

Finished but Unshippable: how buyer-specified packaging becomes a factory's hidden bottleneck

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Received: 28.08.2026, Revised: 15.09.2026, Accepted: 23.09.2026

doi: <http://10.29015/cerem.1058>

Aim: Contract manufacturers compete on delivery reliability but rarely control the packaging their buyers specify. This study examines how buyer-controlled specifications convert packaging from a material cost into a constraint on supplier capacity and shipment readiness.

Research methods: A retrospective embedded single-case design at a Bangladeshi ceramic tableware manufacturer triangulates a two-year management-account comparison, a ten-month carton-expenditure schedule, a channel-capacity workbook, order-level carton records and a controlled buyer standard. Evidence types are classified separately.

Findings: Packing materials reached 10.31 per cent of revenue and 34.4 per cent of raw-material cost; a separate schedule placed carton expenditure at 11.25 per cent. One buyer's planning model assigned 3,000 pieces per day to online packing and 12,000 to shopline packing, a fourfold difference. Exception records show finished goods waiting for late, incorrect or unstarted cartons.

Originality/value of the article: The paper develops the specification-induced capacity tax, capacity consumed by required, correctly executed work that another firm controls, and treats packaging as a shadow production technology governing when output becomes shippable.

Implications of the research: Suppliers should plan configuration-adjusted packing capacity, place packaging readiness on the order's critical path and record product-ready, packaging-ready and despatch dates. Buyers should assess the capacity implications of their specifications.

Limitations of the research: This is one retrospective case: the capacity workbook is a planning model, the accounts are not customer-specific and the exception files lack a denominator. The study bounds a mechanism; it estimates neither prevalence nor causal magnitude.

Keywords: packaging logistics; buyer-supplier governance; capacity planning; e-commerce fulfilment; shipment readiness; specification management; supply chain coordination; emerging-market manufacturing

JEL: L23, M11, L14

1. Introduction

A factory can complete the product and still fail to complete the sale. In fragile-goods manufacturing, finished ware may remain commercially unusable because the buyer-specified carton is late, wrong or unavailable. The factory has produced the item, but the box stops the shipment. The missing element may not be the product, a transport booking or an export document. It may be the exact carton, insert, print, board grade and pack configuration specified by the buyer. Until that package exists and conforms, the product is operationally incomplete.

This distinction matters because packaging is usually discussed as a material to reduce, a design to optimise or a logistics interface to coordinate. Those views are important, but they imply that the firm examining the cost has meaningful discretion over the package. A contract manufacturer may have little such discretion. The retail channel chosen by the buyer can dictate how each unit must be protected, presented and handled. A store-bound order may move in efficient bulk cases. The same ware destined for individual online despatch may require separate protection and additional manual handling. The downstream channel decision then reaches backward into the supplier's factory and changes the rate at which finished ware can become shippable ware.

The case examined here makes this mechanism visible with internal records that are rarely available to researchers. At a Bangladeshi ceramic tableware manufacturer, packing materials reached 10.31 per cent of revenue in the final year of a two-year account comparison and 34.4 per cent of raw-material cost. A separate ten-month schedule placed carton expenditure at a weighted 11.25 per cent of revenue. Cost magnitude alone, however, is not the central result. An internal packing-capacity model prepared for one large international apparel and homeware retailer assigned 3,000 pieces per day to its online configuration and 12,000 pieces per day to its shopline configuration. Within the assumptions of that planning workbook, the online pack consumed four times as much packing capacity per piece. Separate exception records show why this matters commercially: finished or nearly finished goods sometimes waited for cartons that were late, incorrect, not yet quoted or not yet started.

Packaging logistics research has shown that packaging interacts with manufacturing, warehousing, transport and retail processes rather than functioning as an isolated material choice (Chan et al., 2006: 1088-1101; Hellström, Saghir 2007: 197-216; Pålsson, Hellström 2016: 351-368). Research on e-commerce packaging has further shown that channel structure changes packaging requirements across connected actors and resources (Brüel Grönberg, Hulthén 2022: 450-467; Brüel Grönberg 2026: 698-717). Capacity-planning research, meanwhile, models packaging production as a finite-capacity scheduling problem (Chen et al., 2017: 153-169). These streams establish the system character of packaging, but they leave three openings. First, the focal decision is commonly treated as a design or coordination choice, not as a buyer-controlled requirement imposed on a supplier. Second, evidence seldom combines supplier management accounts, channel-specific packing-capacity models and live carton exception records. Third, the mechanism by which a retail-channel specification reduces upstream packing throughput and delays the shipment readiness of otherwise completed fragile goods remains underdeveloped.

