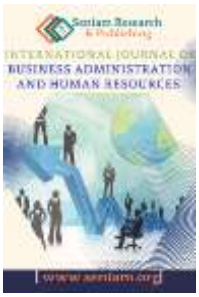
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Workforce Planning, Delivery Certainty, and the Performance of Online Shopping Businesses: A Last-Mile Perspective from Singapore

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ABSTRACT

Last-mile delivery performance is frequently treated in the e-commerce literature as a function of route optimisation, technology, or carrier selection, with comparatively little attention paid to the internal workforce capabilities that make those systems function. This paper draws on survey data from 56 online shopping businesses operating in the Singaporean market to examine how workforce planning, lead-time certainty, and customer-perceived delivery reliability relate to business performance. Rather than treating lead-time outcomes as a flat set of independent correlates, the paper proposes the Delivery Reliability Cascade Model (DRCM), which positions workforce planning as the upstream driver of a sequential chain running through lead-time certainty and customer-perceived reliability to business performance, with lead-time uncertainty acting as the point at which the cascade is most likely to break down. Descriptive results indicate that most surveyed businesses report close attention to lead-time reduction, improved delivery efficiency attributable to workforce planning, and a positive relationship between delivery reliability and customer perception, while also identifying lead-time uncertainty as a persistent constraint on performance. The findings are discussed in relation to existing lead-time variability and last-mile logistics literature, and the paper concludes by noting the descriptive, cross-sectional limits of the underlying data and proposing directions for research that would test the cascade logic more directly.

Keywords:
last-mile delivery, lead-time management, workforce planning, online retail, Singapore, business performance

INTRODUCTION

Online shopping businesses compete on a dimension that is largely invisible until it fails: the interval between an order being placed and a product arriving at a customer's door. This interval, commonly termed order lead time, has become one of the more consequential determinants of customer satisfaction and repeat purchase behaviour in e-commerce markets, particularly in dense, delivery-intensive markets such as Singapore (Ding, 2014; Yang & Geunes, 2007). Much of the existing literature on lead-time management approaches the problem from a systems or network perspective, examining transportation modes, routing efficiency, and delivery technology (Lim et al., 2018)).

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Comparatively less attention has been paid to the workforce dimension of lead-time performance: the extent to which businesses staff, train, and schedule the personnel responsible for order fulfilment and delivery coordination.

This paper addresses that gap using survey data collected from 56 online shopping businesses operating in Singapore, examining the relationship between order lead time, workforce planning, and business performance. Rather than presenting lead-time findings as a list of loosely related correlates, this paper advances the Delivery Reliability Cascade Model (DRCM), a framework in which workforce planning functions as the upstream driver of a sequential chain of outcomes: lead-time certainty, customer-perceived delivery reliability, and ultimately business performance (Mohammed & Mandal, 2024). The model further identifies lead-time uncertainty not as a separate variable but as the point of vulnerability at which the cascade is most likely to be interrupted.

The Singaporean market offers a particularly relevant setting for this question. As a compact, densely populated, and highly digitally connected economy, Singapore presents online retailers with comparatively favourable underlying conditions for fast, predictable delivery relative to geographically dispersed or infrastructure-constrained markets, which means that where lead-time uncertainty nonetheless persists as a reported constraint, the explanation is less likely to lie in fixed geographic or infrastructural limitations and more likely to lie in organisational factors within businesses' own control, of which workforce planning is a primary candidate (International Trade Administration, 2025; Tan, 2025). This makes Singapore a useful setting in which to examine the workforce dimension of lead-time performance specifically, since the market's favourable logistics conditions reduce, without eliminating, the confounding influence of infrastructure-level constraints that might otherwise obscure the contribution of workforce-related factors.

The paper proceeds as follows. The literature review situates last-mile delivery within the broader lead-time management literature, distinguishing among the production, shipping, border-clearance, and receipt-and-inspection dimensions of lead-time variability before turning to workforce planning and lead-time uncertainty specifically. The DRCM framework is then introduced. The methodology section describes the descriptive survey design underlying the data. The findings and discussion sections interpret the survey results through the cascade logic, and the conclusion addresses the study's limitations and directions for further research.

