ISSN: 2688-8645

Direct Sourcing or Agent Sourcing? A Triadic Nash-Bargaining Optimization Framework for Liberian Firms Importing from China

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Abstract

Many Liberian small and medium-sized enterprises (SMEs) source goods from China but face high transaction frictions, including supplier-search costs, quality and compliance risk, and limited bargaining leverage. This paper develops a triadic decision framework to evaluate whether Liberian importers should pursue Direct Sourcing (DS), where the buyer negotiates separately with the supplier and a service agent, or Agent Sourcing (AS), where a procurement agent coordinates upstream and downstream contracts. We integrate (i) a centralized benchmark under stochastic demand (Weibull), (ii) decentralized profit functions under DS and AS, and (iii) generalized Nash bargaining to obtain equilibrium wholesale and service prices as well as profit allocations. Using calibrated baseline parameters ($p = 20$, agent cost $C_a = 5$, supplier cost $C_s = 3$, compliance cost K=2; Weibull shape κ=2 and scale λ=100; bargaining powers α=0.4, β=0.3, γ=0.5), the centralized optimum yields total expected profit of 516 at q*=83.26. Under bargaining equilibrium, both DS and AS achieve the centralized total profit (channel coordination), but AS increases the buyer's profit from 107.90 to 129.67 (about 20.2%) and produces a more balanced surplus split between agent and supplier. Sensitivity analysis shows that the AS advantage is robust across wide ranges of costs, demand scale, and bargaining power, with buyer–agent bargaining power being the strongest driver of the buyer's relative gain. The results imply that AS is a rational and scalable strategy for Liberian SMEs when compliance complexity and information asymmetry are high; policy recommendations include strengthening accredited agent networks and reducing procedural trade costs.

Keywords

Agent Sourcing; Direct Sourcing; Nash Bargaining; Triadic Supply Chain; Developing-Economy Procurement; Weibull Demand; Liberia-China Trade; Transaction Costs; Coordination.

1. Introduction

China has become a major source of manufactured consumer and industrial goods for many African economies. For Liberian importers, procurement from China can offer meaningful unit-cost advantages and product variety, yet the realized performance of an import transaction depends on more than posted prices. International procurement exposes SMEs to supplier identification and verification problems, weak cross-border contract enforceability, quality uncertainty, multi-actor logistics coordination, foreign-exchange frictions, and compliance procedures at both origin and destination. These frictions are especially salient for SMEs that lack overseas representation and face limited bargaining leverage. [1-2]

In practice, many SMEs rely on procurement agents and trading intermediaries to reduce information and coordination costs. Intermediaries can lower supplier-search costs, improve match quality, and facilitate contracting in markets that are difficult to penetrate. However,

ISSN: 2688-8645

intermediation also introduces explicit fees and potential dependency risk. The managerial question is therefore not whether agents are useful in general, but under which conditions an agent-mediated sourcing architecture dominates a direct architecture in terms of buyer profit, risk mitigation, and scalability.

This paper develops a triadic decision framework to compare Direct Sourcing (DS) and Agent Sourcing (AS) for Liberian firms importing from China. In DS, the buyer negotiates separately with the supplier (for the product) and with an agent (for complementary services such as supplier search, quality inspection, documentation, and logistics coordination). In AS, a procurement agent coordinates upstream (agent–supplier) and downstream (agent–buyer) contracts and bundles product and service into a single interface for the buyer. The framework separates efficiency effects (total surplus) from distribution effects (how surplus is allocated among parties).

Three modeling choices distinguish the approach. First, procurement is modeled as a triadic bargaining problem rather than a dyadic buyer–supplier interaction. Second, stochastic demand is incorporated and a centralized benchmark defines the maximum attainable expected profit. Third, generalized Nash bargaining is used to endogenize negotiated prices and profit allocations under DS and AS. The resulting model yields closed-form expressions for the centralized optimal order quantity under Weibull demand and provides equilibrium prices and profits for DS and AS under calibrated parameters.

Results show that DS and AS both match the centralized total expected profit under the bargaining-over-(price, quantity) structure, but AS reallocates surplus toward the buyer, raising buyer profit by about 20.2% relative to DS and yielding a more balanced split between the agent and supplier. Sensitivity analysis indicates that this advantage is robust across wide ranges of costs, demand scale, and bargaining power.