Three gaps follow from this body of work. First, packaging logistics research has largely treated the packaging decision as one the focal firm can make: a design to optimise, a material to reduce or an interface to coordinate (Azzi et al., 2012: 435-456; García-Arca et al., 2014: 325-346; Pålsson, Hellström 2016: 351-368). To the best of the authors' knowledge, it has not examined the case in which the specification is set and frozen by a buyer, so that the supplier's discretion is limited to execution. Second, the available evidence is drawn predominantly from focal-firm interviews, network-level accounts or scheduling models. Prior studies rely on data that cannot connect a channel specification to the supplier's own management accounts, to its internal capacity assumptions and to the order-level records showing which finished goods actually shipped. Third, the practical problem remains unresolved for contract manufacturers: conventional efficiency measures count packed pieces as equivalent, so a team executing a demanding specification exactly to standard appears to be underperforming.

This study therefore asks how buyer-controlled channel packaging specifications convert packaging from a material cost into a supplier capacity and shipment

constraint, and examines that question using internal records from one fragile-goods manufacturer that are rarely available to researchers.

How can buyer-controlled channel packaging specifications convert packaging from a material cost into a supplier capacity and shipment constraint?

The paper makes three contributions. Conceptually, it develops the specification-induced capacity tax: the usable capacity lost when a buyer-controlled requirement makes the supplier's packing configuration more labour intensive. Empirically, it triangulates cost, modelled capacity and order-level exception evidence from inside one manufacturing system. Managerially, it distinguishes production completion from shippable completion and identifies the control points that must be visible by order: specification freeze, carton quotation, supplier release, conformance and packaging readiness.

The argument is deliberately bounded. The internal capacity workbook is a planning model, not a controlled productivity study. The carton trackers are exception and status lists, not the universe of all orders. Commercial pass-through is a practitioner account rather than a measured selling-price decomposition. The paper does not claim that online packaging always produces a fourfold gap, that packaging caused all shipment delay, or that the studied specifications were economically inefficient for the buyer. It shows a mechanism in one evidence-rich case and establishes propositions for wider testing.

2. Literature Review

2.1 From protective material to logistics resource

Packaging performs several functions simultaneously. It protects the product, enables handling and storage, carries information, supports retail presentation and affects transport and warehouse utilisation (Azzi et al., 2012: 435-456; Rundh 2016: 2491-2511). A packaging decision can therefore alter costs and performance well beyond the purchasing line where board, print and inserts appear. Hellström and

Saghir (2007: 197-216) map interactions between packaging and logistics activities across retail supply chains. Chan et al. (2006: 1088-1101) similarly argue that treating packaging as an isolated task inhibits manufacturing efficiency and propose a systems approach linking it to handling and distribution.

Later work has made the cross-functional nature of the decision more explicit. McDonald (2016: 208-221) integrates packaging quantities with manufacturing, transport, warehousing and picking costs. Pålsson and Hellström (2016: 351-368), drawing on 22 cases across three actor groups, identify packaging trade-offs and improvement potential across supply chain practice. García-Arca et al. (2014: 325-346; 2016: 261-272) connect packaging logistics with supply chain efficiency and show that improvement requires organisational and inter-organisational change. Pålsson and Hellström (2023: 969-981) extend this logic by treating packaging innovation as a process that needs a coherent system of measures rather than a single cost target.

The recurring message is that local packaging optimisation can be systemically poor. Less material may increase damage. A larger handling unit may improve transport utilisation but complicate picking. A standard pack may suit a producer's line while frustrating a retailer's warehouse. This literature replaces the box as an isolated object with packaging as a resource interface.

Recent research broadens this systems view. Pålsson and Sandberg (2022: 25-52) show that packaging decisions create persistent tensions within and between supply-chain organisations, rather than simple trade-offs that one actor can optimise alone. Silva and Pålsson (2022) find that industrial-packaging research increasingly connects supply-chain efficiency with environmental, development and regulatory demands. Meherishi et al. (2021: 930-952) likewise model product and packaging decisions jointly, demonstrating that packaging choices affect operating and channel outcomes together. These studies reinforce the need to examine who controls a packaging requirement and where its operational burden appears.

2.2 Channel requirements and control across firms

E-commerce makes the interdependence especially visible. Store distribution and individual despatch expose products to different handling, order and presentation conditions. Brüel Grönberg and Hulthén (2022: 450-467) conceptualise e-commerce packaging as a resource embedded in product-development, packing and sorting settings. Their network view shows that no single actor can define an effective package without considering the resources controlled by others.

Brüel Grönberg (2026: 698-717) provides a closely adjacent empirical account of connected automation initiatives in a retail distribution network. Automation at logistics providers, retailers and producers created or reinforced packaging requirements across business relationships. The study shows that a requirement regarded as efficient by one actor can create cost, inflexibility or operational burden for another. It is important evidence that packaging requirements travel across firm boundaries.