LITERATURE REVIEW

Last-Mile Delivery and Customer Satisfaction

Last-mile delivery refers to the final stage of the fulfilment process, covering the movement of goods from a local distribution point to the customer's specified location (Ding, 2014; Tsai et al., 2024). Because it is the stage of the transaction at which the customer has direct, tangible contact with the business, last-mile performance carries disproportionate weight in shaping overall satisfaction relative to its share of total logistics cost (Lim et al., 2018; Srivatsa Srinivas & Marathe, 2021). Order lead time, understood as the interval between order placement and delivery completion, is the primary metric through which customers evaluate this stage. Darko et al. (2018) distinguish between transaction-specific satisfaction, which reflects a customer's evaluation of a single delivery encounter, and cumulative satisfaction, which reflects an aggregated judgment formed across repeated encounters with a business. Lead-time consistency is more strongly associated with cumulative satisfaction than any single fast delivery, since customers appear to weight predictability alongside speed when forming judgments about a retailer's reliability.

Suwal (2018), studying lead-time management in a Nepalese service organisation, found that the availability and competence of service personnel were significant predictors of customer

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satisfaction, alongside more commonly studied factors such as location and spare-parts availability. This finding is notable because it locates a meaningful share of lead-time performance within workforce-related variables rather than purely logistical or infrastructural ones, a distinction that motivates the framework developed later in this paper.

The centrality of lead time to online retail specifically, as distinct from brick-and-mortar or business-to-business contexts, follows from the structure of the transaction itself. In a physical retail encounter, the customer inspects and takes possession of the product at the point of sale, so lead time as conventionally defined does not enter into the immediate purchase experience. In an online transaction, the purchase decision and the fulfilment experience are temporally separated, and it is the fulfilment experience, not the checkout process, that most directly shapes the customer's post-purchase evaluation of the business (Yang & Geunes, 2007). This separation means that online retailers carry a structural exposure to lead-time risk that physical retailers do not, and that lead-time management functions, in effect, as an extension of the customer-service relationship rather than as a purely operational or back-office concern.

A further complication specific to online retail is that customers typically cannot directly observe the internal causes of a delivery delay. A customer who receives a late order cannot distinguish, without additional information, between a delay originating in inventory processing, carrier performance, or address verification; the delay is experienced uniformly as a failure attributable to the retailer. This asymmetry of information means that businesses bear reputational exposure for lead-time failures regardless of whether the proximate cause lies within their direct operational control, which strengthens the practical case for treating workforce planning, one of the few lead-time determinants a business can directly control, as a priority lever rather than one factor among many of comparable weight.

Dimensions of Lead-Time Variability

Lead-time variability is rarely attributable to a single cause. Ndubi et al. (2016), examining inbound logistics performance, decompose lead-time variability into four component processes: production lead-time, the interval required to prepare goods for dispatch; shipping lead-time, the interval associated with physical transportation; border-clearance turnaround time, relevant for cross-border or import-dependent retailers; and receipt-and-inspection velocity, the interval associated with verifying and processing incoming goods before they become available for onward delivery. Each of these components is subject to its own sources of delay: process-time inconsistency and rework in production; carrier reliability and mode selection in shipping; documentation and regulatory compliance at the border; and specialist inspection requirements at the receipt stage.

For online shopping businesses, several of these dimensions are compressed or reconfigured relative to traditional manufacturing supply chains, but the underlying logic persists. A retailer that sources inventory internationally inherits border-clearance variability upstream of any last-mile delivery decision; a retailer with weak internal stock-verification processes introduces receipt-and-inspection delay before an order can even be dispatched (Li, 2025). Okyere et al. (2015), writing on lead time in a service-delivery context, distinguish between value-adding time, defined as activity that directly contributes to the customer's perception of value received, and non-value-adding time, characterised by delay, rework, or redundant contact. They argue that lead-time reduction efforts are most effective when targeted at eliminating non-value-adding time rather than simply accelerating every stage of the process uniformly, since indiscriminate acceleration can increase error rates and generate rework that ultimately lengthens the effective lead time.

Chung et al. (2018) extend this decomposition by examining how lead-time uncertainty at the border-crossing stage interacts with safety-stock

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decisions in a just-in-time supply chain, finding that businesses operating under uncertain border-clearance conditions tended to compensate through elevated safety-stock holdings, effectively converting a time-based risk into a cost-based one. This substitution logic is instructive for online retail: a business unable to reduce lead-time variability directly, whether because the variability originates outside its operational boundary or because eliminating it would require infrastructure investment beyond its scale, can partially offset that variability through inventory buffering, staffing buffers, or communication strategies that manage customer expectations during periods of elevated uncertainty (Smeets, 2021). This suggests that lead-time variability should not be treated as a single undifferentiated construct in survey-based research; a business's reported experience of lead-time challenges may reflect any combination of these four component processes, and different businesses within the same market may be responding to substantially different underlying causes even when they report similar overall levels of concern.

