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Evolution of International Fare Regulation Standards in Civil Aviation amid Industry Digital Transformation

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Abstract *— The article examines the transformation of international fare regulation standards in civil aviation under the pressure of NDC, API distribution, continuous pricing, dynamic offer creation, and airline retailing. The topic gains relevance because airlines still depend on common fare, ticketing, and distribution standards, while digital tools move pricing decisions closer to the customer request. The study aims to explain how unified fare rules coexist with differentiated airline pricing strategies. The methodology combines source analysis, comparative interpretation, conceptual synthesis, typologization, and analytical generalization. The source base consists of recent academic and industry publications on IATA distribution standards, ATPCO fare infrastructure, dynamic offers, continuous pricing, ancillary optimization, inter-organizational systems, and value migration in aviation. The article identifies the movement from filed fares toward offer-based commercial architecture, explains the changing function of tariff specialists, and proposes governance principles for airlines that introduce dynamic fare tools without losing distribution reliability.*

Keywords *— **civil aviation, fare regulation, IATA, ATPCO, NDC, dynamic pricing, continuous pricing, airline retailing, API distribution, regional airlines.***

I. INTRODUCTION

International air fare regulation now sits at the junction of standard-setting, pricing strategy, digital sales architecture, and operational control. The earlier fare environment rested on a chain that airlines, global distribution systems, travel agencies, and settlement bodies understood well: tariff filing, fare rules, booking classes, availability control, ticketing, servicing, and accounting. Digital distribution has added another commercial layer to this chain. Airlines want to construct offers during the shopping request, combine flight and ancillary products, use richer customer and itinerary signals, and send content through APIs instead of relying only on traditional display logic.

The aim of the study is to identify structural changes in international fare regulation standards under digital transformation and to determine their impact on airline pricing differentiation.

The first research objective is to identify how IATA's standard-setting function and ATPCO's fare-data function change under the influence of NDC, dynamic offers, and offer-order architecture. The second objective is to explain how continuous pricing and algorithmic offer construction modify the traditional relationship between fare rules, booking classes, revenue management, and tariff control. The third objective is to compare the strategic positions of large and regional airlines in the global fare environment, with attention to technological capacity, distribution dependence, and commercial autonomy.

The novelty of the article lies in the treatment of fare standard evolution as a regulatory-commercial process. Digital pricing is interpreted not as a narrow revenue management technique, but as a shift in the

institutional grammar of air distribution. Common standards continue to organize the market, yet airlines now seek greater control over offer composition, price granularity, channel presentation, and product differentiation.

The hypothesis is that digital transformation does not weaken the need for international fare standards. It changes their function. Standards increasingly operate as interoperability infrastructure, while fare policy becomes more differentiated through data, segmentation, distribution control, and offer management capability.

II. MATERIALS AND METHODS

The materials were selected through a targeted search of publications from 2021 to 2026 in Scopus-indexed and major publisher databases, including SpringerLink, ScienceDirect, Taylor & Francis Online, and open industry repositories of IATA and ATPCO. The search terms combined "airline retailing," "NDC," "dynamic offer," "continuous pricing," "ATPCO," "fare filing," "airline revenue management," "API distribution," "global distribution systems," and "regional airlines." Twenty-eight records were screened. Eighteen sources were excluded because they focused on general tourism platforms, airport operations, sustainability policy, outdated NDC debates before large-scale retailing transition, or non-peer-reviewed commentary without technical relevance. The final corpus contains two industry standard sources and ten academic sources. The thematic map covers five groups of questions: IATA and NDC as interoperability standards [1], ATPCO as a fare and offer-data infrastructure [2], airline retailing and dynamic offer management [3-6], continuous and segmented pricing [7, 8], distribution-side asymmetry between airlines, agencies, platforms, and technology providers [9-11], and algorithmic pricing under different data conditions [12].

The study applies comparative analysis to contrast traditional fare filing and offer-based retailing, source analysis to extract the regulatory and technological meaning of the selected publications, conceptual synthesis to connect standards with pricing strategy, typologization to classify airline positions in the evolving fare environment, and analytical generalization to formulate implementation principles for carriers that move from static fare publication toward digitally mediated offer control.