1.1. Research Questions

This study addresses three research questions:

- RQ1: Which sourcing mode (DS or AS) yields higher buyer profit, and how does this advantage vary with bargaining power, cost parameters, and demand conditions?
- RQ2: Which parameters bargaining power, service and production costs, compliance costs, and demand characteristics most strongly influence the buyer's preference for DS or AS?
- RQ3: What policy interventions can enhance the efficiency and fairness of sourcing strategies for Liberian firms importing from China?

1.2. Contributions and Organization

The paper contributes a decision-ready, triadic bargaining framework that integrates stochastic demand and a centralized benchmark, derives equilibrium prices and profit allocations under DS and AS, and provides sensitivity-based managerial and policy insights. Section 2 reviews related literature. Section 3 presents the model and methodology. Section 4 reports results and robustness checks and discusses managerial and policy implications. Section 5 concludes and outlines future research directions. [3-5]

2. Literature Review

This section synthesizes relevant literature in four streams: (i) intermediaries in international trade, (ii) governance choice and transaction cost economics, (iii) total cost of ownership and sourcing, and (iv) bargaining and supply chain coordination. We then situate the Liberia–China import setting as an institutional context for applying these theories.

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2.1. Intermediaries in International Trade

A growing empirical literature documents that intermediary firms mediate a substantial share of exports and imports and are especially important when markets are difficult to penetrate. In Chinese export data, intermediaries account for a large fraction of trade and are more active in markets with higher trade costs (Ahn et al., 2011). Related research examines why intermediaries arise and how direct versus indirect trade responds to fixed and variable trade costs (Bernard, Grazzi, & Tomasi, 2011; Antra's & Costinot, 2011). On the theory side, intermediaries can be modeled as network builders that reduce information frictions in matching between buyers and sellers (Petropoulou, 2011). These insights imply that intermediaries are not merely "extra layers" but can be efficiency-enhancing institutions under information and contracting frictions. For SMEs, the DS–AS decision is therefore comparative: does the intermediary's margin exceed the value of reduced frictions, improved reliability, and better negotiated terms? [6-9]

2.2. Transaction Cost Economics and Governance Choice

Transaction cost economics (TCE) explains governance choices as responses to transaction hazards such as uncertainty, opportunism, and asset specificity (Coase, 1937; Williamson, 1979, 1985). When contracting and enforcement are costly, firms may adopt hybrid governance forms that provide coordination and safeguards without full vertical integration. Procurement agents can be interpreted as such a hybrid form: they provide monitoring, relationship-specific knowledge, and coordination mechanisms while allowing the buyer to remain independent.

2.3. Total Cost of Ownership in International Sourcing

Purchasing and sourcing decisions increasingly rely on total cost of ownership (TCO), which evaluates costs beyond the purchase price. Ellram (1995) emphasizes that relevant costs include acquisition, logistics, quality, and administrative costs, many of which are hidden when decisions focus only on quoted prices. In international procurement, TCO is particularly relevant because compliance, inspection, and coordination costs can be large relative to unit purchase costs. In the DS–AS context, AS introduces explicit agent fees but may reduce hidden costs such as search, quality failures, dispute resolution, and clearance delays.

2.4. Bargaining, Contracting, and Supply Chain Coordination

Nash (1950) provides a foundational axiomatic solution for splitting surplus in a bargaining problem based on disagreement payoffs and bargaining weights. In supply chains, negotiated wholesale prices and service fees influence both efficiency (coordination) and distribution (profit split). Contracting mechanisms such as revenue sharing can coordinate channels by aligning incentives and allocating surplus (Cachon & Larivière, 2005). Most sourcing studies analyze dyadic bargaining (e.g., buyer–supplier). However, in many cross-border transactions, a third actor such as a procurement agent participates in the coordination of search, contracting, and logistics. A triadic bargaining framework is therefore needed to capture both the efficiency and distributional impacts of DS and AS.

2.5. Bargaining Power in Developing-Economy Sourcing

SME importers often have weak outside options because they cannot easily switch suppliers, lack verified information, or cannot credibly commit to high-volume orders. Agents can strengthen bargaining position by pooling orders, exploiting established relationships, and reducing informational asymmetry consistent with evidence that intermediaries matter more when trade costs and information frictions are high (Ahn et al., 2011; Petropoulou, 2011).

