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Formation of a partnership network of service providers for the transportation of bees

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Abstract

This article examines the key aspects of forming a partnership network of service providers for the transportation of honey bees, taking into account the specifics of a live cargo and the narrow pollination time windows. The study aims to identify the structural elements and mechanisms of interaction among participants in the logistics chain and to substantiate the proposed partnership models as a means of minimizing biological and operational risks in the migratory practice of hive transportation. The relevance of the work is determined by the high dependence of global agriculture on bee pollinators and the significant economic losses resulting from transport failures. Using the example of February almond shipments in California and the incident involving a hive loss outbreak in Washington State, the critical vulnerabilities of current logistics schemes are demonstrated, along with the need to establish resilient delivery channels with redundant routes and unified standards. The novelty of the study lies in its interdisciplinary approach, which combines content and comparative analysis of the IATA Live Animals Regulations and CEIV standards with economic models such as LTA, revenue-sharing, and white-labeling, as well as case studies of BeeHero and GBA TFreight Inc. A multi-level network architecture is proposed, in which each role—from certified carriers to digital aggregators—has clearly defined KPIs and standardized data-exchange protocols, enabling the creation of a digital twin of each hive consignment and rapid response to deviations in biological parameters. The main conclusions indicate that integrating telemetry with predictive analytics and insurance assessment, along with the application of financial instruments, creates a resilient ecosystem capable of ensuring stable pollination amid unprecedented climatic and market volatility. This article will be beneficial to logistics and agribusiness managers, contract pollination specialists, and researchers in the fields of green and digital logistics.

Keywords: Partnership Network; Bee Transportation; Pollination; Live-Cargo Logistics; IATA CEIV Live Animals; IoT Telemetry; Revenue-Sharing; LTA; Digital Traceability

1. Introduction

Over the past decade, the accelerated integration of intensive agriculture with contract-pollination services has rendered honey bees part of global logistics: hives are moved in sync with crop flowering zones to close the narrow pollination window, which in some regions lasts only one to two weeks. While this migratory model increases yields, it simultaneously places apiculture in the sensitive category of live cargo, where any disruption in the transport chain immediately translates into direct losses for farmers and carriers. Currently, approximately 75% of the world's commercial crops depend to varying degrees on pollinators. In the absence of bees, global yields may decline by up to 8%, equivalent to roughly USD 577 billion annually [1]. Thus, the biological service of pollination is already comparable in importance to classic production inputs such as fertilizers or seed material.

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The scale of bee transportation underscores this economic role: for the 2024 February almond bloom in California alone, 2.7 million bee colonies were required, nearly matching all commercial hives in the United States [2]; revenue from this single operation amounted to USD 325.8 million [3]. However, bee biology makes such operations vulnerable: commercial apiaries report up to 62% colony losses per season [4]. In addition to high mortality, operational risks persist: a recent accident in Washington State released some 250 million bees and blocked the highway for 24 hours, highlighting the costs incurred when redundant delivery channels are lacking [5].

Therefore, for live cargo, a resilient partnership network is critical—a consortium of beekeepers, freight forwarders, airlines, insurers, and veterinary services operating under unified protocols. First, the network distributes biological and logistical risk: if some colonies fail, reserve apiaries fulfill the grower's needs; if a route is obstructed, an alternative carrier is deployed without losing the pollination window. Second, end-to-end certification—from vehicle ventilation modules to compliance with the IATA Live Animals Regulations for air transport—requires synchronous procedural updates. A common partner platform eliminates standard incompatibilities and reduces document-processing times. Finally, amid growing demand for sustainable agriculture, the network facilitates the collection and exchange of bee health data with agronomists, thereby enhancing the efficiency of subsequent shipments and reducing the overall ecological footprint.

