ABSTRACT

After the market liberalization for long-distance bus services in Germany in 2013, rail operators had to face a completely new kind of competition. Even though long-distance trains have been more severely affected than local trains, latter also have been struggling with passenger declines. However, the extent is dependent from the line since buses only connect big cities, whereas many local trains do not.

The gap in research with regard to this new market was big: up-to-date literature was yet seldom retrievable for the market in general, but it was virtually impossible to find analyses of particular lines.

However, there was strong evidence that the Munich-Nuremberg line has been one of the most affected lines in terms of these two traffic carriers (Mader, Uekötter 2015). Therefore, this Master's thesis sought for a better understanding of the passenger's mode choice between long-distance buses and local trains on the Munich-Nuremberg line. The core element was a survey on both trains and at the central bus station in Munich, sided by market and price observations. In addition, the second Module gave a broad introduction to the general competitive conditions and also illustrated the market development until late 2016.

In consideration of all decision criteria for the mode choice of passengers, especially quantifiable items such as fares, duration, connection frequency were analyzed. In addition, also other, rather qualitative criteria like seating comfort, WiFi access and other subjectively stated components of a trip were evaluated. Next to Nuremberg, the examination of the Munich-Nuremberg line also included relevant passenger streams from Munich to Würzburg, Erlangen, Bamberg and Bayreuth.

The results are mostly unambiguous: young people travelling alone between the two cities are the ideal customer group for buses. Further, the ticket structure of local trains shows weaknesses in comparison to buses. However, there is a generally more positive perception of trains than of buses. The bigger a group was, the bigger the likelihood to choose local trains.

However, the thesis does not suggest that the results are simply applicable to other cases. Nevertheless, both local train and bus operators can derive similar methodical approaches for comparable case studies on other lines.

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List of Abbreviations

ADAC	*Allgemeiner Deutscher Automobil-Club (German General Automobile Club)*
AEG	*Allgemeines Eisenbahngesetz | General Railroad Act*
BC	*BahnCard (discount card for LTs and LDTs)*
BEG	*Bayerische Eisenbahngesellschaft (Bavarian Railway Agency (sector entity))*
BLB	*BerlinLinienBus | Long-Distance Bus Line of Deutsche Bahn AG*
BT	*BayernTicket*
CBS	*Central Bus Station*
DB	*Deutsche Bahn AG | German National Railway Company*
DB FV	*Deutsche Bahn - Fernverkehr | German National Railway Company - Department for long-distance rail transport*
LDB	*Long-Distance Bus*
LDT	*Long-Distance Train*
LPuT	*Local Public Transport*
LT	*Local Train*
LT/CBS	*survey location (LTs and at the CBS Munich)*
MFB	*MeinFernbus-Flixbus (LDB operator)*
MIH	*Ingolstadt Central Station*
MN	*direction Munich to Nuremberg*
MNT	*Munich-Nuremberg-Regio Ticket*
MNx	*München-Nürnberg-Express Train*
MVV	*Münchner Verkehrs- und Tarifverbund (Munich Tariff and Transport Union)*
NM	*direction Nuremberg to Munich*
PBefG	*Personenbeförderungsgesetz / Passenger Transportation Act*
raw	*dataset "raw" (untreated; not used for any evaluations)*
reduced	*dataset "reduced" (homogenous dataset used for most evaluations)*
SBH	*Schwerbehinderte / Severely Disabled People*
StVZO	*Straßenverkehrs-Zulassungsordnung | Road Traffic Licensing Regulations*
total	*dataset "total" (inhomogenous dataset used for single evaluations)"*
V1.1 and V3.1	*questionnaire version 1.1 (pretest) and 3.1 (final version)*
wtp	*(theoretical) willingness-to-pay*

LIST OF ANNEXES

Attachment Nr.	for Module(s)	Content
1	B	Graphical overview of the LT sector organization
2	B/C	Protocol Interview BEG publication restricted
3	C	DB Regio Bayern: Examination of LDB impacts (unpublished document by Mader, Uekötter (2015); on CD only) publication restricted
4	C	Passenger Count RES (on CD only) publication restricted
5	C	Fare observation tables MN_LDB ("all observations", "per daytime" and "per observation day"; without BLB, on CD only)
6	C/D	Pictures of the CBSs in Munich and Nuremberg

Attachment Nr.	for Module(s)	Content
7	D	Map visualizations of passenger's origins / destinations
8	D	E-Mails from MFB and BLB: Cooperation Denials
9	D	E-Mail from the CBS operator Munich: Permission for surveying
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A. MODULE A: INTRODUCTION AND STRUCTURAL FRAMEWORK

A.1. INTRODUCTION

> "Passengers travelling […] on long-distance buses must have very strange preferences with regard to their mode choice"[1] (Spiegel Online 2013)
>
> **ULRICH HOMBURG, BOARD DIRECTOR OF LONG-DISTANCE TRAFFIC AT DEUTSCHE BAHN AG (DB) ON 21 JUNE 2013**

Homburg made his statement in a press conference in June 2013, only months after long-distance bus (LDB) services were deregulated on 01 January 2013. Before this, a law dating back to the 1930ies had denied any competition with trains (details see chapter B.1.1). Journalists in the conference were surprised to hear ambivalent announcements from one of the most powerful DB managers: LDB operations would not make sense at all due to negligibly small profit margins. DB did not care about how many bus offers there are. Eventually, Homburg added the statement quoted above. The journalists would not have been surprised to hear Homburg announce quitting the whole LDB involvement of DB, which right then was on a rather low level anyway. Interestingly, he then started advertising quite the opposite: DB was planning to expand its bus network in order to "improve the network coverage of the existing rail services" (Spiegel Online 2013). Expert spectators also consented that DB had dramatically underestimated the new growing market of LDB services in Germany. (Spiegel Online 2013)

Some three years later, the whole market situation has again changed tremendously. The feared LDB operator National Express from UK has withdrawn from the market again, together with others such as the German Automobile Club (ADAC) and the German Mail Service. Most of the remaining players on the market were eventually taken over by the uncontested market leader MeinFernbus – Flixbus (MFB). (Die Zeit 2016b) Homburg's expansion with DB's own operator BerlinLinienBus (BLB) was also proven to be unsustainable. In mid-2016, DB announced that they are ceasing almost all LDB activities by the end of 2016. (WirtschaftsWoche 2016) A couple of months earlier, DB's CEO, Rüdiger Grube, had already announced about quitting "this nonsense" business soon again. (Die Zeit 2016b)

Eventually, the market consolidated in late 2016, with MFB as the only considerable player. Also DB's long distance rail transport division, DB Fernverkehr (DB FV), has reacted to the LDB's competitive behavior, e.g. by introducing reduced tickets, accelerating its attempts to offer WiFi also in 2nd class and making concessions with seat reservations (Spiegel Online 2015).

Statistical analyses agree that, within rail-bound systems, DB FV has been suffering the most from the emerging LDB businesses (Statista GmbH 2016b). However, there was another field which has come under pressure: many local trains (LTs) operating on long lines between two big cities were also potential victims of LDB operators. Naturally, this was less true for secondary lines in rural environments than for bigger city pairs which were attractive for LDB operators. Internal examinations of DB Regio soon produced a ranking, where exactly these LT lines were

[1] Original quote: „Wer […] den Bus bevorzugt, muss schon speziell veranlagt sein"

listed. On top position of all Bavarian lines was the Munich-Nuremberg line. (Mader, Uekötter 2015).

Pondering the reasons, this rank was totally comprehensible: the two biggest cities in Bavaria which were served by almost all northbound LDB lines from Munich, with the cheapest tickets at just a few Euros, to only name the most important factors. However, other characteristics of LDBs such as trip duration and comfort perception, were rather unattractive to customers. So - how sensitive were customers to which factors?

In order to understand the structure of this particular market it was necessary to dig into the details and examine the details of the Munich-Nuremberg line. Since the various analyses could be separated from each other, the thesis was designed in a modular structure:

- **Module A:** methodology of the thesis, including definitions and delimitations
- **Module B:** a general, line-independent view on LTs and LDBs
- **Module C:** a profound view into the Munich-Nuremberg line, including a more detailed analysis of fare structures
- **Module D:** a survey among both LT and LDB passengers and its analysis
- **Module E:** conclusions, outlook and recommendations

Eventually, the thesis should help understand the passenger behavior on the Munich-Nuremberg line with regard to both quantitative and qualitative evidence. Rephrased in a research question, the thesis was to find out...

"...for what reasons people chose LTs or LDBs, and through which factors could operators influence this behavior?"

A.2. Cooperation with DB Regio AG

The topic of the thesis was drawn up with the LT operator of the Munich-Nuremberg line: DB Regio AG, an affiliate company of the DB Group. Since the outcomes of the thesis were expected to be highly relevant to improve competitiveness over LDBs, DB Regio also provided staff for the survey and granted access to confidential data (passenger counts, internal preliminary examinations, etc.). However, the data access had to be limited causing a restriction note upon the thesis.

The major prerequisite of a scientific work is to carry out research in a neutral way. Consequently, the thesis was not written in bias but rather compared both modes on the line. The only exceptional chapter was Module E, where recommendations were given with particular emphasis on LTs. However, this was less caused by the cooperation, but rather argued from a macroeconomic / state point of view. The exact argumentation can be read in Module E.

A.3. Legal Definitions

Most terms used in context of public transport products are clearly defined by laws and standards. However, these regulations have partially lost contact with the actual realities over time.

> *The sources mentioned in the subsequent paragraphs must not be misinterpreted: even though they might date back to recent years, most of the content is much older. The year only indicates the year when they were last updated.*

Local Public Transport, **in German "(Personen-)Nahverkehr"**, is defined in §8, paragraph 1 of the Passenger Transportation Act (PBefG). According to this law, Local Public Transport (LPuT) is the *"publically accessible transport of passengers on streetcars, trolley buses and motor vehicles in regular services. This transportation process is dedicated to fulfil transport demand in citywide, suburban or regional traffic. In case of doubt, this is true for transport services which mostly serve distances within 50km or within one hour of travel time."*[2] (Bundesministerium der Justiz 2012b)

This regulation suggests its own inapplicability to LT services, which is excluded even more clearly in §1 PBefG. However, the threshold of 50km, respectively one-hour travel time, is already mentioned and is also retrievable in §42a, which was added to the law text in 2013 and defines LDB services.

Long-distance Transport, in German "(Personen-)Fernverkehr", are "*regular road-bound services which cannot be considered LPuT according to §8 PBefG […]. Long-distance transport is unpermitted for distances within 50km or within one hour of travel time. Exemptions can be granted in case of unsatisfactory LPuT offer or if the LPuT passenger potential remains unharmed."*[3] *(Bundesministerium der Justiz 2012b)*

Excluding the characteristics of LPuT, the definition of long-distance transportation is made in reverse. However, all definitions from PBefG are only applicable to road and city traffic. Moreover, PBefG draws a clear line between LDB services and other forms of bus services that would otherwise be seen as LDBs, too. In particular, long-distance travel for secluded groups ("Fernzielreisen"), as well as infrequent excursions ("Ausflugsverkehr") are treated differently. LDBs are seen as long-distance *regular transportation services*.

Regular transportation services, in German "Linienverkehre" are defined by PBefG, §42, which already highlights the vicinity to the LDB paragraph in §42a. Regular services are defined as "regular transport connections that connect certain origin and destination points on which passengers can board or exit the vehicle. This does not necessarily assume the existence of a publically accessible schedule"[4] (Bundesministerium der Justiz 2012b)

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[2] „Öffentlicher Personennahverkehr im Sinne dieses Gesetzes ist die allgemein zugängliche Beförderung von Personen mit Straßenbahnen, Obussen und Kraftfahrzeugen im Linienverkehr, die überwiegend dazu bestimmt sind, die Verkehrsnachfrage im Stadt-, Vorort- oder Regionalverkehr zu befriedigen. Das ist im Zweifel der Fall, wenn in der Mehrzahl der Beförderungsfälle eines Verkehrsmittels die gesamte Reiseweite 50 Kilometer oder die gesamte Reisezeit eine Stunde nicht übersteigt."

[3] Personenfernverkehr ist der Linienverkehr mit Kraftfahrzeugen, der nicht zum öffentlichen Personennahverkehr im Sinne des § 8 Absatz 1 und nicht zu den Sonderformen des Linienverkehrs nach § 43 gehört. Die Beförderung von Personen zwischen zwei Haltestellen ist unzulässig, wenn
a) der Abstand zwischen diesen Haltestellen nicht mehr als 50km beträgt oder
b) zwischen diesen Haltestellen Schienenpersonennahverkehr mit einer Reisezeit bis zu einer Stunde betrieben wird. In der Genehmigung sind auf Antrag für einzelne Teilstrecken Ausnahmen zu gewähren, wenn
c) kein ausreichendes Nahverkehrsangebot besteht oder
d) das Fahrgastpotenzial der vorhandenen Verkehrsangebote nur unerheblich beeinträchtigt wird.

[4] Linienverkehr ist eine zwischen bestimmten Ausgangs- und Endpunkten eingerichtete regelmäßige Verkehrsverbindung, auf der Fahrgäste an bestimmten Haltestellen ein- und aussteigen können.

LDB operators must have their services approved in advance, according to §2 PBefG. The authorities in charge are determined by the regions ("Bundesländer"). (Bundesministerium der Justiz 2012b)

Local Train Transportation, in German "Schienenpersonennahverkehr" is defined by §2, paragraph 12 of the General Railroad Act (AEG), following the same regulatory thresholds as PBefG (50km / one-hour travel time). However, the passage leaves space for divergences, since only the *majority* of LT services must not exceed the thresholds. (Bundesministerium der Justiz 1993a) Over time, the thresholds have become more and more unrealistic and are simply not true for most LT services today.
For almost 25 years, the regions have been in charge of organizing LPuT and LT services in their respective administrative competence ranges (see chapter B.2.2.1). The regional Competence Transfer Act, in German "Regionalisierungsgesetz" (RegG) therefore contains a certain regulatory framework, with particular emphasis on financing. Also here, the 50km / one-hour rule applies. Even though RegG is not only dedicated to LT services, §6 points out that the law should predominantly aim at this mode. (Bundesministerium der Justiz 1993b)
Long-distance Train (LDT) Transportation, in German "Schienenpersonenfernverkehr", is organized differently, neither RegG nor PBefG apply. The only rough legal frame is the constitutional obligation for the Federal Government to "satisfy the general needs of the population, also beyond the scope of LPuT and LT services".[5] (Bundesministerium der Justiz 2012a) Generally, LDTs have to be operated self-sufficiently – which is the main difference to LPuT and LT. Most of latter two have to be publically subsidized (see chapter B.2.2.1 also). LDTs are almost exclusively operated by DB, whereas the market share of DB in LT operations has steadily dropped since 1994, when the LT market was delegated to the regions and opened to competition (Statista 2015). See chapter B.2 for more information.

The German legislation defines a **Bus** as "a motor vehicle with more than eight seats, without counting the driver's seat"[6], according to §30d, German Road Traffic Licensing Regulations ("Straßenverkehrszulassungsordnung", StVZO). There is no closer delimitation to LDBs. (Bundesministerium der Justiz 2012c)

A.4. Literature Review

In anticipation of the thesis, it was important to trace similar work. However, it was quite clear that due to the topicality and the fast development of the LDB market, only few relevant studies would be available. Single line-dependent examinations were not available at all, whereas generic comparisons of LTs and LDBs were retrievable in small numbers. In addition, the literature review was also particularly relevant for drawing up the survey in Module D. The most pertinent results were as follows:

The limited scope of a particular origin-destination pair – Munich to Nuremberg – was a case study. The understanding of how such kind of research design had to be built up in a proper

[5] Der Bund gewährleistet, daß dem Wohl der Allgemeinheit, insbesondere den Verkehrsbedürfnissen, beim Ausbau und Erhalt des Schienennetzes der Eisenbahnen des Bundes sowie bei deren Verkehrsangeboten auf diesem Schienennetz, soweit diese nicht den Schienenpersonennahverkehr betreffen, Rechnung getragen wird.

[6] Kraftomnibusse sind Kraftfahrzeuge zur Personenbeförderung mit mehr als acht Sitzplätzen außer dem Fahrersitz.

manner was mainly derived from Yin (2013) and Moeckel (2016). The literature did not only help identify the case type and to build up a logical structure, but also provided guidance through the later steps of analysis, evaluation and reporting.

For the case study also data collection had to be carried out. Key sources were LDB and LT passengers, who were interviewed on trains and at the Central Bus Station (CBS) Munich (see Module D). The book by Flick et al. (2007) explained how to conduct surveys, with a strong focus on interviewing. The literature helped design a suitable questionnaire. In addition, Fowler (2009) stressed common interviewing issues such as errors, biases, statistical analyses. The combination of these publications enabled a goal-oriented survey and data analysis.

Another element of the thesis was about understanding price setting methods. Bus operators predominantly attracted their customers with very low fares – especially in comparison to trains. LDB operators use demand-dependent systems, which is not the case for LT operators. Since latter are strongly regulated, it is more difficult for them to introduce dynamic, yield-maximizing tariffs. The basic understanding of pricing was adopted from Diller (2014). It covered all fields of pricing (e.g. basics, strategies, price behavior, instruments) and also referred to real applications, one of which treating the fare system of DB.

Next to key elements of mode choice such as pricing and travel times, there was another, more abstract component: convenience. The term is not clearly defined and rather remains vague. OECD Intl. Transport Forum (2014) tried to structure all possible extents of convenience. Further, the organization tried to assess the impacts of convenience on passengers. In context of the thesis' topic, convenience was especially relevant for some single dimensions: free WiFi on LDBs, which is not available on LTs. In addition, there is a prevailing feeling that buses are not as comfortable as a trains. On the other hand, there is guaranteed seat availability for trips on LDBs. All these qualitative elements were also considered in the survey on both LTs and LDBs. The OECD Intl. Transport Forum was also aware of cultural differences with regard to convenience perception.

Case-related literature

Over time, all railway operators have become aware of the severe impacts of the LDB competition, which was initially underestimated. In Deutsche Bahn AG (2016h), the market leader of LDT and LT transport, Deutsche Bahn, published its latest assessment of all kind of competition in the previous year. It dated back to May 2016, and was thus even more relevant than the preceding publication (Deutsche Bahn AG 2014) from March 2014. Among other segments such as freight transport, it highlighted intramodal competition in LT operations, but also in long-distance traffic. In 2014, the LDB competition has opened a new chapter in this report. However, it did not examine the impacts on a certain line, but rather observed the situation in general.

Also LT competitors of DB publish similar reports. Organized in an association, they also try to estimate the buses' impact on their business. Several chapters of mofair e.V. (2016) were therefore dealing with this topic. Interestingly, they had a considerably different (and less excited) view than DB. Also this report did not go into the details of single line though.

