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Research Article

Keywords:

Posted Date: April 22nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9331302/v1

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Beyond Apples-to-Apples: A Cross-Category Explanation of the Alchian – Allen Effect

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Abstract

This paper develops a unified framework that extends the Alchian – Allen mechanism beyond the restrictive assumption of close substitutes. The framework emphasizes a fixed-cost selection mechanism in which logistics structures filter goods according to their ability to sustain profitable long-distance exchange. Empirical analysis uses high-dimensional U.S. import data from 2023 to 2025. The main quantitative evidence is presented at the HS2 level, consistent with the cross-category logic of the paper, while HS10 specifications and stricter sample definitions are used as robustness checks. The results yield two main findings. First, more distant trade flows exhibit significantly higher observed unit values at the HS2 level, indicating that the good-apples-shipped-out pattern operates not only within narrowly defined products but also across broad product categories. Second, the positive distance – unit-value relationship is stronger for observations involving air transport, especially in broader samples, consistent with the view that higher-cost transport channels impose a stricter selection filter. Overall, the findings support a cross-category interpretation of the Alchian – Allen mechanism and suggest that lower logistics and institutional fixed costs can broaden participation in long-distance trade.

JEL Classifications: F10, F11, F14, D22, R40.

1. Introduction

Why does Scotch whisky ship globally while bottled water rarely crosses borders? Why did the ancient Silk Road carry silk and spices—but never sand or gravel—across continents? Imagine a merchant facing a per-unit transport cost large enough to cross the Taklamakan Desert. Bottled water sells for only a few coins at origin. Once the transport charge is added, the delivered price rises far above what buyers are willing to pay. Silk, by contrast, carries much higher value relative to its weight and volume; even after the same transport cost is added, the delivered price can still remain within the range buyers will accept. The desert did not sort goods by taste or culture alone. It screened them by economic viability. This contrast is intuitively obvious, yet standard formal derivations of the Alchian–Allen effect remain tied to "close substitutes" and therefore struggle to compare fundamentally different goods.

This paper reconstructs the Alchian–Allen mechanism as a fixed-cost selection process rather than a narrow substitution effect within finely defined product classes. The familiar "good apples shipped out" pattern arises because long-distance trade is not a random sample of goods. Instead, logistics and trade costs filter out products that cannot sustain profitable exchange over distance, leaving a traded set with systematically higher observed unit values. This reframing shifts attention from relative price changes within narrowly defined goods to the broader problem of economic viability across heterogeneous goods.

The theoretical literature on the Alchian–Allen mechanism is divided between the original intuition and later formal derivations. The core insight of Alchian and Allen is simple: adding a common per-unit cost lowers the relative delivered price of the higher-quality variety. Yet once the theorem is formalized in standard consumer theory, the result becomes much narrower. Gould and Segall (1969) showed that it may fail in a general multi-good setting, while Borcherding and Silberberg (1978), Saito (2006, 2008), Liu (2011), and Minagawa and Upmann (2013, 2015) recover it only under increasingly restrictive preference structures. In practice, the formal theorem survives mainly within the close-substitutes setting. The theoretical contribution of this paper is therefore to move beyond that restriction and reconstruct the mechanism as one of cross-category selection under fixed trade costs.

The empirical literature most closely associated with the Alchian–Allen mechanism has generally remained within narrowly defined product categories. The classic direct empirical tradition is built around within-category evidence at highly disaggregated product levels, typically HS6. Hummels and Skiba (2004), for example, use HS6 bilateral trade data and interpret average prices within narrowly defined product categories. In agriculture, Fiankor and Santeramo (2023) also work with HS6 data and revisit the effect of per-unit duties on export prices in a product-category-specific setting. By contrast, some adjacent studies use even finer product definitions. Baldwin and Harrigan (2011), for example, use U.S. trade data at the HS10 level. What the existing literature does not do is place the main test at a broad cross-category level. This paper differs precisely on that margin: the main quantitative evidence is presented at the HS2 level, which allows the analysis to ask whether the good-apples-shipped-out pattern extends across broad product categories rather than only within narrowly defined goods. The empirical contribution of this paper is therefore to test the mechanism where cross-category selection becomes

observable, while HS10 specifications and stricter sample definitions are used only as robustness checks.

The framework yields two testable hypotheses. H1 predicts that value density determines transport radius: higher‑value-density goods can profitably travel farther because the marginal revenue declines more slowly with distance. H2 predicts that reductions in unit transport costs lower the value-density cutoff for long-distance tradability, enabling previously non-tradable ordinary goods to enter global markets. Crucially, distance and fixed costs represent two distinct dimensions of the total cost structure: while H1 captures the spatial decay of profitability, H2 captures the threshold viability of trade. Together, they define the multidimensional filtering mechanism that governs global trade patterns.

This paper tests these hypotheses using a combination of high-dimensional quantitative evidence and qualitative case analysis. On the quantitative side, the main test uses U.S. General Import data from 2023 to 2025, comprising more than 11 million HS10 observations aggregated to the HS2 level in order to match the cross-category logic of the framework. The baseline specification relates observed unit values to distance with product and year fixed effects, while a second specification interacts distance with an air-transport indicator to examine whether a higher-cost transport channel strengthens the selection mechanism. To ensure that the HS2 results are not merely an artifact of broad aggregation, the paper also reports a more disaggregated HS10 specification and stricter sample definitions as supporting evidence and robustness checks. On the qualitative side, the paper complements the regressions with a set of stylized historical and contemporary cases—ranging from the Silk Road and containerization to transport-mode choice, quotas, and the WTO accession of China—to illustrate how changes in fixed trade costs reshape the set of tradable goods.

The results support the proposed mechanism. In the main HS2 estimates, more distant trade flows exhibit significantly higher observed unit values, indicating that the good-apples-shipped-out pattern survives beyond narrowly defined goods and appears at the level of cross-category selection. The evidence also shows that this positive distance‑unit-value relationship is stronger for observations involving air transport, which is consistent with the view that higher-cost channels impose a stricter selection filter. More disaggregated HS10 specifications and stricter subsamples provide supporting evidence, while the qualitative cases show the same logic operating across very different institutional and technological settings. Taken together, these findings extend the Alchian‑Allen mechanism from a within-category proposition to a broader account of how fixed trade costs shape the composition of global trade.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical debates surrounding the Alchian‑Allen mechanism. Section 3 develops the unified derived-demand model and derives the testable predictions based on value density and fixed costs. Section 4 tests H1 and H2 using a combination of quantitative regression analysis and qualitative extreme cases. Section 5 concludes.

2. Literature Review

The intellectual development of the Alchian–Allen theorem has diverged into three distinct strands. Although each produced valuable insights, their separation has also generated persistent confusion. Formal models became increasingly dependent on restrictive preference assumptions; practical cost-based explanations remained informal; and empirical studies often tested the theorem without understanding its theoretical preconditions. This section synthesizes these trajectories and identifies the gaps that motivate the present study.

2.1 Formal Derivations: Elegant Mathematics, Narrow Applicability

The classical statement by Alchian and Allen (1964) rests on a simple intuition: adding an equal per-unit cost to all qualities of a good reduces the relative price of the higher-quality variety, inducing substitution toward it. Early empirical applications (e.g., Staten & Umbeck 1989; Bertonazzi, Maloney & McCormick 1993) seemed broadly consistent with this view.

Yet the formal literature quickly revealed how fragile this intuition becomes once embedded in standard consumer theory. Gould and Segall (1969) showed that in a realistic multi-good environment the effect may simply fail. Borcherding and Silberberg (1978) could "save" the theorem only by imposing highly restrictive assumptions, most importantly that the two qualities behave as near-perfect substitutes with identical substitution patterns relative to all other goods. A long sequence of refinements—Saito (2006, 2008), Liu (2011), and Minagawa and Upmann (2013, 2015)—extended the theorem to multiple qualities, conditional versus unconditional demand, and generalized Slutsky-type decompositions. But these results all rely on carefully engineered preference structures and remain confined to close substitutes, conditions that rarely hold empirically.

