MARKET-BASED ALLOCATION OF AIRPORT SLOTS

Can a gradual, quality-sensitive auction improve the use of scarce airport capacity?

MARKET-BASED ALLOCATION OF AIRPORT SLOTS

Can a gradual, quality-sensitive auction improve the use of scarce airport capacity?

Authors: Eduardo Cardadeiro, João E. Gata

Airport capacity is scarce, but the rules used to allocate it remain largely administrative. This note proposes a cautious way to introduce market signals: auction a small share of slots through a progressive combinatorial mechanism that rewards both price and service quality.

Air traffic has rebounded strongly from the pandemic and long-term demand is expected to keep growing. Yet infrastructure cannot expand at the same pace everywhere. IATA identifies hundreds of airports facing capacity restrictions, including more than 200 Level 3 airports where demand for runway and terminal capacity exceeds what can be accommodated. A large share of global passengers therefore travels through airports where an arrival or departure slot is a scarce input.

Slots are indispensable for predictable schedules and safe operations. The question is not whether they should be coordinated, but whether the present allocation system makes the best use of scarce capacity. In Europe and many other jurisdictions, allocation is anchored in historical precedence rather than in an explicit market test. This gives incumbents stability, but it can also make entry and reallocation difficult when another airline could use a slot more productively.

A market mechanism is not a simple substitute for coordination. Airport operations involve complementarities, network effects, public-service obligations and environmental objectives. A carrier typically needs compatible departure and arrival slots; a single isolated slot may have little value. Any reform must therefore go beyond a conventional auction in which the highest monetary bid automatically wins.

We consider an extension of the Progressive Adaptive User Selection Environment (PAUSE): a transparent, multi-stage auction in which airlines can bid for packages, and the coordinator evaluates offers using a score that combines payment with a pre-defined measure of service quality. The proposal is deliberately incremental. It would initially apply only to a small proportion of slots and would coexist with the Worldwide Airport Slot Guidelines (WASG).

1. Why the current system is under pressure

At coordinated airports, an independent coordinator allocates the available arrival and departure times. The framework is built around two familiar rules. Historical precedence — often called “grandfather rights” — allows an airline to retain a series of slots from one equivalent scheduling season to the next. The “use-it-or-lose-it” rule makes that priority conditional on using the series at least 80% of the time.

The framework has clear advantages. It supports schedule planning, offers a harmonised method across a global industry and limits discretionary intervention. Airlines may also exchange slots, generally on a one-for-one basis, and unused or newly created slots enter a pool from which coordinators allocate capacity according to priority rules. Half of this pool is normally reserved for new entrants, while other considerations may include year-round operations, connectivity, and public-service needs.

However, historical allocation does not reveal the scarcity value of a slot. When airport charges do not reflect scarcity, a slot can remain attached to a service that produces less value than an alternative use. New or expanding airlines may be willing and able to use it more efficiently but still be unable to obtain access. The system may also encourage strategic retention of slots and can slow the adjustment of schedules to changes in demand.

The policy challenge is therefore a balancing exercise. Reform should improve allocative efficiency and entry opportunities without undermining network coordination, operational resilience, or legitimate public-interest objectives.

2. Why pricing alone is not enough

ICongestion pricing is one possible response: charge more for scarce peak capacity and less at uncongested times. In principle, this can give carriers greater scheduling flexibility and discourage slot hoarding. In practice, the regulator must set the right price for each relevant period before observing demand. The task becomes difficult when demand, airline strategies, network connections, and airport constraints change over time.

Pricing also interacts with the regulation of airport charges. Many congested airports are regulated because of their market power, and tariff rules may cap or constrain scarcity-based prices. A badly calibrated charge could either fail to clear demand or impose costs without delivering a better allocation. For these reasons, congestion pricing may form part of the solution, but it does not remove the need for a mechanism that discovers how airlines value different combinations of slots.

An auction changes the informational burden. The authority defines the capacity available; airlines reveal their valuations through bids. But airport slots create three design problems that a simple auction handles poorly:

- Complementarity: a route requires compatible slots, and a package can be worth more than its components considered separately.
- Public value: the authority may care about connectivity, service continuity, aircraft characteristics, or emissions, not only revenue.
- Transition risk: reallocating a large share of slots at once could disrupt schedules and weaken confidence in the reform.