III. RESULTS

The evolution of international fare regulation standards begins with a change in the object of regulation. The legacy fare environment treated the fare as a structured commercial unit. Airlines filed tariffs, attached conditions, linked them to booking classes, controlled availability, and distributed the result through channels that could price, ticket, exchange, refund, and account for the transaction. The standard did more than transmit a price. It gave the market a shared operating grammar.

IATA's NDC fact sheet presents the newer distribution standard as an XML-based data transmission standard built around Offer and Order management. Airlines use it to create and distribute more relevant offers through different sales channels [1]. This shift changes the practical meaning of standardization. The industry no longer standardizes only the publication of a pre-defined fare. It increasingly standardizes the exchange of an offer that may contain the flight, ancillaries, product attributes, payment conditions, servicing rules, and seller-specific presentation logic.

ATPCO's recent materials describe a related movement from static fare structures toward dynamic content, adjusted offers, optimized offers, and continuous offers [2]. ATPCO still organizes fare and product data: fares, rules, services, taxes, surcharges, availability, branded fares, and product attributes. Yet airlines now use this structured base as input for offer creation. A filed fare becomes one element inside a broader commercial engine. For tariff specialists, this changes the practical task. They still maintain fare construction, rules, routing restrictions, advance purchase conditions, combinability, and filing discipline. They also need to understand how those elements feed offer engines, API messages, branded content, and downstream servicing.

The first research objective therefore leads to a dual interpretation of IATA and ATPCO. IATA defines the shared language for distribution interaction, while ATPCO converts airline commercial intent into structured fare and product data that

sellers and systems can consume. These functions do not merge. They interact. The rule architecture without accurate fare data cannot produce a stable offer. Fare data without interoperable messaging cannot move through the distribution chain with enough reliability.

The pressure behind this shift comes from the limits of fare-based offer creation. A 2021 framework on airline dynamic offering reports that airlines need changes in technology, organization, and process because current offer creation often remains tied to rigid fare structures [3]. This finding matters for the article's first objective because standards do not sit outside commercial practice. They define what an airline can sell, what a seller can display, and what a customer can understand before purchase. A carrier may design a product-rich fare family, but an old display structure can flatten that offer into a booking class and a short fare rule note.

Continuous pricing studies develop the same issue from the revenue management side. Traditional airline pricing used discrete fare classes and price points. NDC-based distribution can support continuous quotation, allowing airlines to move closer to a customer's estimated willingness to pay [4]. Booking classes historically carried several functions at once: inventory control, price differentiation, restriction logic, and distribution compatibility. Continuous pricing separates those functions with greater precision. Inventory control remains part of revenue management, but the quoted price can vary with finer increments than the old fare ladder allowed. The change affects the priced object itself (Figure 1).

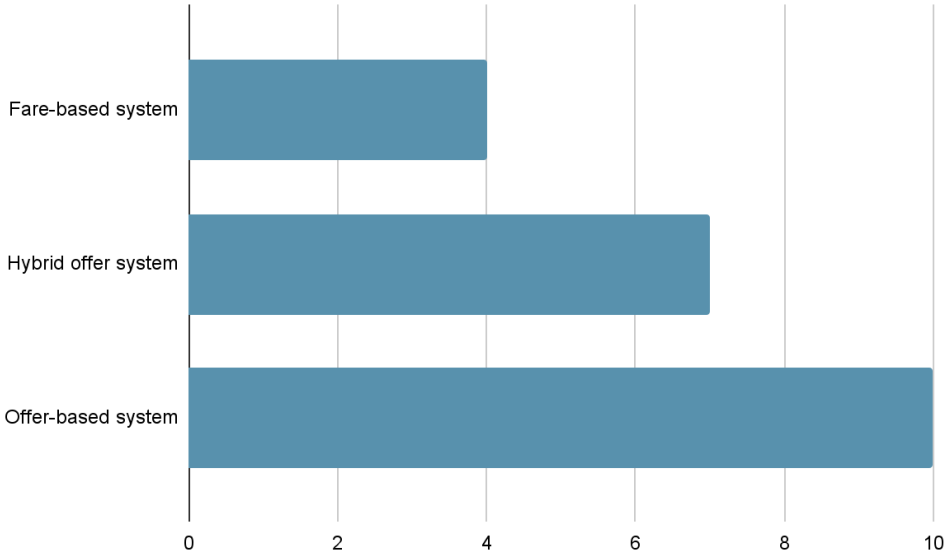

Fig.1. Shift of airline control across pricing architecture layers (compiled by the author based on [1-3, 5, 8])