The present study shifts the unit of attention. Rather than asking how connected automation initiatives reshape packaging requirements across a network, it examines what happens inside a fragile-goods supplier when one buyer's own channel choices dictate two materially different packing configurations. The focal outcome is not packaging adaptation itself. It is the supplier capacity absorbed by that adaptation and the separation it creates between production completion and shipment readiness.

Global value-chain theory helps explain why supplier discretion can be narrow. Gereffi et al. (2005: 78-104) argue that governance depends partly on the complexity and codifiability of transactions and on supplier capability. Packaging requirements involving board, print, construction, pack ratios and conformance are highly codifiable. They can be transmitted through controlled documents and inspected against explicit rules. The supplier may advise, quote and execute, but once the buyer freezes the requirement, changing it unilaterally is not ordinary cost reduction. It is non-conformance.

More recent global-value-chain research also sharpens the power dimension. Bair and Mahutga (2023: 814-831) argue that inter-firm governance and value distribution depend on bargaining power embedded in the wider network of possible buyers and suppliers. In the present case, the relevant implication is operational rather than a

direct estimate of value capture: a powerful buyer can transmit codified packaging requirements across the firm boundary while the supplier remains responsible for the labour, timing and conformance consequences inside its factory.

2.3 Capacity without a machine stoppage

Capacity is normally represented as the output attainable from equipment, labour and process time. Packaging research recognises production and handling effects, and packaging-industry scheduling research explicitly models finite capacity and due-date performance (Chen et al., 2017: 153-169). Yet a contract manufacturer's usable capacity can also be altered by an external specification without any machine breaking and without nominal production capacity changing.

The mechanism is simple. If a buyer's online channel requires every piece to be protected and packed individually, the same labour hours and packing area convert fewer finished pieces into shippable pieces than a bulk shipline configuration. The extra work is not a random inefficiency. It is embedded in the required output. A conventional efficiency measure can therefore misdiagnose the loss because it treats all packed pieces as equivalent even when the work content per piece is not.

This paper calls the resulting burden a specification-induced capacity tax. It is a tax in the operational, not fiscal, sense: part of the supplier's usable capacity is consumed by satisfying a requirement controlled elsewhere in the chain. The term does not imply that the requirement is unnecessary or value destroying. Individual despatch may reduce downstream handling, damage or consumer complaints. The point is that the capacity consequence appears upstream and must be priced, scheduled and governed there.

Packaging in this setting also behaves as a shadow production technology. It is not the equipment that forms or fires the ceramic body, but it determines how much finished ware can be released per day and whether a completed order can cross the shipment gate. The concept joins three observations that are usually separated: packaging has a large cost share, different configurations have different throughput, and missing cartons can hold completed goods.

3. Methodology

3.1 Research design and setting

The study uses a retrospective embedded single-case design. Case research is appropriate where the mechanism is contemporary, context-dependent, and difficult to separate from its organisational setting (Eisenhardt 1989: 532-550; Yin 2014). In operations management, theoretically informed cases can combine contextual depth with analytic generalisation when the evidence chain and boundary conditions are made explicit (Voss et al., 2002: 195-219; Ketokivi, Choi 2014: 232-240).

The setting is a Bangladeshi manufacturer of ceramic tableware serving export and domestic customers. Fragility makes packaging operationally consequential, while export buyers commonly specify presentation, protection and pack configuration. The author held a senior commercial and operations role at the firm for approximately a decade. That access is a data advantage because it made internal accounts, planning workbooks, order trackers, controlled buyer documents and commercial records available. It also creates a risk of retrospective interpretation. The analysis therefore separates contemporaneous documentary evidence, derived calculations, practitioner recollection and unexecuted proposals.

The unit of analysis is the specification-to-shipment mechanism, not the firm as a whole. Embedded observations cover cost structure, one buyer's channel-specific packing-capacity model, carton procurement status and shipment-readiness exceptions.

3.2 Evidence base

The accounting sources are independent of the operational trackers. The capacity workbook was prepared in July 2018, the exception report in October 2018, and the packing-department planning report containing the carton-machine proposal in February 2019. Their timing places the capacity and exception evidence within the same broad operating period, but the files were not designed as a research dataset and do not share a common order key. Triangulation is therefore mechanism-based rather than a row-level statistical merge. Tab. 1 summarises the evidence used and the claims each source can support.