More neutral was a report published by LT sector entities ("Aufgabenträger" / "Besteller"). These organizations are in charge of funding and organizing LT transportation on a tendering basis (see chapter B.2.2.1). They are ruled by the regions, which are responsible for organizing LT services. In their joint publication dating back to 2016 (Bundesarbeitsgemeinschaft der Aufgabenträger des SPNV 2016), they were very aware and obviously significantly worried about the developments on the LDB market. Next to infrastructure financing, the LDB topic was the most important part of the whole report. The document was already relatively close to the topic of the Master thesis since it only reflected impacts on the LT business. Nevertheless, there was no emphasis on single lines.

In the first years after the market was liberalized, there were some authors trying to describe the impacts and relationships between LDBs and trains. However, their focus was mainly on long distance transport (and thus LDTs), and their examinations were never applied to a particular line. Noack (2013) published his findings short time after the market had been opened. It contained a more detailed view on how well bus services would be accepted among students. Next to data collection, the author tried to understand and explain students' preferences and decision factors for mode choices. Since this group was one of the most attractive group for LDB operators, the literature was relevant for the thesis.

Naturally, case studies can hardly be fed with existing research. Prior to the thesis the case Munich-Nuremberg had only been assessed by DB Regio itself. The company tried to estimate the monetary losses caused by LDBs. Being one of several Bavarian lines examined by Mader, Uekötter (2015), it became clear that the LT performance on the line had dropped in the past three years (see chapter C.2.3). However, there was no detailed analysis of this line but a calculative approximation only. The unpublished document tried at least to mention the most crucial differences between the two traffic carriers on the Munich-Nuremberg line. The examination is part of Attachment 3.

The contribution of the thesis to the scientific knowledge

The thesis should help understand a currently pressing issue, which has hardly been studied at all. Remotely comparable research has had a focus on the same general problem, but never on these two traffic carriers: E.g. Pels, Behrens (2012) sought to understand interactions between airline and high-speed rail passenger demand in France. Also Morgan (2009) focused on passenger shifts between air and rail transport in consideration of safety issues after 11 September 2001. However, there was hardly any literature on LDB operations, and even less in context of the young German market. Investigations of other bus services were mostly limited to city transport. The few LDB examinations available rather stressed issues such as traffic safety due to fatigue of the driver (e.g. Raggatt, et al. (1997)) .

In his presentation on the 18th Symposium on Transport Economics and Policy, Didier van de Velde (2010) pointed out that LDBs are rather in an unfavorable position in terms of reputation and perception in the public opinion. Consequently, LDBs were also not as politically focused as rail and air transport. Van de Velde dwelled on a comparison of some European countries and their LDB market handling, with UK and Scandinavia showing a very liberal approach. Regulative issues have been particularly strong in Central Europe, where rail transportation had always been popular and was thus well protected. Especially France and – back in 2010 – Germany had

a very conservative market administration. However, van de Velde did not compare any traffic carriers but only LDBs in different national environments. Moreover, the publication dated back to 2010, when LDB's had hardly any range to develop. (van de Velde 2010)

Single publications, such as Noack (2013), Leisch (2013) and Windpassinger (2014a) tried to highlight reasons for passenger shifts towards LDBs in Germany. They described the system differences, legal framework and other observable characteristics *in general*. However, the scientific gain of those documents (with regard to certain lines) is low, as they rather contain *general* market observations. Same applied for data collection, which was either limited to a certain group (e.g. students at Noack), or was carried out online, thus with *potential* LDB and train passengers only. Moreover, these studies of the domestic market were carried out only months after the market liberalization (Noack and Leisch). In other cases, data collection fell back upon official databases such as "statista" and "destatis": Windpassinger (2014a) tried to understand the general conditions on the new LDB market, using scarce existing statistics in the early time after the market liberalization.

However, as stated before, none of the literature mentioned made a link to a single line, and there were virtually no up-to-date sources.

Why is it important to understand a single line?

Lines differ in many ways. Naturally, trains or buses are more attractive on connections where alternatives are missing. A more in-depth analysis of a line is ideal to point out individual conditions on it.

In the case of the Munich-Nuremberg line, buses have proven huge substitution potential since they are able to compete with trains in all fields: accessibility, travel time, frequency, convenience – and low fares. This observation made by Mader, Uekötter (2015) was the most important base document for the line-dependent examination. Even though LTs are faster than LDBs on this line, they are pressured by high-speed trains in terms of travel time. Consequently, LTs are confined from both travel time and fares on the Munich-Nuremberg line and thus in an unfavorable position.

As mentioned earlier, the extent of influence varies from case to case: other local train lines with more "local" orientation (e.g. S-Bahn) are able to continue their operations undisturbed. In more remote regions, the potential of LDTs and LDBs is negligible. And since buses are actually prone to compete with other modes between bigger cities, the Munich-Nuremberg case conjecturally represents one of the "worst-cases" from the LT operator's perspective: Three modes of public transport (without counting air transport) are in tenacious competition, of which LTs are neither the cheapest nor the fastest – and certainly the least flexible ones.

The examination, approach and also the results of the situation on the busy, well-demanded Munich-Nuremberg line can thus be useful other relations, where the conditions might be similar.

> *Not all of the literature mentioned was explicitly used in the text. Some sources were only used for getting familiar to the topic or to understand the basic principles of e.g. pricing, surveying etc.*

A.5. DELIMITATION OF THE THESIS

Even though the thesis covered numerous influences and impacts, there were still many interfaces which had to be described and defined.

A.5.1. Methodological delimitation

The assignment of the survey to the typology used in Social Sciences was a basic precondition for data acquisition and analysis. In order to improve comprehensibility, untrue and excluded attributes were marked in *italic and underlined* in the following paragraphs, while applicable characteristics were written in **bold** letters.

Examination attributes

Since there was no hypothesis right in advance, the way information was gathered was seen as **inductive method,** rather than *deductive approach***.** Even though after the first set of survey runs some vague hypothesis suspicions emerged they were not considered at this moment. These observations were only analyzed after data collection was finished (see Module D).

Even though the situation on the market was very up-to-date and has hardly been studied so far, the *exploratory* component was limited: LDBs were not a completely new phenomenon in the world of transportation, but only were in the national context. The general attributes, impact potentials and developments could be estimated, be it from foreign experiences or other transport modes. Same applied for *forecasting*: the actual purpose of the thesis was not designed to forecast or even simulate the future development for the market. Instead, the examination sought to understand, thus **explain and describe** the market environment, as well as the players on it.

With this practically oriented focus, it was not only *pure research*, but rather reflected the **application of research methods** to a certain case.

With journeys consisting of multiple, complexly related elements of **both qualitative and quantitative** scales, both types of data had to be dealt with. This was particularly true for travel time and travel costs (quantitative), and all kinds of comfort elements (qualitative).

Even though the survey was carried out in order to understand individual behavior and could thus be considered *idiographic* in this phase, the outcome unambiguously sought to understand cohort behavior (**nomothetic**). (Moeckel 2016a)

Case Study

The better part of the examination of this thesis were classical case study elements – though these are not harmonically defined by literature, as remarked by Yin (2013). Yin therefore tried to find a common base for several different definitions and eventually ended up with the following twofold explanation:

1. “A case study is an empirical inquiry that investigates a contemporary phenomenon (the “case”) in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident.”

2. "[A case study] relies on multiple sources of evidence […]" and benefits thus "from the prior development of theoretical propositions to guide data collection and analysis" (Yin 2013, p. 15)

All the included terms "empirical", "contemporary" and "real-world context" met the environment of the thesis, and most importantly the survey. The survey was, at the same time, the most contributing "source", together with the line-dependent examination in Module C. In latter, the price development observation was another important source.

In the survey, detailed information was gathered among a certain amount of participants. Later, the role of items was observed and analyzed (see Module D). The analysis was trying to **holistically** understand why passengers chose LDBs or LTs as their preferred mode.

On the other hand, some characteristics were not (totally) true. (Moeckel 2016b) The explorative dimension did not apply to a considerable extent as the basic attributes of the LDB and LT market was known already. What was explored instead, was the calibration of influence factors on the certain Munich-Nuremberg line.

Instead of the exploratory component, there were however explanatory elements: the differences between the *general* market observations (see Module B) and the situation observed in the *line-dependent* analysis (see Modules C-D).

A.5.2. Content delineation: line-independent (Module B)

The general framework of the market was explained from the point of view in late 2016. However, the market was still in considerable movement, with the inherent risk that some results or statements may be outdated months, if not weeks later. To relativize this statement, it has to be highlighted that the market consolidation phase was considered to be over by several experts by mid-2016 (TCI Transport Consulting 2016, p. 10).

The line-independent analysis was not designed to find a "better" vs. a "worse" mean of transport. It did not attempt to *compare* all single characteristics of LTs and LDBs. Instead, the target was to show the market environment. Moreover, it should be highlighted that from both cost perspectives and legal preconditions, the two modes LT and LDB were administered totally differently. The line-independent analysis was – like the line-dependent examination – to highlight the interactions between the two traffic carriers LDB and LT, excluding other modes. In particular, LDTs were left out, even though they impact LTs and LDBs.

If not stated otherwise, all information in the thesis refers to the fixed day 30 November 2016. In particular, the following events were not adopted any more:

- Fare structure change of LTs on 13 December 2016
- Latest fare and schedule adaptions of both LTs and LDBs

The line-independent analysis also went down to the regional level (=Bavaria). This level was the (structural) boundary to the line-dependent examinations.

A.5.3. Content delineation: line-dependent (Modules C/D)

The Munich-Nuremberg rail line does not only consist of one single connection. There are four different infrastructural links between the two cities, which are more or less direct:

1) **München – Pfaffenhofen – Ingolstadt – Allersberg – Nürnberg = München-Nürnberg Express (MNx)**
2) München – Pfaffenhofen – Ingolstadt – Treuchtlingen – Roth – Nürnberg (Ring West)
3) München – Freising – Landshut – Regensburg – Nürnberg (Ring East)
4) München – Augsburg – Donauwörth – Treuchtlingen – Roth – Nürnberg (Ring West)

Figure 1 shows the geographical context of the lines.

Even though all four lines were operated by DB Regio, the thesis **only** dealt with the so-called "München-Nürnberg-Express" line (number #1) if not highlighted differently throughout the text.

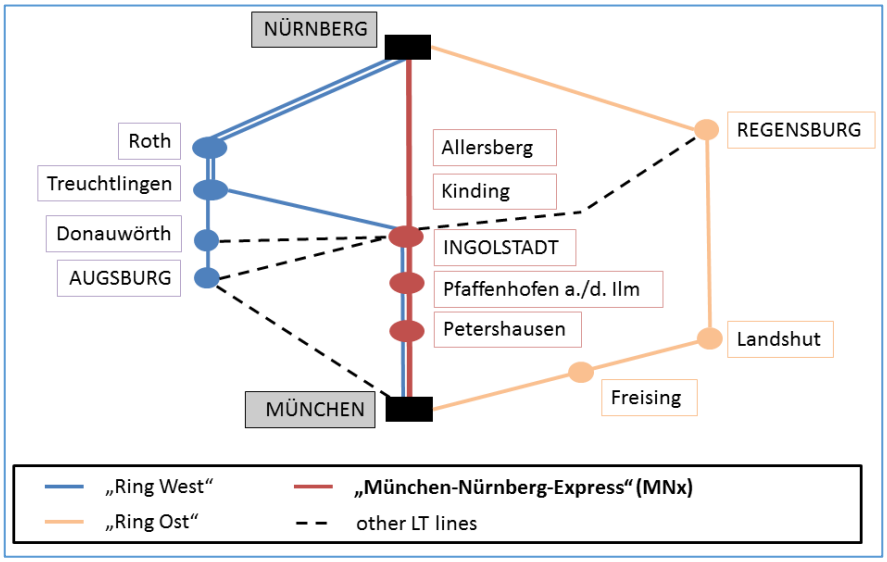


Figure 1: Overview of all LT directly served rail links between Munich and Nuremberg

Source: own graph

Planes, LDTs, Private cars, carsharing offers, as well as carpooling agencies were generally excluded in order to keep the workload manageable. Examining only two modes was certainly a big compromise. Other passenger shifts, which occurred together with the LDB market liberalization, were automatically excluded.

> *However, the survey in Module D proved great substitution effects of LDBs for LT services (70%). Therefore, the exclusion of other modes was tenable.*

All in-between stations of the MNx line were ignored since LDBs are not allowed to serve any of these towns. Same applied for Ingolstadt, even though this relatively big town *does* have access to the LDB network. However, bus operators are must not offer connections from Munich / Nuremberg to/from Ingolstadt, since the admission criteria are not met (see chapter 0). Since also the first LT stop after Munich (= Petershausen, northbound) and Nuremberg (= Allersberg, southbound) is already relatively far away from the adjacent cities, people from those locations were not supposed to board a bus.

> *Example: inhabitants of Petershausen would have to go to Munich in order to take a LDB to Nuremberg. This is not only temporally effortful, but also requires an additional ticket. Consequently, such cases were deemed unrealistic (see also Figure 1).*

The omission of in-between stations also included leisure traffic on holidays and weekends to/from Kinding, a local holiday area north of Ingolstadt, which is known to frequently cause seat and bike transport capacity problems.

On the other hand, the passengers of interest were not only the ones travelling all the way from Munich and Nuremberg on MNx trains (or vice versa), but also to destinations beyond. Regarding

LDBs, all passengers who were deemed likely to choose MNx trains if they decided on a rail-bound mode were relevant. These delimitations were extraordinarily relevant for Module D.

In Munich and Nuremberg, the CBSs are very close to the city centers and were considered equally accessible than the respective central train stations. In fact, there is little distance between the station types (350m at Nuremberg, respectively 900m or one S-Bahn station at Munich; see Figure 2).

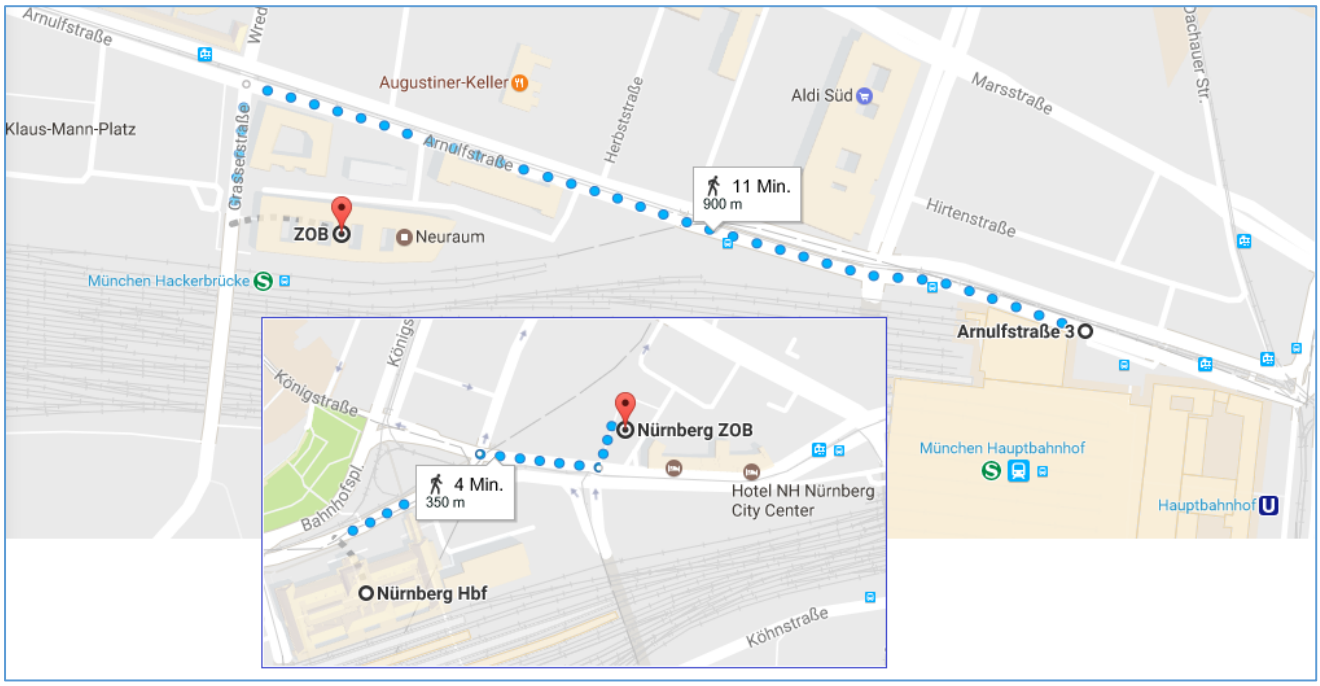


Figure 2: Accessibility of the Central Bus Stations in Munich and Nuremberg (source: maps.google.de)

Seasonal influences (daytimes, extended weekend, school holidays, Oktoberfest, …) were tangible in the Modules C and Modules D. How they were dealt with was described in the respective chapters C.6.1 and D.2.3.

Airport traffic was only considered indirectly. Even though the better part of LDBs connected Munich CBS and Nuremberg CBS without any intermediate stops, there was a certain number of other connections like "Munich CBS – Munich Fröttmaning – Nuremberg Airport" or "Munich CBS – Munich Fröttmaning – Munich Airport – Nuremberg CBS", and all kind of variations. The stations "Munich Fröttmaning" and Munich Airport were not at all part of the Master's thesis and neither was Nuremberg Airport. As a matter of fact, some slight inaccuracies occurred when surveying LTs and LDBs. On LTs, people travelling from Munich-Airport to Nuremberg or beyond, *were* part of the survey, whereas bus customers in this OD-pair were mainly not considered. They were supposed not to travel via Munich CBS but rather board the bus to Nuremberg directly at Munich Airport).

The datasets from the survey in Module D contained a lot of information. The evaluation and analysis of those data was only partially possible in the thesis. However, ideas and recommendations with regard to future other interesting analyses were given in the last Module E "Recommendation, Outlook and Conclusion".

The final conclusion eventually proposed pricing measures. Other recommendations referred to certain customer groups which should be focused in a certain way. This did not take into account the self-sufficiency of recommended prices/measures, since (entrepreneurial) cost structures were not part of the thesis.

B. MODULE B: THE LT AND LDB MARKET CONDITIONS (LINE-INDEPENDENT)

B.1. THE LDB MARKET

B.1.1. Situation before 2013

On 01 January 2013, modifications to the PBefG liberalized the market for domestic LDB transport and allowed operators to compete with rail services (Bundesministerium der Justiz 2012b).

Before, the Passenger Transport Act had prohibited companies from operating between destinations within the country that were already served by public transport. The law dated back to the 1930ies and had never been changed since. A new line was only approved if it provided substantial improvements over existing transport services, such as significantly shorter travel times or increased service coverage. Pricing was previously not a factor for approving LDB services.

All admitted LDB lines before 2013 were either exemptions for certain connections, or were lines from/to Berlin, which used to be subject to special treatment for historical reasons.

However, the Federal Administrative Court (Bundesverwaltungsgericht) ruled on 26 April 2010 that pricing can indeed be considered as substantial improvement within the meaning of § 13 (2) PBefG. Therefore, the Federal Cabinet (Bundeskabinett) decided on 03 August 2011 to change the Passenger Transport Act accordingly, allowing LDB services to compete freely in the market. The market was eventually opened on 01 January 2013. (Bundesministerium für Verkehr und digitale Infrastruktur 2016)

In 2012, the market shares of LDB services among all mobility offers only numbered 0.1% - with virtually all lines going to Berlin. Figure 3 shows the shares of the most important traffic carriers among person kilometers from 2012.