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2.6. Institutional Context: Liberia–China Importing Frictions

Trade facilitation reforms are ongoing, but clearance processes can still involve multiple actors and delays. Liberia's TRS report (Freeport of Monrovia) highlights that TRS is recommended under the TFA to measure clearance time and identify bottlenecks, and it notes that the Freeport accounts for over 95% of trade flows in Liberia. Such context supports modeling "compliance/coordination cost" as a meaningful component of sourcing decisions.

2.7. Research Gap and Propositions

Despite significant research on intermediaries and bargaining in supply chains, there remains a practical gap in decision-ready models that integrate: (i) triadic bargaining structures, (ii) stochastic demand and ordering decisions, and (iii) explicit compliance and coordination costs relevant to developing-economy importers. Based on theory, we test two propositions:

- Proposition 1 (Transaction-cost channel): AS becomes more attractive as compliance and coordination frictions increase (higher K), holding other factors constant.
- Proposition 2 (Bargaining channel): AS becomes more attractive for the buyer when the buyer's bargaining power is weak and when the agent has meaningful upstream bargaining capability ($lower\ \alpha, higher\ \gamma$).

3. Model and Methodology

We model procurement as a triadic interaction among a buyer (B), a procurement agent (A), and a supplier (S). The buyer sells in the local market at price p and chooses an order quantity q under demand uncertainty. The agent provides complementary services at unit cost C_a, and the supplier produces at unit cost C_s . The import process incurs a per-unit compliance/coordination cost K. Two decentralized governance structures Direct Sourcing (DS) and Agent Sourcing (AS) are evaluated against a centralized benchmark. Contract terms are determined via generalized Nash bargaining over wholesale/service prices and quantity. [10-12]

3.1. Demand Model and Expected Sales

Let demand D follow a Weibull distribution with scale $\lambda > 0$ and shape $\kappa > 0$. The cumulative distribution function (CDF) and probability density function (PDF) are:

$$F(x) = 1 - \exp[(\frac{x}{\lambda})^k],\ f(x) = \frac{k}{\lambda}(\frac{x}{\lambda})^{k-1}\ \exp\left[-\left(\frac{x}{\lambda}\right)^k\right]. \quad (1)$$

Expected sales under order quantity q are

$$\mu(q) = \mathbb{E}[\min(D, q)] = \int_0^q [1 - F(x)]dx,\quad with\ \mu'(q) = 1 - F(q). \quad (2)$$

We assume an increasing generalized failure rate (IGFR) regularity condition to ensure well-behaved optimization (Larivière, 2006).

3.2. Centralized Benchmark

In the centralized benchmark, the triad is coordinated by a single decision-maker who selects q to maximize total expected supply-chain profit. Let total unit cost be:

$$c = C_a + C_s + K^L \quad (3)$$

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Centralized expected profit is:

$$\Pi^c(q) = p \cdot \mu(q) - c \cdot q \tag{4}$$

The first-order condition is:

$$\frac{d\Pi^c(q)}{dq} = p\big(1 - F(q)\big) - c = 0 \quad \Rightarrow \; 1 - F(q^*) = \frac{c}{p} \tag{5}$$

For Weibull demand, $1 - F(q) = \exp\left[-(\frac{q}{\lambda})^k\right.$, yielding a closed-form solution:

$$q^* = \lambda[-\ln\left(\frac{c}{p}\right)]^{\frac{1}{k}}, (0 < c < p) \tag{6}$$

This benchmark separates efficiency (maximum feasible total surplus) from distribution (how surplus is shared under DS vs AS).

3.3. Decentralized Structures and Profit Functions

3.3.1. Direct Sourcing (DS)

Under DS, the buyer negotiates separately with the agent for services at price W_a and with the supplier for product at wholesale price W_s. The buyer also incurs compliance cost K. Given order quantity q, expected profits are:

$$\text{Buyer Profit} = \quad \Pi_B^{DS} = p\mu(q) - (w_a + w_s + K^L)q \tag{7}$$

$$\text{Agent Profit} = \quad \Pi_A^{DS} = (w_a - c_a)q \tag{8}$$

$$\text{Supplier} \quad = \quad \Pi_S^{DS} = (w_s - c_s) \tag{9}$$

3.3.2. Agent Sourcing (AS)

Under AS, the agent acts as coordinator and offers a bundled price w̃_a to the buyer while negotiating an upstream wholesale price w_s with the supplier. In the baseline structure, K^L is internalized in the agent's bundled offering. Profits are:

$$\text{Buyer Profit} = \quad \Pi_B^{AS} = P\mu(q) - \tilde{w}_a q \tag{10}$$

$$\text{Agent Profit} = \quad \Pi_A^{AS} = (\tilde{w}_a - w_s - C_a - K^L)q \tag{11}$$

$$\text{Supplier Profit} = \quad \Pi_S^{AS} = (w_s - C_s)q \tag{12}$$

3.4. Generalized Nash Bargaining

To determine contract terms, we use generalized Nash bargaining (GNB). For a dyad (i, j) bargaining over decision vector x, the Nash product is:

$$\max_{(q)} \Omega ij = (\Pi_i)^{\theta}(\Pi_j)^{1-\theta}, \; \theta \in (0,1) \tag{13}$$

Disagreement payoffs are normalized to zero ($\Pi_i^0 = 0$). In DS, bargaining occurs in buyer–agent ($buyer\ power\ \alpha$) and buyer–supplier ($buyer\ power\ \beta$). In AS, bargaining occurs in

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buyer–agent ($buyer\ power\ \alpha$) and agent–supplier ($agent\ power\ \gamma$). Solving first-order conditions of $ln\ \Omega\_ij$ yields equilibrium prices and (under regularity) preserves the efficient quantity characterized by Eq. (6).

3.5. Coordination Property

Because expected revenue $p \cdot \mu(q)$ and total unit costs enter linearly in q, the bargaining problem over (price, quantity) yields the same marginal condition for q as the centralized benchmark under standard regularity. As a result, DS and AS can achieve the same total expected profit as the centralized benchmark while differing in how the surplus is split across buyer, agent, and supplier. This separation between efficiency (total profit) and distribution (profit allocation) is central to the DS–AS comparison.

3.6. Calibration and Baseline Parameters

Due to limited firm-level transaction data for Liberian importers, the analysis uses calibrated parameters to reflect plausible conditions and focuses on comparative performance rather than absolute profit prediction. Baseline values are shown in Table 1.

Table 1. Baseline parameter values (calibration).

Parameter	Description	Value
p	Unit selling price (USD)	20
C_a	Agent unit service cost (USD)	5
C_s	Supplier unit production cost (USD)	3
K^L	Compliance/coordination cost per unit (USD) In Liberia	2
κ	Weibull shape parameter	2
λ	Weibull scale parameter	100
α	Buyer power in buyer–agent bargaining	0.4
β	Buyer power in buyer–supplier bargaining (DS)	0.3
γ	Agent power in agent–supplier bargaining (AS)	0.5

3.7. Numerical Solution and Sensitivity Analysis

Equilibrium outcomes are computed in MATLAB by: (i) computing q* from Eq. (6) and evaluating μ(q*) numerically; (ii) solving bargaining first-order conditions to obtain equilibrium wholesale prices; (iii) evaluating profits under DS and AS at q*; and (iv) performing sensitivity analysis by varying key parameters across economically meaningful ranges. Table 2 summarizes the parameter ranges used in sensitivity tests. [13-18]

Table 2. Sensitivity analysis parameter ranges.

Parameter	Baseline	Range tested
α	0.4	[0.1, 0.9]
C_s	3	[2, 6]
C_a	5	[3, 8]
K	2	[1, 4]
λ (demand scale)	100	[0.7×, 1.3×]
κ (demand shape)	2	[1.5, 3]

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4. Results

4.1. Centralized Benchmark

With baseline parameters, total unit cost is $c = C_a + C_s + K = 10. Using\ Eq.(7)$:

$$q^* = 100[\ln(\frac{20}{10})]^{\frac{1}{2}} \approx 83.26 \quad (14)$$

Expected sales at q* are μ(q*) ≈ 67.43 (computed numerically for Weibull demand). Centralized expected profit is:

$$\Pi^{c*} = p.\mu(q^*) - c \cdot q^* \approx 20 \times 67.43 - 10 \times 83.26 \approx 516 \quad (15)$$

This value serves as the efficiency benchmark against which DS and AS outcomes are evaluated.

