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ANALYZING THE IMPACT OF SUPPLY CHAIN EFFICIENCY ON THE COMPETITIVE ADVANTAGE OF COFFEE PRODUCERS IN NORTHERN THAILAND: A QUANTITATIVE APPROACH

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Abstract

This study aimed to examine the impact of supply chain efficiency on the competitive advantage of coffee producers in Northern Thailand, with green innovation tested as a mediating variable. Specifically, it investigated four relationships: the direct effect of supply chain efficiency on competitive advantage, the effect of supply chain efficiency on green innovation, the effect of green innovation on competitive advantage, and the mediating role of green innovation between supply chain efficiency and competitive advantage. A quantitative, cross-sectional survey design was adopted. The target population comprised coffee producers in the northern provinces of Chiang Mai, Chiang Rai, and Mae Hong Son. The minimum sample size was determined using Taro Yamane's formula (1973) at a 95% confidence level, and a structured five-point Likert questionnaire was distributed through the Questionnaire Star online platform (www.wjx.cn). Of 300 questionnaires distributed, 198 valid responses were obtained, yielding a valid response rate of 66.0%. Data were analyzed using SPSS through descriptive statistics, one-way ANOVA, Pearson correlation, multiple regression, and mediation analysis. The results indicated that supply chain efficiency had a significant positive effect on competitive advantage ($r = 0.782$, $p < 0.01$); supply chain efficiency significantly influenced green innovation ($\beta = 0.731$, $p < 0.001$); green innovation significantly enhanced competitive advantage ($\beta = 0.798$, $p < 0.001$); and green innovation partially mediated the relationship between supply chain efficiency and competitive advantage. Finally, it is recommended that coffee producers strengthen supply chain efficiency and invest in green innovation, and that policymakers support sustainable practices to sustain competitive advantage.

Keywords: Supply Chain Efficiency, Green Innovation, Competitive Advantage, Coffee Producers, Northern Thailand

Introduction

The global coffee industry is one of the most dynamic and competitive sectors in international trade, involving millions of farmers, producers, suppliers, and consumers worldwide. Among the diverse coffee-producing regions, Northern Thailand has emerged as an important origin for high-quality Arabica coffee, supported by favorable highland geography, a cooler climate, and a growing local coffee culture (Lilavanichakul, 2020). Despite these advantages, coffee producers in the region face persistent challenges, particularly supply chain inefficiencies, fluctuating market prices, and rising demand for sustainability. As competition intensifies, the role of supply chain efficiency in enhancing the competitive advantage of coffee producers has become increasingly critical.

Supply chain efficiency refers to a firm's ability to optimize procurement, logistics, production, and distribution processes so as to reduce waste and cost while enhancing value creation (Li, Ragu-Nathan, Ragu-Nathan, & Subba Rao, 2006). A well-managed supply chain can lower lead times and operational costs and improve customer satisfaction, thereby providing producers with a competitive advantage in the marketplace (Li, Rao, Ragu-Nathan, & Ragu-Nathan, 2005). However, many coffee producers in Northern Thailand, particularly small and medium-sized enterprises, face barriers such as inadequate infrastructure, limited access to advanced technologies, and difficulties in coordinating supply chain activities effectively (Rattanawiboonsom, 2020).

In recent years, green innovation has gained prominence as an important factor shaping supply chain and firm performance (Zhu & Sarkis, 2004; Gelmez, Özceylan, & Mrugalska, 2024). Green innovation refers to the development and application of environmentally friendly products, processes, and technologies that reduce the ecological footprint of business activities (Chen, 2008; Dangelico, Pujari, & Pontrandolfo, 2017). In the coffee sector, green innovation may take the form of sustainable farming practices, energy-efficient processing, and eco-friendly packaging. As consumer preferences increasingly shift toward sustainability (Liu, Chen, & Chen, 2019; Merbah & Benito-Hernández, 2024), coffee producers are under pressure to integrate green innovation into their supply chains, not only to meet regulatory requirements but also as a strategic means to enhance market positioning, brand reputation, and customer loyalty (Wang, 2019).

Although prior studies have separately examined supply chain efficiency and competitive advantage, and green innovation and competitive advantage, limited empirical research has integrated all three constructs in a single framework, especially in the context of the coffee industry in Northern Thailand. Therefore, this study aimed to examine the relationships among supply chain efficiency, green innovation, and competitive advantage, treating green innovation as a mediating variable. The findings are expected to contribute to the literature on green supply chain management and to offer practical guidance for producers and policymakers in Northern Thailand's coffee sector.