In short, the formal branch of the Alchian–Allen literature evolved into an internally consistent but increasingly narrow exercise: the theorem holds, but only in a world where quality differences are small, preferences are well-behaved, and all substitutes interact symmetrically. These are precisely the situations in which empirical identification becomes weakest.

It is also useful to clarify the relationship between the present framework and the standard iceberg trade-cost formulation widely used in international trade (Samuelson, 1954; Anderson and van Wincoop, 2003). Iceberg costs scale proportionally with shipped quantities and primarily govern trade volumes conditional on market entry. By contrast, the mechanism developed here centers on fixed or quasi-fixed trade costs that generate a discrete selection threshold. Goods whose marginal revenue cannot clear this threshold are excluded from long-distance trade altogether. In this sense, the two approaches are conceptually distinct rather than merely complementary.

The pure iceberg formulation, by assuming costs are a constant fraction of value, rules out the relative price shifts necessary for the Alchian–Allen effect to operate. Our

framework fills this gap by showing that it is precisely the non-proportionality of unit and fixed costs that drives the selective filtering of trade.

2.2 The Cost-Based Tradition: Value Density, Rent Pairing, and Real-World Constraints

A second intellectual trajectory, originating from Steven N.S. Cheung (2002) and refined by Junhui Li (2012), operates largely independently of the micro-axiomatic preference theory. This approach dispenses with the need for curvature assumptions on indifference curves or the "close substitutes" constraint. Instead, it identifies a universal allocative principle: Rent Pairing. When a fixed or quasi-fixed cost—whether in the form of transport, monitoring, land rent, or regulation—is imposed, economic efficiency dictates that high-value assets be paired with these high-fixed-cost margins. In this framework, Value Density (market value per unit of physical constraint) becomes the decisive sorting metric. While the preference-based literature (Saito, 2006; Minagawa, 2015) treats the Alchian – Allen effect as a subtle shift in consumer choice, the Cheung-Li tradition views it as a fundamental rule of resource allocation. As Li (2012) argues, the pairing of high-value buildings with high-rent land, or premium products with high-tariff barriers, is a mechanical necessity of cost-amortization rather than a mere quirk of substitution.

This tradition is empirically powerful and widely applicable, but remains under-formalized. It rarely interacts with the modern preference-based literature, leaving a methodological gap between micro-axiomatic models and real-world allocation patterns.

2.3 Empirical Evidence: A Proliferation of Tests Without Theoretical Discipline

A third strand of the literature—by far the largest—is empirical. This body of work confirms that researchers have repeatedly tested predictions reminiscent of the Alchian – Allen mechanism, often without ensuring that the underlying theoretical preconditions are satisfied. As a result, the empirical record is rich but conceptually uneven.

A broad set of studies shows that when fixed or quasi-fixed per-unit costs rise, market outcomes tend to shift toward higher-value, higher-quality, or more compact varieties. Evidence of such upward substitution has been found in cigarette excise taxation (Sobel and Garrett, 1997; Chiou and Muehlegger, 2014), alcohol prohibition (Werle and Zedillo, 2018), illicit drug markets (Miron and Zwiebel, 1995; Beletsky and Davis, 2017), sex work (Della Giusta et al., 2008; Cunningham and Kendall, 2011; Cunningham and Shah, 2018), coffee trade (Miljkovic and Gómez, 2019), and seafood distribution (Amin et al., 2021). Despite the diversity of institutional settings, these studies point to a common empirical regularity: higher fixed or quasi-fixed costs tend to screen out lower-value varieties and shift transactions toward goods with greater value relative to the relevant constraint.

Similar evidence appears in international trade. Hummels and Skiba (2004) provide the classic direct empirical confirmation of the Alchian – Allen mechanism, but they do so within narrowly defined HS6 product categories, consistent with a within-category logic. Recent work by Fiankor and Santeramo (2023) also confirms the Alchian – Allen effect in

agricultural trade, showing that per-unit tariffs induce higher export unit values, but their analysis likewise remains confined to HS6-level within-category quality variation. More broadly, a related literature studies transport mode choice and distance sorting. Harrigan (2010) documents that U.S. imports from distant countries are systematically lighter and higher in value density—a pattern fully consistent with H1—but frames it within a Ricardian comparative-advantage model rather than the Alchian–Allen tradition. Emlinger and Lamani (2020) show that trade costs increase the share of higher-quality designations in French Cognac exports, but again within a narrowly defined product class. Hummels and Schaur (2013) examine air versus ocean shipping choices, but focus on time sensitivity rather than the fixed-cost selection logic emphasized here. Takechi (2022) finds that specific per-unit trade costs exhibit substantially higher distance elasticity than ad valorem costs, validating the empirical relevance of non-proportional trade costs, though still within a within-category setting.

At the same time, other studies report mixed or apparently contradictory findings. The classical critique by Gould and Segall (1969), which notes that high-quality goods such as lobster or fresh produce are often consumed locally rather than shipped over long distances, reflects a violation of a key implicit assumption of the mechanism—namely, that quality is preserved in transit. More recent challenges argue that Alchian–Allen-type predictions fail in markets for repugnant goods or heavily regulated activities. Yet empirical evidence often shows systematic sorting precisely in such markets when fixed risks, penalties, or enforcement costs rise. Additional studies in agricultural and retail settings (Lawson and Raymer, 2006; Resiandini, 2014) also generate ambiguous or unstable results, often because the cost mechanism is not modeled explicitly.

Taken together, the empirical literature is extensive but theoretically fragmented. Most studies examine isolated settings—taxation, regulation, risk, perishability, transport mode, or enforcement—without a common analytical structure linking their results. Many empirical tests implicitly assume, or inadvertently violate, different preconditions for the mechanism to operate, including quality preservation, comparability across goods, and homogeneous demand. As a consequence, similar empirical regularities are often interpreted through incompatible theoretical lenses.

The preceding discussion suggests a gap in the literature: existing work either remains confined to close substitutes in theory or to within-category evidence in empirics. This gap motivates the present study, which reconstructs the mechanism as a fixed-cost selection problem and examines whether it remains visible at the cross-category level.

2.4 Synthesis

Across these three trajectories, a clear pattern emerges:

1. **Formal models** prove the theorem only under restrictive preference structures that rarely describe real markets.
2. **Cost-based explanations**—value density, rent pairing, transaction-cost minimization—capture the actual mechanism but lack formal articulation.
3. **Empirical tests** often mix theoretical frameworks, applying preference-based derivations (confined to within-category comparisons) to settings where selection

across disparate goods or modes drives behavior, leading to confusion.

The result is conceptual fragmentation: the literature recognizes the empirical regularity that "fixed costs push high-quality goods outward," yet lacks a unified microfoundation that integrates relative prices, transaction costs, and real-world constraints. This gap motivates the present study.

3. The Theoretical Model

This section develops a unified microeconomic framework that reconstructs the Alchian–Allen mechanism as a general principle of economic selection under fixed trade costs. The model proceeds in three steps. First, it briefly reviews the classical algebraic logics of Alchian–Allen, Cheung, and Li. Second, it introduces a geometric representation based on marginal revenue and fixed-cost thresholds. Third, it uses this structure to derive two testable hypotheses—H1 on transport radius and H2 on cost-induced category shifts—and shows how apparent "exceptions" are naturally accommodated.

3.1 Classical Logics: A Brief Review

Three distinct formulations have historically explained the "good apples shipped out" phenomenon.

