V. Conclusions and Future Directions

In this paper, we have presented an agent-based model aimed to investigate the effects of different airport slot allocation mechanisms. The model simulates the behavior of a set of airlines competing over a congested airport network, allowing the prediction of the resulting schedule and the utilities obtained by the airlines. We have applied this model to evaluate the impact of primary slot allocation through a combinatorial price-setting auction in a simplified scenario. The simulation illustrates how the auctioning mechanism allows the balancing of capacity and demand in a decentralized manner, without the need for airlines to disclose sensitive information. Different airlines are affected in different ways, depending on their business model. The available capacity is allocated to those airlines able to make best economic use of it, and the economic value of each slot emerges from the auction.

Several model extensions are being implemented and will be used for future studies, in particular a more complex airline behavioral model. Instead of using a set of pre-defined flights, each airline will determine its preferred schedule as a function of the forecasted travel demand and the expected profit. Airline agents will be endowed with learning capabilities, so that they are able to improve their estimation of future profits from the observed behavior of their competitors in previous seasons. Behaviors other than utility maximization will also be explored, e.g., anticompetitive practices. Additional experiments will be conducted to optimize the design of the auctions (e.g., testing different price update mechanisms) and explore how the presence of more airports and airlines affects the results and the convergence time. The outcome of slot auctioning will be compared with the current administrative system, as well as with that obtained by solving the equivalent optimization problem, in order to evaluate the ability of different types of auctions to yield an optimal (or nearly optimal) solution according to different optimization criteria (e.g., maximization of social welfare). Finally, simulations will be conducted to evaluate different combinations of primary and secondary slot allocation mechanisms along several seasons in more complex and realistic scenarios, as well as to validate the model, as a necessary step prior to applying the proposed approach to inform decision making in the real world. The developed framework and the proposed computational experiments are expected to advance the state of the art in the strategic management of airport demand, allowing a more comprehensive understanding of the benefits and risks of market mechanisms and informing future policy developments.

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References

[1] Dot Econ Ltd., "Auctioning airport slots: a report for HM treasury and the department of the environment, transport and the regions", London, UK, 2001.

[2] NERA, "Study to Assess the Effects of Different Slot Allocation Schemes", Technical Report prepared for the European Commission (DG TREN), London, UK, 2004.

[3] Mott MacDonald, "Study on the Impact of the Introduction of Secondary Trading at Community Airports", Technical Report prepared for the European Commission (DG TREN), London, UK, 2006.

[4] Steer Davies Gleave, "Impact assessment of revisions to Regulation 95/93", Final report prepared for the European Commission (DG MOVE), London, UK, 2011.

[5] Council of the European Communities, European Council Regulation (EEC) No. 95/93 of January 1993 on Common Rules for the Allocation of Slots at Community Airports. Official Journal of the European Union, L 14, 22.01.1993, p.1. Brussels, Belgium, 1993.

[6] IATA, "Worldwide Slot Guidelines", 7th Ed.. Montreal, Canada, 2015.

[7] European Commission, "Airport package. Proposal for a Regulation of the European Parliament and the Council on common rules for the allocation of slots at European Union airports", COM(2011) 827 final. Brussels, Belgium, 2011.

[8] A. Ranieri, N. Alsina, L. Castelli, T. Bolic, and R. Herranz, "Airport slot allocation: performance of the current system and options for reform", Proceedings of the 3rd SESAR Innovation Days, Stockholm, Sweden, November 2013.

[9] K.G. Zografos, Y. Salouras, and M.A. Madas, "Dealing with the efficient allocation of scarce resources at congested airports", Transportation Research Part C Vol. 21, pp. 244–256, 2012.

[10] L. Castelli, L., P. Pellegrini, and R. Pesenti, "Airport slot allocation in Europe: economic efficiency and fairness", International Journal of Revenue Management, Vol. 6, No. 1-2, pp. 28-44, 2012.

[11] P. Pellegrini, L. Castelli, and R. Pesenti, "Secondary trading of airport slots as a combinatorial exchange", Transportation Research Part E 48, pp. 1009-1022, 2012.

[12] P. Pellegrini, P., L. Castelli, and R. Pesenti, "Metaheuristic algorithms for the simultaneous slot allocation problem", IET Intelligent Transport Systems, Vol. 6, Iss. 4, pp. 453–462, 2012.

[13] P. Klemperer, The economic theory of auctions, Edward Elgar, 1999.

[14] S. Moss, "Relevance, Realism and Rigour: A Third Way for Social and Economic Research", Report No. 99-56, Centre for Policy Modelling, Manchester Metropolitan University. Manchester, UK, 1999.

[15] ACCESS Consortium, "Position Paper: Application of Agent-Based Computational Economics to Strategic Slot Allocation. State-of-the-art and Future Challenges", April 2013.

[16] SESAR WPE ACCESS Project (E.02.29), Deliverable D3.1 "Simulation framework specification", October 2014.

[17] SESAR WPE ACCESS Project (E.02.29), Deliverable D3.2 "Simulation and analysis toolset", July 2015.

[18] M. Ramírez, F.A. Villafáñez, A. Araúzo, A. López-Paredes, "Agent-Based Pilot Model for Alternative Primary Airport Slot Allocation with Price-setting Auctions", Proceedings of the 4th SESAR Innovation Days, Madrid, Spain, November 2014.