Research on machine-learning-based ancillary pricing notes that many airlines have managed ancillary prices through manual review, competitor benchmarking, historical data, and filing in ATPCO or merchandising systems [5]. The same study proposes automated ancillary pricing using variables such as passenger type, itinerary, aircraft type, ancillary product, and season [5]. This finding expands the fare-regulation question. The commercial object presented to the passenger increasingly combines base fare, baggage, seat selection, flexibility, priority services, and other attributes. A standard that carries only the base fare cannot represent the actual retail product with enough accuracy.

Dynamic offer research moves the discussion one step further. A study using a Markov chain choice model defines a dynamic offer as a set of flight and ancillary products shown at one price during a specific customer request [6]. The authors report that airlines need progress in distribution and scientific modeling to customize and price offer sets at scale [6]. This creates a new competence boundary for tariff and pricing teams. In the traditional model, tariff expertise focused on correct fare construction and controlled

publication. In the digital model, the same expertise must connect fare rules with offer governance, attribute logic, product catalogues, price testing, and exception control.

Continuous pricing research supports this reading because new algorithms still compare themselves with traditional revenue management mechanisms and often build upon inherited pricing structures [4]. ATPCO's description of dynamic offers follows the same logic: static data, adjusted offers, and continuous pricing operate as connected stages, not as isolated regimes [2]. The change is gradual. Airlines continue to need standardized fare data because agency sales, corporate programs, interline flows, refunds, exchanges, servicing, and accounting require stable references.

A comparison of continuous pricing studies gives the second research objective a sharper shape. One 2021 study reports revenue-positive outcomes from continuous pricing algorithms, with gains of 2.0% for a first mover and 1.2% when both carriers adopt the method in a simulated two-carrier network [4]. A later segmented continuous pricing study reports larger possible first-mover gains in a calibrated scenario, yet competitors can reverse those gains by changing fare restrictions [7]. These findings point to the same conclusion from different angles. Digital pricing gives an airline more control over price granularity, but that control remains exposed to competitor reaction, market density, fare restrictions, and customer segmentation quality.

Dynamic offer creation studies add a broader commercial interpretation. The Markov chain model for ancillaries reports revenue potential from relevant bundled offers and price optimization [6]. Research on traveler-centric offer design reports that a method combining booking data, segmentation, conjoint analysis, and revenue simulation produced revenue improvement in a mid-size full-service carrier case [8]. The two studies emphasize different mechanisms. One focuses on scalable choice modeling for offer construction [6]. The other places more weight on traveler segmentation and market research in a carrier-specific environment [8]. Together they show that digital fare evolution cannot be reduced to price movement. The airline changes the commercial unit from a seat with a fare condition into an offer that combines price, product, attribute, and customer relevance.

NDC adoption research adds a distribution-side constraint. A 2024 study of agency conflicts in innovation adoption states that network-based innovations require more than one firm to adopt them before the intended results appear [9]. The study links NDC outcomes to institutional pressure, agency incentives, information asymmetry, and selective distribution of ticket sales [9]. This matters because NDC does not function as a private airline instrument. Airlines, aggregators, global distribution systems, travel management companies, retail agencies, corporate booking tools, payment providers, and servicing platforms all participate in the distribution chain. One airline can invest in NDC, but the commercial result depends on whether sellers can display, service, and account for the offer.

Large and regional airlines enter this environment from different starting points. Research on airline industry architecture reports that the interfaces between airlines, distribution partners, and airports create opportunities for value migration. Larger multi-airline groups and well-positioned low-cost carriers have stronger ability to capture that value, while smaller independent airlines often need more focused niche strategies [10]. This evidence does not exclude regional airlines from digital fare transformation. It shows that their path depends more heavily on shared infrastructure, vendor capability, and disciplined implementation.