Research Objective (s)

Based on the above background, the specific objectives of this study were:

(1) To examine the effect of supply chain efficiency on the competitive advantage of coffee producers in Northern Thailand.

(2) To examine the effect of supply chain efficiency on the green innovation of coffee producers in Northern Thailand.

(3) To examine the effect of green innovation on the competitive advantage of coffee producers in Northern Thailand.

(4) To examine the mediating role of green innovation in the relationship between supply chain efficiency and competitive advantage.

Literature Review

1. Supply Chain Efficiency

Supply chain efficiency reflects the degree to which a firm coordinates procurement, inventory, logistics, and distribution to deliver value at the lowest possible cost (Li et al., 2006). Li et al. (2005)

developed and validated a widely used instrument that conceptualizes supply chain management practices through dimensions such as supplier partnership, customer relationship, information sharing, and lean processes. Efficient supply chains shorten lead times, lower operational costs, and enhance responsiveness, all of which strengthen a firm's market position (Rattanawiboonsom, 2020). For coffee producers, efficiency in sourcing cherries, processing, and distribution is central to profitability in a price-sensitive global market.

2. Competitive Advantage

Competitive advantage denotes a firm's capacity to create more economic value than its rivals through cost leadership, differentiation, or focus (Porter, 1985). From the resource-based view, sustained competitive advantage arises from valuable, rare, inimitable, and non-substitutable resources and capabilities (Barney, 1991). In agricultural and coffee contexts, competitive advantage is commonly expressed through superior product quality, brand reputation, cost efficiency, and the ability to satisfy evolving consumer demands.

3. Green Innovation

Green innovation encompasses product, process, and managerial innovations that conserve resources, reduce pollution, and improve environmental performance (Chen, 2008). Dangelico et al. (2017) characterize green product innovation as a sustainability-oriented dynamic capability that enables firms to respond to environmental pressures while creating market value. Within supply chains, green practices examined by Zhu and Sarkis (2004) and Schmidt, Foerstl, and Schaltenbrand (2017) have been linked to improved environmental and operational outcomes.

4. Supply Chain Efficiency and Competitive Advantage (H1)

A substantial body of research links efficient supply chain practices to competitive advantage. Li et al. (2006) found that higher levels of supply chain management practice significantly improved both competitive advantage and organizational performance. Efficient supply chains reduce cost and enhance agility, enabling firms to respond quickly to market change (Rattanawiboonsom, 2020). Accordingly, the following hypothesis is proposed:

H1: Supply chain efficiency has a positive effect on competitive advantage.

5. Supply Chain Efficiency and Green Innovation (H2)

Efficient supply chains provide the resources, information flows, and coordination capacity required to develop and implement green innovations (Zhu & Sarkis, 2004; Gelmez et al., 2024). Yupat and Rojniruttikul (2024) showed, in the Thai manufacturing context, that green supply chain management practices and external pressure jointly promote sustainable and innovative outcomes. Thus:

H2: Supply chain efficiency has a positive effect on green innovation.

6. Green Innovation and Competitive Advantage (H3)

Green innovation has been widely identified as a driver of competitive advantage. Chang (2011) and Wang (2019) demonstrated that green innovation enhances differentiation and competitiveness, while Porter and van der Linde (1995) argued that well-designed environmental practices can yield net competitive benefits. Fatoki (2021) similarly reported a positive green-innovation effect on green competitive advantage. Therefore:

H3: Green innovation has a positive effect on competitive advantage.

7. The Mediating Role of Green Innovation (H4)

Beyond its direct effects, green innovation is increasingly viewed as a mechanism that transmits the benefits of supply chain capabilities into competitive advantage. Chang (2011) found green innovation to mediate the relationship between corporate environmental ethics and competitive advantage, and Fatoki (2021), Rosdiana, Khomsiyah, and Yanti (2024), and Soesetyo, Siagian, and Tarigan (2025) reported comparable mediating effects of green innovation or green practices on competitive and firm performance outcomes. Building on this evidence, this study proposes:

H4: Green innovation mediates the relationship between supply chain efficiency and competitive advantage.

8. Conceptual Framework

Drawing on the resource-based view (Barney, 1991) and the green-innovation literature, the conceptual framework positions supply chain efficiency as the independent variable, competitive advantage as the dependent variable, and green innovation as the mediating variable. Supply chain efficiency is hypothesized to influence competitive advantage both directly (H1) and indirectly through green innovation (H2, H3, and H4).

Methodology

1. Research Design

This study adopted a quantitative, cross-sectional survey design with an explanatory (correlational) approach to test the hypothesized relationships among supply chain efficiency, green innovation, and competitive advantage. Participation was voluntary and anonymous, and respondents were informed of the academic purpose of the study.