3. A progressive, quality-sensitive auction

PAUSE is a simultaneous ascending combinatorial auction designed to make a large allocation problem manageable. Even with only 15 slots, the number of possible packages and compatible combinations can run into the thousands. Asking the coordinator to collect every possible package bid and then search across all combinations would quickly become impractical. PAUSE distributes part of that task to bidders and introduces complexity gradually.

The first design choice concerns the objects being auctioned. A lot need not be a permanent or homogeneous “slot”. It can be a time-limited right — for a period that takes into account airlines’ investment and the proportion of slots auctioned each year — covering an individual arrival or departure, a matched arrival-departure pair, a series of slots or a package that includes relevant ground services. Lots may differ by time of day, aircraft restrictions, origin or destination, noise limits and other operational characteristics. They may also carry specific public-service obligations. Defining the lots is therefore the first layer through which the authority can protect public-interest objectives.

The auction then progresses through stages, with multiple bidding rounds possible within each stage:

- Stage 1 — individual lots. Airlines bid only for individual slots. The leading offer for each lot produces a provisional allocation. Complementarities are deliberately left aside at this point, keeping the opening stage simple and establishing reference values.
- Stage 2 — individual lots and pairs. Airlines may introduce bids for packages of up to two lots. Each airline submits a composite bid: a set of non-overlapping bids that, together, covers every lot in the auction. For lots it does not wish to acquire, it may incorporate valid bids already made by other participants in previous rounds.
- Later stages — progressively larger packages. At stage n, packages may contain up to n lots. Bidders can therefore express increasingly complex network complementarities only when they are relevant, while retaining earlier bids for the remaining lots. The process continues until the maximum permitted stage is reached or all bidders stop bidding.

The coordinator compares complete composite bids rather than trying to assemble thousands of isolated offers. In effect, each participant proposes a feasible allocation of the entire set of lots, even though only some components contain that participant’s own new bids. The best-scoring composite bid becomes the provisional allocation for the round. This transfers much of the package-building effort to bidders while allowing the coordinator to verify that bids are compatible and respect operational, competition or market-share

constraints.

Our extension adds a second dimension to each offer. The coordinator assigns a score to the combination of a monetary payment and a verifiable quality commitment. Quality could reflect, for example, the provision of a strategically important connection, the use of a less-polluting aircraft or another policy objective set out before bidding begins. The exact metric and its weight must be transparent, measurable and non-discriminatory.

The economic logic can be expressed through a formula that defines how an offer can compensate for a lower payment through higher quality, or for lower quality through a higher payment. This formula plays a crucial role, and its design is a technically delicate task that must aim at representing correctly social preferences. In any case, what matters for selecting the auction winners is the total score under the published rule. This turns the mechanism into a scoring auction rather than a price-only auction.

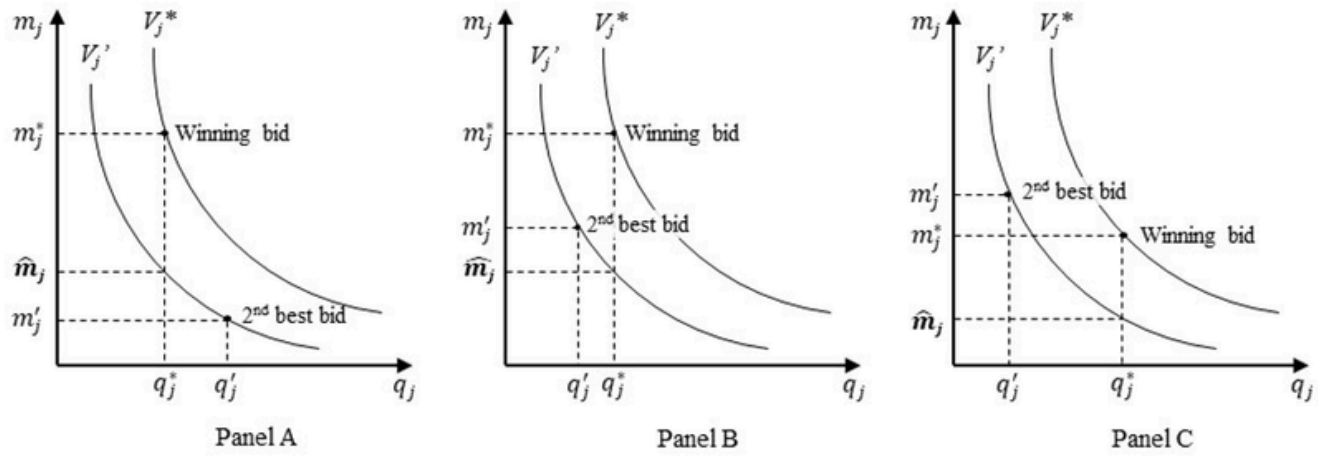
Within each stage, the rounds work as follows:

- The coordinator defines the lots, eligibility conditions, market-share constraints, quality indicators, and scoring rule.
- At the end of each round, the leading composite bid and its score are disclosed in a controlled and transparent way. Any new bid must improve on the previous best score by a limited increment, preventing abrupt "price-jump" bids.
- A stage closes when no bidder submits a valid improvement. The package-size limit is then increased for the next stage, unless the auction has already reached its final stage.
- When all bidding ends, the highest-scoring feasible composite bid determines the final allocation. That allocation may combine individual slots and blocks of different sizes, reflecting the complementarities identified by airlines.

Winners may be asked to pay according to a second-score principle rather than their full offered amount. As for the scoring formula, the application of the second-score principle involves technical aspects that call for expert advice. However, and in a nutshell, the principle is simple: the second-score rule asks a winner to deliver a score equivalent to the best displaced alternative. Since the quality promised by another airline may not be technically replicable, the winner keeps its own quality commitment, and the monetary payment is adjusted to reach the relevant second-best score.

Figure 1 illustrates three possible cases [1].

Figure 1. The "second-score" rule: the winner adjusts its monetary payment so that its final score matches the second-best offer, while retaining its own quality commitment.



The figure highlights the core trade-off. A winner offering lower quality than the runner-up may pay more than the runner-up's monetary bid; a winner offering higher quality may pay less. If quality is identical, the result reduces to the familiar second-price logic. The rule is intended to reward genuine quality while limiting incentives to overbid.

4. What the design is intended to improve

The extended PAUSE mechanism has several properties that are attractive in the airport context:

- Computability. Bidders assemble the packages they value, reducing the winner-determination burden on the coordinator and making the allocation suitable for algorithmic implementation.
- Transparency. Participants can compare their offers with the leading score after each round and understand why an offer is not winning.
- Protection against exposure. Package bids reduce the risk that an airline wins one component of a route or network plan but not the complementary slots needed to operate it.
- More disciplined bidding. Limits on bid increments reduce strategic "price jumps" and signalling intended to deter competitors.
- A more even progression. Gradually increasing package size can mitigate the threshold problem faced by smaller bidders when competing against a large package bid.
- Price discovery. Multiple ascending rounds and the second-score rule help participants update their valuations and reduce the risk of a winner's curse.

These benefits are design objectives, not automatic outcomes. Transparency must be balanced against risks of coordination; the scoring function must not become a vehicle for arbitrary preferences; and the package structure must remain computationally and operationally manageable. Independent oversight, data publication and ex-post evaluation would therefore be essential.

5. A gradual application in Portugal

Lisbon, Porto and Funchal are classified as Level 3 airports throughout the year; Faro is Level 3 during the summer season. Persistent congestion, delays and limited capacity make the Portuguese system a relevant setting in which to test a market-based complement to existing allocation rules.

The case is particularly pressing in Lisbon, where the long-term infrastructure response remains central but cannot by itself solve short-term scarcity.

We propose a pilot at Lisbon, Porto and Funchal, followed by an evidence-based decision on whether and how to expand it. The reform should begin by auctioning only 5% to 10% of slots annually. Existing historical rights would not disappear overnight; for the auctioned portion, they would progressively become limited-duration lease rights. Airlines would continue to use WASG procedures, including slot exchanges and the international coordination calendar, at other airports and for the non-auctioned capacity.

