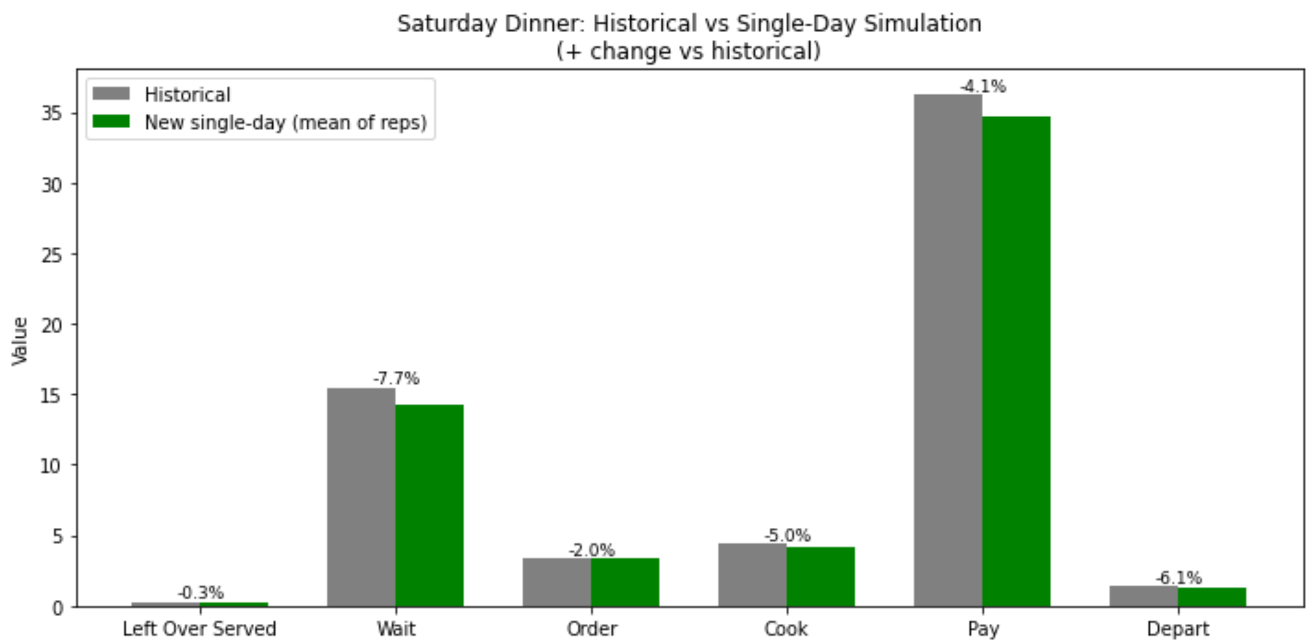

Figure 3: Validation Comparison

These two steps confirm that:

- Customers are never seated after closing time,
- Balking occurs only when visible queue demand exceeds the specified threshold,
- Reneging occurs only after patience expiration, and
- Resources (tables, bar seats, servers, chef, helpers) are acquired and released in the correct sequence.

This validation process increases confidence that the DES does not exhibit implausible behavior and is suitable for baseline performance and congestion analysis.

Baseline Performance and Congestion Risk

Under the baseline configuration, the restaurant serves an average of 282.6 diners per open day while losing approximately 45.1 diners per day due to balking and reneging (Figure 4).