The relative weight of each dimension is also likely to vary with a business's position in the marketplace-type spectrum common to online retail, ranging from general marketplaces carrying a broad assortment of third-party or wholesaler-sourced goods to niche or on-demand production marketplaces in which goods are manufactured or customised only after an order is placed (Gielens & Steenkamp, 2019; Smeets, 2021). On-demand production models compress the production and shipping lead-time stages into a single sequential process visible to the customer as one undifferentiated wait, which places correspondingly greater weight on workforce-driven production scheduling as the primary lever available to the business, since there is no pre-existing finished-goods inventory to buffer against delay.

Workforce Planning and Lead-Time Management

Workforce planning, understood as the process of ensuring the availability of personnel with the appropriate skills and capacity to meet operational demand, has an established but underexplored relationship with lead-time performance (Suwal, 2018). In a last-mile delivery context, workforce planning determines whether a business has sufficient logistics personnel to process, package, and dispatch orders within the promised delivery window, independent of whether the underlying transportation infrastructure is adequate. A well-forecasted inventory position is of limited value if a business lacks the staffing capacity to convert that inventory into fulfilled orders on schedule.

The competency dimension of workforce planning is distinct from its capacity dimension. Even where sufficient personnel are available, the quality of service delivery depends on the skills, training, and judgment those personnel bring to bear on non-routine situations, such as address discrepancies, damaged goods, or customer complaints during the delivery window (Suwal, 2018). Businesses that treat last-mile personnel as a fixed operational cost, rather than as a determinant of customer-facing service quality, are more likely to experience variability in delivery outcomes that is attributable to human rather than purely logistical factors.

A further distinction relevant to online retail specifically concerns the location decision embedded within workforce and fulfilment planning. The physical siting of picking, packing, and dispatch operations determines both the baseline transit distance to the customer base and the pool of labour available to staff those operations at the volumes and shift patterns e-commerce fulfilment typically requires, including evening and weekend peaks that do not necessarily align with conventional retail staffing patterns. A business that locates fulfilment capacity for cost reasons, without regard to proximity to its customer base or to labour-market depth, may find that workforce planning decisions made at the facility-location stage constrain lead-

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time outcomes in ways that cannot be corrected through scheduling adjustments after the fact (Dethlefs et al., 2022; Dubey & Veeramani, 2024). This suggests that workforce planning, as a determinant of lead-time performance, should be understood as extending backward into strategic decisions about where and how fulfilment capacity is built, not only forward into the day-to-day scheduling of existing personnel.

Workforce planning also interacts with demand volatility in ways that are specific to online retail's promotional and seasonal patterns. Because online retailers frequently run time-bound promotions, flash sales, and seasonal campaigns that generate sharp, short-duration spikes in order volume, static staffing levels calibrated to average demand are structurally mismatched to the demand pattern the business actually faces. Effective workforce planning in this context requires not simply adequate average capacity but flexible capacity, whether through cross-trained staff, temporary labour arrangements, or demand-responsive scheduling, that can absorb volume spikes without a corresponding spike in lead time. Businesses lacking this flexibility are likely to experience lead-time uncertainty that is concentrated around promotional periods specifically, a pattern that a simple average lead-time metric would tend to understate.

Lead-Time Uncertainty and Business Performance

A distinction exists in the literature between lead-time length and lead-time uncertainty, and the two do not necessarily move together. A business may have a relatively long but highly predictable lead time, or a relatively short but volatile one; the evidence suggests that uncertainty, more than length per se, is what most directly undermines customer trust and operational planning (Chung et al., 2018). Bagshaw and Ejiroghene (2018), examining lead-time uncertainty and inventory scheduling among manufacturing firms, found that uncertain, fluctuating scheduling patterns were associated with higher average inventory holdings and higher stock-out incidence than uniform, predictable scheduling patterns, even when the average lead time across both conditions was comparable. This finding generalises to the last-mile context: unpredictable delivery windows compel businesses to hold excess buffer capacity, whether in the form of safety stock, additional staffing, or slack in delivery-partner contracts, all of which raise operating cost without necessarily improving average service speed.

Lead-time uncertainty in an online retail context can originate from causes outside a business's direct control, including weather disruption, carrier capacity constraints, and, increasingly, disruptions to the digital ordering infrastructure itself, such as platform or connectivity failures that delay order processing before physical dispatch even begins. Regardless of origin, the consequence is similar: postponed scheduling, delayed communication with customers, and an erosion of the predictability on which cumulative customer satisfaction depends (Darko et al., 2018). This suggests that lead-time uncertainty functions less as an independent variable in a list of performance correlates and more as a structural weak point, a stage at which an otherwise well-functioning chain of workforce planning and delivery execution can break down and undermine performance outcomes that would otherwise be expected from strong upstream planning.

