RESUMEN DE LA TESIS PARA OPTAR AL
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EFFECTS OF THE INTRODUCTION OF SPATIAL AND TEMPORAL COMPLEXITY ON THE OPTIMAL DESIGN, ECONOMIES OF SCALE AND PRICING OF PUBLIC TRANSPORT

In this thesis we study microeconomic models for the strategic design of buses transit systems, taking into account the distribution of trips in space and its representation over a simplified but meaningful urban network, as well as the heterogeneity of demand across different periods of the day. This is done by means of models that extend in space and time the classic single-line ones and analyzed by Jansson (1980) and Jara-Díaz and Gschwender (2009).

Regarding the spatial analysis, we study the optimal lines structure (i.e. the spatial arrangement of transit routes) design over the urban model proposed by Fielbaum *et al* (2016, 2017) based on the hierarchy of centers, obtaining and analyzing the results from the application of existing heuristics, examining the presence of scale economies and its causes, and introducing the spatial density of transit lines as part of the design.

The heuristic approach is studied by comparing the four basic structures proposed by Fielbaum *et al* (2016) with those that emerge when applying four previously existing heuristics. Scale effects are analyzed defining the concept of "directness", showing that when the number of passengers increases, the best system evolves such that routes reduce transfers, bus stops and the length of passengers' routes. Directness is shown to be yet another source of scale economies; optimal subsidies and fares are also studied. When spatial density is considered as a new design variable together with lines structure, frequencies and vehicle sizes, it increases with patronage keeping access and waiting time costs equal, showing some substitution with directness and inducing scale economies as well.

The heterogeneity of demand across different periods is analyzed using single-line models that consider peak and off-peak conditions regarding duration, trip length and traffic conditions. The system is optimized under different operating rules, such as considering a single fleet, considering two fleets that operate independently in each period, or considering two fleets that run together at the peak (only one of them runs at the off-peak); this last system is shown to be the most efficient one, with the single-fleet system just slightly worse. Solutions are compared with those obtained when considering each period in isolation, and crossed-effects among periods are identified. In addition, we study *second-best* strategies: we optimize the peak period in isolation and use a sub-fleet for the off-peak, and we compare the results of this strategy with the opposite one: an approximate rule is to optimize the system according to the conditions of the period that presents the highest total number of passengers (across its whole extension).