2. Materials and Methodology

This study is based on the analysis of 15 key sources, including FAO international reports on the role of pollinators in global agriculture [1]; industry publications on migratory hive logistics in California [2, 3]; data on colony-loss rates among U.S. commercial beekeepers [4, 7]; and descriptions of recent live-cargo transport incidents [5]. The theoretical foundation comprises works on IATA certification and regulations for live-animal transport: the Live Animals Regulations and CEIV Live Animals standards [6, 12], reports on the practice of long-term agreements (LTAs) in UN procurement [10], and research on freight-matching optimization from BloombergNEF [9]. To analyze technological solutions, data on cold-chain integrity and IoT telemetry were drawn from reports by Global Market Insights and Zion Market Research [8, 15], and economic models of revenue-sharing and white-label formats were reviewed in a Dataintelo contract-pollination market overview [11] and an article on coordinating green logistics chains [14]. Special attention was given to the BeeHero case, with its extensive sensor network, and GBA TFreight Inc., which utilizes a proprietary monitoring and routing methodology [13].

Methodologically, the study combines four main approaches. First, a systematic review and content analysis of legal and industry documents—from IATA LAR and CEIV regulations to the two-hour corridor requirement in airport quarantine zones [6, 7, 12]. Second, a comparative analysis of partnership models is conducted, contrasting specialized CEIV-certified carriers with ramp handlers, mobile veterinary teams, IoT providers, and insurers based on criteria of biological risk reduction, regulatory traceability, and operational efficiency [9, 10, 15]. Third, case studies of BeeHero and GBA TFreight Inc.—analyzing monitoring procedures, routing schemes, tariff structures, and financial metrics to identify best practices for network construction [13]. Finally, a correlational analysis of secondary statistical data examines the relationship between the frequency of temperature excursions and colony losses per shipment (cold-chain telemetry metrics [8]) as well as the dynamics of bee mortality and checkpoint holding times [7].

3. Results and Discussion

The current risks outlined in the Introduction impose strict requirements on the topology of the partnership network: it must bring together nodes capable simultaneously of reducing biological colony mortality, ensuring regulatory traceability of the cargo, and avoiding capacity downtime. Practice shows that at the core are specialized carriers validated under the IATA Live Animals Regulations (LAR). By 2025, only 30 companies had achieved CEIV Live Animals status, of which eight are airlines and four are ramp handlers, underscoring the shortage of competent providers and rendering their selection strategic [6].

At the next level are veterinary inspection points and mobile teams, which complete sanitary examinations of apiaries and issue international certificates. For bees, it is critical to comply with the two-hour corridor between off-loading and release in airport quarantine zones; exceeding this window correlates with increased transport mortality, which reached 62% of colonies among U.S. commercial beekeepers during the last winter season [7]. The chart below illustrates that seasonal colony losses gradually rose to a peak in 2020–21, then fell sharply in 2021–22 and have since remained at a relatively lower but fluctuating level.