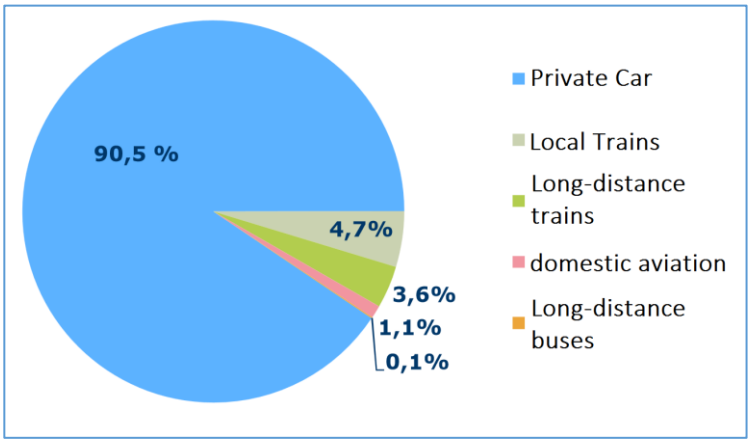


Figure 3: Modal shares on the domestic mobility market in 2012
Source: (IGES Institut 2013, p. 19)

Between 2013 and 2015, LDB operators have multiplied their passenger kilometer volumes by six (from 1.2 billion to 7.3 billion). Assuming constant levels for the other modes (confirmed by Statista GmbH (2016a)), the modal split of LDBs is still in the order of magnitude of ~1%.

B.1.2. Development after 2013

Even after the liberalization, the new version of the Passenger Transport Act still contained regulations. The reason was that LDT services are run self-economically, whereas LPuT / LTs are mostly publically subsidized by the German regions. Consequently, LDB services should not have any impact on publically (co-)funded LPuT/LT services. (Bundesministerium der Justiz 2012b)

In this context, it has to be pointed out that there are no other restrictions: buses can freely decide on origins, destinations, service standards, schedules etc. *on their own.*

This is a very important advantage of LDB operators over the LT sector.

For example, the distances between stops on long-distance bus routes must be at least 50km in order to protect LPuT/LTs. LDBs also cannot operate between destinations already served by passenger rail in less than one hour of travel time. Similar to the situation before 2013, exceptions can only be granted if there is inadequate transport supply or if the impacts to existing passenger transport services is marginal (Bundesministerium der Justiz 2012b)(see also definitions in chapter A.3). However, latter two arguments had little relevance in practice.

> *The 50km/ one-hour regulation was not only subject to complaints by LT operators in general, but also its enforceability has proven problematic: Even though it is not possible to purchase tickets for such short destinations, no one could prevent passengers to board/exit a bus on a closer station than they had actually booked. Indeed, the regulations have been undermined in such a way (Deutsche Bahn AG 2016h, p. 11)*

In reality, the thresholds of 50km/one-hour travel time only protect inner-city transportation, including suburban rail. However, depending on the line, the performance on certain LT lines has dropped as a consequence of LDB services: long lines with few stops on which most passengers travel mostly further than 50km / longer than one-hour. The Traffic Club Germany (VCD) estimated a 70 million EUR loss of annual turnover of the LT market due to LDBs. (Deutsche Bahn AG 2016h, p. 11) Nevertheless, the actual impact on LTs was strongly dependent from the line.

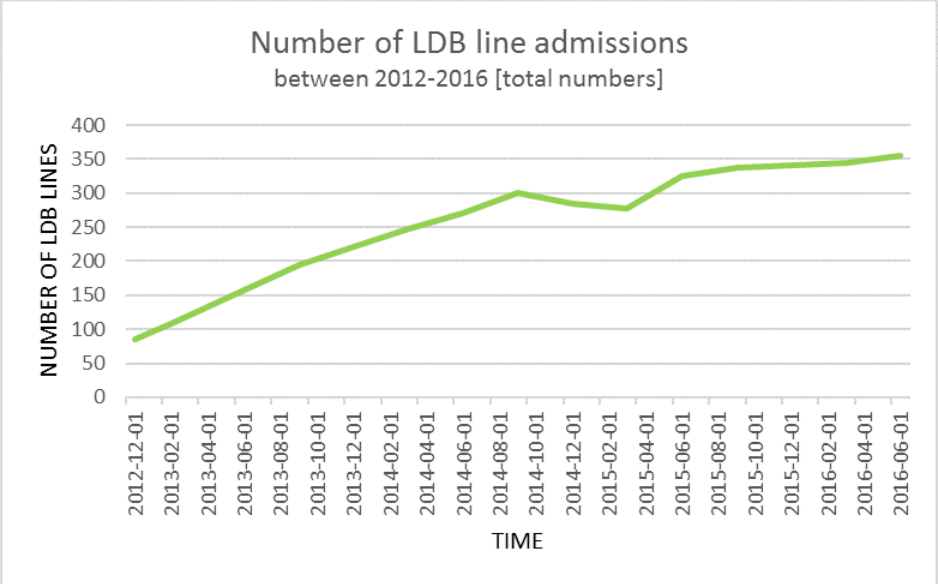


Figure 4: Development of LDB line admissions from between 2012 and 2016
Source: own graph based on: (Bundesministerium für Verkehr und digitale Infrastruktur 2016)

LTs are publically funded and complexly organized by the regions. Therefore, regional LPuT/LT administrations and operators are not able to quickly adapt tariff structures, contracts with the operators and revenue splitting

procedures. LT operators are thus in an unfavorable position: most of their contracts had been calculated and signed years before LDBs were liberalized. Consequently, the economic damage is noticeable, as the impact of LDBs had not been considered in the financial calculation of the subsidies. (Schulz 2016)

Since LDBs offer generally lower fares than rail passenger transportation, they have opened a competitive alternative.

B.1.2.1. The role of LDBs on the mobility market

The impacts of the liberalization were soon visible among the rising number of LDB services in Germany. According to a first evaluation of the Federal Ministry of Transport and Digital Infrastructure, there were 109 lines in February 2013. By the end of March 2014, there were already 247, with further increase to 355 by 30 June 2016 (see Figure 4). Before 2013, there were only 86 lines, most of which were serving Berlin.

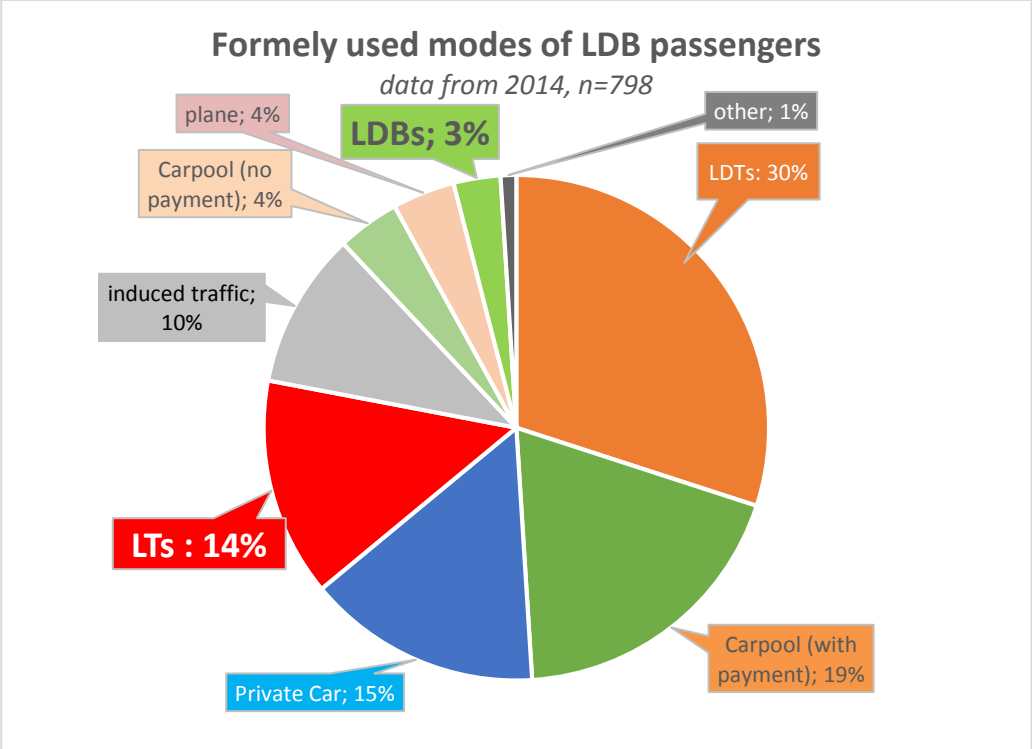


Figure 5: Formerly used modes of LDB passengers

Source: own graph based on (Statista 2014)

An examination of the IGES Institute for Mobility, Berlin, found out that LDB passengers had predominantly used LDTs prior to the market liberalization, followed by carpooling agencies and private cars. Also LTs have proven considerably affected. Figure 5 illustrates these passenger movements:

> *Other sources suggest slightly different numbers: e.g. LTs 12%, LDTs 22%, Private Car 13%. For the thesis, the exact numbers were not relevant because they are "only" average numbers and differ greatly from line to line. (Bundesarbeitsgemeinschaft der Aufgabenträger des SPNV 2016, p. 6). More other studies brought up similar values, too (exeo Strategic Consulting 2016).*

Regarding the age distribution, statisticians stated that about 60% of all LDB passengers are aged between 18 and 35 years. (Bundesarbeitsgemeinschaft der Aufgabenträger des SPNV 2016, p. 78)

Similarly concentrated values were also observed in the survey in Module D.

Figure 6 shows a graph about passenger kilometer volumes for both LDBs and LTs. In 2015, the traffic volume of LTs was about five times higher than for LDBs. The figure is only to illustrate the *order of magnitude* of the two markets since direct substitution of LTs by LDBs is seldom possible (e.g. suburban rail, connections to small cities). Other modes were not included in the graph.

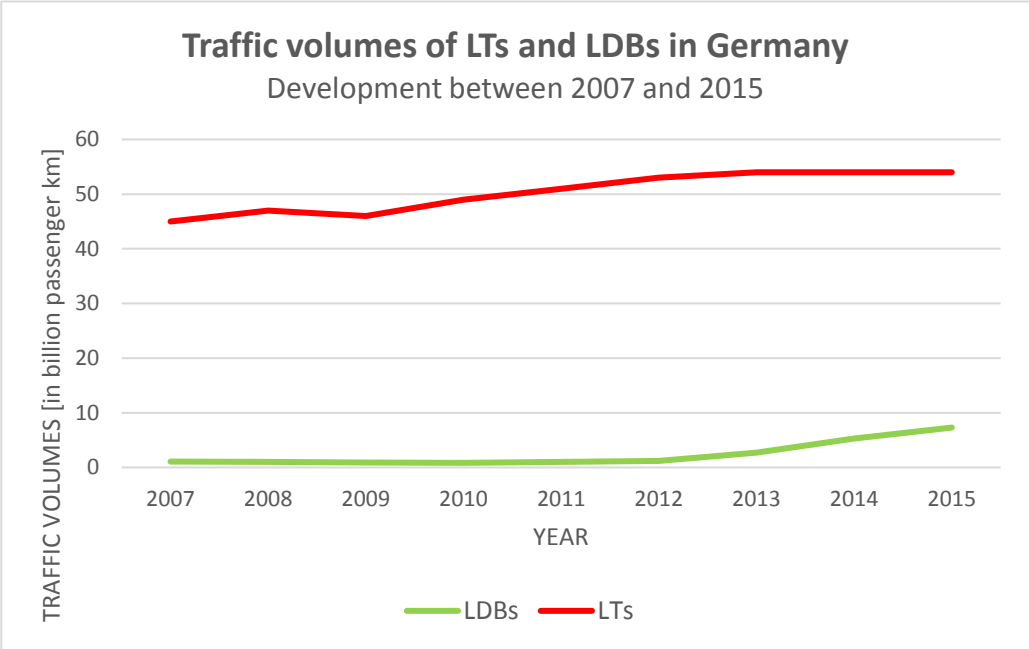


Figure 6: Traffic volumes development of LDBs and LTs from 2007 till 2015
Source: own figure based on (Statista 2015, 2016d)

Some interesting observations from Figure 6:

- *The performance of LT services has had a positive development until 2013 (and actually started back in the 1990ies). Since, the level has remained constant.*
- *In contrary, the rise of LDB services is still in progress, drawing a relatively constantly thriving development line*

Moreover, LDB services were involuntarily pushed by labor disputes at DB, as demonstrated in November 2014. Back then, train drivers organized the longest strike in DB's history. Shortly after the announcement of the four-day strike, the market leader MFB recorded five times more hits on the booking page than he would have expected under normal circumstances. (ARD Erstes Deutsches Fernsehen 2014)

B.1.2.2. The situation within the LDB market

In anticipation of the market liberalization, numerous companies stated their interest in participating in the new market. However, experts were astonished that the DB Group, as biggest mobility operator in Germany, was acting hesitantly. Also Postbus and its partner, the German General Automobile Club (ADAC), were not among the pioneer players on the market.

Consequently, the initial phase of the market was mainly shaped by three start-up enterprises: Flixbus, MeinFernbus and DeinBus.

The development of the market from 2013 till late 2016 is graphically shown in Figure 7.

Most LDB operators do not own buses themselves. They act as agents, maintaining webpages, booking systems and taking care of marketing activities. For the actual bus services, they have hired subcontractors. According to bus associations, the payment of those subcontractors has become increasingly competitive though. Consequently, many subcontractors have compromised the cooperation with the LDB operators. (Bayrischer Rundfunk 2016)

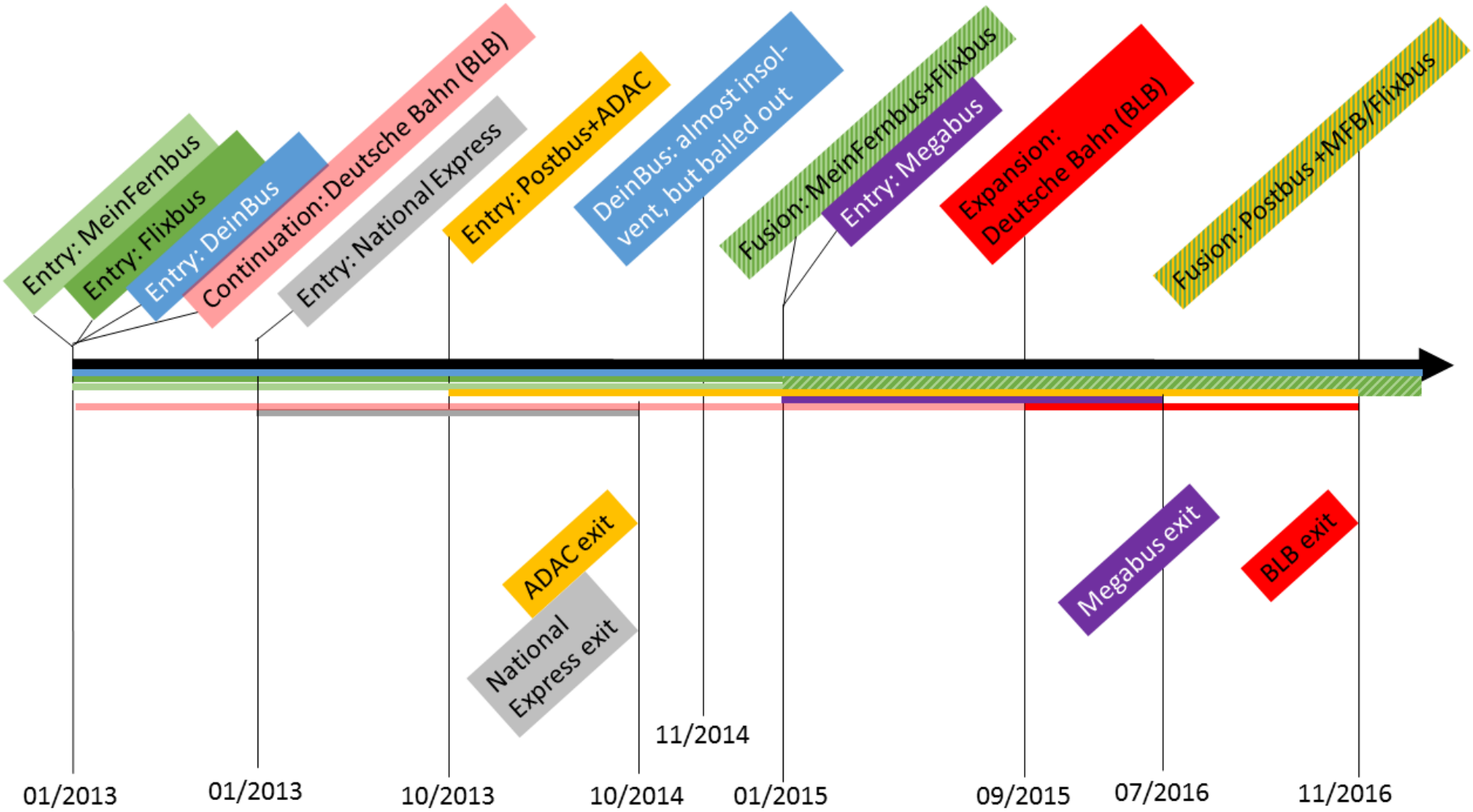


Figure 7: Graphical overview of the market development
(Frankfurter Allgemeine Zeitung GmbH 2013b), ManagerMagazin 2013), (Bundesamt für Güterverkehr 2015, p. 8),(ZEIT ONLINE GmbH 2016a), (Spiegel Online 2014)

Development of market shares

The development within the LDB market has proven volatile in the past years and was thus typical for the initial phase of a new market. Figure 8 compares the market shares between 2013 and 2016 for the most important market players.