The difference between standardization and strategy becomes visible here. A regional carrier in Kazakhstan, a Gulf network airline, a North American major, and a European low-cost group can operate within the same basic fare and distribution standards. Their strategic use of those standards differs. One airline may protect interline and corporate flows. Another may expand branded fare families. A third may introduce continuous pricing in dense competitive markets. A fourth may retain filed fares and controlled availability because its hosted system, sales mix, or partner dependence limits the safe use of dynamic tools. International fare regulation creates formal equality at the standard level and capability-based inequality at the implementation level.

Inter-organizational systems research explains why API distribution can increase managerial complexity. Evidence from airlines and travel agencies indicates that IT links between firms support business process modularization and allow firms to recombine processes as market conditions change [11]. APIs, NDC messages, and offer-order standards therefore reshape the boundary between airline and seller. Shopping, booking, payment, servicing, and order management become part of the same digitally mediated process. A technically valid offer can still create commercial trouble if the agency workflow cannot show the bundle, if a corporate tool strips a restriction, if the refund process cannot reconstruct the order, or if accounting receives incomplete information.

The third research objective concerns the strategic comparison between large and regional airlines. The source base does not support a simple division between innovative large carriers and passive regional carriers. A stronger interpretation is more precise. Large carriers usually possess more internal resources to turn standards into proprietary retailing capability. Regional airlines rely more on the quality of shared infrastructure, hosted systems, aggregators, and vendor governance. For a regional carrier, the standard has protective value because it grants access to global distribution infrastructure without requiring full internal ownership of every system component. For a large carrier, the same standard has strategic value because it supports differentiated offers while preserving access to agencies, corporate buyers, interline partners, and settlement processes.

Algorithmic pricing research adds a final qualification. A study comparing reinforcement learning and data-driven dynamic programming in airline-inspired pricing markets reports that data-driven dynamic programming remains competitive when training data are scarce, while reinforcement learning becomes stronger with larger data volumes [12]. This finding limits any universal claim about immediate AI-led fare transformation. Many airlines will operate in mixed regimes. Some markets will remain close to filed fares and dynamic availability. Other markets will use adjusted offers. Dense routes with rich shopping data may support segmented or continuous pricing. International fare standards need to support all of these regimes because civil aviation remains a network industry with uneven technological maturity.

IV. DISCUSSION

Fare regulation standards in civil aviation are moving from tariff publication control toward commercial interoperability. The older fare system gave airlines, agencies, and settlement bodies a shared structure for fares, rules, tickets, exchanges, refunds, and accounting. The digital system expands the number of commercial objects that must remain consistent. A static fare requires correct publication, rule application, and availability control. A dynamic offer requires those elements plus product attributes, customer or shopping signals, ancillary logic, servicing conditions, payment handling, order persistence, partner visibility, and audit trails.

This shift changes the practical work of tariff and pricing teams. In a filed-fare environment, an error often comes from a wrong fare basis, missing rule, incorrect routing, or inconsistent restriction. In an offer-based environment, the error can spread across fare data, product catalogues, API messages, seller displays, ancillary logic, and servicing systems. A price may satisfy the airline's internal rule set, yet fail in the sales chain because a seller cannot show the bundle or because the servicing process cannot reconstruct the original offer after a schedule change. Fare governance therefore needs to move beyond publication accuracy and cover the whole offer lifecycle.

A workable implementation model begins with layer separation. The airline first defines the elements that remain stable reference data: base fares, fare rules, fare families, product attributes, taxes, surcharges, eligibility conditions, corporate restrictions, interline rules, and settlement requirements. The second layer covers elements that teams may adjust at the shopping stage: price increments, ancillary combinations, bundle composition, channel display, and flexibility options. The third layer sets the boundary for algorithmic decision-making. Pricing teams need to know which decisions a model can make alone, which decisions require analyst review, and which decisions stay outside automated control because the operational risk outweighs the revenue opportunity. Table 1

compares three fare-standard regimes. The purpose is to separate the operational logic of the traditional filed-fare environment, the hybrid NDC-enabled environment, and the offer-order environment. The comparison helps identify where airlines need governance controls during digital transformation.