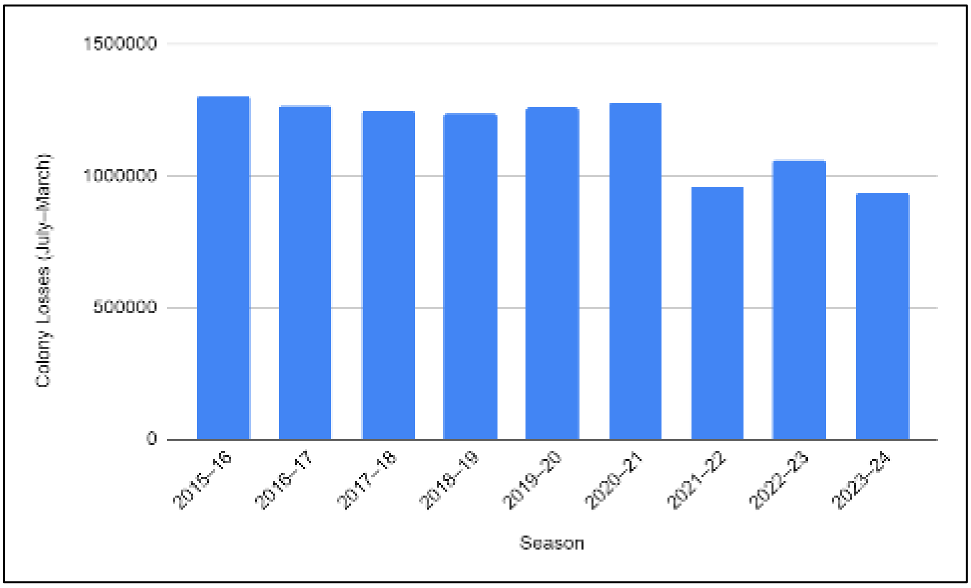

Figure 1 Analysis of Seasonal Honey Bee Colony Losses [7]

The digital perimeter of the network is maintained by IoT-telemetry providers. The total value of cold-chain logistics in 2024 was estimated at USD 341 billion, owing to the widespread deployment of temperature, CO_2, and vibration sensors that transmit telemetry to cloud platforms for predictive analytics [8], as shown in Fig. 2.

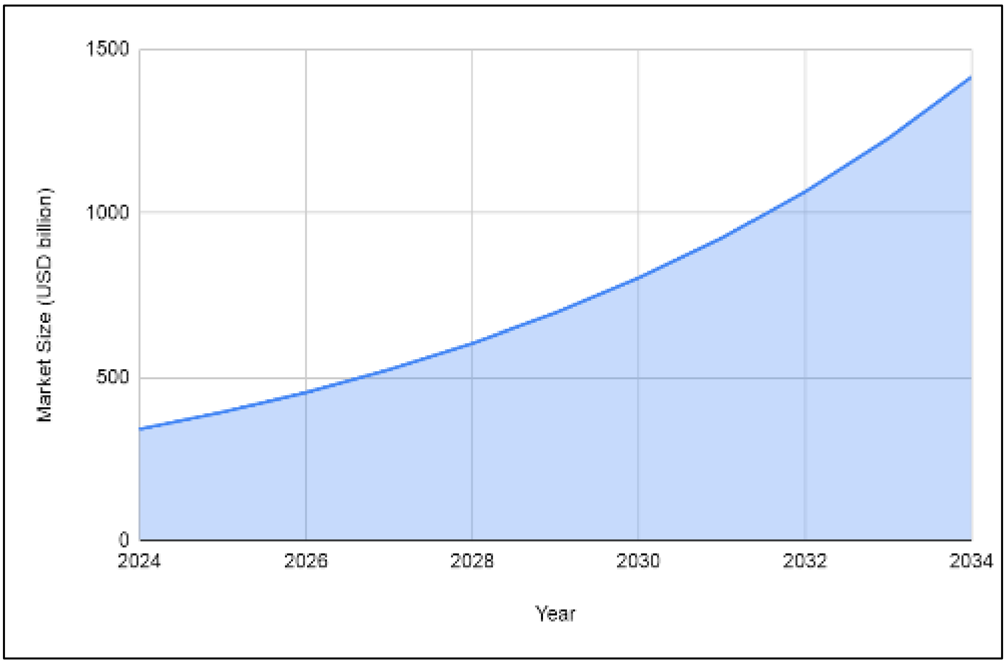

Figure 2 Cold Chain Logistics Market Size [8]

For these companies, the key metrics are the duration of uninterrupted data transmission and the number of temperature excursions per flight hour; a reduction in the latter metric directly translates into lower losses of queens and brood.

Insurance providers servicing live cargo assess risk based on telemetry and the carrier's history; accordingly, the application approval rate has become a key performance indicator (KPI) that incentivizes network participants to comply with IATA and veterinary standards. Simultaneously, digital load aggregators close the loop by converting disparate farmer requests into optimized routes. BloombergNEF analytics show that effective freight-matching software can eliminate 20–40% of empty miles in a truck fleet, thereby freeing up tonne-kilometers without investing in additional vehicles [9].