1. **Alchian–Allen (1964)** emphasized relative price: a fixed per-unit cost lowers the delivered price ratio of high- to low-quality goods, inducing substitution toward the former.
2. **Cheung (2002)** highlighted unit-quality economics: once a fixed shipment cost is incurred, adding high-value units spreads the cost more efficiently—e.g., a mother fills a care package with premium chocolates rather than cheap candy.
3. **Li (2012)** framed it as rent pairing: only goods generating sufficient economic rent can justify high-fixed-cost channels, such as luxury retail in prime urban locations.

Although these views differ in emphasis, they share an implicit selection logic: **fixed costs act as a filter that admits only goods capable of covering them**. However, none of them explicitly clarify the relevant assumptions of the theorem. To generalize, we need a framework that transcends "close substitutes" and incorporates distance, value density, and cost thresholds explicitly.

3.2 A Unified Geometric Framework

We model trade decisions as a derived-demand problem. Let the marginal revenue, $MR(L)$, from serving a market at distance Lbe a declining function of distance, reflecting falling net returns due to logistics friction, time decay, or risk. Define:

- $\mathrm{MR}_H(L)$: marginal revenue curve for a high–value-density good
- $\mathrm{MR}_L(L)$: marginal revenue curve for a low–value-density good

Both curves slope downward, but $\mathrm{MR}_H(L) > \mathrm{MR}_L(L)$for all L, because **value density**—market value per unit mass or volume—determines the initial height and decay rate of marginal revenue.

Transport markets are segmented by two threshold trade costs:

F_{local}, the average and marginal cost of local distribution; and F_{trade}, the average and marginal cost of entering long-distance trade channels, including coordination, compliance, insurance, and infrastructure fees.

A good is shipped to distance Lonly if:

$$\mathrm{MR}(L) \geq F_{\text{trade}}$$

This simple inequality generates both spatial and institutional predictions.

3.2.1 Deriving H1: Value Density Determines Transport Radius

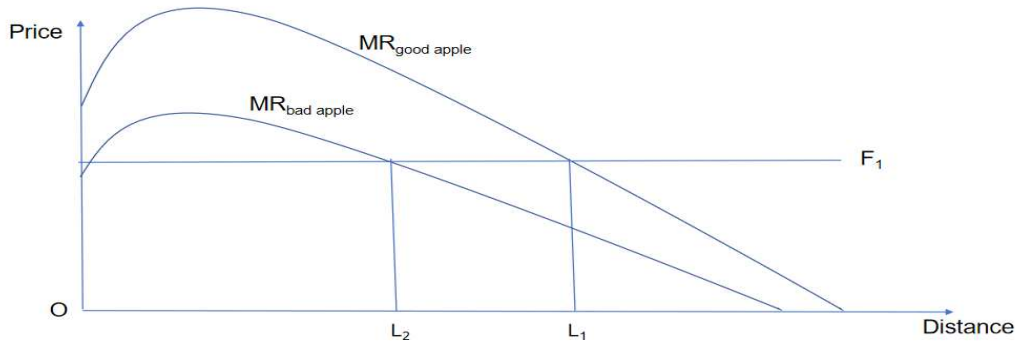

Figure 1. Value Density and the Feasible Transport Radius (H1)
Horizontal axis: distance; vertical axis: price. The high–value-density curve $\mathrm{MR}_{good\ apple}$ *intersects the fixed-cost threshold* F_1 *at (*L_1*)*, while the low–value-density curve $\mathrm{MR}_{bad\ apple}$ intersects it at $L_2^* < L_1^*$.* As shown in Figure 1a, the transport radius for each good is defined by the intersection:

$$L^* = \max\{L \mid \mathrm{MR}(L) \geq F_1\}$$

Because $MR_H(L)$starts from a higher level and remains above the threshold over a longer distance, the feasible transport radius is larger for high-value-density goods.
Thus:

Hypothesis 1 (H1): Higher value density implies a longer feasible transport radius.
This reframes the Alchian–Allen effect not as substitution, but as **selection by economic viability**: only high–value-density goods survive the fixed-cost filter at long distances.

3.2.2 Deriving H2: Fixed-Cost Reductions Expand the Tradable Set

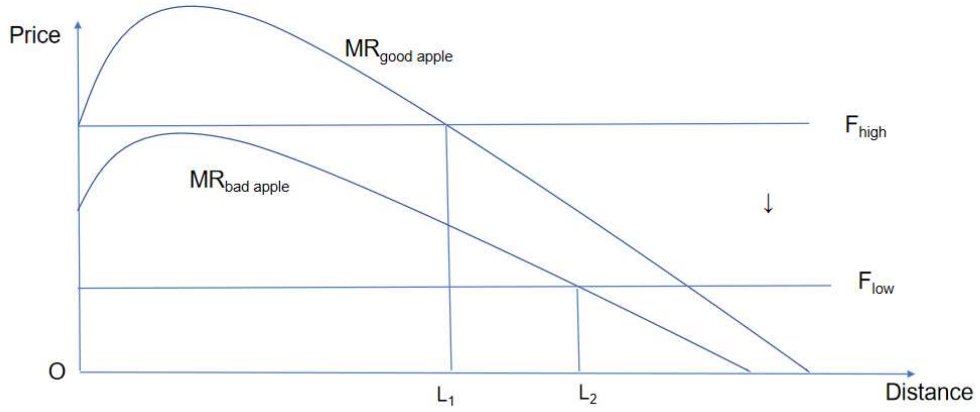

Figure 2. Fixed-Cost Reduction and Category Entry (H2)

At a fixed distance L_1 (e.g., China to U.S.), a reduction in average trade cost—due to technological or institutional change such as containerization or WTO accession—shifts the fixed-cost threshold downward from F_{high} (pre-reform) to F_{low} (post-reform). A medium–value-density good, whose marginal revenue $\text{MR}_{bad\ apple}$ was previously below F_{high} and thus excluded from trade, now satisfies $MR_M(L_2) \geq F_{low}$ and enters the market. This mechanism explains how falling fixed costs systematically lower the value-density cutoff for long-distance tradability, generating the category-level shifts predicted by H2.

Hypothesis 2 (H2): Reductions in fixed trade costs lower the value-density cutoff, enabling previously non-tradable goods to enter long-distance markets.

This logic applies equally to differences in transport technologies. Faster but more expensive modes of transportation, such as air shipping, effectively raise per-unit trade costs, while slower and cheaper modes, such as ocean shipping, lower them. Consistent with this mechanism, existing studies of transport mode choice document systematic sorting of goods by value density across shipping technologies (Hummels and Skiba, 2004; Harrigan, 2010; Hummels and Schaur, 2013).

More broadly, reductions in fixed or quasi-fixed trade costs do not merely increase trade volumes, but alter the composition of the global tradable set. As fixed costs decline, the minimum viable value-density threshold falls, allowing a wider range of goods to profitably serve distant markets. The graphical illustration in Figure 1b depicts this mechanism by showing a downward shift in the cutoff from F_{high} to F_{low}, with intermediate-value goods crossing into the set of tradable varieties.

3.3 Reinterpreting "Exceptions" Within the Unified Framework

Perishability and localized demand do not violate the model; they reshape the marginal revenue curve itself.

- **Perishable goods**: rapid quality decay steepens $\text{MR}(L)$, causing it to fall below F_trade even at short distances (e.g., fresh seafood pre–cold chain).

- **Localized demand**: cultural or taste-specific premiums inflate $\mathrm{MR}(L)$ locally but collapse it beyond a "demand cliff" (e.g., region-specific festival foods).

In both cases, the condition $\mathrm{MR}(L) \geq F$ fails—not due to cost, but due to **endogenous revenue erosion**. The framework thus absorbs "exceptions" as boundary predictions, not anomalies.