Table 1. Fare-standard regimes in civil aviation digital transformation (compiled by the author based on [1-4, 6])

Comparison criterion	Filed-fare regime	Hybrid NDC-enabled regime	Offer-order regime
Commercial unit	Fare with rules and booking class	Fare-based offer with enriched content	Offer generated and stored as an order
Main control object	Tariff publication accuracy	Consistency between filed data and dynamic adjustment	Full lifecycle consistency from shopping to servicing
Pricing logic	Discrete fare classes	Discrete base with adjusted or continuous elements	Real-time offer logic governed by product and pricing controls
Role of ATPCO data	Primary distribution reference	Reference layer for dynamic offer construction	Structured input into broader retailing architecture
Role of IATA standards	Common passenger and distribution rules	NDC-based offer and order exchange	Standardized offer, order, payment, servicing, and settlement interaction
Tariff specialist function	Fare coding and rule discipline	Fare governance plus channel and content validation	Offer governance, product logic, auditability, and exception control
Main operational risk	Misfiled fare or rule inconsistency	Channel mismatch, incomplete display, servicing gap	Algorithmic opacity, order reconstruction failure, partner incompatibility
Suitable airline profile	Carriers with stable distribution dependence	Carriers moving selectively into NDC and branded offers	Carriers with mature retailing, data, and API governance

The table shows a transitional zone that many airlines will occupy for years. Most carriers will not move directly from filed fares to a mature offer-order model. They will operate hybrid structures in which filed fares, branded products, dynamic adjustments, and API distribution coexist. This hybrid phase deserves close managerial control because responsibility fragments across departments. Revenue management controls availability and price logic. Pricing teams maintain fare data. Distribution teams manage channel access. Digital teams supervise APIs. Finance and settlement units handle consequences that appear after sale. A carrier that leaves ownership unclear gains technical complexity without stable commercial control.

The decision sequence should start with a map of fare products. Airlines need to identify which fare rules remain necessary because of corporate contracts, interline obligations, market regulation, public-service routes, refund requirements, or local commercial practice. The next decision concerns markets suitable for dynamic or continuous pricing. Dense competitive markets with enough search data support stronger experimentation. Thin regional routes, subsidy-linked services, and partner-dependent flows often require conservative controls. After that, the carrier needs to test channel parity at the level of customer meaning. The same offer does not need identical presentation in every channel, but the traveler and intermediary must understand the

price, included services, restrictions, and servicing rights.

Servicing tests should precede broad commercial rollout. Airlines often evaluate pricing tools through shopping conversion and revenue movement. That test is incomplete. The offer must survive exchange, refund, disruption, schedule change, ancillary modification, payment reconciliation, corporate reporting, and interline transfer. If the airline cannot reconstruct the original offer after the sale, dynamic pricing has created a downstream control problem. The revenue gain then competes with manual rework, agency friction, customer complaints, and accounting exceptions.

A monitoring system for the new fare environment should go beyond revenue uplift. A carrier can raise short-term revenue while weakening customer trust, agency adoption, servicing quality, or auditability. Metrics need to capture both commercial effect and operational durability. Table 2 proposes a monitoring frame for airlines that shift from static fare publication toward dynamic offer control.

Table 2. Monitoring metrics for digital fare standard implementation (compiled by the author based on [5, 7, 9-12])