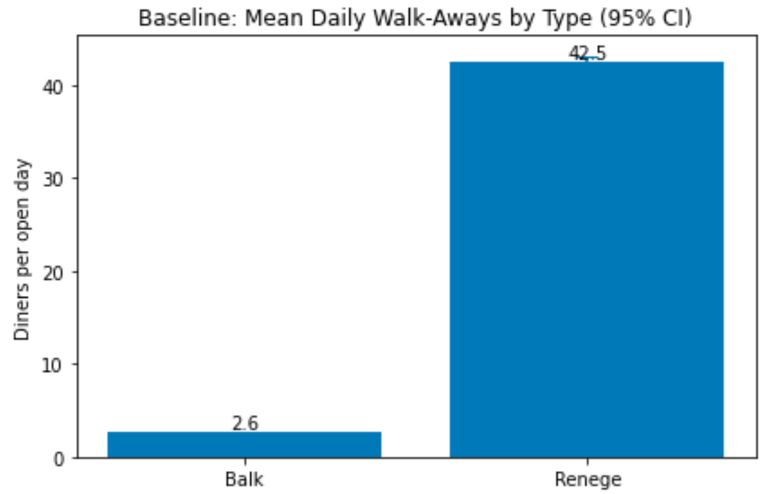

Figure 4: Mean Daily Walk-Aways (Balk vs Renege)

When performance is examined by weekday versus weekend, average metrics mask substantial tail risk, particularly during weekends. As shown in Figure 5, the 95th percentile of the weekend daily left-to-served ratio reaches approximately 0.32, approaching the congestion failure threshold of 0.33. While such extreme congestion days are not typical, they occur with meaningful frequency: on approximately 4.4% of open days, more than one-third of potential demand is lost.

These high-congestion days are economically significant despite their rarity, as they contribute a disproportionate share of total walk-aways and lost revenue. In contrast, weekday operations exhibit a tighter distribution with substantially lower tail risk, highlighting the asymmetric impact of weekend demand surges on system performance.

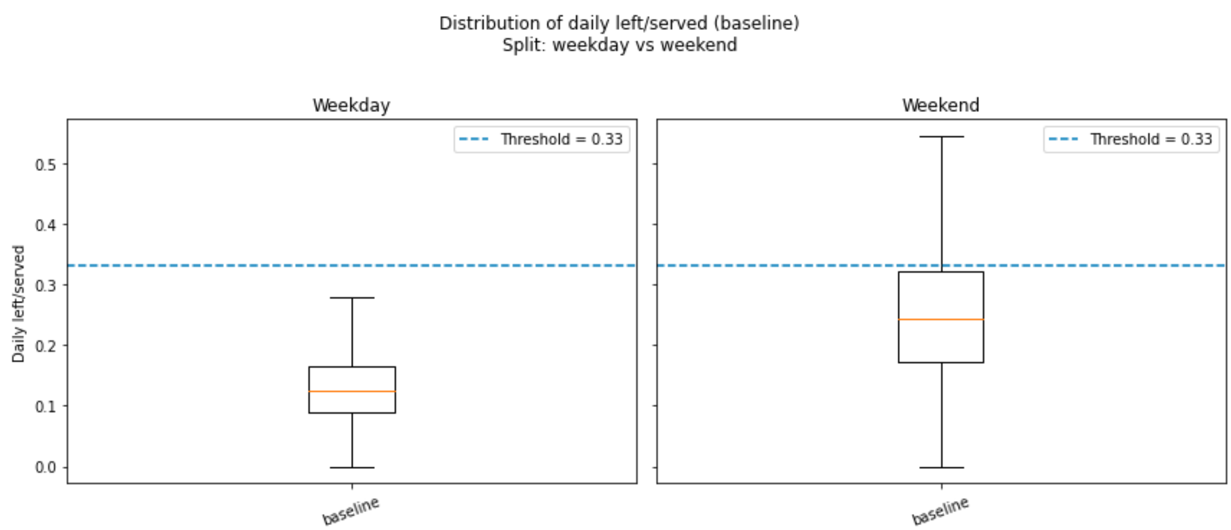

Figure 5: Distribution of Daily left/served by Weekday vs Weekend

Financial Impact

Despite an average customer wait time of only 10.4 minutes across the week, the discrete-event simulation reveals substantial invisible financial losses driven by queue-related abandonment. Under baseline operating conditions, the model estimates that 13.8% of total potential revenue is lost due to customer balking and reneging (Figure 3).