Technology, Automation, and the Limits of Infrastructure-Centric Solutions

A substantial share of the last-mile logistics literature has focused on technological and infrastructural solutions to lead-time variability, including route-optimisation software, delivery-tracking systems, and, more recently, automated and drone-based delivery methods (Lim et al., 2018; Meyer-Waarden et al., 2026). These solutions address a real and substantial source of lead-time variability, particularly the shipping and transportation stage identified by Ndubi et al. (2016), and there is little dispute in the literature that businesses able to invest in such technology gain a measurable reduction in transportation-stage delay. What is less consistently addressed is the extent to which these technologies

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presuppose, rather than substitute for, adequate workforce capacity at the stages that precede transportation: order processing, picking, packing, and dispatch scheduling. A routing algorithm can optimise the sequence in which orders are delivered once they leave a facility, but it cannot compensate for delay accumulated before dispatch if the facility lacks sufficient staff to process orders at the rate the business's order volume requires.

This distinction matters for smaller and mid-sized online retailers specifically, since large-scale automation and routing technology typically require capital investment that is more readily available to larger, more established businesses than to newer entrants or smaller-scale operators. For businesses without ready access to this investment, workforce planning represents a comparatively lower-cost and more immediately actionable lever for improving lead-time performance than infrastructure investment, which reinforces the practical relevance of a framework that positions workforce capacity as the primary upstream determinant of downstream delivery outcomes rather than treating it as secondary to technological solutions. This is not to suggest that infrastructure investment is unimportant to lead-time performance in an absolute sense, but rather that its returns are conditional on adequate workforce capacity being in place at the earlier stages of the fulfilment process, a conditionality that the existing literature has not always made explicit.

DELIVERY RELIABILITY CASCADE MODEL

The literature reviewed above suggests that lead-time outcomes in online retail are not well captured by treating workforce planning, lead-time certainty, customer perception, and business performance as a flat set of independently correlated variables. Each appears instead to occupy a distinct position in a sequential chain, in which the strength of an upstream stage constrains, rather than merely correlates with, the outcomes observed downstream. This paper proposes the Delivery Reliability Cascade Model (DRCM) to formalise that sequence.

The DRCM specifies four stages. The first stage, workforce planning adequacy, captures the extent to which a business has sufficient, competently trained personnel available to process and dispatch orders within a target window. The second stage, lead-time certainty, captures the consistency of the interval between order placement and delivery, independent of its absolute length (Khleel & Khlefha, 2021; Zhang et al., 2024). The third stage, customer-perceived delivery reliability, captures the customer's cumulative judgment of whether the business reliably meets its stated delivery commitments, a judgment that is shaped by, but not identical to, the business's internal lead-time data. The fourth stage, business performance, captures the downstream commercial outcomes, including customer retention, satisfaction-linked repeat purchase, and competitive positioning, that the preceding three stages are hypothesised to jointly produce.

The distinguishing claim of the DRCM is that these four stages behave as a cascade rather than as parallel inputs into performance. Strength at the workforce-planning stage is a precondition for, rather than merely a contributor to, lead-time certainty; a business cannot achieve consistent delivery windows through favourable logistics infrastructure alone if it lacks the staffing capacity to process orders on a predictable schedule(Khleel & Khlefha, 2021; Zhang et al., 2024).. Lead-time certainty, in turn, is a precondition for customer-perceived reliability, since a customer's cumulative judgment is formed through repeated exposure to consistent, or inconsistent, delivery experiences rather than through a single fast delivery. It follows that interventions aimed directly at the performance stage, such as marketing or loyalty programmes, are likely to yield limited returns if the upstream stages of the cascade, particularly workforce planning, remain weak.

The model also formalises the role of lead-time uncertainty as a point of structural vulnerability

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rather than as a fifth, independent variable. Uncertainty is best understood as a failure mode at the transition between the first and second stages of the cascade: it is what occurs when workforce planning capacity is insufficient, or is undermined by external disruption, such that lead-time certainty cannot be sustained even where the business's average delivery performance appears adequate. A business may report a reasonable average lead time while nonetheless experiencing frequent breakdowns in certainty that undermine customer trust; the DRCM predicts that such businesses will show weaker customer-perceived reliability, and weaker downstream performance, than their average lead-time figures alone would suggest.