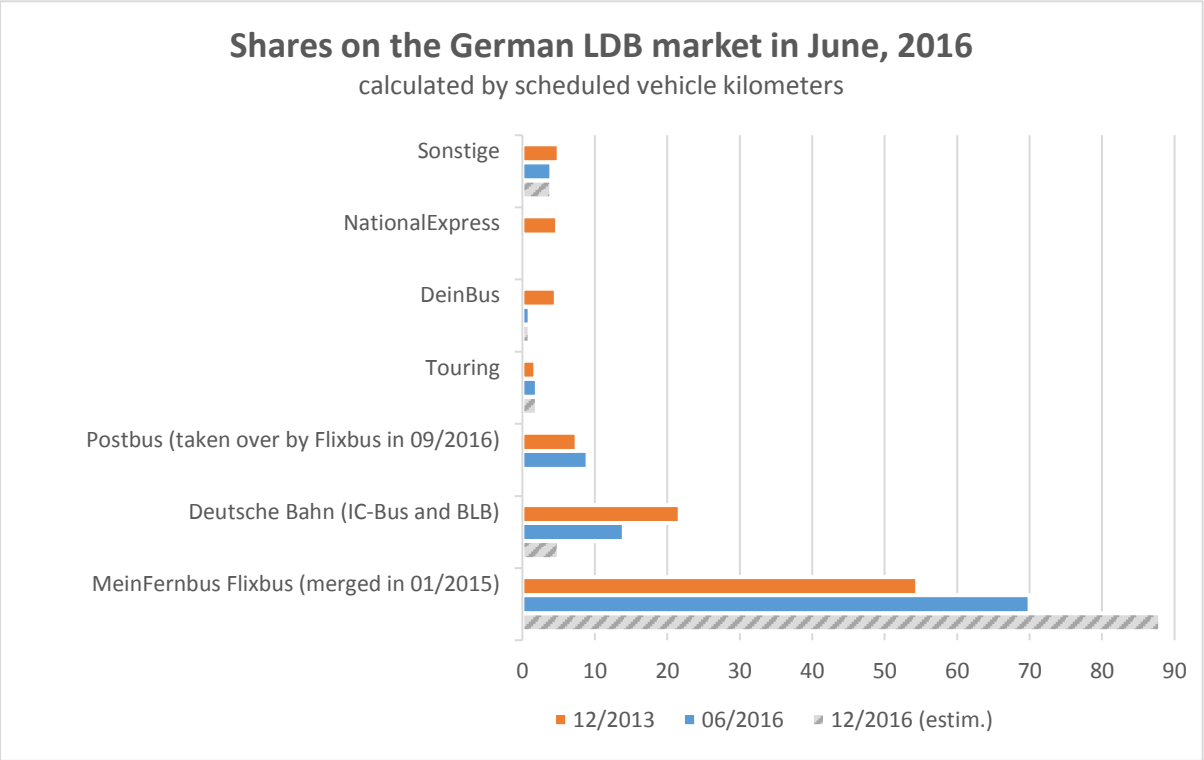


Figure 8: Market share developments on the LDB market from 2013 till late 2016
Source: own graph based on (Statista 2016b)

Although the verified data in Figure 8 only dates back to June 2016, the context has again changed fundamentally: Postbus was taken over and integrated into the MFB structures. In September, DB announced withdrawing its brand BLB from the domestic LDB market. The associated IC Bus brand of DB which operate international LDB connections was though not affected. Based on these developments, an estimation was added to the graph to Figure 8.

B.1.2.3. Expected future development

Virtually all players on the LDB market have tried to impose their position on their opponents with low fares. This so-called penetration price strategy is typical for the early stages of a new market: customers should be attracted by all means necessary. Since there were hardly any qualitative differences between the LDB operators, the market power struggles were fought on basis of the fares.

After the consolidation of the LDB market, experts and business analysts consented that price increases are overdue and can be expected soon. Since MFB has meanwhile succeeded in eliminating most of its competitors, there is space for such adaptions. (Die Zeit 2016c)

The low fares are often not profitable. After the withdrawal of all or most other players, the fares can be raised slowly. That is exactly the phenomenon which could be observed in September 2016, when LDB fares on the Munich-Nuremberg line were evaluated in Module C (see chapter

C.6). However, the penetration price strategy comes with an inherent danger that customers react sensitively to higher fares. (IFH Consultants GmbH 2016).

> *For today's market leader MFB, there were always several, fixed increments of fares which were partially based on the actual demand. However, for each city pair there was also a regular fare, which is also the maximum price. It could also be bought directly at the driver, as long there was still capacity on the bus. 15 minutes before a bus departed, the fare on the internet always surged to the normal price.*

A line-dependent analysis of LDB tickets was made in Module C, chapter C.6.

MFB has eventually managed to obtain a quasi-monopolist position on the market by the aid of several, financially strong investors: General Atlantic, Holtzbrinck Ventures und Daimler AG.

In December 2016, MFB announced the participation of an additional investor: Silver Lake, an enterprise from Silicon Valley with strong emphasis on technological improvements. With this step, MFB was then aiming at substantial improvements:

- Data mining of own traffic demand data in order to quickly adapt lines to the actual passenger needs.
- Further WiFi improvements
- Introduction of a so-called "Flix-University", i.e. an online learning tool for drivers
- Traceability of real-time bus positions in the frame of a program called "Where is my Bus"

(FlixMobility GmbH 2016d)

Despite expectable fare adaptions, LDBs are expected to remain an important pillar of public transport in Germany. Even though MFB has achieved a quasi-monopolist situation, there are potential new competitors waiting to enter the market. (Süddeutsche.de GmbH 2016b)

B.1.2.4. LDB operators

The decentral, unregulated organization of the LDB sector does not suggest a detailed line-independent description of LDB operators. Therefore, most contents with regard to the operators is contained in the line-dependent chapter C.3.

Ticketing / Pricing

Ticketing is highly dependent on the line. Next to distance, the expected and actual demand is decisive for price setting of LDB operators. These vague statements were explained more practically in the line-dependent analysis in the chapters C.3 and C.6.

Comfort

MFB tries to harmonize seat spacing independently from the bus type. Also WiFi connection quality should not vary from bus to bus. In late 2016, MFB was working on the implementation of LTE speed on all buses. (FlixMobility GmbH 2016b). For more information about comfort on LDBs refer to chapter C.3.

B.2. THE LT MARKET

Other than the LDB market, the LT administration is very complex with many parties to coordinate. A graphical overview was added to Attachment 1.

B.2.1. Situation before 1994

From WWII till 1994, all rail administration procedures were made by order of the authority "Deutsche Bundesbahn", which back then was in high deficit. In addition, when Germany was reunified in 1990, the financial conditions became even worse due to the poor economic condition of the East German counterpart "Deutsche Reichsbahn". Latter had operated a technically run-down rail network with giant personnel costs. Consequently, a huge restructuration of the whole rail sector was initiated in 1994.

The Federal Government decided to completely reorganize the all-German rail administration. In 1996, the organization and planning responsibility of LT transportation was transferred from the Federal level to the Regions (Bundesministerium der Justiz 1993b). With this measure, the reformation of rail administration, was consequently pursued and started a new era in LT transportation. (Deutsche Bahn AG 2016c)

B.2.2. Organization after 1994

B.2.2.1. Sector entities

On behalf of the regions, rail sector entities (in German "Aufgabenträger") have since been in charge of organizing and financing LT transport. In most cases LT operations are not feasible in a self-sufficient way. For that reason, bidding processes for smaller, coherent so-called part-networks (German: "Netze") were established. In these processes, all potential LT operators can take part in tendering and are chosen for various criteria, such as price, service level and other factors. The successful bidder receives public subsidies from the sector entity, and is exclusively in charge of operating a part-network for a time of mostly 10-15 years. By the end of 2016, 65 LT operating companies were actively involved in the German market, with DB still being the biggest. (Bayerische Eisenbahngesellschaft 2016b)

Another important overall target of all sector entities though is to provide a comprehensible tariff structure for passengers. (LNVG - Landesnahverkehrsgesellschaft Niedersachsen mbH 2016)

Depending on the region, the spatial responsibility can greatly differ from the surface of the region – for various, mostly historical reasons or local initiatives. The map in Figure 10 shows the spatial distribution of the 27 regional LT administration responsibilities throughout Germany.

Figure 10: Responsibilities of sector entities throughout Germany
Source: (Bundesarbeitsgemeinschaft der Aufgabenträger des SPNV)

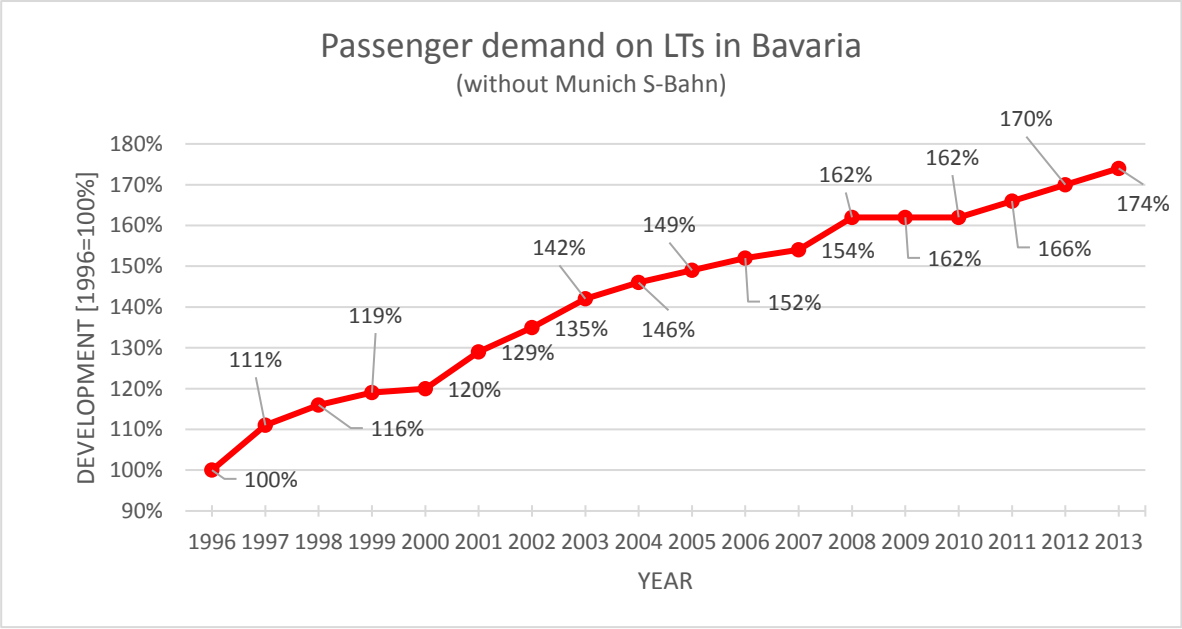


Figure 9: Development of passenger demand of LT lines in Bavaria
Source: own graph based on (Bayerische Eisenbahngesellschaft 2014)

Sector entities are financially equipped by the Federal Government for organizing LT transportation. However, the extent of LT funding varies from region to region, since the Federal means are mainly not sufficient for a "global" LT train service offer and are thus replenished by regional funds (Staatsministerium Baden-Württemberg 2014).

In general, the sector entities launch their tendering processes in one out of two predominant contract types:

- **NET COST CONTRACTS:** the actual LT operator can keep all ticket fare revenues. Consequently, the risk for the operator is higher, since he has to estimate the economic and passenger development for several years to come. If the expected revenue forecasts fail – for whatever reason – or do not develop as planned, it might cause tremendous problems for the operator.
- **GROSS COST CONTRACTS:** the sector entities are given all ticket fare revenues. The economic risk is thus taken away from the operator. However, one of the most important pivots for successful bidding is not available to them anymore. This may cause a bidding behavior that is mainly won by low personnel costs or economies of scale. Moreover, there is little motivation for the LT operator to improve passenger demand.

Depending on the sector entities, there is a wide mixture of net and gross cost contracts throughout Germany, with no clear favorite. Between the two contract types, mixed forms have developed, trying to unite the respective advantages. (ZVNL 2016)

Bavaria

As it can be seen in Figure 10, the situation in Bavaria is not as complicated as in other regions, where subsidies are administered by miscellaneous sector entities. Unlike other regions, there is only one sector entity for Bavaria: the so-called Bayerische Eisenbahngesellschaft (BEG). Its responsibility is widely identical to the surface of Bavaria.

As virtually all sector entities, BEG has managed to extend the LT service offer while reducing prices by (competitive) tendering (see Figure 9). After more than 20 years, these leverage effects are declining though, whereas infrastructure costs keep rising. The graph in Figure 11 explains the general cost-financing-structure of LT services in Bavaria. Until 2016, BEG has concluded net cost contracts only, without any exemptions so far. (Bayerische Eisenbahngesellschaft 2016a)

One of the main targets of the BEG is to provide attractive LT offers throughout Bavaria. The vision is to introduce a region-wide one-hour frequency on virtually all lines – with few exemptions only. The marketing and work title for this frequency was given the name "Bayern-Takt". Accompanying measures were made with regard to ticketing: The Bayern-Ticket (BT) offer was still one of the most well accepted tickets in Bavaria by the end of 2016 and was highly relevant in the survey (see Module D, the ticket was explained in chapter 0). In addition to pricing and offer designs, BEG has introduced several quality rankings and measurement tools, which themselves influence the subsidy payments from BEG to the LT operators. (Bayerische Eisenbahngesellschaft 2016b)

With the start and prosperity of LDBs, also BEG was indirectly confronted with the economic impacts the market opening had on LT operators. As described in chapter 0, many LT operators have started suffering from the LDB competition soon after the market was opened in 2013. Consequently, after first observations and collection of revenue data, the operators reported the disadvantageous situation to the BEG, asking for intervention. In this context, DB acted rather quietly compared to other operators. In particular, the private operator agilis, which is in charge

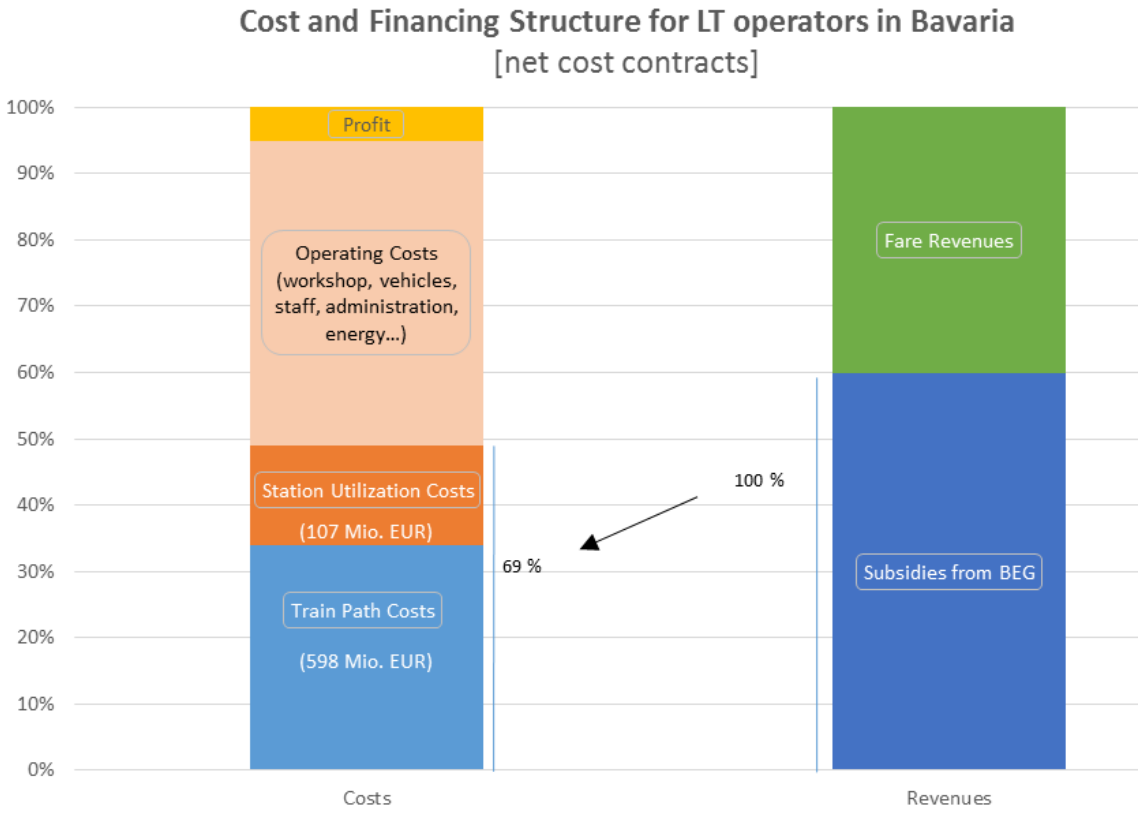


Figure 11: Financing structure of LT services in Bavaria
Source: own graph based on (Bayerische Eisenbahngesellschaft 2016a)

of LT operations for several lines around Regensburg and Bamberg, as well as for the line Regensburg – Ingolstadt – Donauwörth – Ulm, caused sensation with a press article. Therein, the CEO complained intensely about the LDB impacts, and blamed BEG for the unfair market conditions. In his opinion, BEG had to compensate losses by providing additional funds. According to the CEO, the LDB market liberalization was not at all foreseeable when the tendering process and contract awarding had taken place back in 2007. (Süddeutsche Zeitung [Online] 2016)

Interview at BEG publication restricted

B.2.2.2. Tariff unions

Tariff unions administrate and define ticket structures for a certain (metropolitan) scope, which in many cases encompasses a city and its catchment area. Since LPuT and LT services are often operated by different companies in those areas, such kind of administration is a prerequisite for operator-independent ticket structures. Within a tariff union, timetables are harmonized and tickets are mutually accepted among all operators. Figure 12 shows an overview of all tariff unions in Germany and illustrates the predominant small-scale organization.

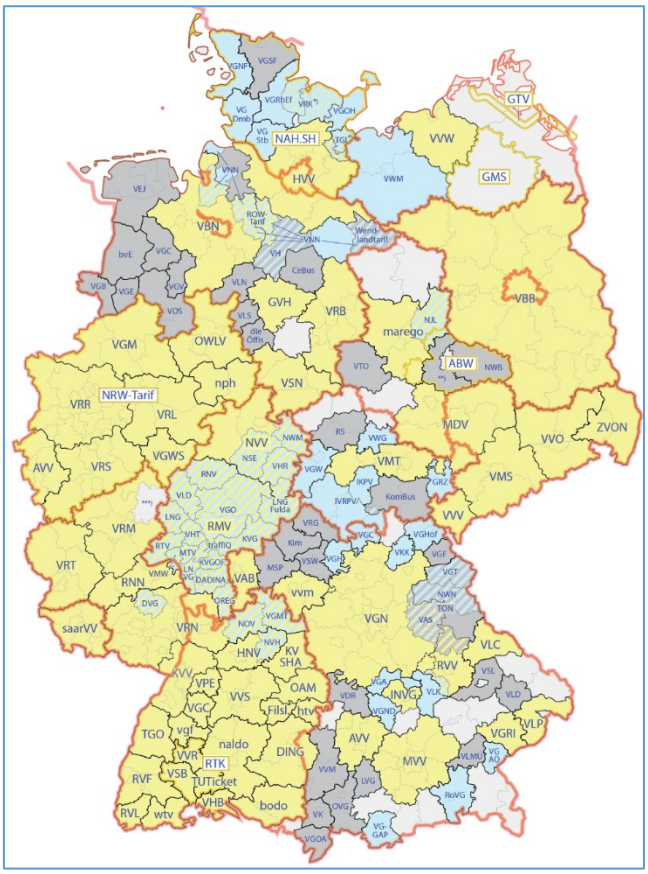


Figure 12: overview of tariff unions in Germany
Source: (Dörrbecker 2016)

A suitable example is the Munich Tariff and Transport Union (MVV), where the municipal transport company, the S-Bahn operator Deutsche Bahn and many other LT operators (Bayerische Oberlandbahn, Länderbahn with Alex-trains etc.) are administered. (MVV Münchner Verkehrs- und Tarifverbund GmbH 2013)

However, Tariff unions are often criticized for their extensive and complicated fare structures – also in Munich. (Süddeutsche.de GmbH 2016a)

In Bavaria, the most important Tariff unions are: MVV (Munich), VGN (Nuremberg), AVV (Augsburg) and RVV (Regensburg). (Bayerisches Staatsministerium des Innern, für Bau und Verkehr 2016)

Next to sector entities (chapter B.2.2.1), tariff unions play the most important and constraining role for operators - also for LT operators. However, these two institutional levels hinder the ability of the LT market to quickly react to new conditions. However, this statement is not meant to question the existence of sector entities and tariff unions.