For long-term capacity reservation, LTA frameworks are employed, which fix prices and minimum hive quotas for several years, thereby reducing transaction costs and protecting parties from price volatility. This is evidenced by UN agencies that systematically use LTAs to lower administrative expenses by tens of percent [10]. When it is necessary to distribute the premium tariff benefits for live cargo, revenue-sharing schemes are introduced. Finally, operational SLAs codify quantitative KPIs and penalties, ensuring a seasonal audit of practice versus declared standards.

Thus, a multi-layered architecture is formed in which each role is endowed with transparent metrics and embedded in a contractual model. Digital traceability links biological parameters of colonies with the logistics schedule. It is this connectedness that transforms a set of independent services into an integrated ecosystem capable of guaranteeing agribusiness stable pollination even amid record climatic and market fluctuations.

The key to a resilient network is proper market segmentation: at the top level, anchor partners are identified who ensure uninterrupted pollination in response to rapidly growing demand. The commercial pollination services market alone is valued at USD 9.5 billion, with a projected growth to USD 14.7 billion by 2032 [11]. This renders bee transportation a high-margin yet high-risk niche, where a single failed delivery cannot be compensated later because the flowering window closes irrevocably. Therefore, the first category comprises carriers certified under the IATA CEIV Live Animals program. The second layer consists of specialized airport veterinary inspections; the third, IoT-telemetry providers; the fourth, insurance companies; and the fifth, digital load-aggregators that reduce empty miles and thereby lower the logistics carbon footprint.

To maintain a high-quality operational loop, the network must rapidly implement unified standards and train personnel. Experience from CEIV has shown that, after ten years of operation, the program encompassed 699 companies, trained over 10,000 employees, and established 25 airport communities with harmonized procedures at a 99% certificate renewal rate. These metrics serve as a template for the apicultural segment and are incorporated into partner SLAs as a mandatory minimum [12]. In addition, operators complete the IATA LAR module and biosecurity training. The rejection rate of consignments metric is tied to bonuses and penalties, and the training protocol is updated annually in line with the latest regulatory version.

The technological linkage of GPS, multi-sensor loggers, and open APIs creates a digital twin for each shipment. In apiculture, networks of the scale of BeeHero are already operational, where 300,000 hives generate more than 25 million data points daily. Such data volumes enable the real-time detection of overheating or ventilation deficits and the dispatch of corrective commands to drivers or dispatchers, thereby reducing the transport mortality of colonies [13]. Open REST APIs grant insurers and aggregators access, allowing them to adjust tariffs or routes based on actual biological load and weather forecasts.

Co-marketing efforts enhance end-user trust: products certified under the Bee Better Certified and marketed by U.S. federal retailers demonstrate the market premium for transparency regarding pollinator welfare. The network publishes a unified glossary and visual brand guide. This approach increases repeat-order conversion rates and reduces customer-acquisition costs, as verified indicators of environmental responsibility become integral to the retailer's marketing narrative.

The network's economics hinge on an effective incentive system. For long-term engagement with critical carriers, LTA contracts with fixed prices and high volumes are concluded. To share the premium margin for live cargo, revenue-sharing schemes are applied. Quantitative models indicate that such schemes increase the aggregate profitability of network links while aligning incentives to invest in service quality [14]. SLAs remain the operational control layer: temperature breaches or delays automatically incur penalties. Concurrently, the network's legal unit secures rights to predictive analytics algorithms and trademarks—for example, the bee-activity-assessment algorithm or the Bee Better visual mark—so that intellectual property is protected and can be licensed to new participants without risking the network core. Collectively, this combination of financial incentives, standardization, and digital transparency transforms disparate services into a self-learning ecosystem capable of guaranteeing agribusiness stable pollination and predictable economics even amidst abrupt climatic and market fluctuations.