Table nr 1. Evidence architecture and claim boundaries

Evidence source	Coverage	Permitted inference	Prohibited overclaim
Management accounts	Two consecutive years	Packing-material scale and change relative to revenue and raw materials	Customer-level or channel-level causation
Carton-expenditure schedule	Ten populated months	Monthly variation and weighted carton-to-revenue ratio	Attribution of a month to a particular buyer or specification
Channel capacity workbook	One buyer; three configurations	Assigned daily and monthly capacity within the model	Realised throughput or a universal online-versus-store effect
Packing-department planning report	Current and projected departmental model	Capacity planning treated packing as a material factory constraint	Realised gain from the proposed expansion
Carton exception report	Twelve live exception lines	Process tracing of late, wrong and not-started cartons holding orders	Overall delay incidence
Carton status snapshot	Twenty-nine live lines	Distribution of packaging-readiness states in that snapshot	Failure rate across all orders
Dated carton trackers	Multiple dates	Recurring order-level control and supplier-status categories	Complete longitudinal performance series
Buyer and project documents	Controlled standards and item schedules	Requirements were codified by item, pack ratio and conformance	Economic optimality of the specification
Commercial agreement	Documented contract architecture	Packaging, price, delivery, title and transit risk were jointly governed	Proof that every clause was executed or enforced
Practitioner recollection	Approximately a decade of direct involvement	Interpretation of channel configurations and commercial practice	Independently verified pass-through or causal effect

Source: Author's own elaboration based on the case evidence.

No new interviews or human-participant data were collected for this study. Personal names and private counterparties are removed. Bangladesh is identified because the emerging-market manufacturing context is analytically relevant, while the focal company and buyer are not named. Monetary figures are rounded where needed to reduce commercial disclosure risk.

3.3 Calculations and analytical procedure

Packing-material ratios were calculated from the two-year accounts after indexing the final year's revenue to 100. The weighted ten-month carton ratio equals total carton expenditure divided by total revenue in the separate monthly schedule. For the channel model, the online-to-shopline capacity ratio equals 3,000 divided by 12,000, while the capacity reduction is calculated against the shopline baseline. The result is a fourfold difference, or 75 per cent lower modelled daily throughput for the online configuration.

The 29-line status snapshot was coded using the file's own categories: received, partially received and not received. Notes such as waiting for offer were counted separately. The 12-line exception report was read as process-tracing evidence. It identifies sequences in which carton quotation, production, correctness or delivery failed to keep pace with the ware. Because both files concentrate on outstanding or problematic orders, their proportions are descriptive of the lists only.

Analysis proceeded in four passes. First, accounting records established whether packaging was material enough to deserve independent managerial attention. Second, the capacity workbooks tested whether different specifications altered planned packing throughput. Third, exception and status records examined whether packaging availability could separate production completion from shipment readiness. Fourth, buyer standards and commercial documents were used to locate control rights and obligations across the chain. Convergence across these independent sources was used to develop the specification-induced capacity tax and shadow-production-technology concepts.

4. Findings

4.1 Packaging was a first-order economic item

Tab. 2 reports the two-year account comparison. Packing materials rose from an amount equivalent to 6.75 per cent of final-year revenue to 10.31 per cent. Over the same comparison, raw materials rose from 23.29 to 29.95 and direct labour from 12.98 to 16.98. Packing therefore increased by 52.7 per cent, faster than raw materials at

28.6 per cent and direct labour at 30.8 per cent. In the final year, packing equalled 34.4 per cent of raw-material cost.

Table nr 2. Packing materials in the two-year account comparison, final-year revenue = 100

Component	Prior year	Final year	Change
Raw materials consumed	23.29	29.95	+28.6%
Packing materials	6.75	10.31	+52.7%
Direct labour	12.98	16.98	+30.8%
Utilities	6.56	7.41	+13.0%
Repairs, maintenance and spares	3.64	4.17	+14.4%
Packing as a percentage of raw materials	29.0%	34.4%	

Source: author's own calculations from the manufacturer's management accounts.

A separate ten-month management schedule provides a robustness check. Carton expenditure totalled approximately Bangladeshi taka (BDT) 124.7 million against revenue of approximately BDT 1.108 billion, producing a weighted ratio of 11.25 per cent. Monthly ratios ranged from 6.76 to 15.07 per cent. The source schedule is internally undated, although its file history places its last modification in November 2022. It cannot therefore be assigned to a precise financial year. The 10.31 and 11.25 per cent figures come from separately prepared records with different coverage and are not expected to reconcile exactly. Their value is independent convergence: both place packaging close to one tenth of revenue.

The monthly range also indicates composition sensitivity. The highest ratio is more than twice the lowest. The schedule does not reveal whether board prices, buyer mix, product mix, volume or timing caused the movement. It does show why a pooled annual overhead is a weak control object. A material and volatile cost requires order-level explanation.

4.2 One buyer's channel model produced a fourfold capacity gap

The strongest new evidence comes from an internal workbook titled as the packing department's current capacity. It assigns packing capacities for three

configurations serving one international apparel and homeware retailer: online, shopline and a mixed configuration. Tab. 3 reproduces the model's outputs in anonymised form.

Table nr 3. Channel-specific packing capacity in the internal planning model

Buyer A configuration	Modelled pieces per day	Modelled pieces per month	Relative daily capacity
Online	3,000	90,000	0.25
Shopline	12,000	360,000	1.00
Mixed online and shopline	8,000	240,000	0.67

Source: Author's own calculations from the internal channel-capacity workbook.