B.2.2.3. LT operators

Until 2016, the number of LT operators in Bavaria has risen up to six different companies (Bayerische Eisenbahngesellschaft 2016c). This is a comparable small number to other regions given the big size of the Bavarian rail network.

Cost structures and restrictions

As LT operators are constraint by miscellaneous organizational influences described in chapters 2.1 to 2.3., there is not much space for entrepreneurial freedom: depending on the sector entity, the level of service is profoundly predefined. For example, the presence of conductors, cleaning intervals, loudspeaker announcements and other details are defined in the transportation

contract which is signed between the operator and the entity after a successful tendering process.

Therefore, the preconditions for winning such a procedure is mainly influenced by the following characteristics:

- **staff costs:** based on the collective wage agreement, private operators can usually offer cheaper operations
- **economies of scale:** here, the DB group is in an advantageous position. Rolling stock availability, know-how and overhead costs can be well handled for numerous transport contract areas.

As mentioned earlier, LT operators can seldom freely design their tariffs. However, it is easier when a ticket is only valid for *one* contractual area, say not for trains of other operators and beyond the scope of responsibility of tariff unions. This circumstance has led to niche tickets, which every operator can bring out itself. In this way, numerous different tickets were sold on the market – with negative impact on comprehensibility for customers and cost fairness. Two examples in Bavaria are the so-called GutenTagTicket (operator: Meridian for its area of operation in southern Bavaria) and the München-Nürnberg-Regio-Ticket (operator: DB Regio with MNx trains).

> *For LDT operators (where DB FV is virtually the only one), the conditions are completely different. They can act freely on the market without relying on sector entities. They seldom have to consider tariff unions, only for combined tickets. However, there are political influences on DB FV, e.g. for maintaining stops which should actually be cancelled from an economic point of view. This is possible because the DB Group is still entirely possessed by the Federal Republic of Germany and administered by the Ministry of Transport. Latter also applies for LT transportation.*

The traffic volume development on LT trains in Bavaria was already shown in an earlier chapter B.1.2.1, Figure 6.

Ticketing / Pricing

LT operators are restraint in their tariff structure design. The most important influence sources are tariff unions (for their harmonized tariff area, see chapter 0) and sector entities. The influence of latter strongly depends on the contract types, as well as on the individual organization and involvement of the respective sector entities.

Despite the regional organization of LT services there are numerous offers with regionwide or nationwide validity. Details on the following tickets are available in Table 1 below.

- **Regular fare ("Flexpreis"):** the normal price for a ticket. It is cheaper for LTs ("C-Preis") in comparison to LDTs (within the latter group there is a further distinction for IC/EC trains ("B-Preis") and ICE highspeed trains ("A-Preis")). The calculation basis is always the distance.

  > *Annotation: For the survey (Module D) these tickets were marked as EF ("Einzelfahrt" = single ticket). However, the EF tickets had little relevance during the survey.*

- **Special offer tickets ("Sparpreis"):** available only if the connection contains a LDT. It is also valid on LTs, in order to enable passengers to reach the LDT connection. Its availability is limited and mainly dependent on the (expected) demand. In some cases, such tickets are not valid on privately operated trains. The cheapest "Sparpreis" is on sale for 19 EUR and rises in different, relatively small increments for both 1st and 2nd class.

  However, for the survey on MNx trains (Module D) these tickets were hardly relevant as the Munich-Nuremberg line is directly served by LDTs and LTs. MNx trains from Munich to Nuremberg are therefore never part of a special offer LDT ticket.

- **Flat rate LT tickets with nationwide validity:** there are two tickets available:
  - **Schönes-Wochend-Ticket:** valid on the weekend without any temporal restraints (valid for one day).
  - **Quer-durchs-Land-Ticket:** similar to the weekend ticked mentioned above, but available for all weekdays.

  Both tickets were seldom seen during the survey.

- **Flat-rate regionwide / line-dependent LT tickets:** for a long time, most regions have offered certain tickets that are valid on all LTs and public transport within the region. However, most of these tickets have restraint validity after 9a.m. only and can be bought for up to five people.
  - For trips within Bavaria and to some border cities, the **BayernTicket** can be purchased. It also includes all kinds of LPuT transport (especially Munich, Nuremberg etc).

    This ticket was playing the biggest role during the survey.
  - For the Munich-Nuremberg line, the operator DB Regio introduced a **München-Nürnberg Regio Ticket** in 2015**.** It is slightly cheaper than the BayernTicket (20 EUR + 5 EUR) and is only valid on regional trains between Munich and Nuremberg (thus also *not* on public city transport).

  (Deutsche Bahn AG 2016f)

Studying in a German city mostly encompasses a semester ticket. Students can thus use all means of public transport within the administration area of the respective tariff union. Those tickets are also available for Munich and Nuremberg.

Table 1 below shows an overview about all tickets mentioned. For contextual reasons, the light blue marked ticket was included in anticipation of the line-dependent analysis in the Modules C and D

Ticket	Abbreviation in the survey (Module D)	**Base price [EUR]**	**Per additional passenger [EUR]**	**Limit [people per ticket]**	**Restraints**	**Area of validity, types of trains**
Single Ticket (compatible with BahnCard (BC) discount)	EF (+BC25 / +BC50)	Distance dependent	--	(paid per person)	None	Relation-based, available for LTs and LDTs
BayernTicket	BT	23	5	5	After 9.a.m. (except for weekend)	Within Bavaria, LTs and all LPuT / city transport
M-N Regio Ticket (MNT	MNT	20	5	5	After 9.a.m. (except for weekend)	Munich-Nuremberg only, LTs
Schönes-Wochenend-Ticket	SWT	40	4	5		Nationwide, LTs
Quer-Durchs-Land-Ticket	QDL	44	8	5	After 9.a.m. (except for weekend)	Nationwide, LTs
Disabled people	SBH	0	0	0	Special permission needed	Nationwide, LTs

Table 1: Overview of the most important LT tickets in Germany and Bavaria

- **BahnCard (BC) discounts:** a tried and tested offer from DB which dates back to the 1980ies. Even though the market environment has changed continuously, the discount rates 25%, 50% or 100% are still well-accepted among private operators, sector entities and tariff unions. The discount is not applicable to flat-rate offers (like BT etc.), but only to relation-based tickets. At the moment, the cost for the 2nd class of a…
  - BC25 is 62 EUR (adults) for adults and 41 EUR for retired people and handicapped persons. There are special reductions for students, as well as associated offers for this card.
  - BC50 is 255 EUR or 127 EUR (reduced). Young people (<28 yrs) only have to pay 69 EUR.

- BC100 is 4,090 EUR

A LDT single ticket with BC25 / BC50 encompasses a so-called city-ticket. It allows the usage of all LPuT modes in both origin and destination city.

(Deutsche Bahn AG 2016a)

Moreover, LT operators and state agencies agreed on special treatment of the following passenger groups:

- **Free transport for children 0-14 years:** children up to 6 years are always free of charge. Those aged up to 14 years can also travel for free if they are accompanied by either their parents or grandparents. For children travelling alone, a 50% reduced fare applies. (Deutsche Bahn AG 2016e)
- **Severely disabled people ticket** (in German "Schwerbehindertenausweis", SBH): Since 2011, this group has been allowed to travel free of charge on all LTs. Prerequisites are a degree of disability of 50% and the possession of a respective ID-card, which can be purchased for 80 EUR per year. Depending on the degree of disability, an accompanying person may travel for free as well. (Deutsche Bahn AG 2016b)

  During the survey, there was a relatively high number of SBH tickets. However, the overall share was still low.

Also additional items can be transported. Fees vary:

- **Bicycles** can be carried on the train, though capacity is limited by the number of parking spaces on the train. Bike tickets are available for 5 EUR (day pass).
- **Dogs** are allowed on trains, but have to be paid for. Guide dogs are exempted from this regulation. The fare for dogs is basically half of the ticket price. In case of flat-rate tickets, dogs are priced equally to adults.
- **Luggage** is not subject to additional pricing.

(Deutsche Bahn AG 2016i)

LT and LDT operations of course contain much more aspects and more detailed regulations than mentioned here. For this reason, the content reflected a selection of topics that were most important for both the competitive distinction between LTs and LDBs and the general understanding of the respective markets.

According to §12 AEG, LT operators must have their tickets approved before selling them. Depending on the ownership of the LT operators, the approving level in charge is either federal (for federally owned rail operators, i.e. DB) or regional (for all other rail operators). (Bundesministerium der Justiz 1993a) In some cases, tariffs were indeed denied.

Short annotation deleted due to confidential data

In practice, Bavarian LT fares have to be approved by the regional council ("Regierungspräsidium") at Darmstadt, as a consequence of multiple delegations. (Regierungspräsidium Darmstadt 2016)

Schedule design is the result of intense coordination. Eventually, they respective train paths have to be ordered at another DB company which is in charge of the network administration: DB Netz AG. Depending on the type of train path and the contract, lead-times of 6-12 months have to be considered. (DB Netz AG 2015a)

C. MODULE C: THE MUNICH-NUREMBERG LINE (LINE-DEPENDENT)

For better writing and understanding, the various mode and direction combinations were abbreviated as follows and were often used in both Modules C and D:

	Munich to Nuremberg	Nuremberg to Munich
On LTs	MN_LT	NM_LT
Combination	MNNM_LT	
On LDBs	MN_LDB	*not subject to examinations*

Table 2: Common abbreviations of directions used in Modules C and D

In addition, the term MNx is particularly relevant for the two Modules, too. It was used synonymous for "LT" in these two chapters. See chapter A.5.3 for the meaning / delineation of "MNx".

Where it was applicable, LDB data in diagrams were colored green and LT data red, based on the main brand colors of the respective predominant market leaders MFB and DB.

In addition, the station of Ingolstadt Central was sometimes relevant and therefore abbreviated as MIH (according to the DB internal name convention)

Targets of this module

Unlike Module B, this chapter was focused on the Munich-Nuremberg line, under consideration of the delimitations made in chapter A.5.3. Quantitative sizes were playing a bigger role in order to compare both traffic carriers.

Moreover, differences, strengths and weaknesses of both traffic carriers on the line (frequency, tariff structure etc.) were illustrated and explained.

One of the core parts of Module C was the evaluation of line-dependent LDB fare observations which were made between 28 August and 13 October. Its purpose was to understand the dynamics of the development of the fares on the line in order to find answers to questions like:

- To which extent are fares predefined by MFB (and BLB), respectively how big is the influence of the actual passenger demand?
- What is the fare development like with regard to daytime, events (e.g. Oktoberfest) and weekends?

Intermediate results were delivered by the end of the Module C in chapter C.7.

C.1. POPULATION ESTIMATION PUBLICATION RESTRICTED

LDB population

The approach for the passenger number estimation of LDBs was totally different, as no passenger counts were available. MFB denied any cooperation with regard to their passenger data.

> *The data available at MFB would have certainly been on a very good qualitative level, since all tickets reflect a certain destination and a lot of additional information which is automatically collected by MFB.*

It was consequently necessary to estimate the number of passengers in a different way, thus based on available public data:

- Average load factor of LDBs (59%), available for entire Germany only. The number was counterchecked with own values from the survey (55.45% @ 22 LDBs). Latter value was chosen.
- Average capacity of LDBs (60 seats). Depending on the destination, the Flixbus subcontractors operate different bus types, which capacity is ~60 seats on average (Mader, Uekötter 2015, 2015, p.8).

The target group to estimate was the number of people who were **likely to travel on MNx trains if they had chosen the train.** There was thus the necessity to distinguish two groups of LDB passengers:

- LDBs to northbound/southbound **destinations within Bavaria** were likely to carry virtually *only* potential MNx customers. This set included buses starting in Munich, with terminus at Nuremberg, Würzburg, Bayreuth, Bamberg and Erlangen. Since MFB had hardly any competition, other operators were neglected at this time. Also BLB had already ceased its involvement. All destinations of this segment were within reach of a train connection that included MNx trains. If people decided to take the train, they would have been offered a connection with MNx trains from Munich to Nuremberg (or vice versa).

The fact that some people would in reality choose other modes than LTs (LDTs, private car, carpool…) was recalculated based on the line-dependent result from the survey in Module D: 70% would have chosen the train on trips between Munich and the towns mentioned above.

- Those travelling along the Munich-Nuremberg line on *LDBs which were going to long-distance targets* were less likely to choose MNx if they had chosen the train. The better part of passengers would proceed to more distant destinations. For someone travelling from Munich to Nuremberg, it was though not important whether a bus would continue to a long-distant location after she/he has left the bus.
  Based on the capacity-load factor framework introduced earlier in this chapter, these LDB lines were treated separately: intermediate stops within Bavaria were rated on the basis of their inhabitant numbers.

Eventually, this approximation resulted in the following numbers:

	Nr of LDBs affected	**Nr of passengers per year**
From MN_LDB (long-distant destination)	6,692 LDBs per year	42,498
From MN_LDB (Inner-Bavarian destinations)	1,456 LDBs per year	48,441
	Σ	90,939
Result for MN_LDB (equal to NM_LDB)	~71% potential train passengers (value from the survey)	**64,180 people**

Table 3: Calculated populations for MN_LDB

The calculation was done for MN_LDB only. Other than for LTs, there was no line-dependent data available. Consequently, the number would be estimated equal for the other direction.

The order of magnitude seemed realistic since in combination with the monetary loss calculated by Mader, Uekötter (2015), p. 8, the average substituted ticket fare would be 16.37EUR. Given the fare structures and similar examinations in the survey data (see chapter D.4.3.1; e.g. average fare per person Munich-Nuremberg = 13.80EUR) and chapter D.4.3.3 (theoretical willingness-to-pay), the figure is comprehensible.

C.2. LT OPERATOR: DB REGIO WITH MNX

As mentioned in earlier chapters, internal examinations of DB Regio found out that the Munich-Nuremberg line was the most affected LT line of LDB activities in Bavaria. The calculation was done based on the number of LDB services on the line per weekday, the average load factor and the mean seat capacity. Eventually, there was a separation of turnover between LDTs and LTs which was based on statistical data too. It was furtherly adjusted in case of other parallel operators on a line.

The result was a ranking of all 12 part-networks operated by DB Regio in Bavaria. The first three ranks are listed below. (Mader, Uekötter 2015, p. 8)

1.				
2.				
3.				

Table 4: Estimation of cannibalization potentials of LDBs for Bavarian LT lines ***publication restricted***

Source: (Mader, Uekötter 2015)

The highlighted figure in red color was the crucial number and suggested that Munich-Nuremberg was strongly affected by parallel LDB services.

The following subchapters were designed to give an introduction to this line from the LT operator's perspective.

C.2.1. Schedule

The schedule for MNx trains was designed in a two-hour-frequency. Having in mind that the sector entity actually aims at a consistent hourly frequency on every line in Bavaria (Bayern-Takt), MNx is exceptional. There have been two main reasons for this divergence:

- The MNx trains operate on a high-speed line between Ingolstadt and Nuremberg. The use of this line is permitted with special rolling stock only. Currently, there is a lack of suitable vehicles, which sometimes causes inconvenient transfers at MIH.
- The high-speed line is subject to relatively high train path costs, as the infrastructure maintenance is particularly effortful. The company in charge of administering the infrastructure, DB Netz AG, set a price of 9.74 EUR per km, per train (category Fplus).

  Some additional information for better comparability: the next lower category F1, on which trains can operate with up to 230km/h (e.g. Hamburg-Berlin) costs 4.97 EUR, the cheapest secondary line (cat. F6) is 2.94 EUR)

(DB Netz AG 2015b)

Since the line is generally well accepted among passengers, the two-hour frequency is though replenished during hours of high passenger demand.

Other noticeable advantageous facts are the departure times in the morning: for both directions, there are trains shortly after 9a.m. This was relevant because the validity of the most commonly used ticket, BT, starts at 9a.m. sharp (except for weekends, see chapter 0).

A very high share of this ticket among MNx passengers travelling all the way between Munich and Nuremberg was observed during the survey (Module D).

Table 5 and Table 6 list all MNx trains with regard to the days of operation. Next to the LDB schedules (see Table 8), the LT schedules was the primary source for the figures later in Module C.

MN_LT					
TRAIN NR.	DEPARTURE	ARRIVAL	DURATION	DAYS OF OPERATION	PARTICULARITIES
4002	04:55	06:35	01:40	Mon-Fri	
4004	05:22	06:52	01:30	Sat	
4006	06:05	07:48	01:43	Sun	
4010	07:05	08:48	01:43	Mon-Sat	
4890 | 4012	09:01	10:48	01:47	Mon-Fri	Transfer at MIH
4012	09:06	10:48	01:42	Sat-Sun	
4016	10:06	11:48	01:42	Sat	
4018	11:05	12:48	01:43	daily	
4022	13:05	14:50	01:45	daily	
4026	14:02	15:48	01:46	Sat-Sun	
4892 | 4026	14:00	15:48	01:48	Fri	Transfer at MIH
4030	15:04	16:48	01:44	Mon-Fri	
59692 | 4030	15:00	16:48	01:48	Sat-Sun	Transfer at MIH
4034	16:00	17:51	01:51	Sat-Sun	
4894 | 4034	16:00	17:51	01:51	Mon-Fri	Transfer at MIH
4038	17:12	18:51	01:39	Mon-Fri	
4896 | 4038	16:58	18:51	01:53	Sat-Sun	Transfer at MIH
4040	18:06	19:48	01:42	Sat-Sun	
4042	19:09	20:48	01:39	Mon-Fri	
59696 | 4042	19:00	20:48	01:48	Sat-Sun	Transfer at MIH
4046	21:09	22:39	01:30	Fri-Sun	
59108 | 4048	21:29	23:09	01:40	Mon-Thu	Transfer at MIH

Table 5: MN_LT: schedule of MNx trains

Source: (Deutsche Bahn AG 2016g)

NM_LT					
TRAIN NR.	DEPARTURE	ARRIVAL	DURATION	DAYS OF OPERATION	PARTICULARITIES
4001	05:10	06:45	01:35	Mon-Fri	
4003 | 4891	06:07	07:57	01:50	Mon-Fri	Transfer at MIH
4005	06:32	08:04	01:32	Sat-Sun	
4007	07:32	09:00	01:28	Mon-Fri	
4009	08:10	09:54	01:44	Sat	
4011	09:10	10:55	01:45	Sat-Sun	
4011 | 4893	09:10	11:00	01:50	Mon-Fri	Transfer at MIH
4013	11:10	12:57	01:47	Mon-Fri	
4015	11:10	13:01	01:51	Sat-Sun	
4019	12:10	13:53	01:43	Sat	
4021	13:10	14:53	01:43	Mon-Fri	
4021 | 59689	13:10	15:00	01:50	Sat-Sun	Transfer at MIH
4025 | 4895	14:11	16:01	01:50	Fri	Transfer at MIH
4027	15:10	16:54	01:44	Mon-Fri	
4027 | 59691	15:10	16:58	01:48	Sat-Sun	Transfer at MIH

NM_LT					
TRAIN NR.	DEPARTURE	ARRIVAL	DURATION	DAYS OF OPERATION	PARTICULARITIES
4029	16:10	17:54	01:44	daily	Fri as train Nr 4031
4033	17:10	18:58	01:48	Mon-Fri	
4033 | 59693	17:10	19:02	01:52	Sat-Sun	Transfer at MIH
4037	18:10	19:53	01:43	Sat-Sun	
4039	19:10	20:57	01:47	Mon-Fri	
4039 | 59699	19:10	21:01	01:51	Sat-Sun	Transfer at MIH
4043	21:10	22:56	01:46	Fri-Sun	
4045 | 59163	21:40	23:36	01:56	Mon-Thu	Transfer at MIH
4047	23:40	01:22	01:42	Fri-Sat (depart)	

Table 6: NM_LT: schedule of MNx trains

Source: (Deutsche Bahn AG 2016g)

Most MNx trains could actually shorten their travel times. However, there are ICE trains which schedules are designed in a way that they overtake MNx trains at MIH station.