4.2. Direct Sourcing (DS) Equilibrium Outcomes

Under DS, bargaining yields equilibrium wholesale/service prices that allocate the joint surplus among buyer, agent, and supplier. Using $\alpha = 0.4$ and $\beta = 0.3$ and evaluating at q^*, the equilibrium prices are:

$$W_a^{DS} \approx 6.92, \quad W_s^{Ds} \approx 5.99 \quad (16)$$

Substituting into Eqs. (7)-(8)-(9) yields profits (USD):

$$\Pi_B^{DS} \approx 107.90,\ \Pi_A^{DS} \approx 159.90,\ \Pi_S^{DS} \approx 248.90 \quad (17)$$

Total DS profit matches the centralized benchmark within numerical tolerance:

$$\Pi_{DS}^{TOTAL} = \Pi_B^{DS} + \Pi_A^{DS} + \Pi_S^{DS} \approx 516 \quad (18)$$

4.3. Agent Sourcing (AS) Equilibrium Outcomes

Under AS, the agent coordinates contracts and offers a bundled price $\widetilde{w}_a$ to the buyer. With $\alpha = 0.4\ and\ \gamma = 0.5$, equilibrium prices are:

$$\widetilde{w}_a^{AS} \approx 14.64,\ w_s^{AS} \approx 5.32 \quad (19)$$

Profits (USD) follow from Eqs. (10)-(11)-(12):

$$\Pi_B^{AS} \approx 129.67, \Pi_A^{AS} \approx 193.20, \Pi_S^{AS}193.20 \quad (20)$$

Total AS profit matches the centralized benchmark:

$$\Pi_{AS}^{TOTAL} = \Pi_B^{AS} + \Pi_A^{AS} + \Pi_S^{AS} \approx 516. \quad (21)$$

4.4. Comparative Results and Buyer-Optimal Sourcing Choice

Table 3 summarizes baseline equilibrium outcomes. Buyer profit is higher under AS than under DS, while total profit remains identical, indicating that governance affects surplus allocation rather than total attainable surplus under the calibrated bargaining structure.

AS increases buyer profit by about 20.2% relative to DS

$$\left[\left(\frac{\Pi_B^{AS} - \Pi_B^{DS}}{\Pi_B^{DS}}\right) \times 100\right] = 20.2\% \Rightarrow \frac{129.67 - 107.90}{107.9} \times 100 \approx 20.2\% \quad (22)$$

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Table 3. Baseline equilibrium outcomes (USD).

Metric	Direct Sourcing (DS)	Agent Sourcing (AS)
Buyer profit	107.90	129.67
Agent profit	159.90	193.20
Supplier profit	248.90	193.20
Total profit	516.00	516.00
Buyer-preferred mode	—	AS

4.5. Sensitivity Analysis

Sensitivity analysis evaluates robustness of the AS advantage when bargaining power, costs, and demand parameters vary. The key patterns are summarized below; detailed scenario tables and figures may be included in the Appendix depending on journal requirements.

4.5.1. Buyer-agent Bargaining Power (α)

Buyer profit increases with α in both DS and AS. Across the tested range, AS remains above DS, and the AS-DS profit gap widens at higher α, identifying α as the dominant driver of buyer advantage.

4.5.2. Supplier Cost (C_s)

Higher supplier production costs reduce buyer profit in both modes. The decline is typically sharper in DS, indicating greater exposure to supplier-side cost shocks under direct negotiation.

4.5.3. Agent Cost (C_a)

Rising agent costs reduce buyer profit in AS. The AS advantage shrinks with C_a and can disappear at sufficiently high agent costs, highlighting the importance of monitoring fees and service quality.

4.5.4. Compliance/Coordination Cost K^L

In DS, the buyer bears compliance/coordination costs directly, so higher K^L reduces buyer profit sharply. In AS, these burdens are internalized in the agent's bundled offering in the baseline structure, producing comparatively stable buyer outcomes. This supports Proposition 1.

4.5.5. Demand Scale (λ) and Demand Variability (k)

As demand scale increases, buyer profit rises under both modes, often with stronger gains under AS due to improved coordination. Changes in κ have smaller effects on the DS-AS ranking than bargaining and cost parameters. Overall, AS remains robustly preferred across broad demand conditions.

Table 4 provides a concise robustness summary.

Table 4. Robustness summary: effect of key parameters on AS advantage (buyer perspective).