2. Population and Sample

The target population comprised coffee producers operating in the northern Thai provinces of Chiang Mai, Chiang Rai, and Mae Hong Son, regions known for their contribution to Thailand's high-quality Arabica coffee, with an estimated population of 376 producers. A probability (simple random) sampling approach was used. The minimum sample size was determined using Taro Yamane's (1973) formula at a 95% confidence level and a 0.05 sampling error: $n = N / (1 + Ne^2) = 376 / (1 + 376 \times 0.05^2) \approx 194$. The calculation yielded a minimum required sample of 194 respondents. A total of 300 questionnaires were distributed through the Questionnaire Star online platform (www.wjx.cn). After 39 days of data collection and the exclusion of invalid responses, 198 valid questionnaires were retained for analysis, corresponding to a valid response rate of 66.0% and exceeding the minimum required sample.

3. Research Instrument

Data were collected using a structured questionnaire comprising four parts: (1) the demographic and firm profile of respondents (province, firm size, annual turnover, and years of operation); (2) a supply chain efficiency scale adapted from Li et al. (2005, 2006); (3) a green innovation scale adapted from Chen (2008) and Chang (2011); and (4) a competitive advantage scale adapted from Li et al.

(2006). All construct items were measured on a five-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree").

4. Data Analysis

Collected data were processed using SPSS. Descriptive statistics summarized the respondent profile; one-way ANOVA examined differences in the three constructs across firm characteristics; Pearson correlation assessed the bivariate relationships among the constructs; multiple regression estimated the direct effects; and mediation analysis (Baron & Kenny, 1986; Preacher & Hayes, 2008) tested the indirect effect of supply chain efficiency on competitive advantage through green innovation. The significance level was set at $p < 0.05$ (Hair, Black, Babin, & Anderson, 2019).

Results

1. Differences by Firm Characteristics (One-way ANOVA)

One-way ANOVA was conducted to examine whether supply chain efficiency, green innovation, and competitive advantage differed by firm size, annual turnover, and years of operation. As shown in Table 3, all three firm characteristics had significant effects on the three constructs ($p < 0.001$), indicating that larger, higher-turnover, and longer-established producers reported significantly higher levels of supply chain efficiency, green innovation, and competitive advantage.

Table 3: One-way ANOVA of Constructs by Firm Characteristics

Firm characteristic	Supply Chain Efficiency (Sig.)	Green Innovation (Sig.)	Competitive Advantage (Sig.)
Firm size	$p < 0.001$	$p < 0.001$	$p < 0.001$
Annual turnover	$p < 0.001$	$p < 0.001$	$p < 0.001$
Years of operation	$p < 0.001$	$p < 0.001$	$p < 0.001$

Source: SPSS data analysis.

2. Correlation Analysis

Pearson correlation analysis (Table 4) revealed significant positive relationships among all three constructs. Supply chain efficiency was strongly correlated with competitive advantage ($r = 0.782$, $p < 0.01$) and with green innovation ($r = 0.731$, $p < 0.01$), and green innovation was significantly correlated with competitive advantage ($r = 0.675$, $p < 0.01$). These results indicate that producers with higher supply chain efficiency also tend to exhibit higher green innovation and competitive advantage.

Table 4: Pearson Correlation Matrix

Construct	SCE	GI	CA
Supply Chain Efficiency (SCE)	1		
Green Innovation (GI)	0.731**	1	
Competitive Advantage (CA)	0.782**	0.675**	1

*Note: **p < 0.01. Source: SPSS data analysis.*

3. Regression Analysis

Multiple regression was used to test the direct effects (Table 5). Supply chain efficiency significantly predicted competitive advantage ($R^2 = 0.489$; $F = 372.887$, $p < 0.001$; $\beta = 0.700$, $t = 19.310$), supporting H1. Supply chain efficiency significantly predicted green innovation ($R^2 = 0.807$;

F = 1621.257, p < 0.001; β = 0.731, t = 40.265), supporting H2. Green innovation significantly predicted competitive advantage (R^2 = 0.541; F = 211.245, p < 0.001; β = 0.798, t = 43.265), supporting H3.

Table 5: Regression Results for Direct Effects

Path	R^2	F	β	t	Sig.
SCE → CA (H1)	0.489	372.887	0.700	19.310	< 0.001
SCE → GI (H2)	0.807	1621.257	0.731	40.265	< 0.001
GI → CA (H3)	0.541	211.245	0.798	43.265	< 0.001

Source: SPSS data analysis.