C.2.2. Vehicles in operation

When the MNx concept was launched on 10 December 2006, the trainsets were not built of regular LT wagons. Using the new high-speed line from Nuremberg to Ingolstadt, the trains have to fulfill particular requirements such as signaling system compatibility and pressure-proof doors and windows in tunnels. (Feldwisch, Schülke 2006) The only such trains available in 2006 were LDT trains in possession of DB FV. The company agreed to lease out some of their LDT cars to DB Regio. However, uncertainties with regard to the contractual future, as well as with trainsets available on the market have led to further utilization of the old cars, which will last until 2018.

Another argument for new trains were capacity problems that have occurred over time due to high passenger demand. Table 7 shows the current situation in comparison with the future vehicle concept.

	Nr of trains available	**V_{max}**	**Capacity per train** 2nd cl. | 1st cl. | bikes	**Other features**	**Nr of wagons per train**
2006-2018	3	200 km/h	395 | 18 | 16* 284 | 18 | 16*	Occasional plugs	2x 6 1x 4
After 2018	6	189 km/h**	679 | 26 | 37	Plug for each seat Double-deck trains	6
	*) 2nd class: 395 seats (6-wagon train), 284 seats (4-wagon train) **) the odd number is caused by stricter regulations that apply with 190km/h or more (TEIV)				

Table 7: Current and future vehicle concepts of MNx LTs

Sources: (DB Regio AG 2013), (DB Regio AG 2016a), (DB Regio AG 2016b)

The new contract between BEG and DB was designed in a way that an hourly frequency for the entire line could be easily implemented after 2018. However, it is only an optional position over the defined 2-hour frequency.

New double-floor vehicles of the Czech manufacturer Škoda will replace the current trains by the end of 2018. The trip duration will remain at today's level (about 1:40 hours). The extended bike transportation capacity is though urgent for leisure traffic to the Altmühl valley (Kinding station), rather than for passengers from Munich to Nuremberg (or vice versa).

After 2018, all currently necessary transfers at MIH will become obsolete (see chapter C.2.1) (Heinrich 2016).

As the new trains will improve plug availability, this feature was not focused in the survey in context of qualitative distinction between LTs and LDBs (see chapter C.5.2).

Figure 13: Excerpt from Skoda's design brochure of MNx trains Source: (Skoda Transportation 2014)

The renewal of the trainsets comes also with a traction change: the currently used 101 locomotive series (built 1996-1999) will be replaced by the new series 102, also manufactured by Škoda. Even though the maximum speed of the 102 series is lower than before, it does not influence travel times. The maximum speed is hardly achieved anyway due to the rather short distances between the stations. In addition, the train path design does not require higher speeds either.

C.2.3. Passenger number development 2007-2016

Generally spoken, the passenger numbers of MNx have seen a very positive development since the train has started operating in 2006. In the first three years, the annual passenger number surged by more than a million passengers. During the subsequent years, the growth was still positive, though less steep, with an almost constant phase between 2010 and 2011. The actual decline of passenger numbers then started in 2013, when the LDB market was liberalized. However, there were also other effects:

- Timetable adaptions in 2013 caused a higher share of connections in which passengers had to change at Ingolstadt Central Station
- More other, relatively fast LTs between Munich and Ingolstadt reduced the pressure on MNx trains, but were not part of the counting.
- Construction works between Munich and Ingolstadt caused passenger shifts from other LTs. When the construction works were finished in 2015, most passengers conjecturally shifted back again. (Heinrich 2016)

Future development

In the Interview at the sector entity BEG on 31 October 2016, Mr. Schulz seemed optimistic that MNx trains would operate in a one-hour frequency with the new rolling stock. The main reason is that due to a new train path pricing system, train path prices will drop from 14EUR per km to 5EUR per km. BEG will then look whether hourly train connections are affordable. From today's point of view, it seems realistic. The frequency improvement appears to be sensible, as the load factors of MNx trains are considerably big. Nevertheless, BEG will have to pay more for other lines as a consequence of the new pricing system. (Schulz 2016)

Figure 14: Development of passenger numbers on MNx trains 2007-2016
publication restricted
Source: (Uekötter 2016)

C.3. LDB OPERATORS: BLB AND FLIXBUS/MEINFERNBUS

As highlighted in chapter B.1.2.2, only few operators have succeeded to remain on the LDB market by the end of 2016. For the Munich-Nuremberg line, MFB is now a quasi-monopolist. DeinBus, the only player with an at least remarkable, though low one-digit market share percentage, does neither serve this connection nor any other related route. (DeinBus 2016) Another operator, Deutsche Touring, is focused on international transport and thus irrelevant for Munich-Nuremberg, too.

Table 8 shows the schedules for all LDB trips from Munich to Nuremberg (and back accordingly). Also other Inner-Bavarian destinations are included, which would encompass a MNx train connection (bold letters). In this context, it is important to mention that the timetable design of LDBs is subject to continuous changes and can therefore be outdated weeks or months later. However, the general framework can be assumed to persist, as frequencies are based on the demand (for detailed evidence see C.6.2), which is not supposed to change substantially.

MN_LDB						
OPERATOR	LINE	DEPARTURE	ARRIVAL	DURATION	DAYS OF OPERATION	FROM MUNICH TO [OR FROM]
MFB/FB	129	06:55	09:05	2:10	Thu-Sun	**Bayreuth** – Leipzig - Hamburg
MFB/FB	028	07:10	09:40	2:30	Tue, Thu-Sun	**Würzburg** – Frankfurt - Bochum
MFB/FB	121	08:00	10:10	2:10	Mon, Thu	Chemnitz – Dresden
MFB/FB	121	08:30	10:50	2:20	Tue, Wed	Chemnitz – Dresden
MFB/FB	121	08:30	10:40	2:10	Fri, Sun	Chemnitz – Dresden
MFB/FB	087	08:55	11:05	2:10	Fri, Sat, Sun	Kassel – Paderborn – Hamburg
MFB/FB	029	09:00	11:10	2:10	Daily	Jena – Hamburg
MFB/FB	128	09:05	11:15	2:10	Tue, Wed, Thu, Sun	**Würzburg** – Frankfurt - Aachen

MN_LDB						
OPERATOR	**LINE**	**DEPARTURE**	**ARRIVAL**	**DURATION**	**DAYS OF OPERATION**	**FROM MUNICH TO [OR FROM]**
MFB/FB	005	09:10	11:20	2:10	Thu-Sun	Fulda – Hannover – Hamburg
MFB/FB	128	09:15	11:15	2:00	Mon, Fri, Sat	**Würzburg** – Frankfurt - Aachen
MFB/FB	037	09:15	11:30	2:15	Mon, Wed, Thu, Fri, Sat	**Würzburg** – Gießen – Duisburg
MFB/FB	087	09:55	12:05	2:10	Mon	Kassel – Paderborn – Hamburg
MFB/FB	028	10:45	12:55	2:10	Fri	**Würzburg** – Frankfurt – Bochum
MFB/FB	028	10:45	12:55	2:10	Mon, Thu, Sat	**Würzburg** – Frankfurt – Bochum
MFB/FB	186	10:50	13:35	2:45	Tue, Wed, Sun	**Erlangen – Bamberg**
MFB/FB	037	11:15	13:30	2:15	Sun	**Würzburg** – Gießen – Duisburg
MFB/FB	205	11:30	13:40	2:10	Mon, Tue, Fri- Sun	Leipzig – Braunschweig
MFB/FB	028	12:45	14:55	2:10	Daily	**Würzburg** – Frankfurt – Bochum
MFB/FB	186	12:50	15:35	2:45	Mon, Thu, Sat	**Erlangen – Bamberg**
MFB/FB	029	13:35	15:45	2:10	Daily	Jena – Hamburg
MFB/FB	121	14:00	16:10	2:10	Sat	Chemnitz – Dresden
MFB/FB	186	14:50	17:50	3:00	Tue, Wed, Fri	**Erlangen – Bamberg**
MFB/FB	028	15:00	17:10	2:10	Tue, Sun	Würzburg – Frankfurt – Bochum
MFB/FB	121	15:00	17:10	2:10	Mon	Chemnitz – Dresden
MFB/FB	028	15:00	17:10	2:10	Mon, Fri, Sat	**Würzburg** – Frankfurt – Bochum
MFB/FB	028	15:30	17:40	2:10	Wed, Thu	**Würzburg** – Frankfurt – Bochum
MFB/FB	121	15:30	17:40	2:10	Sun	Chemnitz – Dresden
MFB/FB	121	16:30	18:40	2:10	Thu, Fri	Chemnitz – Dresden
MFB/FB	028	16:30	18:40	2:10	Sun	**Würzburg** – Frankfurt – Bochum
MFB/FB	186	16:50	19:35	2:45	Sun	**Erlangen – Bamberg**
MFB/FB	028	17:15	19:25	2:10	Mon, Thu- Sat	**Würzburg** – Frankfurt – Bochum
MFB/FB	028	17:15	19:25	2:10	Tue	**Würzburg** – Frankfurt – Bochum
MFB/FB	121	17:30	19:40	2:10	Sun	Chemnitz – Dresden
MFB/FB	028	18:00	20:10	2:10	Sun	Würzburg – Frankfurt – Bochum
MFB/FB	186	18:35	21:35	3:00	Mon, Thu, Fri	**Erlangen – Bamberg**
MFB/FB	186	18:50	21:35	2:45	Sat	**Erlangen – Bamberg**
MFB/FB	006	19:30	21:35	2:05	Thu, Fri, Sun	[Zürich] – **Bayreuth** - Berlin
MFB/FB	186	21:00	23:45	2:45	Sun	**Erlangen – Bamberg**
MFB/FB	N05	21:45	23:50	2:05	Daily	Fulda – Hannover – Hamburg
MFB/FB	N40	22:15	00:20	2:05	Daily	[Innsbruck] – **Bayreuth** – Berlin
MFB/FB	N87	22:30	01:20	2:50	Daily	Kassel – Paderborn – Hamburg

Table 8: MN_LDB: schedule of MFB buses

Source: (FlixMobility GmbH 2016c)

The departure structure was illustrated in Figure 19 (MN) and Figure 20 (NM) in order to provide a comprehensible graphical comparison between LTs and LDBs.

All general line-*independent* information with regard to pricing and fare structures was arranged in chapter B.2.2.3.

Vehicles in use

MFB does not operate buses itself, but only relies on medium-sized bus partners throughout Germany. It was thus virtually impossible to narrow down the bus types operating on the

Munich-Nuremberg line. In general, most LDBs are manufactured by Setra, Neoplan, Irisbus, MAN or Scania. The average number of seats is 60. (Mader, Uekötter 2015)

Passenger number development

The attempt to obtain official data about passenger numbers from MFB was not successful. The answers from MFB and BLB denied any cooperation. (see Emails in Attachment 8)

C.4. Central Bus Stations in Munich and Nuremberg

As already mentioned in chapter A.5.3, both cities Munich and Nuremberg have public CBSs. They are located in direct vicinity of the respective Central Train Stations. Approximate distances are:

- Munich: 900m foot walk, or 1 stop on suburban rail / 2 on tram
- Nuremberg: 350m foot walk

However, the station administration of the two CBSs is totally different:

Munich

Figure 16 shows a CAD view of the CBS building seen from southeast.

The CBS was inaugurated in September 2009, so more than three years before the LDB bus market was opened. It is privately owned by WealthCap, an investment company in possession of the HVB Bank, part of the Italian UniCredit Bank. Being a financial company, WealthCap does not operate the CBS itself, but has licensed another company: Rot Kreuz Betriebe (Red Cross Operations). The involvement of Rot Kreuz was surprising, as it is actually a basic pillar organization of the German health care system.

This operator was also asked prior to beginning the survey at the CBS and agreed.

The building was designed following the example of an airport. There are 29 terminals, all equipped with screen indicators for better administration and orientation of both bus drivers and passengers. There are moreover employees of the LDB operators (i.e. MFB) all over the place in order to assist people in finding their buses. These were also the most important (positive) differences compared to the CBS Nuremberg.

The CBS does not only consist of the bus bays, but also includes numerous shops and a couple of restaurants, as well as a supermarket and ticket agencies of practically all LDB operators that are active in Munich. On the bus level, there is also a waiting room for passengers. (Landeshauptstadt München 2014; Wealth Management Capital Holding GmbH 2016; Bayrisches Rotes Kreuz KV München 2013)

While doing the survey, pictures of the station were taken (see Attachment 6).

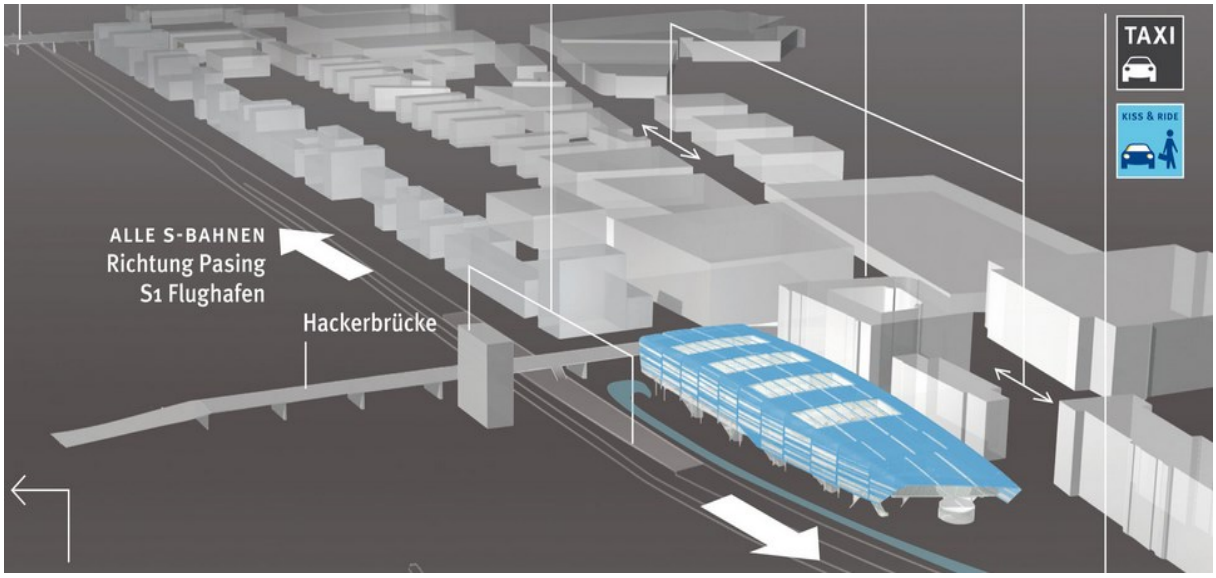


Figure 15: The Central Bus Station in Munich and its LPuT connections
Source: (Bayrisches Rotes Kreuz KV München 2013)

Nuremberg

Since the initial plan was to carry out the survey at the CBS Nuremberg, it was visited in combination with a pre-test on 8 August 2016. Already this first visit revealed that it would not be sensible to carry out a survey here. The reasons were explained in chapter D.2.2.

The main difference to the CBS in Munich is that there is no information available: neither signage nor screens help passengers to find their way to the bus. When a bus was arriving, the driver looked out for free bus bay and occupied it. The only signs at the site are to numerate the bus bays (numbers 1-9). With the exception of some single stores, like a Kebab stall and a MFB ticket shop, there are no possibilities to buy food or to warm oneself on a cold day. The architectural structures however allow people to stay dry in case of a rain shower.

Especially for passengers the situation at the CBS is unfavorable. They always have to lurk for the entering buses and check on the destination indicators in the front window. Doing the pre-test, the conditions of the CBS were subject to several complaints. Eventually, the described frame made the pretest at the CBS end unsuccessfully.

The CBS is surveilled by security staff, which is organized in a municipal group called “NOA kommunal”. Next to single MFB agents, these were the only officials at the CBS.

Together with the pre-test, pictures were also taken at the CBS Nuremberg. They date back to 8 August 2016 and are part of the Attachment 6.

C.5. Comparison of MFB/BLB and MNx

C.5.1. Quantitative characteristics

Figure 17 shows a comparison between LT and LDB fares for trips from Munich to Nuremberg. The y-axis labeled the most common trip duration for each carrier. For better comparability, LDTs were included with dotted lines too.

The fare system of MFB appears to be thoroughly calibrated without only relying on demand (yield-pricing) and distance. The maximum fare was still (slightly) below the cheapest one-person LT ticket.

> *Short digression on LDT operations on the line: the trip duration of LDTs from Munich to Nuremberg is mostly about 1 hour, with a high frequency of usually two trains per hour. About every 2nd LDT has a stop at Ingolstadt Central. The regular 2nd class fare is 55 EUR, while special offers are available for at least 19 EUR, or even 14.25 EUR (!) with a BC25 discount. All LDT fare types are also contained in Figure 17. (Deutsche Bahn AG 2016g)*

Having a look at the fares to other destinations which were relevant for the LT connections, some cases became particularly prominent (see Figure 18). The white dotted line represents the quotient of "trip duration by LTs" and "trip duration by LDTs". If the number is <1, the LT connection is faster than the LDB connection – which was true for most destinations.

The two subsequent diagrams (Figure 19 and Figure 20) illustrate the departures per mode and per day. As Sundays were the busiest days for LDBs and the number of LT services were almost constant over the week, the graphs represent operations from Munich to Nuremberg (and back accordingly) with regard to the daytime (x-axis) and trip duration (y-axis).