Monetization of the live-cargo partnership network begins with selecting models that support economic incentives with biological KPIs. The basis is an 80/20 revenue-sharing structure, where 80% of the revenue accrues to the owner of the key asset (bee colonies or specialized transport) and 20% to the platform operator, who manages orders and risk. Such a ratio is long established as an industry standard in capital-intensive projects. In the U.S. infrastructure, the rail carload segment operates on a similar logic. For bee transport, this yields a straightforward algorithm: the beekeeper or carrier knows in advance their guaranteed revenue share. At the same time, the aggregator receives a fixed percentage that finances reserve routes and insurance funds. The white-label format addresses the inverse challenge, lowering the entry barrier for small operators. For the bee-transport network, this implies rapid roll-out of uniform booking interfaces, where local operator logos preserve farmer trust, yet all data converge into a unified analytics layer.

By granting partners the right to use the CEIV + IATA LAR trademark and protocols, the network owner secures a master-license fee and royalties per colony transported. In contrast, the partner gains access to a proven methodology and centralized insurance, accelerating market entry in new jurisdictions compared to organic growth. Finally, pay-per-use IoT or SaaS models generate recurring revenue without requiring a capital outlay. The cloud-based cold-chain monitoring market reached USD 5.95 billion in 2023 and is growing at an annual rate of 13.8%, driven not by carriers but by insurers and retailers who require live temperature and CO_2 data [15].

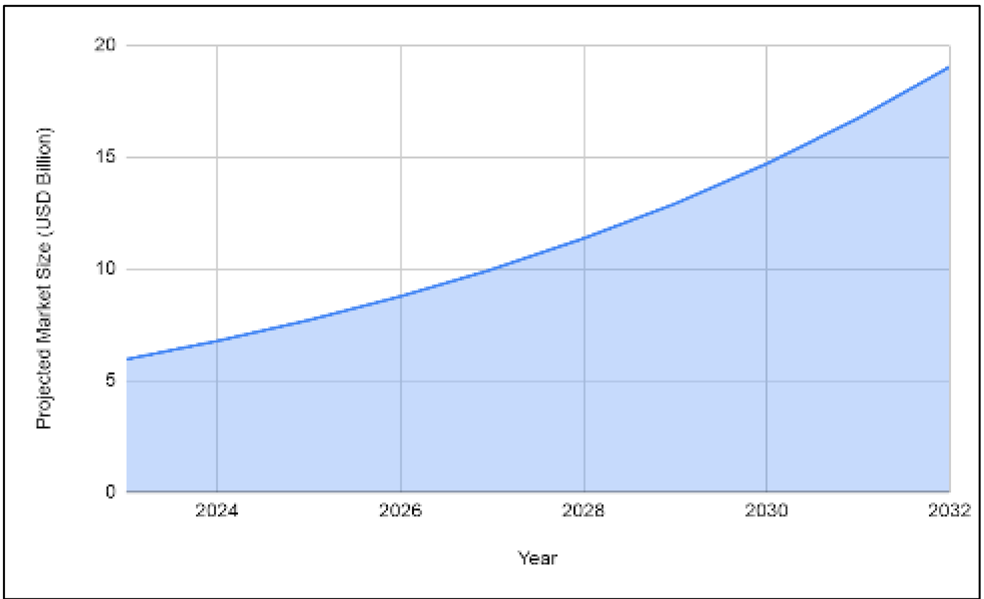

Figure 3 IoT For Cold Chain Monitoring Market [15]

Amazon Web Services already offers LoRaWAN connectivity, which has become a benchmark for beekeepers. They pay only for the actual use of sensors during transit, while the network secures a stable cash flow, regardless of the seasonality of transport operations.

The combination of the models as mentioned above forms a hybrid payment matrix, in which the long-term 80/20 structure guarantees capital payback, white-label solutions reduce the transactional costs of connectivity, franchising accelerates international replication, and pay-per-use IoT cements the network's technological leadership and transforms bee health data into an independent product for insurers and regulators. Such a symbiosis enables partners to synchronize investments with market dynamics, maintaining service quality and financial resilience amid the exponential growth in demand for pollination.