3.4 Synthesis

The geometric model unifies classical insights under a single selection principle: **fixed costs filter goods by their capacity to generate rent over distance**. By replacing "relative price" with "value density versus cost threshold," it:

- Eliminates the "close substitutes" restriction
- Generates two falsifiable hypotheses (H1 and H2)
- Endogenizes previously external exceptions

The following section presents empirical tests of H1 and H2.

4. Empirical Results

4.1 Qualitative Evidence: The Spatial and Modal Sieve

To validate the core mechanisms of the model, we provide nine stylized cases that map directly onto the theoretical parameters (R_m and F). These instances demonstrate that the Alchian-Allen effect is not merely a statistical regularity but a universal economic law. Specifically, the cases illustrate how the interplay between fixed trade costs (F) and the rent-margin (R_m) dictates which varieties are selected into global markets and which remain confined to local distribution.

4.1.1 Case Studies for H1: Rent-Buffers and Geographic Reach

A significant body of empirical literature echoes these patterns. For example, in the global coffee trade, Arabica (the variety of higher value density) disproportionately dominates long-distance export flows compared to Robusta when specific transport charges rise (Miljkovic & Gómez, 2019). Similarly, in seafood logistics, premium species exhibit significantly wider trade radii than bulk fish of low value, even when sharing the same system of cold-chain infrastructure (Amin et al., 2021). The core contribution of this research is to move beyond these category-specific observations and demonstrate that this selection mechanism is a universal economic law driven by the physical density of value.

Case 1: Physical Density (Bottled Water vs. Spirits)

Industry practice illustrates stark differences in shipping radii based on the ratio of value to weight. Bottled water, characterized by extremely low value density, faces a sharply limited economic transport radius. Logistics reports document break-even distances of only 300–500 km for budget water brands, beyond which the cost of freight absorbs the majority of the final retail price (Dongwu Securities Research Institute, 2025).

In contrast, premium spirits—such as Chinese Moutai or imported Scotch—are routinely traded over intercontinental distances. Because the value density of these goods is several orders of magnitude higher, the fixed cost of transport ($\boldsymbol{F}$) represents a negligible fraction of the marginal revenue ($\boldsymbol{R_m}$). This contrast confirms the prediction of $H1$: only products with high value density can generate sufficient rent-buffers to survive the "distance tax" of

global trade (Hummels, 2007).

Case 2: Bulk Materials vs. Electronics (Sand vs. Microchips)
Construction aggregates, such as sand and gravel, exhibit an even more extreme constraint regarding value density. According to the U.S. Geological Survey (2023), the average unit value for construction sand and gravel is approximately $10.60 per ton. Because of this exceptionally low value density, the cost of transportation represents a disproportionate share of the final price, rendering these markets "intrinsically local" in nature. The physical weight of the commodity acts as a structural barrier, typically restricting the distribution radius to immediate local areas to remain economically viable.
Conversely, microchips possess some of the highest value densities in the global economy. For these components, the cost of transportation constitutes a near-zero percentage of the total value, allowing them to circulate worldwide with negligible regard for distance (World Semiconductor Trade Statistics, 2025). This contrast provides a non-parametric validation of the selection mechanism: the fixed-cost threshold ($\boldsymbol{F}$) selects high-value-density goods into the set of tradable varieties while effectively censoring low-value commodities from the global trade network, regardless of the intensity of demand in distant markets.

Case 3: Distributional Arbitrage (Gray Markets)
Evidence from gray markets confirms that only high-VD goods generate sufficient rent-buffers (R_m - F) to cover the fixed costs of secondary transport, concealment, and enforcement. Gray-market and parallel-import activity is heavily concentrated in high-value branded goods—cameras, perfumes, and luxury watches—where region-specific price gaps are large enough to amortize arbitrage frictions (Cespedes, Corey, & Rangan, 1988; Skoko & Krivokapic-Skoko, 2005). Legal cases such as Kirtsaeng v. John Wiley & Sons further demonstrate that even books become targets of arbitrage when their unit value is high enough to justify re-export. In contrast, there is virtually no documented gray-market movement for low-value staples such as bottled water or generic snacks. In contrast, low-value staples rarely exhibit sustained gray-market movement due to insufficient absolute margins.

Case 4: “Fu-Character Apples” and the Geography of Taste
This case demonstrates the ability of the model to explain "exceptions" where physical properties are identical. "Fu-character" apples command a cultural premium ($\boldsymbol{R_m}$) only within specific regions, such as Canton. Crossing a cultural boundary causes $\boldsymbol{R_m}$ to collapse, turning the rent-margin negative ($\boldsymbol{R_m - F} < 0$) and truncating the transport radius—even if $\boldsymbol{F}$ remains unchanged. This proves that the selection engine is an economic filter driven by perceived rent, effectively internalizing demand-side heterogeneity as a spatial constraint.
A more general version appears in global trade: exporters from China or Vietnam routinely ship higher-quality varieties to Japan or the EU and lower-quality varieties to Africa or South Asia at similar distances. Destination income—not distance—determines whether the market can absorb the fixed cost of quality.

4.1.2 Case Studies for H2: Fixed-Cost Thresholds and Mode Selection
To validate the H2 mechanism, we provide a series of stylized cases that map directly onto

the fixed-cost parameter (F). These cases demonstrate how exogenous shocks to transaction costs — whether from logistical technology, institutional shifts, or enforcement—raise the value-density threshold for market participation.

Case 5: The 117-fold "Value-Density Gap" (Contemporary Mode Choice)

The most direct cross-sectional evidence of H2 comes from the stark bifurcation in transport mode selection. According to 2018 data from the Bureau of Transportation Statistics (as cited by the U.S. International Trade Administration, 2018), a massive "decoupling" exists between tonnage and value in U.S. international trade. Air transport accounts for a mere 0.40% of the total weight but commands 27.55% of its total value. Conversely, maritime transport handles 70.93% of the weight but represents only 41.88% of the value.

As shown in Table 1 below, the implied average value density (VD) of air cargo is approximately $128.78 per kilogram, whereas maritime cargo averages only $1.10 per kilogram (ITA, 2018). This 117-fold difference in the intensive margin of trade value proves that the high fixed costs of air transport ($\boldsymbol{F_{air}}$)——comprising specialized handling, airport fees, and rapid-clearance infrastructure——create a high "profitability threshold." Within our unified framework, only goods with ultra-high VD can amortize these fixed charges. This structural regularity, consistent across the 2010–2025 longitudinal records, confirms that the transport mode itself acts as a persistent economic filter for value density, independent of specific product categories.

Table 1: U.S. International Trade by Mode (2018)

Mode	Weight Share (%)	Value Share (%)	Implied VD ($/kg)
Air	0.40%	27.55%	$128.78
Maritime	70.93%	41.88%	$1.10

Source: U.S. Department of Commerce, International Trade Administration. (2018). Maritime Services Trade Data: U.S. International Freight Trade by Transportation Mode. Bureau of Transportation Statistics (BTS). Available at: https://www.trade.gov/maritime-services-trade-data (Accessed: March 14, 2024).

Notes: 1. BTS data excludes U.S.-Canada-Mexico cross-border trade by value and tonnage for specific maritime comparisons.2. *Implied VD ($/kg) is calculated by the author as (Value / Tonnage) / 1000 to demonstrate the value-density threshold for $H2$.3. The 117-fold difference in value density between Air ($128.78/kg) and Maritime ($1.10/kg) provides direct empirical support for the fixed-cost selection mechanism.