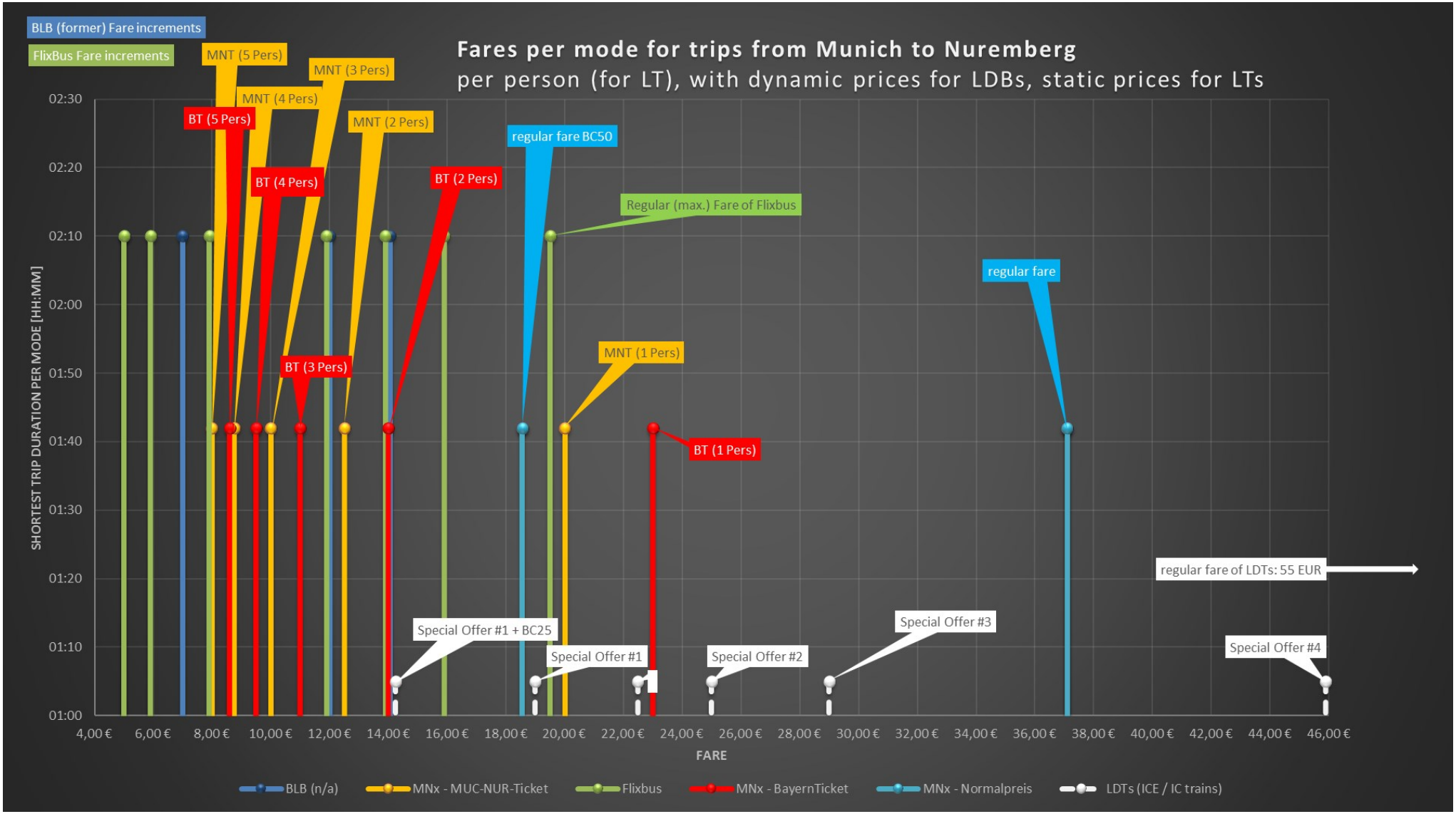


Figure 16: Fare overview for LTs and LDBs for trips Munich-Nuremberg

own figure based on (MFB MeinFernbus GmbH 2016b; BerlinLinienBus GmbH 2016; Deutsche Bahn AG 2016f)

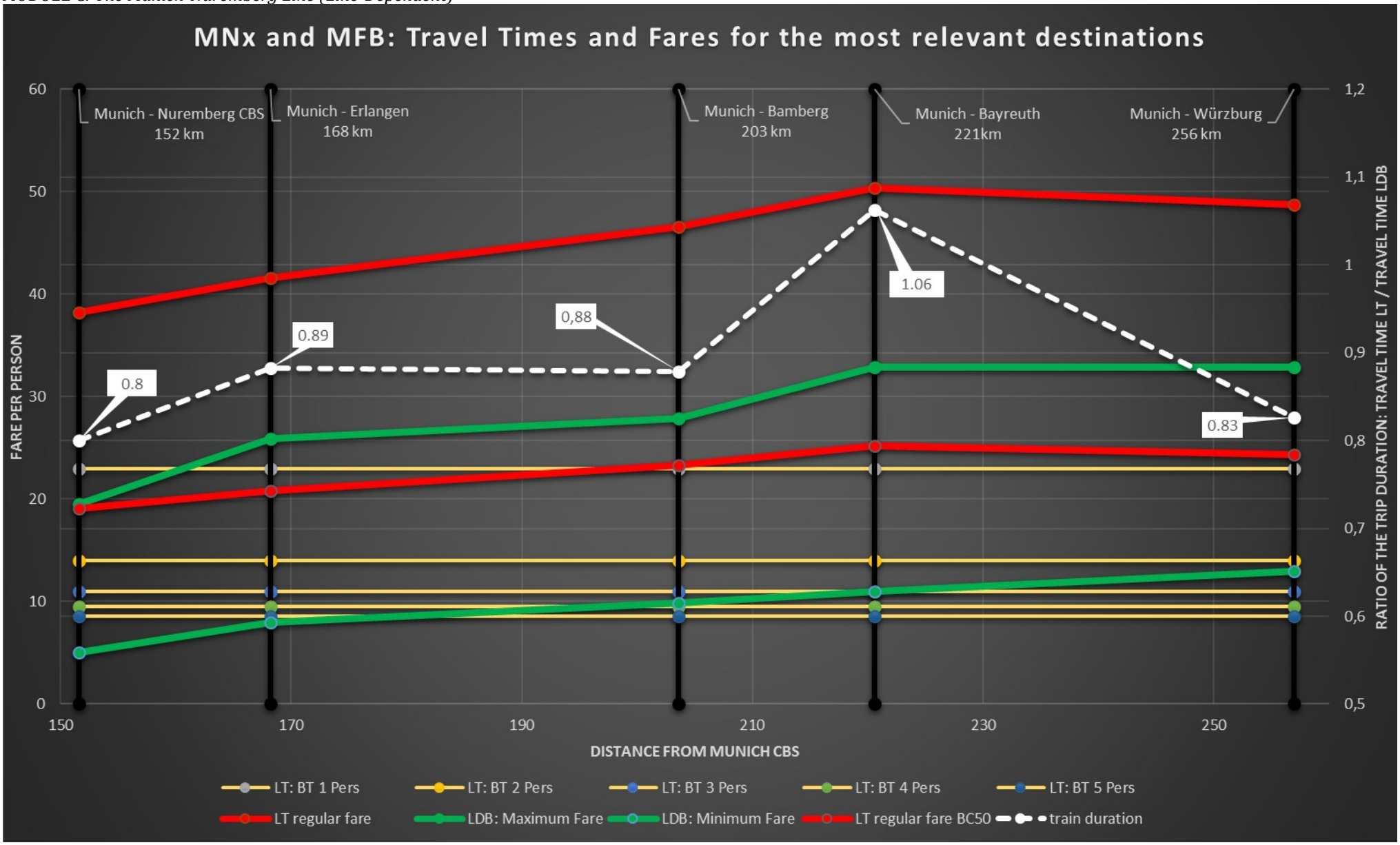


Figure 17: LT and LDB travel times and fares from Munich to most relevant destinations

Source: own figure based on (MFB MeinFernbus GmbH 2016b; BerlinLinienBus GmbH 2016; Deutsche Bahn AG 2016f)

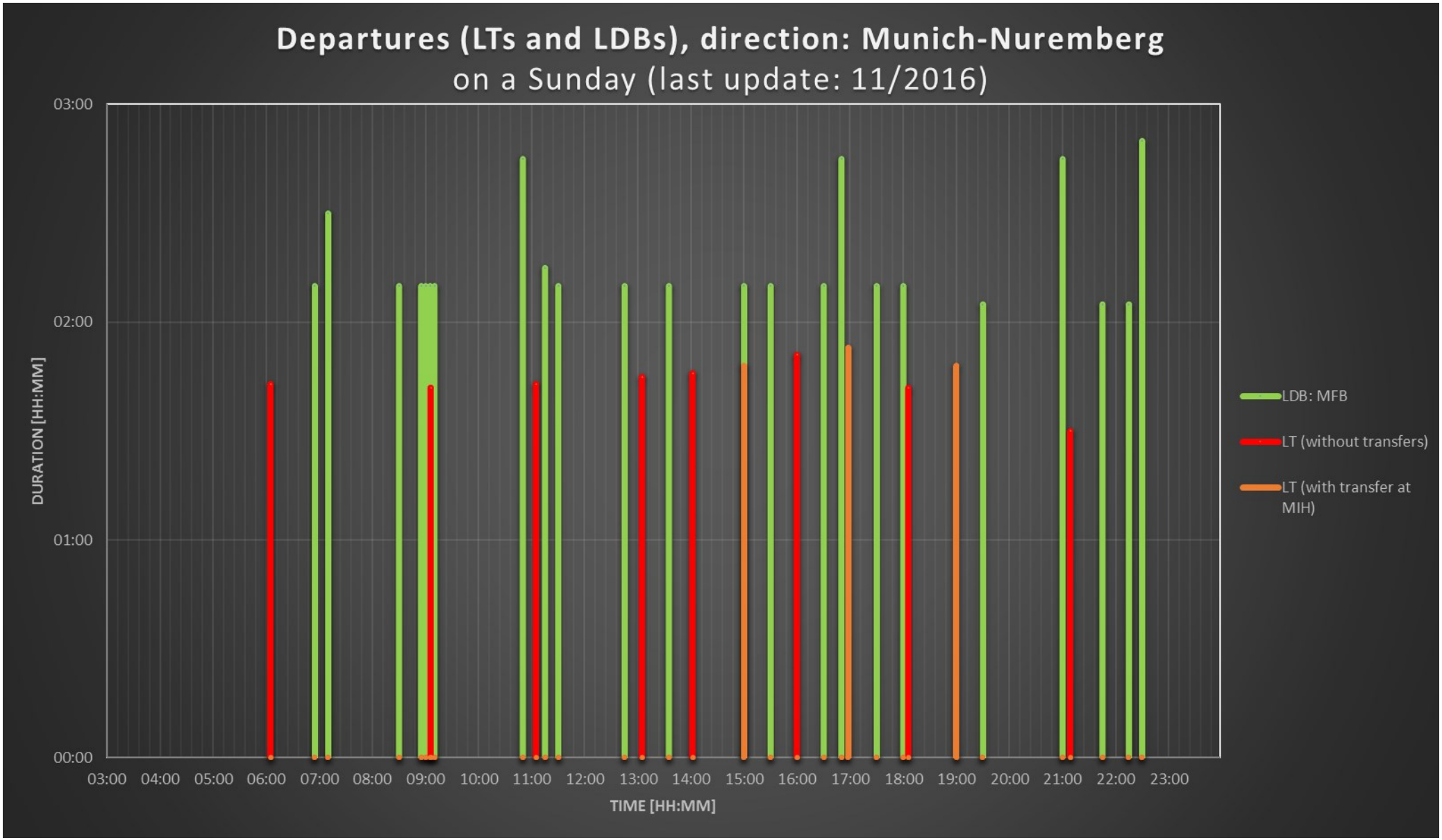


Figure 18: MN_LDB+MN_LT: Departures in Munich on a Sunday (23 LDBs, 11 trains)

Source: own figure based on (Deutsche Bahn AG 2016f; MFB MeinFernbus GmbH 2016)

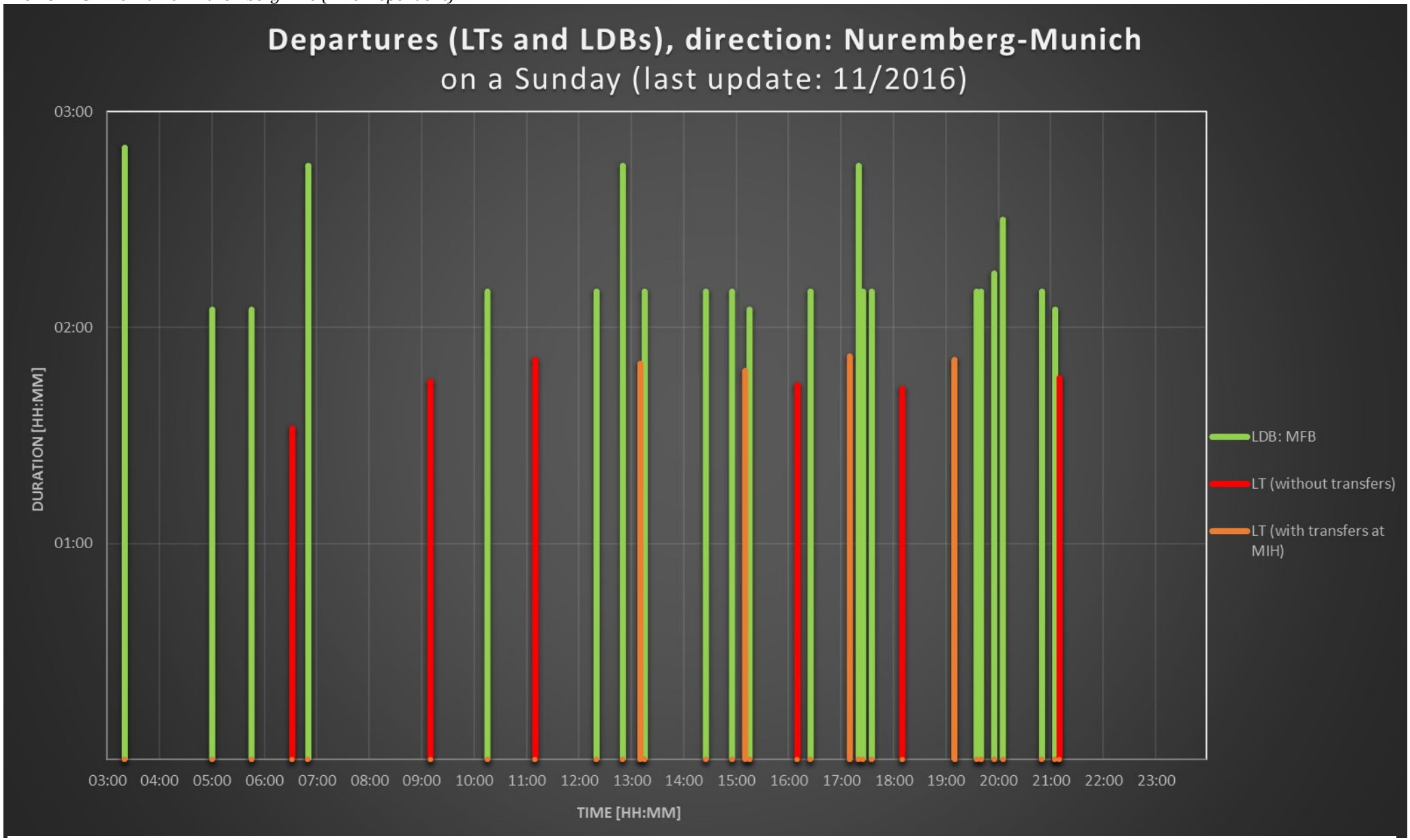


Figure 19: NM_LDB+NM_LT: Departures in Munich on a Sunday (21 LDBs, 10 trains)

Source: own figure based on (Deutsche Bahn AG 2016f; MFB MeinFernbus GmbH 2016)

C.5.2. Qualitative characteristics

Even though measurements of qualitative criteria are difficult, the understanding of them is crucial. A simple definition by OECD Intl. Transport Forum 2014, p. 11 is the "absence of effort" on means of transport that are "fit for purpose". However, there is no general consent among researchers with regard to which elements the term "comfort" should take into account.

For the thesis, this problem could be narrowed down to non-quantifiable *differences* between LTs and LDBs on the Munich-Nuremberg line. However, single elements could hardly be dealt with: how to measure the resistance of transfers? What is the impact of good or poor passenger information? Since those single aspects were seldom mentioned on the survey too, they were not included in both Modules C and D.

Table 9 below lists the differentiation of qualitative characteristics on LTs and LDBs on the Munich-Nuremberg line.

	LTs	**LDBs**
Customer Rights	**25% reimbursement** for >60min delay **50% reimbursement** for >120min Special regulations for flat-rate ticket (BT, MNT etc.)	**No reimbursement**. Trip cancellation with full refund is possible for passengers in case of delays of >120min.
Ticket exchange	**Dependent on the ticket type** (15 EUR for regular fares, no exchange possibility for special offers and flat-rate tickets	**Possible** for every fare type up to 15min prior to departure; no extra costs.
Comfort feeling	Highly subjective. The survey revealed a general tendency in favor of the train (see chapter D.4.3.1). Especially "freedom to move" and "view" were perceived to be better on LTs, whereas "WiFi" was a clear comfort advantage of LDBs. Those elements were also taken over for the survey (see chapter D.3).	
Seat reservations:	**Not standard on LT trains.** On MNx trains between Munich and Nuremberg there is however a possibility to book a certain seat when buying a ticket. (Deutsche Bahn AG 2016g)	**Guaranteed seating** since standing on road vehicles with >60km/h is prohibited by law (Bundesministerium der Justiz 2012c)
Bike transport	Extra fee: 5 EUR (day pass)	Extra fee: 9 EUR (per ride)
Baggage capacity	No limitations	Limited to 2 pieces per person
Plugs	**One per table** (8-10 per wagon, availability will improve with the	**Available**

	LTs	LDBs
	introduction of new rolling stock after 2018)	
Snacks&Drinks	**Available**	**Available**
Free WiFi	**Not available**	**Mostly available**

Table 9: Comparison of qualitative characteristics of MNx (LT) and MFB (LDB)
Sources: (Deutsche Bahn AG 2016d) (FlixMobility GmbH 2016b)

According to §21a of the German Road Traffic Regulations (StVO), passengers on LDBs must wear a seatbelt if available on the bus. It must not be loosened but for short interruptions, e.g for going to the toilet. However, in practice many passengers ignore it and the LDB operator is not in charge for checking it. (n-tv Nachrichtenfernsehen GmbH 2012)

C.6. MN_LDB: Fare observations September-October

C.6.1. Methodology

Setup

In the early stages of the thesis, the pricing strategy of LDBs was a mystery, though important to understand: how do LDB companies, in particular MFB, design their fares? Since inquiries to Flixbus and BLB remained without success (see emails in the attachment 8 and 9), it was decided to observe a certain period of bus departures of MN_LDB. In order to keep the dataset manageable and meaningful at the same time, basic preconditions were defined as follows:

- **Observation period 23 Sept -16 Oct 2016:** this was the period in which the observed trips were taking place. The period was chosen in a way that it contained one week of the Oktoberfest, which in 2016 was in combination with an extended weekend due to a public holiday on 03 October. This extraordinary season was representative for all kind of special events throughout a year. Fare performance was expected to be particularly interesting for this period.
  The two remaining weeks (4.10 – 16.10.) were without any particularities and thus deemed representative for all "normal" weeks in a year. Also semester had started on most universities again.
- **Evaluation period 28 Aug – 13 Oct 2016:** in order to observe the price development, say expected price rises over time, the price observation had to take place several weeks in advance. Since Flixbus opens its booking system about four to six weeks before the bus departure (FlixMobility GmbH 2016a), this evaluation period seemed appropriate. The end of the evaluations was naturally defined by the end of the observation period.
- **Evaluation frequency** was set to **twice a week**. The actual aim was to evaluate every Thursday and Sunday in order to see the changes right before and after weekends. In most cases, it was executed exactly in this way, though in two cases personal appointments interrupted the continuity. Instead, the evaluation was done on the subsequent day.