A credible pilot would require at least five safeguards:

- a clearly defined and stable set of lots, including rules for matching arrival and departure capacity;
- objective quality indicators that can be verified after allocation, with proportionate penalties for non-delivery;
- caps or other competition safeguards to prevent the auction from reinforcing concentration;
- protection for public-service obligations and essential connectivity, expressed transparently in the auction design; and
- independent monitoring of prices, entry, slot utilisation, delays, connectivity, emissions and passenger outcomes.
- The gradual approach has two advantages. First, it limits operational disruption and allows airlines to adapt their network planning. Second, it creates a learning process: the coordinator can test the scoring rule, data requirements and bidding interface before committing a larger share of capacity. If the pilot does not deliver measurable gains, its scope can be revised without destabilising the entire allocation system.

6. Conclusions

The present administrative system provides stability and international coordination, but it does not ensure that scarce slots move towards their highest-value use. Congestion pricing can introduce a scarcity signal, yet it requires the regulator to determine complex prices in advance. A progressive combinatorial auction offers a different route: it lets airlines reveal the value of packages while allowing the coordinator to incorporate transparent public-interest objectives.

The extended PAUSE proposal is designed around the practical features of aviation. Package bidding recognises that slots are complementary; a quality-sensitive score recognises that revenue is not the only policy objective; and a second-score payment rule supports price discovery while rewarding quality. Its multiple stages, controlled bid increments and transparent allocation logic aim to mitigate some of the strategic and computational problems associated with other auction formats.

The case for reform is strongest as a carefully evaluated complement to the current system, not as an immediate wholesale replacement. Auctioning a small share of slots at Lisbon, Porto and Funchal would provide evidence on whether market signals can improve access, utilisation and service quality without compromising coordination. The decisive issue is therefore not “administration or markets”, but how to combine both in a framework that uses scarce airport capacity more effectively and remains credible to airlines, airports, regulators and passengers.

If you would like to discuss these issues further or would like more information about what our economists can do for you, please get in touch with us.

Tel: +39 06 68 300 530

Email: lear@learlab.com

Notes

[1] For each winning lot or block j, the notation used in the figure is as follows: m_j^* is the monetary amount offered in the winning bid; $\hat{m}_j$ is the monetary amount actually paid by the winner after applying the second-score rule; m_j' is the monetary amount offered in the second-best bid; q_j^* is the quality level promised by the winning bid; q_j' is the quality level promised by the second-best bid; V_j^* is the total score of the winning bid; and V_j' is the score of the second-best bid. The two curves are iso-score lines: every combination of money and quality on the same curve produces the same score. The payment $\hat{m}_j$ is therefore chosen so that the winner's own quality q_j^* combined with its adjusted payment reaches V_j' — the score of the best displaced alternative.

References

[1] Ball, M. O., Berardino, F. and Hansen, M. (2018), "The use of auctions for allocating airport access rights", Transportation Research Part A, 114, 186–202.

[2] Cardadeiro, E. and Gata, J. E. (2021), "Scoring auctions: are they the key to market-based allocation of airport slots?", European Review of Business Economics, 1(2), 59–76.

[3] Cardadeiro, E. and Gata, J. E. (2023), "Market based allocation of airport slots: The PAUSE auction mechanism and extensions", European Review of Business Economics, 2(2), 3–22.

[4] Kelly, F. and Steinberg, R. (2000), "A combinatorial auction with multiple winners for universal service", Management Science, 46(4), 586–596.

[5] Land, A., Powell, S. and Steinberg, R. (2006), "PAUSE: A computationally tractable combinatorial auction", in Cramton, P., Shoham, Y. and Steinberg, R. (eds.), Combinatorial Auctions, MIT Press.

[6] Ockenfels, A., Cramton, P., Gritzmann, P. and Bichler, M. (2021), "It is time to auction slots at congested airports", VoxEU/CEPR.

[7] Steinberg, R. (2021), "Slot auctions can help airports reduce congestion and airlines reach environmental targets", Airline Economics – Global Aviation Finance & Leasing Guide.