Case 6: Technological Transformation of *F* (Silk Road vs. Containerization)

The evolution in the composition of global trade provides a longitudinal validation of ***H2***, illustrating how profound shifts in fixed trade costs (***F***) reconfigure the set of tradable goods. Historical and archaeological evidence indicates that long-distance exchange along the ancient Silk Road was confined almost exclusively to goods characterized by extreme

value density—such as silk from China, jade from Central Asian regions, and precious spices (Liu, 2010). Under this high-F regime, defined by slow, risky, and technologically primitive logistics, the "rent threshold" remained so elevated that ordinary or bulky goods were effectively censored from intercontinental routes.

In contrast, contemporary global trade—enabled by containerization and modern trade institutions—is dominated by goods of medium and low value density. Today, the largest exporters ship not only compact, high-value products such as electronics, but also furniture, toys, textiles, and a wide range of mundane consumer staples across identical intercontinental distances (World Bank, 2020). From the perspective of the model, this transition represents a massive downward shift in the parameter $\boldsymbol{F}$. Containerization drastically reduced costs associated with handling and coordination, while modern trade institutions lowered barriers related to policy, jointly collapsing the fixed-cost threshold for participation in global markets (Levinson, 2006). This collapse enabled low-*VD* goods, which previously failed to satisfy the transport-cost condition ($\boldsymbol{R_m - F} < 0$), to cross the threshold into the tradable set. The historical contrast between the trade of the Silk Road and modern shipping thus provides a stylized illustration of how the fixed-cost "sieve" determines which goods enter trade.

Case 7: U.S. Textile Quotas and Quality Upgrading in Hong Kong

A well-known example documented by Steven N. S. Cheung (2003) provides clear evidence of how an increase in fixed trade costs raises the value-density threshold for tradability. Under the Multi-Fibre Arrangement during the 1960s and 1970s, the United States imposed binding quotas on imports of textiles from Hong Kong. Prior to the implementation of quotas, Hong Kong exported low-quality, mass-market garments that were typically sold in the basements of department stores in the United States.

Within a few years of the implementation of quotas, the composition of the exports of Hong Kong shifted dramatically: garments became significantly higher in quality and were sold on the top floors of prestigious stores. As Cheung observed, the quota created a scarce and valuable right to export, effectively adding a fixed cost that firms had to cover. Exporters therefore rationally allocated quota slots to products of higher value and higher margins, upgrading quality even though production technology, preferences, and labor costs remained unchanged.

While direct evidence on quality upgrading induced by quotas is rare, related studies show that per-unit trade costs—whether arising from transportation technology or institutional constraints—systematically shift trade toward goods of higher value (e.g., Hummels & Skiba, 2004; Harrigan, 2010). These cases closely align with the core mechanism predicted by *H2*: when a fixed trade barrier raises the cutoff for value density, only high-value goods can profitably enter the market.

Case 8: Accession of China to the WTO and the Global Entry of Low-Value-Density Exports

The accession of China to the World Trade Organization (WTO) in 2001 represents one of the most consequential reductions in fixed trade costs in modern economic history. Prior to this accession, exporters from China faced a combination of high tariffs, binding quotas under the Multi-Fibre Arrangement, discretionary anti-dumping actions, and policy uncertainty in major destination markets. These barriers functioned as de facto fixed costs

by raising the minimum expected rent required for market entry, a mechanism that disproportionately excluded goods of low value density from long-distance trade.

The accession to the WTO substantially reduced these institutional frictions. Tariff barriers declined, quantitative restrictions were phased out, and the introduction of predictable, rules-based dispute settlement lowered the risk premium embedded in export transactions (Pierce & Schott, 2016). From the perspective of the model, these changes sharply reduced the fixed cost threshold governing participation in global markets.

Existing empirical studies document trade patterns consistent with this mechanism. Following the accession to the WTO, China experienced a pronounced expansion along the set of tradable goods, exporting a large number of new product varieties to high-income markets (Autor et al., 2020). At the same time, the composition of exports shifted toward labor-intensive, bulky, and relatively low-unit-value goods that had previously been confined to domestic or regional markets (Pierce & Schott, 2016).

These developments align closely with the prediction of *H2*: when fixed trade costs fall, the cutoff for value density in long-distance tradability declines. This shift enables ordinary goods—which were previously unable to cover the fixed cost of market entry—to be profitably shipped across global distances[1].

Case 9: Fixed-Cost Shocks in Micro-Institutional and Shadow Markets

Hypothesis 2 is not limited to trade activities. The same mechanism operates with equal clarity—and often sharper identification—in micro-institutional settings where fixed-cost shocks are exogenous and well-documented. As reviewed in Section 2.3, empirical studies consistently show that changes in transaction costs trigger predictable shifts along the value-density spectrum:

- **Alcohol markets**: Prohibition raised smuggling costs, filtering out low-value beer and selecting for high-proof spirits (Werle & Zedillo, 2018).
- **Drug markets**: Enforcement pushed users from bulky heroin to ultra-compact fentanyl (Beletsky & Davis, 2017; Miron & Zwiebel, 1995).
- **Sex work**: High-fixed-cost indoor venues select for higher-priced, higher-quality services than street prostitution (Cunningham & Kendall, 2011; Della Giusta et al., 2008).
- **Tobacco markets:** Sobel and Garrett (1997) find that specific (per-unit) excise taxes on cigarettes act as a fixed cost, inducing a systematic shift toward higher-value-density premium brands. In states with higher cigarette taxes, the market share of premium brands rises. Chiou and Muehlegger (2014) found that, in the long term after excise tax increase, average levels of tar, nicotine, and carbon monoxide consumed per pack rises, as consumers substitute across tiers and brands,

These cases demonstrate that H2 operates as a universal economic filter. Whether the fixed cost arises from a transport mode (Air vs. Maritime), a quota slot, an excise tax, or an enforcement risk, the result is identical: the "fixed-cost sieve" selects for higher value density.

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[1] A contemporary illustration of this mechanism can be observed in the sector of e-commerce logistics in China. Platforms relying on asset-heavy, vertically integrated logistics systems incur high fixed operating costs and therefore tend to specialize in products of relatively high value density. In contrast, platforms operating through asset-light, third-party logistics networks can profitably distribute goods of extremely low value density at scale. This example is suggestive rather than causal and is mentioned solely to illustrate how different regimes of fixed costs shape the lower bound of tradable goods in practice.

4.2 Quantitative Evidence

This section evaluates H1 and H2 using U.S. General Import data from 2023 to 2025. The main quantitative evidence is presented at the HS2 level, consistent with the cross-category logic of the paper, while more disaggregated HS10 specifications and stricter sample definitions are used as supporting evidence and robustness checks. The empirical design asks two related questions. First, do more distant trade flows exhibit systematically higher observed unit values once the data are aggregated to a broad product level? Second, does this positive distance – unit-value relationship become stronger when the shipment involves a higher-cost transport channel?

4.2.1 Data and Sample Construction

We use U.S. General Import data from January 2023 to December 2025. The raw dataset contains more than 11 million observations at the HS10 product level. Unit value (uv) is constructed as the ratio of customs value to quantity. Bilateral distance ($dist$) is measured using the CEPII gravity database. Air transport (is_air) is identified for observations involving air shipment. To avoid contamination from immediate cross-border trade, imports from Canada and Mexico are excluded.

The main empirical analysis is conducted at the HS2 level, where HS10 observations are aggregated to match the cross-category logic of the paper. This aggregation is central to the empirical design, because the objective is not simply to study quality variation within narrowly defined goods, but to test whether the good-apples-shipped-out pattern remains visible at the level of broad product categories. More disaggregated HS10 specifications are reported separately as supporting evidence and robustness checks. All baseline regressions include product fixed effects and year fixed effects to control for time-invariant product characteristics and common annual shocks.