The online configuration is assigned one quarter of shopline throughput. Put differently, the shopline configuration produces four times as many packed pieces per day within the model, while the online configuration carries a 75 per cent modelled capacity reduction against that baseline.

The workbook does not record observed cycle times, labour hours per piece or realised output. It is therefore not evidence that channel specification alone caused exactly a fourfold productivity loss in practice. It is evidence of how management planned the operation. The same organisation that treated packaging as roughly a tenth of revenue also assigned radically different capacities to the buyer's channel configurations. The capacity consequence was visible enough to be encoded before the present study.

A separate packing-department report reinforces the planning importance of the function. It lists current modelled departmental capacity of 910,800 pieces per month and a projected 1,387,800, with employment rising from 96 to 120. Buyer A's category rises from 100,800 to 226,800 pieces per month in that report. The category definitions differ from the channel workbook, so the figures should not be combined. The report still shows that packing capacity was treated as a factory-expansion issue, not merely a purchasing expense.

4.3 Finished goods could wait for packaging

Capacity burden becomes commercially consequential when packaging is also a release condition. A carton exception report prepared for senior management contains 12 live order lines. It documents two lines whose cartons arrived 13 days after the stated expected departure date, with one carton incorrect on arrival. Another line records a wrong carton colour requiring replacement. One line arrived 16 days late. Other notes describe goods completed or capable of completion within one day while carton production had not started, a completed order not yet sent to the carton factory, and a local purchase requisition not sent for ten days. One entry explicitly records buyer frustration.

These are not representative delay statistics. The file was created to surface exceptions and provides no denominator of normal orders. Its contribution is causal-process visibility. In the recorded sequences, ware readiness did not create shipment readiness because the required packaging was absent or non-conforming.

A separate carton-status snapshot contains 29 live lines. Twenty-two were marked not received, four partially received and three received. Eleven carried the status waiting for offer. Some lines associated with June or July dates remained partial or not received in the October snapshot. Again, this is an outstanding-status list rather than the full population of orders. The high concentration of open items is expected from the file's purpose. What matters is the control architecture it reveals: cartons were tracked by customer and order through quotation, supplier assignment, receipt and partial receipt.

Multiple dated carton workbooks repeat these categories. A later supplier-assignment file contains more than 70 order rows linking customers and orders to carton suppliers. A project packaging schedule specifies item descriptions, quantities, pack ratios, inner and master cartons, phased deliveries and logistical volume fields. Together, these records show that packaging was not generic stock drawn after production. It was an order-specific deliverable with its own specification, supplier, timing and acceptance state.

4.4 Specification and conformance were controlled outside the cost line

Buyer and project documents clarify why the producer could not simply replace a demanding configuration with a cheaper or faster one. The available quality documentation is a controlled supplier standard with measurement tolerances and defect classes. Packaging non-conformance is treated as a major defect. Project schedules specify pack ratios and carton structure item by item. Once such a requirement is frozen, deviation creates a quality problem even if it lowers the producer's cost.

An available export-distribution agreement places cartons and pallets alongside price, written orders, title, delivery and transit risk. Its execution status cannot be fully established, and the document is not used as proof that every clause governed practice. It demonstrates the intended architecture: packaging, commercial terms and risk allocation were designed together.

Practitioner recollection adds the commercial interpretation. Buyer-specific requirements were normally included in quotation, and buyers generally paid for the specifications they requested. Selling-price decomposition is unavailable, so complete pass-through cannot be measured. The distinction remains important. Even if material cost is recovered, the supplier still carries quotation risk, timing risk and capacity risk. A carton can be fully priced and still prevent a finished order from shipping.

5. Discussion

5.1 The specification-induced capacity tax

The case supports a five-link mechanism:

buyer channel choice -> packaging specification -> packing work content -> usable packing capacity -> shipment readiness

The buyer's channel choice is upstream of the factory effect. Online and shopline configurations require different handling and protection. The requirement changes the work content per piece. With fixed labour, space and equipment, greater work content lowers the number of pieces that can cross the packing stage. Because the specified pack is also a conformance condition, missing or incorrect cartons can hold goods after ceramic production is complete.

The specification-induced capacity tax is the gap between nominal packing capacity and the usable capacity available under a required configuration. It differs from ordinary inefficiency in three ways. First, the work is purposeful and required rather than waste in the conventional lean sense. Second, control of the requirement sits partly or mainly with another organisation. Third, the supplier may recover material cost while still absorbing operational consequences through slower throughput, scheduling complexity and delayed shipment.

The internal model's fourfold gap is case-specific, but it gives the concept empirical weight. The term would be unnecessary if specifications produced only marginal differences. A 3,000-versus-12,000 daily assignment changes how managers should quote, promise dates, allocate labour and evaluate packing performance. Counting pieces without configuration-adjusted work content makes the online team appear inefficient even if it performs exactly to standard.