GBA TFreight Inc. demonstrates how a highly specialized method of bee transport transforms a high-risk live cargo into a predictable and profitable service. The company, which earns USD 7–8 million annually with profits of USD 1.2–1.5 million, relies on its proprietary protocol, encompassing climatic-zone routing, temperature control, GPS monitoring, and driver regulations. These procedures, which account for the biological requirements of the colonies and minimize stress, are executed strictly in real-time; consequently, in-transit mortality—formerly 30–40%—is maintained below 5%. This outcome increases clients' pollination efficiency and crop yields, prompting large-scale beekeepers to renew contracts each year and entrust the company with exclusive shipments for the most lucrative seasonal operations, such as during almond bloom in California.

The uniqueness of and restricted access to this methodology constitute a competitive barrier: the technology is unpatented yet used exclusively within GBA TFreight, which secures its reputation as one of the few specialized brokers in the United States. Repeat agreements generate over 70% of revenue; many apiaries transition entirely from general-purpose brokers to the company's service, having assessed the increased reliability and reduced risk of under-pollination penalties. Scaling is facilitated by remote management: operational teams are distributed across the United States, Ukraine, Argentina, and Poland, coordinating drivers and beekeepers within a unified tracking and notification system. Internal metrics record not only biological indicators—such as mortality and stress—but also driver satisfaction, which reduces staff turnover and indirectly sustains service quality.

This case clearly illustrates that building a reliable partner network is key to scaling and sustaining a live cargo flow. GBA TFreight's methodology is based not only on its own monitoring and routing protocols but also on the coordination of numerous counterparties, including specialized carriers, GPS equipment suppliers, certified veterinary services, trained drivers, and remote operations centers. Such a concentration of expertise enables rapid adaptation to regional climatic conditions, risk-sharing, and standardized service—from hive loading to final unloading at the client's site. Ultimately, each participant in the network contributes their expertise, reducing bee mortality and enhancing pollination effectiveness. At the same time, GBA TFreight acts as an integrator, guaranteeing quality and transparency across the entire supply chain.

4. Conclusion

The development of a service-provider partner network for the transport of honey bees is founded on a multi-layered interaction architecture, in which specialized carriers, veterinary services, IoT telemetry providers, insurance companies, and digital aggregators play central roles. Each link in this network performs a distinct function: carriers certified under IATA CEIV Live Animals minimize biological risk during transport; mobile veterinary teams ensure compliance with the two-hour corridor and international sanitary standards; and real-time monitoring systems enable prompt responses to deviations in key environmental parameters.

The implementation of a unified platform for certification and data exchange eliminates the problem of incompatible standards and significantly accelerates documentation processing, which is crucial given the compressed timeframe for pollination. Integration of telemetry with prognostic analytics and insurance assessment enables end-to-end traceability of the live cargo, reducing in-transit colony mortality and incentivizing network participants to strictly adhere to procedures through key performance indicators (KPIs) such as insurance claim approval rates or the number of temperature excursions.

Financial mechanisms—including long-term framework agreements (LTAs), revenue-sharing schemes, and white-label formats—facilitate the distribution of economic risks and alignment of stakeholder interests. Fixed hive quotas and tariffs ensure predictable income for both carriers and beekeepers. At the same time, the aggregator platform receives a share of revenue to finance backup capacity and insurance funds. Pay-per-use IoT monitoring models generate additional recurring income and enhance the network's technological flexibility during off-season periods.

The GBA TFreight Inc. case demonstrates that the combination of proprietary routing protocols, temperature control, GPS logging, and remote operations centers can maintain in-transit mortality below 5%, significantly increasing client trust and ensuring long-term loyalty. Restricted access to the methodology and master licensing extends the geographic reach of operations without compromising quality, while remote management of international teams reduces operational costs and speeds market entry.

Thus, the formation of a sustainable partner network for bee transport services represents a comprehensive approach in which technological connectivity, procedural standardization, and balanced economic incentives create an ecosystem capable of guaranteeing reliable pollination even under extreme climatic and market fluctuations. The adoption of such networked solutions not only reduces biological and operational risks but also opens new opportunities for scaling contract pollination services on a global level.

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