The model's boundary conditions merit brief specification. The DRCM is proposed as applicable to businesses that retain direct control over, or at minimum direct visibility into, the personnel responsible for order processing and dispatch scheduling, whether those personnel are employed directly or contracted through a fulfilment partner over whom the business exercises meaningful scheduling influence. Businesses that fully outsource fulfilment to a third-party logistics provider with no visibility into that provider's staffing decisions would fall outside the model's core scope as specified here, since the workforce-planning stage would then sit within the third-party provider's organisational boundary rather than the retailer's own, and the cascade logic would need to be re-specified at the level of the fulfilment partner rather than the retailer. Similarly, the model presumes a business of sufficient scale that workforce planning constitutes a distinct, manageable operational function; for the smallest online retailers, in which the same one or two individuals may simultaneously handle sourcing, customer service, and dispatch, the workforce-planning stage may be better understood as a founder or owner time-allocation decision rather than as a formal planning process, a distinction that would need to be reflected in how the construct is operationalised for very small businesses in future survey work.

This framing carries a practical implication that distinguishes the DRCM from more general lead-time variability frameworks: it suggests that businesses seeking to improve last-mile performance should prioritise investment in workforce planning and scheduling capacity as the primary lever, treating logistics infrastructure and carrier selection as necessary but secondary conditions. The findings and discussion sections below examine the extent to which the survey data collected for this study are consistent with this cascading structure.

METHODOLOGY

This study adopted a descriptive research design based on a quantitative survey instrument, consistent with an exploratory approach to an under-researched relationship between workforce planning and last-mile delivery outcomes in Singapore's online retail sector (Bordens & Abbott, 2018; Creswell & Creswell, 2018). The target population comprised owners and managers of online shopping businesses operating in the Singaporean market, selected without restriction by product category or marketplace type.

A structured questionnaire was administered electronically to 100 online shopping businesses identified through a systematic search of companies operating within Singapore's e-commerce market. The questionnaire combined general business-classification items with a set of Likert-scale statements addressing lead-time management, scored on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Fifty-six completed responses were received, yielding a response rate of 56 per cent, which exceeds the threshold generally regarded as acceptable for survey-based business research (Bernazzani, 2021; Creswell & Creswell, 2018).

Responses were exported and coded for analysis using the Statistical Package for the Social Sciences (SPSS). Given the descriptive nature of the design, analysis was limited to frequencies, percentages, means, and standard deviations; no correlational or regression analysis was

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performed on the underlying data, and this paper does not claim to establish statistically tested relationships between the constructs discussed. Findings are accordingly presented, and should be read, as a description of surveyed businesses' self-reported perceptions rather than as evidence of statistically confirmed causal or correlational effects. Ethical procedures followed standard social-science research protocols, including informed consent, anonymity of respondent identity and business name, and secure data storage, with respondent language reviewed by an academic supervisor prior to distribution (Greener, 2008; Saunders et al., 2024).

The lead-time section of the questionnaire comprised six Likert-scale statements addressing, respectively, general attention to lead-time reduction, the contribution of workforce planning to delivery efficiency, the relationship between customer perception and business performance, the effect of delivery reliability on customer satisfaction, and the perceived limitation posed by lead-time uncertainty. These items were designed to capture respondent perceptions across each of the constructs later organised, for the purposes of this paper, into the four-stage structure of the Delivery Reliability Cascade Model; it should be emphasised, however, that the survey instrument itself was not designed with the DRCM in mind, since the model was developed subsequently as an interpretive framework for organising the resulting data, and the instrument does not contain items constructed explicitly to test mediation or sequencing between the proposed stages. This is a material limitation of the present design, addressed further in the conclusion, and means the analysis below should be understood as a reinterpretation of existing descriptive data through a new theoretical lens rather than as a study designed from the outset to test that lens directly.

Respondent anonymity precluded the collection of firm-level identifiers beyond marketplace classification and duration of operation, which limits the extent to which individual survey responses can be cross-referenced against publicly available performance indicators such as customer review scores or delivery-time benchmarks published by third-party logistics evaluators. All findings reported below are therefore based exclusively on respondents' self-reported perceptions of their own businesses' lead-time practices and outcomes, rather than on externally verified performance data, a limitation common to survey-based organisational research of this kind and one that should be borne in mind when interpreting the strength of the descriptive patterns discussed.

FINDINGS

Respondent businesses varied in market tenure: a majority had operated in the Singaporean market for between one and five years, with a smaller proportion reporting more than five years of operation and a further group reporting less than one year, indicating a survey sample that spans early-stage and more established online retailers rather than being concentrated at either extreme. This spread is relevant to the findings below in that lead-time management practices are unlikely to be uniform across a market population with this degree of variation in operating experience.