5.2 Packaging as a shadow production technology

Calling packaging a shadow production technology highlights a second contribution. Production systems typically define completion at the end of fabrication. In an export fragile-goods chain, commercial completion occurs later. A plate that has been formed, fired, decorated and inspected cannot produce revenue if the specified carton is absent. Packaging therefore governs release in the same practical sense as a final machine or mandatory process step.

This framing extends packaging logistics research. The literature already shows that packaging interacts with many supply chain resources and that e-commerce or automation can create cross-firm packaging requirements. The present evidence adds an internal supplier view that links those requirements to modelled capacity and shipment exceptions. The factory is not merely adapting a resource interface. It is losing or gaining shippable capacity according to a requirement determined by the downstream channel.

The concept also reframes the accounting line. Packaging at ten or eleven per cent of revenue invites a material-reduction programme. The evidence suggests a different first question: what portion of the line buys buyer-required capacity, conformance and shipment eligibility? Reducing that portion without changing the specification may

create rejection, damage or customer failure. The controllable problem is not always material quantity. It may be quotation timing, carton supplier release, specification change control, bottleneck planning or readiness visibility.

5.3 Relation to buyer-driven governance

The mechanism is consistent with buyer-driven value-chain governance. Highly codified requirements allow lead firms to coordinate suppliers without owning them. Packaging is particularly suited to this mode because board grade, construction, print, pack ratio and defect tolerance can be documented and audited.

The case adds an operational consequence to governance theory. A codified requirement is not only an instruction about product attributes. It can allocate capacity consumption across firms. The buyer captures the downstream value of a channel-specific pack, while the supplier must create the physical capability to execute it. Price may compensate for material and labour, but governance determines who can alter the requirement and who must manage the bottleneck.

This observation does not imply exploitation. The buyer may have valid reasons for individual protection, presentation or parcel-network survival. The evidence also does not establish that the supplier was underpaid. The theoretical point is narrower: control rights over specifications and responsibility for capacity are separated. That separation creates a predictable coordination problem.

5.4 Theoretical contribution

The study contributes to packaging logistics theory in three connected ways. The first is the specification-induced capacity tax itself, which names a capacity burden that can be obscured when ordinary efficiency measures treat all packed pieces as equivalent. Recent lean research confirms the continuing importance of removing waiting, defects, excess processing and other non-value-adding activity (Naeemah, Wong 2022: 552-571). The burden identified here is analytically different: the additional work is required, purposeful, contractually mandated and correctly executed. It may still create waiting elsewhere, but it cannot simply be removed by asking the supplier to work more efficiently. The construct therefore separates

required specification work from remediable process waste while keeping both visible to management.

The second contribution extends buyer-driven governance theory. Gereffi et al. (2005: 78-104) explain how codifiable requirements allow lead firms to coordinate suppliers they do not own. The present case shows that such requirements do more than specify product attributes: they allocate capacity consumption across organisational boundaries. Control rights over the specification and responsibility for the capacity it consumes are separated, and that separation is a structural property of the governance form rather than a bargaining failure. Governance research has concentrated on value capture and upgrading; this evidence points to a quieter operational consequence that precedes both.

The third contribution concerns where completion is located in a production system. Operations theory conventionally treats fabrication as the point at which output exists. In a buyer-driven fragile-goods chain, a unit that is formed, fired, decorated and inspected is not yet commercially complete. Treating packaging as a shadow production technology relocates the completion boundary to the point of conforming packaging availability, which makes shippable completion, rather than production completion, the theoretically appropriate output measure for this class of supplier.

5.5 Managerial implications

The practical response is to manage shippable completion, not production completion alone. Five controls follow from the evidence.

First, packing capacity should be expressed in configuration-adjusted units. A single pieces-per-day target is misleading when an online unit and a shopline unit consume different work. Standard minutes, weighted pieces or configuration-specific capacities would make the burden visible.

Second, packaging quotation must precede commercial commitment. The status waiting for offer is dangerous when the product order is already live. The carton price, supplier capability and expected lead time should be confirmed before the manufacturer freezes price and shipment promise.

Third, carton readiness should be a production gate. An order should not enter final scheduling without a dated packaging plan covering artwork or print approval, supplier release, expected receipt and incoming conformance. This does not mean waiting for every carton before production begins. It means treating the carton plan as part of the order's critical path.

Fourth, the dashboard should distinguish produced, packed and shippable quantities. The exception report shows why produced quantity can overstate commercial completion. A shippable-completion measure makes the blocked working capital visible without claiming a financial amount that the present case cannot calculate.

