Summary

The field of economics is concerned with the allocation of scarce resources, such as time, money, goods, or services. Often, these scarce resources are allocated in markets: places, physical or not, where buyers and sellers meet. For economists, markets are particularly interesting if they fail to deliver the best possible outcomes. ‘Best possible’, in this context, can mean multiple things: usually, a Pareto optimum (in which no single market participant can be made better off without harming another) or a social optimum (such that society as a whole cannot do better). In either case, any market outcome below the optimum gives regulators a reason to intervene; the question is then, of course, which interventions can restore the efficiency of the market in the best way.

Markets can fail to deliver Pareto- or socially optimal outcomes for various reasons, collectively called ‘market failures’. In transport markets, the most common market failure is the presence of externalities: costs or benefits of, in this case, traveling, that are not accrued by the traveler, but by others. The increase in congestion a car driver imposes on all other drivers is an example of such a negative externality. Externalities are often analyzed on their own, assuming that there are no other market failures. For instance, studies often assume that markets are perfectly competitive, or assume price-taking behavior in some other way.

However, in practice, market participants do often exhibit non-price taking behavior: there are monopolists who face imperfectly elastic demand and oligopolists that are large enough to influence prices on their own. This market failure, in many settings, cannot be assumed away. As private investment in, and ownership of, transport networks is increasing, it will only become more important. This thesis therefore aims to explore the industrial organization of transport markets: that is, the decisions made by non-price taking market participants, the outcomes of those decisions, and the ways in which regulators can influence them. It develops methods to model these decisions, and uses those to investigate pricing and scheduling behavior, investment, and regulation. In contrast to much of the existing literature, it does so while explicitly taking the networked nature of transport markets into account.

This is not an empirical thesis; instead, it develops theoretical models: simplified mathematical representations of transport markets, which can be used to develop theories about markets that do not yet exist, or explore which effects one would expect to find in real-world markets. Every model makes assumptions. When analyzing a complex market setting, it is therefore usefully to consider several models, each with different assumptions, and each focusing on a particular aspect of the market in question. This thesis therefore consists of five separate chapters, besides the introduction and conclusion. Each chapter focuses on a different setting, and hence, each model is more detailed than others in at least one dimension. All chapters have a dual purpose:
they introduce novel methods, or show how existing methods can be applied to answer questions related to the industrial organization of transport markets, and then also apply these methods to gain new insight.

Chapter 2 analyzes the effects of price differentiation and discrimination by a monopolistic transport operator, which sets fares in a congestible network. Using three models, with different spatial structures, it describes the operator’s optimal strategies in an unregulated market, a market where price differentiation is not allowed (i.e., ticket prices must be the same for all users), and a market where price discrimination is illegal (i.e., ticket prices must only differ with the marginal external costs of users), and analyze the welfare effects of uniform and non-discriminatory pricing policies. The three models allow for separate consideration of the three different forms of price differentiation and discrimination in networks: by user class, by origin-destination pair, and by route. This chapter generalizes the existing literature on price discrimination, in which groups usually only differ in their value of time to also include differences in marginal external costs. In this setting, non-differentiated and non-discriminatory policies may increase or decrease welfare, and non-discrimination can be worse than non-differentiation. The results obtained for a single-link network can be generalized to a situation where operators price-discriminate or differentiate based on users’ origins and destinations, but not directly to a situation in which differentiation is based on the routes users take.

Chapter 3 moves to networks in which transport operators compete. It analyzes the behavior of market participants in a multi-modal commuter network, where roads are not priced, but public transport has a usage fee, which is set while taking the effects on the roads into account. In particular, it analyzes the difference between markets with a monopolistic public transport operator, which operates all public transport links, and markets in which each public transport link is owned by a separate operator. Importantly, users not only choose which mode to use, but also decide when to travel. In this dynamic setting, even if the total travel demand is inelastic, serial Bertrand-Nash competition on the public transport links leads to different fares than a serial monopoly. This results from the fact that trip timing decisions, and therefore the generalized prices of all commuters, are influenced by all fares in the network. The chapter ends with a numerical simulation, which shows that, contrary to the results obtained in classic studies on vertical competition, monopolistic fares are not always lower than duopolistic fares.

Like chapter 3, chapter 4 also considers departure time choices, but this time, with a focus on how these choices affect scheduling decisions made by transport operators. It proposes a generalized Hotelling horizontal differentiation model with price-sensitive demand and asymmetric distance costs. In this model, two competitors choose fares and departure times in a fixed time interval; consumers’ locations indicate their desired departure times. The model is used to show how departure times can be strategic instruments, and how they are best regulated.

Chapter 5 analyzes how user equilibrium assignment models impact outcomes, and which assignment models are best. It compares three competing stochastic user equilibrium traffic assignment methodologies (multinomial probit, nested logit, and
generalized nested logit), using a congestible transport network. The models are used
to evaluate policy decisions, such as profit-maximizing tolling or second-best socially
optimal tolling. The results are then used to investigate how these optimal tolls, and
their performance, depend on the model choice, and hence, how important the differences
between models are. As it turns out, the differences between models are small, as a result
of the congestibility of the network, as long as they are calibrated correctly. Hence, it may
be better to use computationally more efficient logit models instead of probit models, in
at least some applications, even if the latter are preferable from a conceptual viewpoint.

Chapter 6 uses the results from chapter 5 to analyze investment in networks; hence, in
contrast to the earlier chapters, it focuses on long-term decisions. It proposes methods to
analyze the effects of different policies that control the formation of transport networks
by private operators. These are then used to analyze investment in a simple network
with a limited number of nodes and routes, and possibilities to build congestible travel
links with discrete capacities between each pair of nodes. In this setting, fare regulation
and location-independent capacity subsidization are not always sufficient to achieve the
first-best welfare-maximizing solution. Second-best fare regulation can be better than
second-best network regulation in some, but not all, situations.

Together, these chapters give a broad overview of some of the important issues
related to the industrial organization of transport markets. The most important
conclusion that can be drawn from this thesis is that the industrial organization of
transport markets matters. The technical chapters above have each analyzed a specific
competitive setting, but in each case, this competitive setting turned out to be important.
Transport operators can use price discrimination to increase their profits, and this
has implications for social welfare. In a multi-modal network, the fact that users can
change their departure times affects the nature of competition, and the desirability of
various competitive structures. Operators also use their departure times strategically,
and change their investment strategies depending on the competitiveness of the market.
Hence, when analyzing transport markets, it is crucially important to decide if, and how,
the industrial organization of the markets will be modeled. In many cases, assuming that
markets are perfectly competitive, or monopolistic with a perfectly elastic demand, such
that market participants are still price takers, may not be appropriate. Similarly, when
trying to address a policy issue, it is important to consider the full complexity of the
specific transport market in question. Previous analyses of other markets, with different
levels of competition, different demand structures, or other, perhaps on first sight small
differences, will not always be helpful.