Table 1 presents the descriptive results for the six lead-time statements included in the questionnaire, scored on a five-point Likert scale. A mean above 3.0 is interpreted, consistent with the scale midpoint, as indicating agreement with the statement.

It should be noted that the fourth item in Table 1 duplicates the wording of the third; the original data-collection instrument appears to have generated two slightly divergent scored responses for what was intended as a single survey item. Both values are reported here for transparency and are discussed jointly below rather than treated as evidence of two distinct constructs.

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Table 1: Order lead time and performance of online shopping businesses (n = 56).

Statement	Mean	Std. Err.	Std. Dev.
The business has been paying close attention to reducing lead time	4.02	0.086	0.646
The business experienced improved lead-time efficiency due to effective workforce planning	3.93	0.084	0.628
The business experienced positive performance due to customer reviews of its lead-time efficiency	3.79	0.110	0.825
The business experienced positive performance due to customer reviews of its lead-time efficiency (repeated instrument item)	3.89	0.091	0.679
The ability to deliver goods within the stated lead time increased customer satisfaction	3.96	0.088	0.660
Lead-time uncertainty is a limitation to business performance	4.00	0.099	0.739

Workforce Planning and Lead-Time Certainty

The highest-scoring item in the dataset was the statement that businesses have been paying close attention to reducing lead time (M = 4.02, SD = 0.646), indicating that lead-time management is a live operational priority for the surveyed businesses rather than a peripheral concern. This was followed closely by agreement that improved lead-time efficiency had resulted from effective workforce planning specifically (M = 3.93, SD = 0.628). Read together within the DRCM framework, these two results are consistent with the model's first-stage claim: businesses that report active attention to workforce-related scheduling and staffing are also the businesses reporting improved lead-time outcomes, suggesting that workforce planning is functioning as an operative input into lead-time certainty for this sample, rather than as a background administrative concern disconnected from delivery outcomes.

Customer-Perceived Reliability

The two customer-perception items, despite the instrument duplication noted above, both registered agreement (M = 3.79, SD = 0.825; M = 3.89, SD = 0.679), as did the related statement that the ability to deliver within the stated lead time increased customer satisfaction (M = 3.96, SD = 0.660). The relatively higher standard deviation on the customer-review item (0.825) relative to the workforce-planning item (0.628) is notable: it suggests greater dispersion in how businesses perceive customer-facing outcomes than in how they perceive their own internal workforce practices. Within the DRCM, this pattern is consistent with the proposition that customer-perceived reliability is a downstream, cumulative judgment shaped by repeated delivery experiences, and is therefore more variable across businesses than the more directly controllable, internally reported workforce-planning stage that precedes it.

Marketplace Composition and Interpretive Context

Beyond tenure, the surveyed businesses were classified by marketplace type, with general marketplaces, offering a broad assortment of products at a single site, constituting the largest single category, followed by unique-item and on-demand production marketplace segments, with smaller proportions operating as auction or niche marketplaces. This composition is relevant to the interpretation of the lead-time findings above, since, as discussed in the literature review, on-demand production models compress the production and shipping stages of lead time into a single customer-visible interval and are hypothesised to be more sensitive to workforce-planning quality than general marketplaces that can draw on pre-existing finished-goods inventory to buffer against delay. The available data do not permit a segmented breakdown of the Table 1 results by marketplace type, since the underlying dataset reports lead-time responses only in aggregate; this represents a specific limitation of the present analysis and a concrete opportunity for future survey design, discussed further below, since a marketplace-type breakdown would allow a more direct test of the

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DRCM's prediction that workforce-planning sensitivity varies systematically with a business's position in the production-to-delivery pipeline.

Lead-Time Uncertainty as a Point of Vulnerability

Despite generally positive results across the workforce-planning and customer-perception items, the statement that lead-time uncertainty constitutes a limitation to business performance also registered strong agreement ($M = 4.00$, $SD = 0.739$), the second-highest mean in the table. This is a notable pattern: businesses simultaneously report active attention to lead-time management, workforce-driven efficiency gains, and positive customer perception, while also identifying uncertainty as a persistent constraint. Rather than treating this as a contradiction, the DRCM interprets it as consistent with its framing of uncertainty as a structural vulnerability that can coexist with generally strong upstream practice; a business can have adequate average workforce planning and still experience periodic breakdowns, whether from external disruption or from capacity limits at peak demand, that surface as reported uncertainty even where average performance across the other cascade stages is favourable.