4. Mediation Analysis

The mediation test (Table 6) showed that supply chain efficiency significantly affected green innovation (b = 0.771, β = 0.692, p < 0.001) and that the direct effect of supply chain efficiency on competitive advantage remained significant when green innovation was included (b = 0.0910, β = 0.1104, p < 0.001). The indirect effect through green innovation was positive, with a 95% bootstrap confidence interval whose lower bound (0.0190) excluded zero, indicating a significant indirect effect. The overall model explained a substantial share of variance (R^2 = 0.8129; F = 875.404, p < 0.001). Because both the direct and indirect effects were significant, green innovation partially mediated the relationship between supply chain efficiency and competitive advantage, supporting H4.

Table 6: Mediation Analysis (DV: Competitive Advantage)

Effect	Coefficient (b)	Std. β	Sig. / 95% CI
SCE → GI	0.771	0.692	p < 0.001
Direct: SCE → CA	0.0910	0.1104	p < 0.001
Indirect: SCE → GI → CA	0.1377	0.1669	95% CI lower = 0.0190
Model fit	R^2 = 0.8129	—	F = 875.404, p < 0.001

Source: SPSS data analysis.

Discussion

1. Effect of Supply Chain Efficiency on Competitive Advantage

The finding that supply chain efficiency significantly enhances competitive advantage supports H1 and is consistent with Li et al. (2006), who reported that supply chain management practices improve both competitive advantage and organizational performance. For coffee producers in Northern Thailand, efficient procurement, logistics, and inventory management may lower production costs and improve product quality, allowing producers to offer superior value relative to competitors (Rattanawiboonsom, 2020). This result also aligns with Porter's (1985) view that cost leadership and differentiation are central routes to competitive advantage.

2. Effect of Supply Chain Efficiency on Green Innovation

The significant effect of supply chain efficiency on green innovation supports H2 and is consistent with Zhu and Sarkis (2004) and Gelmez et al. (2024), who argued that efficient supply chains provide the resources and coordination capacity needed to adopt green practices. In the coffee context, optimized processes such as waste reduction and improved energy efficiency may enable the adoption

of sustainable farming and processing technologies. The result is also in line with Yupat and Rojniruttikul (2024) in the Thai manufacturing setting.

3. Effect of Green Innovation on Competitive Advantage

Green innovation significantly enhanced competitive advantage, supporting H3. This aligns with Chang (2011), Wang (2019), and Fatoki (2021), who found that green innovation differentiates products and strengthens competitiveness, and with Porter and van der Linde (1995), who emphasized that environmental improvement and competitiveness need not conflict. Coffee producers adopting green practices may attract environmentally conscious consumers (Liu et al., 2019; Merbah & Benito-Hernández, 2024) and enhance brand reputation.

4. The Mediating Role of Green Innovation

Green innovation partially mediated the relationship between supply chain efficiency and competitive advantage, supporting H4. This finding is consistent with Chang (2011), Fatoki (2021), Rosdiana et al. (2024), and Soesetyo et al. (2025), who reported mediating roles of green innovation or green practices. The partial mediation indicates that supply chain efficiency enhances competitive advantage both directly and by enabling green innovation, underscoring the strategic value of integrating sustainability into supply chain management.

5. Practical Implications

The findings offer several implications for coffee producers in Northern Thailand. First, producers should improve supply chain efficiency through better logistics, procurement, and inventory management, as this directly strengthens competitiveness. Second, producers should invest in green innovation—such as sustainable farming, energy-efficient processing, and eco-friendly packaging—because it both improves efficiency and builds a sustainable competitive advantage. Third, policymakers and cooperatives can support producers by facilitating access to green technologies and sustainability-oriented finance.

Conclusion

This study examined the impact of supply chain efficiency on the competitive advantage of coffee producers in Northern Thailand, with green innovation as a mediating variable, using survey data from 198 producers analyzed in SPSS. The following conclusions are drawn:

(1) Supply chain efficiency has a significant positive effect on competitive advantage (H1 supported).

(2) Supply chain efficiency has a significant positive effect on green innovation (H2 supported).

(3) Green innovation has a significant positive effect on competitive advantage (H3 supported).

(4) Green innovation partially mediates the relationship between supply chain efficiency and competitive advantage (H4 supported).

Overall, the results reinforce the importance of supply chain efficiency and green innovation in enhancing the competitive advantage of coffee producers in Northern Thailand. By optimizing their supply chains and adopting sustainable practices, producers can improve operational performance, differentiate their products, and strengthen their market position. The study is limited by its cross-sectional design, single-region sample, and reliance on self-reported data; future research could employ longitudinal designs and extend the model to other agricultural sectors and regions to validate the generalizability of these findings.

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