4.2.2 Empirical Strategy

The first specification tests H1 by examining whether more distant trade flows exhibit higher observed unit values at the HS2 level:

$$\ln\ UV_{rht} = \alpha + \beta_1 \ln\ Dist_r + \delta_h + \lambda_t + \varepsilon_{rht}$$

where r indexes exporter, h indexes HS2 product category, and t indexes year. δ_h denotes HS2 product fixed effects and λ_t denotes year fixed effects. A positive estimate of β_1 indicates that more distant trade flows are associated with higher observed unit values, which is the empirical implication of cross-category selection under fixed trade costs.

The second specification tests H2 by allowing the distance gradient to vary with transport mode:

$$\ln\ UV_{rht} = \alpha + \beta_1 \ln\ Dist_r^c + \beta_2 Air_{rht} + \beta_3 (Air_{rht} \times \ln\ Dist_r^c) + \delta_h + \lambda_t + \varepsilon_{rht}$$

where $\ln\ Dist_r$ is centered log distance and Air_{rht} is an indicator for observations involving air shipment. The coefficient of interest is β_3. A positive estimate implies that the distance–unit-value gradient is steeper when the shipment involves air transport,

consistent with the interpretation that a higher-cost channel sharpens the selection margin. All baseline regressions cluster standard errors at the HS2 level.

4.2.3 Results

HS2 results strongly support the proposed mechanism. In the baseline specification, the coefficient on log distance is 0.2420 and statistically significant at the 1 percent level. Thus, more distant trade flows exhibit systematically higher observed unit values even when the unit of analysis is broadened to HS2 categories. This is the paper's core cross-category result: the good-apples-shipped-out pattern is not confined to narrowly defined within-category comparisons, but remains visible at a level where selection across broad product categories becomes observable. Table 2 reports the full regression output.

Table 2. HS2 Baseline Test of H1

Dependent variable: ln(unit value)

Variables	**(1) H1**
ln(dist)	0.2420***
	(0.0778)
Observations	11,198,307
Within R^2	0.001
Fixed effects	HS2 product, Year
Standard errors	Clustered by HS2

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The sample uses U.S. General Import data from 2023 to 2025 and excludes Canada and Mexico. The positive coefficient on distance indicates that more distant trade flows exhibit higher observed unit values at the HS2 level, consistent with cross-category selection.

H2 specification yields a consistent result. The coefficient on centered log distance is 0.1132 and imprecisely estimated on its own, while the coefficient on the air dummy is -0.3272 and highly significant. Most importantly, the interaction term between air transport and centered distance is 0.3019 and statistically significant at the 5 percent level. The implied total distance slope for observations involving air transport is 0.4151, and the null hypothesis that the interaction effect is zero is rejected with a p-value of 0.0171. Substantively, this means that the positive distance–unit-value relationship becomes steeper when the shipment uses air transport. This is consistent with the view that a higher-cost transport channel sharpens the underlying selection mechanism. Table 3 reports these estimates, and Figure 3 illustrates the difference between the baseline distance gradient and the steeper gradient for air-involving shipments.

Table 3. HS2 Air-Transport Test of H2

Dependent variable: ln(unit value)

Variables	**(1) H2**

ln(dist)_c	0.1132
	(0.0694)
Air (dummy)	-0.3272***
	(0.0298)
Air × ln(dist)_c	0.3019**
	(0.1245)
Observations	11,198,307
Within R^2	0.013
Fixed effects	HS2 product, Year
Standard errors	Clustered by HS2
Air-group total slope	0.4151*** (0.1000)
Test: Air × ln(dist)_c = 0	F = 5.88; p = 0.0171

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The positive interaction term shows that the distance–unit-value gradient is steeper for observations involving air transport.

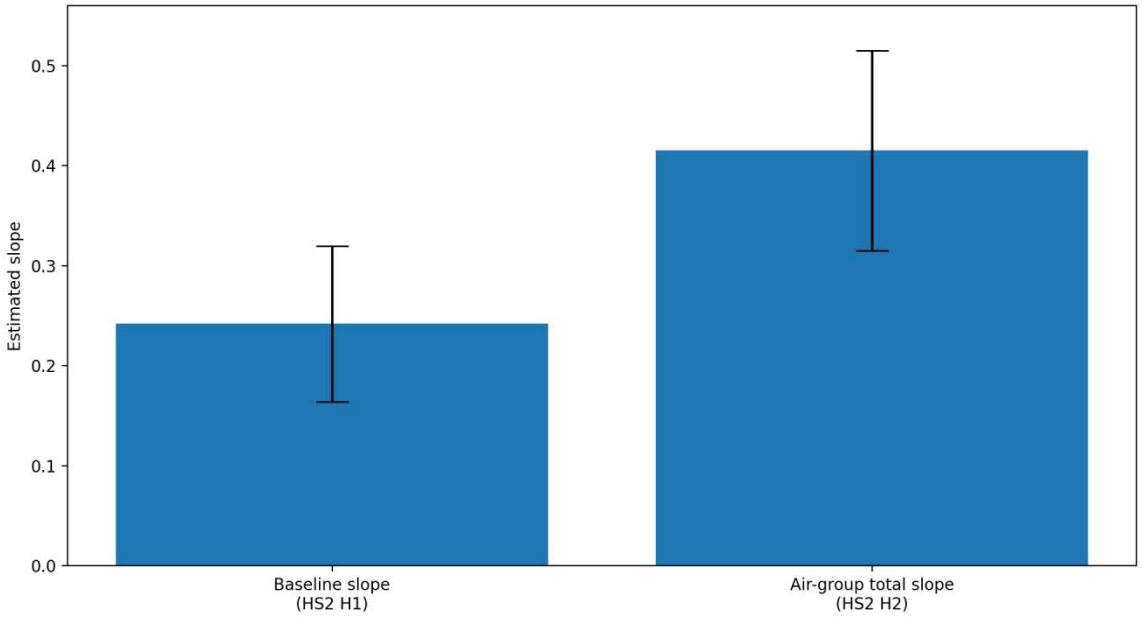

Figure 3. Implied distance slopes for baseline and air-involving shipments

Taken together, the main HS2 estimates establish the paper's central empirical claim. Distance does not merely reduce trade volumes, as in standard gravity reasoning; it also reshapes the composition of the tradable set. Once the data are aggregated to a level

consistent with cross-category logic, more distant markets are supplied by goods with systematically higher observed unit values. In this sense, the evidence supports the reinterpretation of the Alchian–Allen mechanism as a problem of fixed-cost selection rather than a narrow within-category substitution effect.

4.2.4 Robustness

The robustness analysis proceeds in two steps. First, the HS2 interaction specification is re-estimated across five progressively stricter scored subsamples. The results remain directionally stable throughout. The coefficient on centered log distance is positive in every subsample, ranging from 0.1341 in S1 to 0.2379 in S5, while the coefficient on the air dummy remains negative and highly significant in all five cases. The interaction term between air transport and centered distance is positive in every subsample and statistically significant in the two broadest samples, S1 and S2, with coefficients of 0.3025 and 0.3134, respectively. In the stricter subsamples, S3–S5, the interaction remains positive but becomes imprecisely estimated. Table 4 reports the full set of coefficients, and Figure 5 plots the interaction estimates across S1–S5. The pattern is clear: the air-channel effect is strongest in broader samples and attenuates in the stricter ones without reversing sign.

Table 4. HS2 Robustness Across Scored Subsamples (H2)

Dependent variable: ln(unit value)

Variables	S1	S2	S3	S4	S5
ln(dist)_c	0.1341*	0.1517**	0.2084***	0.2189***	0.2379***
	(0.0704)	(0.0687)	(0.0740)	(0.0744)	(0.0742)
Air (dummy)	-0.3305***	-0.3348***	-0.3814***	-0.3822***	-0.3797***
	(0.0313)	(0.0317)	(0.0310)	(0.0313)	(0.0315)
Air × ln(dist)_c	0.3025**	0.3134**	0.0891	0.0863	0.0867
	(0.1276)	(0.1301)	(0.0869)	(0.0864)	(0.0862)
Observations	10,655,839	10,406,329	6,905,993	6,863,715	6,761,401
Within R^2	0.014	0.014	0.018	0.019	0.019

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. All regressions include HS2 product and year fixed effects, with standard errors clustered at the HS2 level. The interaction term remains positive in all five subsamples and is statistically significant in the two broadest samples, S1 and S2.