Fifth, specification changes should trigger automatic review of price, capacity and promise date. A change that appears minor to the buyer may alter inserts, handling or supplier sourcing. The producer needs a formal link between change control and commercial revalidation.

The controls also change the unit of operational accountability. Procurement cannot be assessed only on carton purchase price because a cheaper supplier that misses the release date can immobilise finished ware. Production cannot be assessed only on fired or decorated output because those pieces may still lack the packaging required for despatch. Sales cannot be assessed only on order confirmation if the promised date was accepted before the packaging configuration was costed and capacity checked. A shippable-completion measure makes these interdependencies visible without assigning the entire problem to one department.

For each order, managers could record three dates: product-ready date, conforming-packaging-ready date and actual despatch date. The first gap would isolate packaging readiness from upstream production. The second would capture other release constraints after both product and packaging were available. Configuration-adjusted standard minutes could then be attached to the same order. This would create the prospective dataset that the retrospective case lacks and allow management to distinguish four different problems: demanding but correctly planned specifications, insufficient internal packing capacity, late or non-conforming cartons, and non-packaging shipment barriers. The discipline matters because each requires a different remedy. The first calls for pricing and capacity reservation, the second for

staffing or equipment, the third for supplier and release control, and the fourth for attention elsewhere in the export process.

The proposed control sequence and the failure exposed at each point are summarised in Tab. 4.

Table nr 4. Control points implied by the specification-to-shipment mechanism

Control point	Required evidence	Failure made visible
Specification freeze	Approved pack structure, ratio, print and defect criteria	Uncontrolled change or ambiguous requirement
Quotation readiness	Carton offer and capacity-adjusted work estimate	Order priced before packaging cost or effort is known
Supplier release	Purchase or work order with committed date	Packaging production has not started
Incoming conformance	Correctness, quantity and partial-receipt status	Wrong colour, wrong carton or incomplete delivery
Shippable completion	Finished ware plus conforming packaging available	Goods reported complete while shipment remains blocked

Source: Author's own elaboration based on the case analysis.

5.6 Recommendations to policy and decision-makers

The mechanism has consequences beyond the individual firm, and three groups of decision-makers are positioned to act on it. For buyers and their sourcing organisations, the evidence suggests that a channel specification should be accompanied by a capacity statement rather than price alone. If a configuration consumes several times the packing capacity of its alternative, a supplier that agrees to standard lead times is either absorbing an unpriced burden or will eventually miss dates. Buyers who wish to protect delivery reliability have an interest in knowing the capacity implication of their own requirement before it is frozen.

For export-promotion agencies and industry bodies in emerging manufacturing economies, the case identifies a form of competitiveness loss that does not appear in the usual indicators. Support programmes commonly target production equipment, quality certification and market access. None of these addresses a supplier whose finished goods cannot ship because a specified carton is late or non-conforming. Packaging supply capability, carton lead times and specification change control are

legitimate objects of industrial support, and are considerably cheaper to improve than production capacity.

For standard-setting and buyer-audit bodies, the evidence suggests that packaging conformance regimes should be paired with lead-time and change-control obligations on the requirement owner. A regime that classifies packaging non-conformance as a major defect while imposing no discipline on specification and approval timeliness places the burden of a two-sided process on one side. The recommendation is not to relax conformance, which exists for good reasons, but to make the obligations symmetrical.

5.7 Alternative explanations and boundary conditions

Several alternative explanations remain plausible. The rise in packaging cost may partly reflect board-price inflation rather than richer specifications. The monthly schedule cannot separate price, volume and mix. The capacity workbook may incorporate staffing assumptions or local line arrangements not visible in the surviving file. The online configuration may purchase downstream benefits, including lower parcel damage, that justify its slower upstream rate. Some carton delays may reflect internal requisition failures rather than buyer control. Complete packaging-cost recovery may also have been weaker than practitioner recollection suggests.

These alternatives qualify the magnitude but not the mechanism. A material-price explanation does not remove the documented channel-capacity assignments. A planning-model limitation does not erase the fact that management treated the configurations differently. Internal requisition delay strengthens the need for order-linked governance even if the buyer did not cause it. Downstream benefit changes the economic evaluation of the capacity tax, not its existence at the supplier.

The framework is most applicable where products are fragile, packaging is customer-specific, channels impose different handling requirements, and suppliers cannot substitute materials or configurations without approval. It is less relevant where packaging is standard stock, the producer owns the brand and specification, or automated lines can switch formats without meaningful capacity change.

The appropriate inference is therefore analytic rather than statistical. The case supports the existence and internal logic of a specification-to-capacity mechanism

under the conditions stated above; it does not establish its frequency or average magnitude across industries. The reported 3,000- and 12,000-piece rates are static planning baselines used by the case organisation, not observed output from a controlled time-and-motion study. They show that management itself assigned different capacity consequences to the two configurations, but realised throughput may also depend on staffing, learning, product mix, interruptions and line balance. A prospective study should observe task times and completed output across repeated, comparable orders before estimating a causal productivity effect.