Control area	Metric	What it detects	Managerial use
Fare-data integrity	Fare-rule error rate after publication	Incorrect coding, missing restrictions, inconsistent fare conditions	Blocks unreliable fare bases before they feed offer engines
Offer consistency	Difference between intended and displayed product attributes	Channel display loss, incomplete rich content, bundle distortion	Identifies sellers or APIs that cannot represent the offer
Pricing governance	Share of offers generated within approved price corridors	Algorithmic drift, excessive price dispersion, uncontrolled overrides	Defines when analyst review or rule adjustment is needed
Segmentation reliability	Stability of segment assignment across shopping scenarios	Weak customer inference, noisy request variables, unstable demand grouping	Limits segmented pricing in markets with weak signal quality
Competitive exposure	Revenue change after competitor response	First-mover vulnerability, fare restriction retaliation, price spiral risk	Supports decisions on expansion or containment of dynamic pricing
Servicing durability	Share of offers serviced without manual intervention	Order reconstruction problems, exchange and refund complexity	Measures whether digital offers remain operational after sale
Agency adoption	Share of NDC-capable sellers producing completed bookings	Incentive mismatch, channel resistance, poor workflow fit	Supports changes in commercial terms, training, or technical support
Regional readiness	Vendor dependency index and internal control coverage	Excessive reliance on hosted systems or external aggregators	Determines which functions require stronger in-house oversight

The proposed metrics treat fare modernization as a governance task. Vendors can help a carrier launch dynamic offers, but quick deployment does not replace control over fare data, channel display, servicing, and pricing boundaries. Regional airlines often gain more from fare-data integrity, offer consistency, and servicing durability than from complex segmentation. Larger airlines with strong

data volumes can add continuous pricing, real-time testing, and richer bundling. The difference is strategic. A regional carrier that protects accuracy and channel trust may achieve a stronger commercial result than a larger airline that launches advanced offers while leaving servicing gaps unresolved.

The implementation sequence should remain disciplined. A stable reference fare layer comes first. Product attributes and branded fare logic come next. NDC distribution should begin with channels that can display and service the offer with minimal distortion. Dynamic adjustments belong in markets where teams have enough data, competitor monitoring, and revenue management oversight. Continuous pricing should follow after the airline can explain, reproduce, and audit offer outcomes. Each stage needs rollback rules. A pricing model that cannot be paused, narrowed, or reversed creates unacceptable risk in a network where one error can travel through agencies, corporate tools, settlement processes, and customer service desks.

The unification and differentiation problem has a practical resolution. International standards should remain unified at the level of message structure, fare-data semantics, order lifecycle, payment, servicing, and settlement compatibility. Airline strategy should remain differentiated at the level of product design, price corridor, bundle construction, segmentation, channel selection, and competitive response. A standard that forces identical commercial behavior would weaken airline strategy. A pricing strategy that ignores shared standards would damage distribution trust. The viable model is disciplined differentiation: common infrastructure, airline-specific fare logic, transparent governance, and measurable control over downstream effects. The discussion confirms the hypothesis that digital transformation does not eliminate international fare standards but shifts their role toward interoperability governance while enabling airline pricing differentiation.

V. CONCLUSION

International fare regulation standards in civil aviation are moving from tariff publication toward offer-based interoperability. IATA's NDC and offer-order architecture redefine the standard as a language for shopping, ordering, payment, servicing, and customer-facing offer exchange. ATPCO remains central because fare, rule, service, and product data still require a structured reference layer. The filed fare loses its exclusive position as the commercial unit, yet it continues to serve as an input into dynamic offer construction.

Continuous pricing, segmented pricing, machine-learning-based ancillary pricing, and dynamic offer creation change the relationship between booking classes, fare rules, and revenue management. The source base supports the claim that digital pricing can create revenue opportunities, but those opportunities depend on data quality, market structure, competitor response, and model governance. The priced object changes from a seat attached to a fare class into an offer that combines price, product, attribute, eligibility, and servicing logic.

Large and regional airlines operate under the same international standards, but they do not extract equal value from them. Large carriers have stronger capacity to build proprietary offer engines, direct channels, data science teams, and advanced pricing controls. Regional carriers benefit from standardization because it grants access to global distribution infrastructure, yet their strategic differentiation depends on disciplined vendor governance, accurate fare data, clear product attributes, and selective use of dynamic pricing.

The hypothesis is confirmed. Digital transformation does not reduce the need for international fare standards. It changes their function. Standards now provide the interoperability base on which airlines construct differentiated commercial strategies. Civil aviation needs unified technical and procedural foundations combined with controlled, auditable, and selective fare-policy differentiation.

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