Second, the paper checks whether the basic distance gradient survives at a finer product level. In the HS10 baseline specification with product and year fixed effects, the coefficient on log distance remains positive and highly significant, at 0.2628. This finer-product evidence does not replace the HS2 main test, because the contribution of the paper lies in shifting the main empirical design to HS2. It does, however, show that the positive distance–unit-value relationship is not simply an artifact of broad aggregation. Table 5

reports this HS10 baseline estimate.

Table 5. HS10 Baseline Evidence
Dependent variable: ln(unit value)

Variables	(1) HS10 baseline
ln(dist)	0.2628***
	(0.0136)
Observations	11,197,693
Within R^2	0.002
Fixed effects	HS10 product, Year
Standard errors	Clustered by HS10 product

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. This table reports the finer-product baseline specification. The positive coefficient shows that the distance gradient remains visible even at the HS10 level.

Overall, the robustness exercises reinforce the main interpretation. The HS2 baseline establishes the core cross-category result, the HS2 scored-subsample analysis shows that the air interaction remains positive and is most clearly identified in the broader samples, and the HS10 baseline confirms that a positive distance gradient is also visible at a more disaggregated product level. For completeness, full regression outputs corresponding to Tables 2–5, along with additional HS10-level subsample robustness checks, are reported in Appendix Tables A1–A5.

5. Conclusion

This paper offers a unified resolution to a long-standing theoretical puzzle in economics: why "the good apples are shipped out." The theoretical framework generates two testable hypotheses: H1, higher value density implies a longer feasible transport radius; and H2, reductions in fixed trade costs, whether technological or institutional, lower the value-density cutoff for global tradability.

These hypotheses are examined primarily with high-frequency U.S. import data from 2023 to 2025. The main quantitative test is conducted at the HS2 level, consistent with the cross-category logic of this paper, while HS10 specifications are reported as supporting evidence and robustness checks. The results show that, in the HS2 baseline estimates, distance is positively and significantly associated with unit value, a pattern consistent with fixed-cost selection rather than standard distance friction. In addition, the distance–unit-value gradient is significantly steeper for observations involving air transport in the main specification. This provides strong support for H1 and supporting evidence for H2, with the interaction term remaining positive across robustness exercises and estimated most precisely in the broader samples. Extreme-case comparisons, such as bottled water versus premium spirits or gravel versus semiconductors, together with historical episodes

including the Silk Road, containerization, the accession of China to the WTO, and textile quotas imposed on Hong Kong, consistently show that reductions in fixed costs lower the entry threshold and expand the tradable set from narrow high-value-density niches to increasingly ordinary varieties.

This paper makes two main contributions. First, it reconstructs the Alchian – Allen mechanism as a problem of cross-category selection under fixed trade costs, rather than a narrow substitution effect confined to close substitutes. By treating value density as the key metric of economic viability, the framework explains why some goods can profitably enter long-distance trade while others cannot, and it also brings so-called exceptions, such as perishability and localized demand, within the scope of the same analytical structure. Second, the paper develops an empirical strategy that matches this reinterpretation more closely than the existing literature. Instead of restricting the analysis to within-category quality variation, it tests the mechanism at the HS2 level to capture cross-category sorting and uses transport-mode heterogeneity to examine whether higher-cost channels impose a stronger value-density filter. In this way, the paper translates a broad theoretical claim into an empirically testable framework using high-frequency U.S. General Import data.

These findings also provide a unified policy perspective. Trade facilitation expands the tradable set not merely by increasing trade volume, but by structurally lowering the value-density cutoff. This mechanism does not benefit only high-value industries. It also enables ordinary, labor-intensive goods to profitably reach distant markets. Containerization did not simply make silk easier to trade; it made furniture, toys, and textiles globally tradable on a large scale. Similarly, the accession of China to the WTO allowed exporters to ship not only electronics but also garments and household goods across continents. This logic also has direct implications for contemporary policy debates. The still-limited commercialization of the low-altitude economy, including drone delivery, provides a clear illustration of H2. At present, only goods with extremely high value density, such as life-saving pharmaceuticals or emergency medical supplies in special settings such as mountainous regions without road access or emergency rescue scenarios, can amortize the high fixed costs of drone logistics. Ordinary commodities remain excluded not because of weak demand, but because the fixed-cost threshold remains too high. By contrast, measures that reduce institutional and logistics fixed costs, such as standardized customs procedures, bonded warehouses, and cross-border electronic commerce platforms, expand the tradable set downward and allow increasingly ordinary goods to participate in global exchange. This is the substantive meaning of the realization of comparative advantage: not only the best apples are shipped out, but eventually ordinary apples can be shipped as well.

In sum, the good apples are shipped out not because of relative prices alone, but because only they can afford the ticket. This paper shows that the ticket price is fixed, and that economic selection rather than substitution is the true engine of the Alchian – Allen effect.

Reference

Aggregate resource. (n.d.). In ScienceDirect topics. Retrieved November 28, 2025, from https://www.sciencedirect.com/topics/engineering/aggregate-resource

Alchian, A. A., & Allen, W. R. (1964). *University economics: Elements of inquiry* (3rd ed.). Wadsworth.

Amin, M., Said, F., & Nugroho, A. (2021). Distance, quality, and seafood trade networks. *Marine Policy, 124*, 104349. https://doi.org/10.1016/j.marpol.2020.104349

Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *American economic review*, *93*(1), 170-192.

Autor, D. H., Dorn, D., Hanson, G. H., & Majlesi, K. (2020). Importing political polarization? The electoral consequences of rising trade exposure. *American Economic Review, 110*(10), 3139–3183. https://doi.org/10.1257/aer.20181439

Baldwin, R., & Harrigan, J. (2011). Zeros, quality, and space: Trade theory and trade evidence. *American Economic Journal: Microeconomics*, 3(2), 60 – 88. https://doi.org/10.1257/mic.3.2.60

Beletsky, L., & Davis, C. S. (2017). Today's fentanyl crisis: Prohibition's Iron Law, revisited. *International Journal of Drug Policy*, *46*, 156-159.

Borcherding, T. E., & Silberberg, E. (1978). Shipping the good apples out: The Alchian and Allen theorem reconsidered. *Journal of Political Economy, 86*(1), 131–138. https://doi.org/10.1086/260656

Bertonazzi, E. P., Maloney, M. T., & McCormick, R. E. (1993). Some evidence on the Alchian and Allen theorem: The third law of demand? *Economic Inquiry, 31*(3), 383–393. https://doi.org/10.1111/j.1465-7295.1993.tb00883.x

Bureau of Transportation Statistics (BTS). (2018). U.S. International Freight Trade by Transportation Mode. U.S. Department of Transportation. [Data accessed via U.S. International Trade Administration]. Retrieved from https://www.trade.gov/maritime-services-trade-data

Cespedes, F. V., Corey, E. R., & Rangan, V. K. (1988). Gray markets: causes and cures. *Harvard Business Review*, *66*(4), 75-83.

Cheung, S. N. S. (2003). Quota: Lessons ignored? *Hong Kong Economic Journal* (信报). Reprinted in Cheung (2017), *Economic Explanation, Vol. 1*. Hong Kong: Arcadia Press.