DISCUSSION

The descriptive results reported above are broadly consistent with the sequential logic proposed in the Delivery Reliability Cascade Model, although the descriptive, non-inferential nature of the underlying data means this consistency should be read as suggestive rather than confirmatory. The highest levels of agreement were recorded for the two items most directly tied to the model's first cascade stage, attention to lead-time reduction and workforce-planning-driven efficiency, which is consistent with workforce planning functioning as the primary lever businesses in this sample perceive themselves to be pulling. This aligns with Suwal's (2018) finding that personnel-related factors, including availability and competence of service staff, were significant predictors of customer satisfaction in a comparable lead-time management context, and extends that finding from a single-organisation case study to a cross-sectional sample of online retailers.

The relatively high dispersion on the customer-perception items, compared to the workforce-planning items, is worth examining considering Darko et al.'s (2018) distinction between transaction-specific and cumulative satisfaction. If customer-perceived reliability is genuinely a cumulative judgment formed across repeated delivery encounters, as the DRCM proposes, it would be expected to show more inter-business variability than an internally reported, single-point-in-time assessment of workforce practice, since cumulative judgments are more exposed to the accumulation of occasional service failures over time. The pattern observed in this dataset is consistent with that expectation, though a longitudinal design tracking individual businesses' delivery consistency over time, rather than a single cross-sectional snapshot, would be required to test the cumulative-judgment claim directly.

The co-occurrence of strong agreement on lead-time uncertainty as a limitation, alongside strong agreement on workforce-planning-driven efficiency gains, is the finding most directly relevant to the DRCM's treatment of uncertainty as a structural vulnerability rather than an independent variable. This pattern would be difficult to explain under a model that treated workforce planning and lead-time uncertainty as two parallel, additive predictors of performance, since it would imply that businesses reporting strong workforce planning should report correspondingly lower levels of uncertainty as a limitation. That the data instead show both operating at comparably high levels of agreement is more consistent with the cascade interpretation: uncertainty here reflects intermittent breakdowns, plausibly linked to the border-clearance, receipt-and-inspection, and external-disruption sources of variability identified by Ndubi et al. (2016) and Bagshaw and Ejiroghene (2018), that occur even where average workforce-planning practice is sound, and that a purely additive model would tend to obscure.

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These findings should be read against the backdrop of Lim et al. (2018) observation that last-mile logistics research has historically privileged network- and technology-level explanations for delivery performance over organisational and workforce-level ones. The pattern documented here, in which the workforce-planning item shows both the second-highest mean and the lowest dispersion of any lead-time item in the dataset, suggests that workforce capacity deserves more direct attention in last-mile research on online retail than it has typically received, particularly in markets, such as Singapore, characterised by dense delivery networks where the marginal returns to further infrastructure investment may be smaller than the marginal returns to workforce capacity investment.

It is worth situating the DRCM explicitly against the four-dimension decomposition of lead-time variability proposed by Ndubi et al. (2016), production, shipping, border-clearance, and receipt-and-inspection lead-time, since the two frameworks address related but distinct questions. Ndubi et al.'s decomposition is primarily a taxonomy of where variability originates within a supply chain, and is agnostic as to how those origins translate into downstream customer perception and business performance. The DRCM does not compete with this taxonomy but rather sits downstream of it, taking as given that variability can originate at any of these four points and asking instead how a business's workforce-planning capacity determines whether that variability, wherever it originates, is absorbed before it reaches the customer or is allowed to propagate through to customer-perceived reliability and, ultimately, performance. In this sense, workforce planning in the DRCM functions analogously to a buffering or dampening mechanism sitting between the origin points identified by Ndubi et al. and the customer-facing outcomes that are this paper's primary concern. A business with strong workforce planning might be expected to absorb an occasional shipping delay without the customer ever perceiving a lapse in reliability, whereas a business with weak workforce planning might allow the same shipping delay to cascade into a missed communication, an unmanaged customer expectation, and a corresponding drop in perceived reliability. This framing suggests that future empirical work pairing the two frameworks, measuring both the origin-point taxonomy and the workforce-buffering capacity of surveyed businesses, would offer a more complete account of lead-time performance than either framework could provide independently.

A methodological limitation constrains the strength of these interpretations. Because the underlying survey data are purely descriptive, with no correlational or regression analysis available, the cascade relationships proposed in the DRCM cannot be statistically tested against this dataset; the discussion above identifies patterns consistent with the model's logic without establishing that logic empirically. The duplicated survey item identified in the findings section further introduces a degree of measurement ambiguity around the customer-perception construct specifically, and the two reported values for that item should be read as bracketing a plausible range rather than as two independently validated estimates.