6. Limitations

This is one retrospective case. The accounting data do not identify packaging by customer, channel or order. The ten-month schedule is internally undated. The channel workbook is a capacity model, not a time-and-motion study, and no realised output series validates its assumptions. The status files are exception-focused and cannot provide population failure rates. No matched data connect a particular specification to actual labour hours, carton delay, shipment delay, breakage or margin. The commercial documents show governance architecture but do not establish universal enforcement. Practitioner recollection is valuable for interpretation but is not independent evidence.

7. Recommendations

Three recommendations follow directly from the evidence and can be implemented without new systems. First, suppliers in buyer-driven fragile-goods chains should convert packing capacity into configuration-adjusted units before quoting or promising a date. The case shows an organisation that had already encoded a fourfold difference between two configurations in its own planning workbook while continuing to manage packing as a single department with a single throughput expectation. The information needed for the correction already existed inside the firm.

Second, packaging readiness should be treated as a scheduled deliverable with a dated plan, an assigned supplier and a conformance check, and that plan should sit on the order's critical path rather than beside it. The status waiting for offer, recorded against live orders in the case evidence, marks the point at which a commercial commitment has been made before its packaging cost and lead time are known. That sequence should be reversed.

Third, firms should record three dates against every order: product-ready, conforming-packaging-ready and actual despatch. Two gaps then become visible, the first isolating packaging readiness and the second capturing remaining release constraints. This is the smallest change that would convert the retrospective evidence presented here into the prospective dataset the mechanism needs, and it requires no more than three additional fields against records the firm already keeps.

Future work should measure the mechanism prospectively through time-and-motion observation and repeated order-level records. A multi-order dataset could link specification attributes, observed task minutes, labour deployed, carton lead time, packing output, breakage, shipment date and realised contribution margin. Within-buyer comparison of online and shopline orders for similar ware would be especially valuable. It could test whether the modelled capacity tax persists after controlling for staffing, learning, product mix and order size, and whether downstream damage reduction compensates for the upstream burden. Replication in other fragile-goods sectors and in standardised or highly automated packaging settings would test the boundary conditions identified in Section 5.7.

Comparative cases could examine whether suppliers with formal change control and configuration-adjusted capacity measures quote more accurately and ship more reliably. Research could also test governance responses: buyer-funded dedicated lines, jointly approved standard packs, modular inserts, dual sourcing, reserved carton capacity or commercial clauses that reopen price and lead time when a channel mix changes.

8. Conclusion

The central problem in this case was not simply that packaging cost a great deal. It was that a buyer's downstream channel choice changed the upstream rate at which a factory could release finished goods. Packing materials sat near one tenth of revenue in two independent records. An internal model assigned 3,000 pieces per day to the online configuration and 12,000 to shipline for the same buyer. Order-level records then documented the operational consequence: finished or near-finished goods could wait for late, wrong, or not-yet-started cartons.

Together, these records support two connected ideas. The specification-induced capacity tax describes the usable supplier capacity consumed by a buyer-controlled packing requirement. Packaging as a shadow production technology describes its power to determine both throughput and shipment eligibility. Neither concept says that the requirement is wasteful. Both say that it must be measured where its burden occurs.

The managerial implication is direct. Do not ask only how much packaging costs or how many pieces production completed. Ask which specification consumed the capacity, whether the carton was ready, and how many completed pieces were actually shippable. In buyer-driven fragile-goods manufacturing, the box is not the last detail after production. It is part of the production system.

Conflicts of Interest

The study uses records accessed through the author's former senior commercial and operations role at the unnamed manufacturer. The author also has a continuing professional interest in the ceramics sector. These relationships are disclosed as potential competing interests; no other conflict is declared.

Informed Consent

This documentary case study did not recruit human participants or collect interviews, surveys or identifiable personal data. Informed consent was therefore not applicable.

Funding

This research received no external funding.

Data Availability

The underlying business records contain confidential commercial information and cannot be made publicly available. Aggregated calculations reported in the article may be made available to the editor for verification where confidentiality permits.

Use of Artificial Intelligence

Use of artificial intelligence (AI). During the preparation of this work, the author used generative AI tools (OpenAI Codex, OpenAI ChatGPT, and Anthropic Claude) to plan literature searches, restructure the manuscript, and assist with language drafting from author-provided business records and scholarly sources. After using these tools, the author reviewed and edited the content, made it his own, and validated the evidence, calculations, citations, and conclusions. The author takes full responsibility for the content of the publication. Generative AI did not create the business records, accounts, capacity workbooks, or order trackers on which the findings rest.

Contributor Statement

The sole author was responsible for conceptualization, methodology, investigation, formal analysis, data curation, writing of the original draft, and review and editing.

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