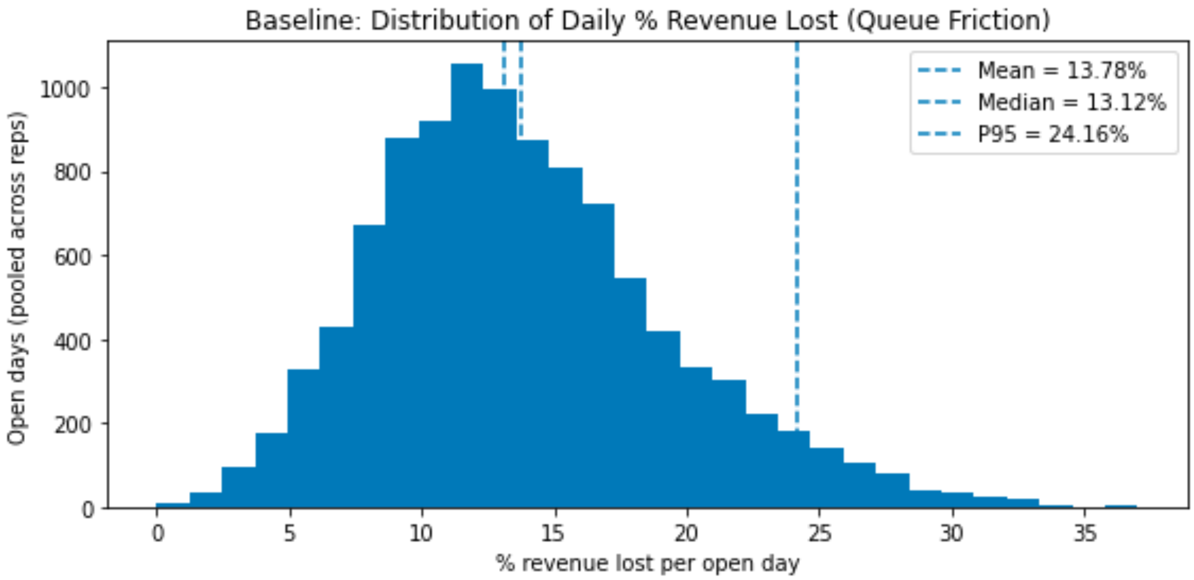

Figure 6: Distribution of Daily % Revenue Lost

On an annualized basis, this corresponds to approximately $227,000 in unrealized revenue (Table 1). Importantly, this lost revenue is nearly twice the modeled annual profit, underscoring that queue-related abandonment represents a material operational concern**.**

Kazu Restaurant Financial Metrics Summary		
Section	**Key metric**	**Baseline**
Financial Performance (Daily)	Avg revenue / day ($)	6,803.66
	Avg cost / day ($)	6,243.35
	Avg profit / day ($)	560.31
Financial Performance (Annual)	Revenue / year ($)	1,421,965.80
	Cost / year ($)	1,304,859.36
	Profit / year ($)	117,106.44
Queue Friction (Invisible Cost)	% revenue lost to balking & reneging	13.77%
	Revenue lost / year ($)	227,023

Table 1: Financial Metrics Summary

Taken together, these baseline results demonstrate that congestion at Kazu is driven primarily by pre-seating delays and queue abandonment, with economically meaningful losses concentrated in a relatively small number of high-congestion days. This finding motivates the need for targeted interventions that reduce queue persistence and visible waiting rather than relying on average-day performance metrics alone.

Managerial Implications

The baseline simulation demonstrates that congestion at Restaurant Kazu is driven primarily by pre-seating delays and visible queues, and that system performance cannot be assessed using average outcomes in isolation. While operations appear stable on most days, a relatively small number of high-congestion days generate disproportionately large economic losses through customer balking and reneging.

From a financial perspective, missed customers represent a first-order managerial concern. The model estimates that nearly 14% of potential revenue is lost due to queue-related friction— an amount that materially constrains profitability under current operations. This finding underscores that congestion is not merely a service-quality issue but a core profitability risk.

Importantly, the validated simulation provides a controlled experimental environment in which alternative operational strategies can be systematically evaluated. In subsequent analysis phases, we will test multiple scenarios and conduct sensitivity analyses to identify which levers—such as seating capacity, staffing levels, operating hours, or pricing—most effectively reduce congestion risk while improving financial performance.