Cheung, S. N. S. (2001). Economic explanation. Hong Kong: Arcadia Press.

Chiou, L., & Muehlegger, E. (2014). Consumer response to cigarette excise tax changes. *National Tax Journal*, *67*(3), 621-650.

Cobb, S., & Olberding, D. (2010). Marathon consumption and travel distances. *Journal of Sports Economics, 11*(4), 408–428. https://doi.org/10.1177/1527002509348415

Cunningham, S., & Kendall, T. D. (2011). Prostitution 2.0: The changing face of sex work. *Journal of urban economics*, *69*(3), 273-287.

Cunningham, S., & Shah, M. (2018). Decriminalizing indoor prostitution: Implications for sexual violence and public health. *The Review of Economic Studies*, *85*(3), 1683-1715.

Dongwu Securities Research Institute. (2025). Nongfu Spring (09633.HK): Adhering to long-termism, the leader remains unchanged [Research report]. Retrieved from https://pdf.dfcfw.com/pdf/H3_AP202504111654557651_1.pdf?1744370747000.pdf
Emlinger, C., & Lamani, V. (2020). International trade, quality sorting and trade costs: the case of cognac. *Review of World Economics*, 156(3), 579-609.
Emlinger, C., & Guimbard, H. (2021). Shipping the good agricultural products out? The differentiated impact of per-unit duties on developing countries. *European Review of Agricultural Economics*, 48(3), 598 – 636. https://doi.org/10.1093/erae/jbaa022
Giusta, M. D., Di Tommaso, M. L., & Strøm, S. (2009). Who is watching? The market for prostitution services. *Journal of Population Economics*, *22*(2), 501-516.
Eid, J., et al. (2013). Racehorse imports and the A–A effect. *Australian Economic Papers, 52*(1), 1–17. https://doi.org/10.1111/1467-8454.12000
Feenstra, R. C., & Romalis, J. (2014). International prices and endogenous quality. *The Quarterly Journal of Economics, 129*(2), 477–527. https://doi.org/10.1093/qje/qju001
Fiankor, D. D., & Santeramo, F. G. (2023). Revisiting the impact of per‐unit duties on agricultural export prices. *Applied Economic Perspectives and Policy*, 45(3), 1472-1492.
Gould, J. P., & Segall, J. (1969). The substitution effects of transportation costs. *Journal of Political Economy*, *77*(1), 130-137.
Gradoz, J., & Dekker, E. (2025). The regulation of repugnant goods and the limits of the Alchian–Allen effect. *European Journal of Law and Economics*, *59*(1), 1-18.
Harrigan, J. (2010). Airplanes and comparative advantage. *Journal of International Economics*, 82(2), 181 – 194. https://doi.org/10.1016/j.jinteco.2010.07.002
Head, K., & Mayer, T. (2014). Gravity equations: Workhorse, toolkit, and cookbook. *Handbook of International Economics*, 4, 131–195.
Hummels, D., & Skiba, A. (2004). Shipping the good apples out? An empirical confirmation of the Alchian–Allen conjecture. *Journal of Political Economy, 112*(6), 1384–1402. https://doi.org/10.1086/422560_
Hummels, D. (2007). Transportation costs and international trade in the second era of globalization. Journal of Economic perspectives, 21(3), 131-154.
Hummels, D., & Schaur, G. (2013). Time as a trade barrier. *American Economic Review*, 103(7), 2935 – 2959. https://doi.org/10.1257/aer.103.7.2935
Lawson, R., & Raymer, L. (2006). Testing the Alchian-Allen theorem: A study of consumer behavior in the gasoline market. *Economics Bulletin*, *4*(35), 1-6.
Levinson, M. (2006). *The box: How the shipping container made the world smaller and the world economy bigger*. Princeton University Press.
Li, J. (2012). *Lecture-notes on Economics*. Beijing: CITIC Press.
Liu, X. (2010). *The Silk Road in world history*. Oxford University Press.
Liu, L. (2011). The Alchian–Allen theorem and the law of relative demand: the case of multiple quality-differentiable brands. *Mathematical Social Sciences*, *61*(1), 52-57.
Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), 1695 – 1725. https://doi.org/10.1111/1468-0262.00467
Miljkovic, D., & Gómez, M. I. (2019). Shipping the good coffee out: the Alchian–Allen

theorem and relative demand for Brazilian Arabica and Robusta coffees. *European Review of Agricultural Economics*, *46*(4), 697-712.
Miljkovic, D., Gómez, M. I., Sharma, A., & Puerto, S. A. (2019). Testing the Alchian–Allen theorem for three goods using the pseudo Poisson model. *Agricultural Economics*, *50*(6), 793-802.
Minagawa, J., & Upmann, T. (2013). A conditional demand approach to the Alchian–Allen effect. *Economics Letters*, *120*(3), 546-551.
Minagawa, J., & Upmann, T. (2015). The generalized Alchian–Allen theorem: A Slutsky equation for relative demand. *Economic Inquiry*, *53*(4), 1893-1907.
Miron, J. A., & Zwiebel, J. (1995). The economic case against drug prohibition. *Journal of Economic Perspectives, 9*(4), 175–192. https://doi.org/10.1257/jep.9.4.175
Pierce, J. R., & Schott, P. K. (2016). The surprisingly swift decline of U.S. manufacturing employment. *American Economic Review, 106*(7), 1632–1662. https://doi.org/10.1257/aer.20121041
Resiandini, P. (2014). Japanese and Korean automobile exports and the Alchian–Allen theorem. *International Journal of Trade and Global Markets, 7*(2), 86–98.
Thornton, M. (1998). The potency of illegal drugs. *Journal of Drug Issues, 28*(3), 725–740. https://doi.org/10.1177/002204269802800306
Saito, T. (2006). *Shipping the good apples out: Alchian–Allen theorem of various qualities*. MPRA Paper No. 901, University of Munich.
https://mpra.ub.uni-muenchen.de/901/
Saito, T. (2008). An expository note on Alchian-Allen theorem when sub-utility functions are homogeneous of degree n> 0 with two-stage budgeting. Economics Bulletin, 6(30), 1-12.
Samuelson, P. A. (1952). The transfer problem and transport costs: the terms of trade when impediments are absent. *The Economic Journal*, *62*(246), 278-304.
Samuelson, P. A. (1954). The transfer problem and transport costs, II: Analysis of effects of trade impediments. *The Economic Journal*, 64(254), 264-289.
Skoko, H., & Krivokapic-Skoko, B. (2005). Theory and practice of parallel imports: an essay. In *International Conference of the Faculty of Management Koper* (pp. 463-472). Faculty of Management, Koper.
Sobel, R. S., & Garrett, T. A. (1997). Taxation and product quality: new evidence from generic cigarettes. *Journal of Political Economy*, *105*(4), 880-887.
Staten, M., & Umbeck, J. (1989). Shipping the good students out: The effect of a fixed charge on student enrollments. *The Journal of Economic Education*, 20(2), 165-171.
Takechi, K. (2023). Quality sorting, Alchian–Allen effect, and distance. *Economics Letters*, *222*, 110924.
U.S. Geological Survey. (2023). *Mineral commodity summaries 2023: Sand and gravel (construction)*. https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-sand-gravel.pdf
Werle, N., & Zedillo, E. (2018). We can't go cold turkey: Why suppressing drug markets endangers society. *The Journal of Law, Medicine & Ethics, 46*(2), 325–342. https://doi.org/10.1177/1073110518782784
World Bank. (2020). *World Development Report 2020: Trading for development in the age of global value chains*. World Bank. https://doi.org/10.1596/978-1-4648-1459-4

World Semiconductor Trade Statistics (WSTS). (2025). *Global semiconductor market shows continued growth in Q2 2025*. https://www.wsts.org/76/Recent-News-Release

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