Parameter change	Effect on buyer profit	Effect on AS advantage
Higher α	Increases in both modes	Increases (gap widens)
Higher C_s	Decreases in both modes	Typically increases (DS more sensitive)
Higher C_a	AS decreases more	Decreases; may reverse at high C_a
Higher K^L	DS decreases strongly	Increases (AS more attractive)
Higher λ	Increases in both modes	Often increases (scalability)
Higher κ (less variability)	Slight increase	Largely stable

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5. Discussion and Implications

5.1. Interpreting the Coordination Result

A key result is that both DS and AS can match the centralized total expected profit under bargaining over (price, quantity). This implies that decentralized negotiation can achieve total-surplus coordination when the negotiated quantity satisfies the same critical fractile condition as the centralized benchmark. However, DS and AS differ in how the coordinated surplus is allocated among buyer, agent, and supplier; the governance decision therefore has strong distributional and risk-management content for the buyer.

5.2. Why AS Increases Buyer Profit in the Baseline

In DS, the buyer manages two bilateral negotiations and bears compliance/coordination burdens directly. In AS, the buyer negotiates a single bundled interface, reducing negotiation friction and enabling the agent to intermediate upstream bargaining. In the baseline calibration, this structure reallocates surplus toward the buyer and yields a more balanced upstream split between agent and supplier.

5.3. Transaction Cost Economics and Total Cost of Ownership

From a TCE perspective, AS is a hybrid governance structure that reduces transaction hazards by outsourcing search, monitoring, and coordination functions to specialized agents. From a TCO perspective, AS can reduce hidden costs failed inspections, delays, disputes, and administrative burden even when it increases explicit fees. Sensitivity results indicate that the AS advantage strengthens when compliance/coordination costs are high (higher K) and when buyers have limited bargaining power. [19-20]

5.4. Managerial Implications for Liberian Importers

Five actionable implications follow:

- Use AS for high-friction categories (high quality risk, documentation complexity, or coordination intensity).
- Negotiate service-level guarantees and link compensation to measurable performance where feasible.
- Monitor the agent-cost threshold; when fees become excessive, DS can become competitive.
- Invest in bargaining leverage (demand aggregation, market intelligence, procurement capability).
- Adopt hybrid sourcing: DS for standardized items; AS for complex or risky imports.

5.5. Policy Implications

The framework implies several policy priorities:

- Strengthen accredited agent networks via service standards, disclosure rules, and dispute-resolution mechanisms.
- Reduce procedural trade costs through streamlined documentation and predictable inspections.
- Build SME compliance capability via training and advisory support to improve outside options.
- Improve transparency through regular clearance-time measurement and public reporting.
- Support digital trade infrastructure (e-documentation and interoperable logistics/payment platforms).

ISSN: 2688-8645

5.6. Limitations

Limitations include calibrated (not estimated) parameters, normalized disagreement payoffs, and the use of K^L as a reduced-form representation of compliance/coordination frictions. The model is also single-period (newsvendor-like). Multi-period relationships, explicit quality and delay risk, and richer outside options are promising extensions.

6. Conclusion

This paper developed a triadic Nash-bargaining optimization framework to evaluate whether Liberian SMEs importing from China should rely on Direct Sourcing (DS) or Agent Sourcing (AS). The model integrates Weibull demand uncertainty, a centralized benchmark, and decentralized bargaining under DS and AS. Under baseline calibration, the centralized optimum yields q*=83.26 and total expected profit of 516. Both DS and AS match this total profit under bargaining over (price, quantity), but AS reallocates surplus toward the buyer, increasing buyer profit by about 20.2% and yielding a more balanced agent–supplier split. Sensitivity analysis shows that the AS advantage is robust across wide ranges of costs, demand scale, and bargaining power, driven primarily by buyer-agent bargaining power and agent cost. The results support AS as a rational and scalable strategy for Liberian SMEs when compliance complexity and information asymmetry are high and motivate policy efforts to strengthen accredited agent markets and reduce procedural trade costs.

6.1. Future Research

Future work can estimate parameters with transaction-level data, explicitly model quality and delay risk, incorporate outside options and nonzero disagreement payoffs, add exchange-rate and financing frictions, and extend the framework to a multi-period setting with learning and relationship investment.

Acknowledgments

I am grateful to God, my heartfelt appreciation goes to my supervisor, Prof. HUANG Dong-bin, for his invaluable guidance, support, and encouragement throughout the course of my research. His expertise and mentorship have been instrumental in shaping my academic and professional growth during my Master's study. I am also deeply thankful to my family, friends, and all those who have supported me in various ways throughout this journey. Their encouragement and unwavering belief in me have been a source of strength and inspiration, enabling me to successfully complete this paper.

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