A related limitation concerns the reliance on owner and manager self-report as the sole source of data for all four constructs in the proposed cascade, including the customer-perceived reliability stage, which was measured through respondents' own assessment of customer perception rather than through direct customer surveys or independently collected review data. This introduces the possibility of common-method bias, whereby a respondent's generally favourable or unfavourable disposition toward their own business's operations could inflate or deflate agreement across all four constructs in a correlated fashion, independent of the businesses' actual underlying performance. This concern is somewhat mitigated by the divergence observed between the workforce-planning items, which showed comparatively low dispersion, and the customer-perception items, which showed comparatively high dispersion, since a purely

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uniform response-style bias would be expected to compress variability similarly across all items rather than producing the differentiated pattern reported above. Nonetheless, a research design incorporating independently sourced customer-satisfaction data, such as third-party delivery reviews or platform-level customer rating aggregates, would substantially strengthen confidence in the customer-perceived reliability construct specifically, and represents a natural extension of the present study.

The findings also carry implications for how online retailers might sequence operational investment. If, as the DRCM proposes, workforce planning functions as an upstream precondition rather than a parallel input, businesses experiencing weak customer-perceived reliability despite adequate logistics infrastructure would be better served by first auditing workforce capacity and scheduling practices than by pursuing further investment in delivery technology, carrier diversification, or routing software, since the model predicts that gains at the customer-perception and performance stages will be constrained by weaknesses at the workforce-planning stage regardless of how much is invested downstream. This is not to suggest that infrastructure and technology investment are unimportant, only that the cascade logic implies a sequencing in which workforce capacity should be treated as a gating condition rather than as one option among several equally weighted levers. Businesses operating in on-demand production or highly customised marketplace segments, where production and shipping lead-time stages are compressed into a single customer-visible wait, would be expected under this framework to show the strongest sensitivity to workforce-planning quality specifically, since they lack the finished-goods inventory buffer available to general marketplace retailers.

CONCLUSION

This paper examined the relationship between workforce planning, lead-time certainty, customer-perceived delivery reliability, and business performance among 56 online shopping businesses operating in Singapore, proposing the Delivery Reliability Cascade Model as a framework for interpreting these relationships as sequential rather than parallel. The descriptive results were broadly consistent with the model's core claims: businesses reported strong attention to lead-time management and workforce-driven efficiency gains, moderate-to-strong but more variable customer-perceived reliability, and a persistent perception of lead-time uncertainty as a constraint on performance, even where upstream workforce practices appeared sound. This last pattern is best understood, within the DRCM, as evidence that uncertainty functions as a point of structural vulnerability within an otherwise functioning cascade, rather than as an independently operating variable.

The study's principal limitation is its descriptive, cross-sectional design, which precludes any statistically tested claim of correlation or causation among the constructs discussed; the interpretations offered here should accordingly be read as consistent with, rather than confirmatory of, the proposed cascade logic. A further limitation is the duplicated survey item affecting the customer-perception measure, which introduces measurement ambiguity that a revised instrument would need to resolve. Future research seeking to test the Delivery Reliability Cascade Model directly should adopt a design capable of estimating the sequential relationships it proposes, whether through mediation analysis on a larger cross-sectional sample or through a longitudinal design capable of tracking individual businesses' delivery consistency, and workforce staffing levels, over time. Extending the framework to compare workforce-planning practices across markets with differing labour-market and logistics-infrastructure conditions would also help clarify whether the workforce-centred pattern observed in this Singaporean sample generalises to other dense e-commerce markets or reflects conditions specific to this context.

A further avenue concerns the marketplace-type segmentation noted in the findings section. Because on-demand production and highly customised marketplace segments are

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hypothesised, under the DRCM, to show stronger sensitivity to workforce-planning quality than general marketplaces able to draw on pre-existing inventory, a survey instrument designed to capture lead-time and workforce items separately by marketplace category would allow this prediction to be tested directly, rather than inferred from aggregate results as in the present study. Finally, given that the technology and infrastructure literature reviewed above has tended to treat automation and routing solutions as largely independent of workforce capacity, future research pairing lead-time survey data with objective measures of staffing levels, turnover, and training investment would help establish whether the workforce-centred pattern identified here reflects a genuine causal precondition, as the DRCM proposes, or a more modest correlational association that would need to be qualified in future refinements of the model.

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