- The term **Analysis** was used for data analysis in chapter C.6.2.1 and C.6.2.2. (in delimitation to "Evaluation")

Evaluations were made on the following 14 dates:

28.08.	01.09.	04.09.	08.09.	11.09.
15.09.	18.09.	22.09.	26.09.	29.09.
02.10.	06.10.	10.10.	13.10.	

Assumptions and restraints

For the evaluation period, the assumption was made that *before* its first day (28.08.) no significant booking activities had taken place. However, this supposition could not be verified, but the evaluation results suggest that there was hardly any impact from preceding bookings on the evaluation (see next chapter C.6.2). Especially the most demanded weekend around 03 October was five weeks ahead of 28 August. Therefore, passengers could have hardly booked trips earlier anyway.

Another compromise had to be made for technical reasons: when a bus was booked out, the booking page returned a text instead of a fare: "This trip is unfortunately booked out and no longer available". For the evaluation, it was not considered at all as it was also not reasonable to simply assume a fare of 19.50 EUR (maximum price). However, out of ~8,700 evaluations, only two single trips were affected (see data table in Attachment 5).

The evaluation and observation brought up that prices suddenly surged up to 19.50 EUR (= regular fare) 15min prior to the departure of MFB buses. Consequently, every evaluation encompassed every (remaining) day of the observation period. Eventually, about 8,700 fares were monitored. The observation and evaluation was done for the two bus companies MFB and BLB. Consequently, the fare surges caused no data distortions.

Tools and Processing

The evaluation of the ca 50 LDB trips per day, per direction between Munich and Nuremberg took place twice a week and eventually produced a set of ~8,700 single fares. Given the huge number of data, it was impossible to carry out the evaluation manually. Instead, a VBA Excel tool was created for data processing. It allowed to process the data automatically. The data only had to be copied from the respective booking webpages prior to processing.

Since BLB quit its activities in November 2016, but was still considered in the evaluation, it was eventually omitted in both of the following evaluation chapters. The BLB fares differed tremendously from the ones of Flixbus, with most offers between 5 and 7 EUR. This price setting behavior has never become clear. Even on busy days when Flixbus had relatively high fares, BLB was still mostly offering tickets for 5 EUR. Possibly, BLB was *only* setting its fares on the basis of the demand, which was then rather low due to the shrinking fame of the company. However, this explanation is only conjectural.

In the following paragraphs, BLB was not considered anymore.

Between the evaluations of 18.09. and 22.09., MFB changed its pricing system: while the fare steps had previously been

5 – 8 – 11 – 13 - 15 - 19.50 EUR,

they were converted to smaller increments. Since, MFB has offered tickets for

5 - 5.90 - 7.90 - 9.90 - 11.90 - 13.90 - 15.90 - 19.50 EUR.

Even though the price system change was noticed, it was not subject to any special treatment. Nevertheless, it is well visible in the data table (see Attachment 5).

C.6.2. Analysis

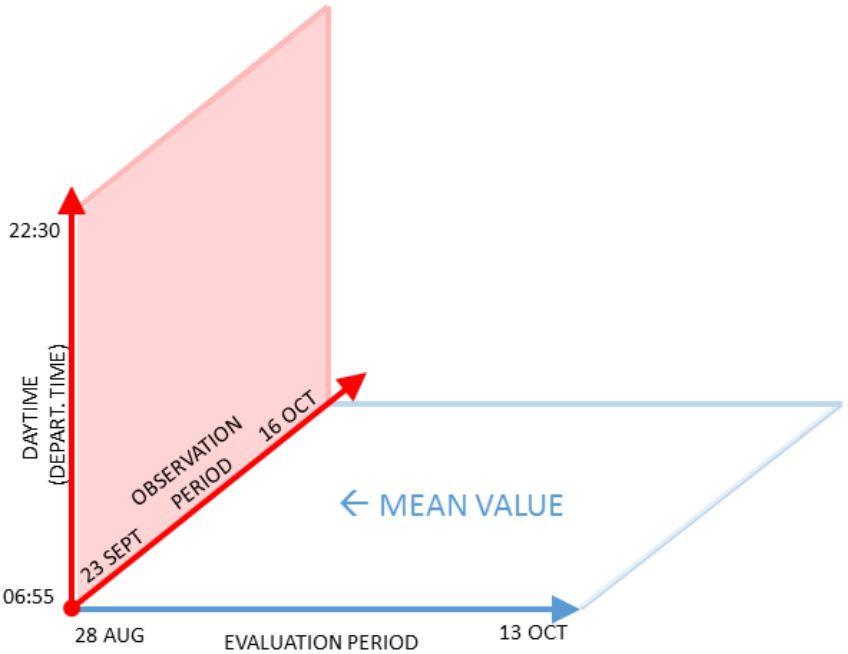
The analysis was done in two different ways, as the multiple dimensions (observed day, observed daytime, evaluation day) did not allow a comprehensive procedure. Both analyses are contained in the following chapters C.6.2.1 and C.6.2.2.

C.6.2.1. Analysis by daytimes over observed days

The chapter was to find out how the fares of the observation period had changed over daytimes. Therefore, the mean value of all evaluation days was taken as input.

Figure 21 graphically shows how the different dimensions were processed. The table in Figure 21 underneath was taken from the *.xlsx analysis sheet in order to improve comprehensibility. The entire table is part of Attachment 5.

Generally, there were no significant fare differences between the times of departure, as the demand of buses was obviously more dependent from the weekday and, more important, of the trip duration.



DAYTIME (=DEPART.TIME) OVER OBSERVED DAY (WITH MEANS OF ALL EVALUATION DAYS)

				23.09.2016	24.09.2016	25.09.2016
06:55	09:05	02:10	Flixbus	5,36	5,00	13,11
07:10	09:40	02:30	Flixbus	12,36	11,74	13,86

Figure 20: Illustration of the evaluation "daytimes over observed days"

For that reason, Figure 22 shows a diagram with the means of the fares of LDBs over trip duration. The better part of departing buses made the journey to Nuremberg in 2:10 hours (14 buses) or less (2 buses). On one line, all 8 buses had a trip duration of either 02:45 hours (7) and 03:00 hours (1). It was the line Munich-Bamberg (MFB line number #186). However, it did not

become clear whether the fare of line #186 was lower because of the relatively long trip duration or as a line-immanent attribute. Both could apply, as Munich to Bamberg was not supposed to be highly demanded line. This impression was also confirmed by the mostly low load factor of these buses while doing the survey.

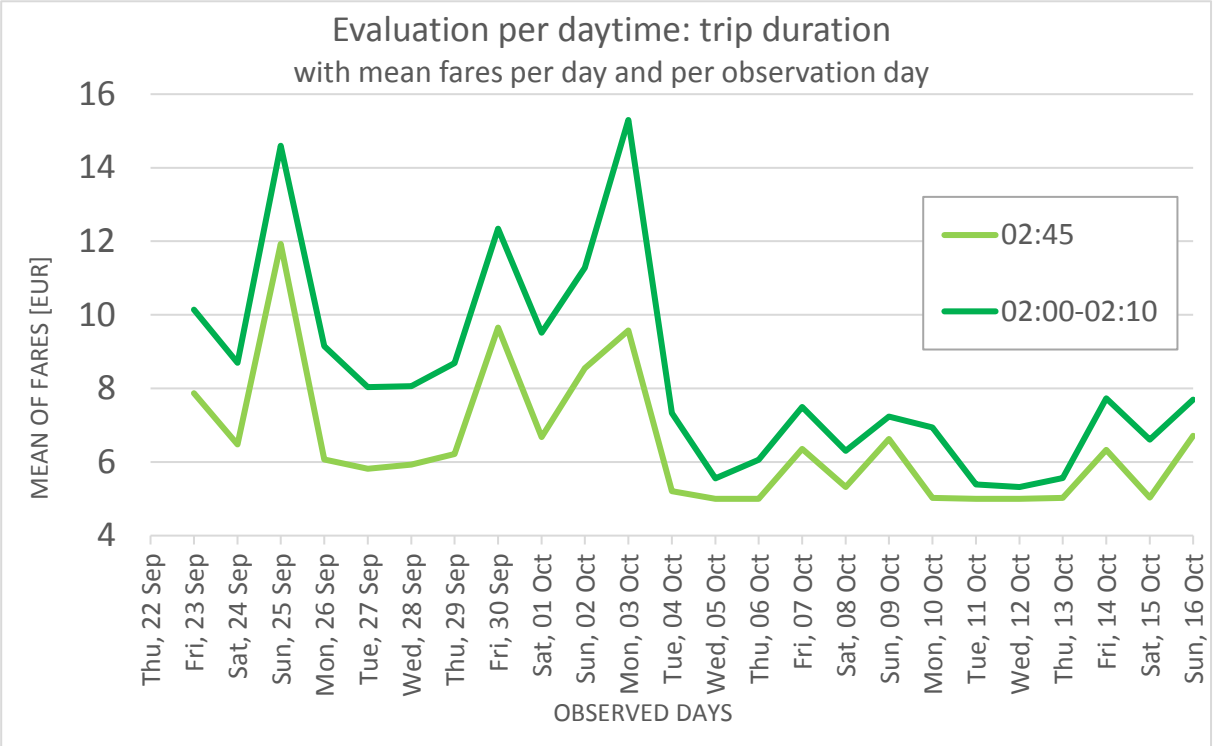


Figure 21: Fare differences per trip duration

The only exception where buses with long trip-duration were well-demanded was a night line LDB. Starting late in the evening for a long-distant destination, people were indifferent towards the trip duration of 02:50, as most of them would spend the night on the bus anyway in order to go further north. For the passengers going from Munich to Nuremberg (or to a destination within Bavaria) only, this phenomenon can be assumed less relevant: it is too short to be considered an overnight destination.

The graph, in combination with the explanation above, suggests **lower demand and thus lower prices on buses with longer travel time**.

Regarding the influence of the daytime, there was a tendency which can be read from the table in Attachment 5: **Buses leaving Munich after 16:30 were more expensive than those departing earlier**: the average after 16:30 was 8.96 EUR, while before it was 7.72 EUR. The "cheap" line #186 did not distract these results, as it was operating in a two-hour frequency throughout the day, and also in the evening hours.

Figure 23 shows the minimum (light green) and maximum (green) values of the means, which were calculated from all evaluation days. The averages per day are shown in dark green color.

The light green line in the diagram points out that low fares were available every day, though without clarification of the respective daytime. The daytime on which the highest fares were achieved were therefore marked in the diagram. It is important to notice that this line does not represent the absolute lowest fare which was measured at some point during the evaluation

period, but rather the minimum mean fare of a certain departure time, averaged over all evaluation days.

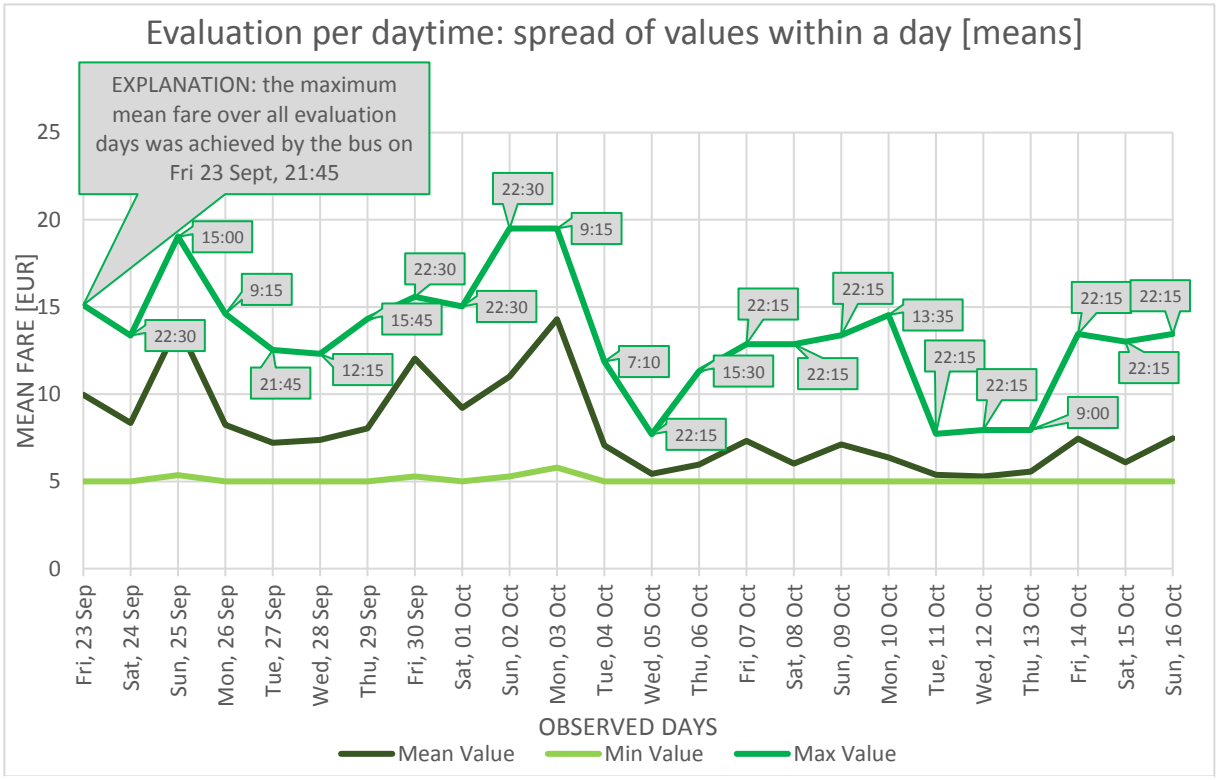


Figure 22: Average fares per daytime with daytimes of the maximum mean fares

> *Example: on 03 October, the small peak of the light green line can be interpreted as follows: over all evaluation days, the mean of the cheapest bus (in this case: departure time 8:20 with trip duration 02:45) was 5.79 EUR. The same method can be used for the interpretation of the maximum value: here it was the bus leaving Munich CBS at 9:15, with a trip duration of 02:15. Since this mean (!) is 19.50EUR, which reflects the normal fare = maximum fare, the price has remained constant from the very beginning of the evaluation period (thus it was also19.50EUR on 28.8.).*

The most demanded weekend around October 3rd had only light influence on the course of the light green line (minimum fare). Given the dynamic course of the other two lines, it indicates an increase of about 1 EUR from 5 to 6 EUR.

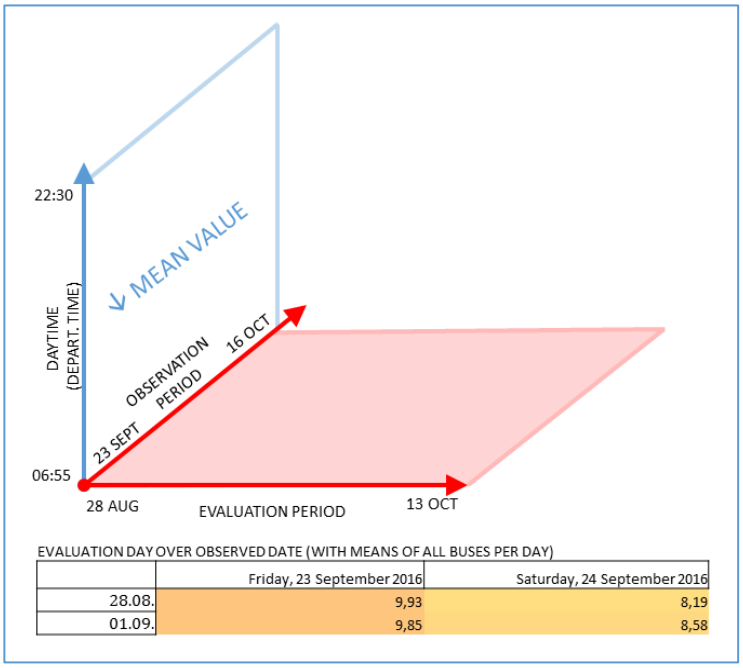
In general, when the mean line (dark green) is close to the minimum or maximum values, it indicates a higher number of more expensive, respectively cheaper fares. Having that in mind, the weekends of 25 September and 03 October were quite expensive – but still offered cheap buses somewhere during the day. Tickets for around 5 EUR were virtually always available between Munich and Nuremberg. However, the graph does not allow any conclusions on the trip durations.

In general, the maximum prices indicate that on days after a weekend has ended, fares for morning buses are the highest. On the other hand, on Fridays, Saturdays and Sundays fares tended to be most elevated for evening buses.

C.6.2.2. Analysis by evaluation days over observed days

Another interesting perspective can be taken when the daytimes (instead of the evaluation days) are concentrated to their mean value and replaced by the single evaluation days instead. The procedure was to find out what the mean fare development was like while the evaluation period was getting closer to the actual departure days (= observed days).

Figure 24 shows a graphical delimitation to the previous chapter C.6.2.1. The Table in Figure 24 was taken from the *.xlsx analysis sheet in order to improve comprehensibility. The entire table is part of the Attachment 5.



EVALUATION DAY OVER OBSERVED DATE (WITH MEANS OF ALL BUSES PER DAY)

	Friday, 23 September 2016	Saturday, 24 September 2016
28.08.	9,93	8,19
01.09.	9,85	8,58

Figure 23: Illustration of "evaluation days over observed days"

The diagram in Figure 26: Mean fare development per day over all evaluation days shows a simplification of the actual dataset, as the data were too extensive to be displayed in such a diagram. Consequently, only four out of 14 evaluation dates were selected for the graph. The observations were though the same for the entire dataset and are still represented by the four timelines in the diagram.

Similar to Figure 21 of chapter C.6.2.1, Figure 26 shows the development of minimum, maximum and mean fares over time. While in the previous chapter the departure times of 32 buses were compared, this graph illustrates the 14 evaluation days.

The later an evaluation took place, the higher were the ticket prices. This seems logical, as the load factor naturally increases while the departure date comes closer. In consequence, the price increases are comprehensible.

> *Example: when passengers wanted to book a LDB for 03 October on 28 August, they had to pay an average fare of 13.93 EUR, whereas on 25 September it was 14.92 EUR and eventually 16.33 EUR on 02 October. The average mentioned refers to all buses per day.*

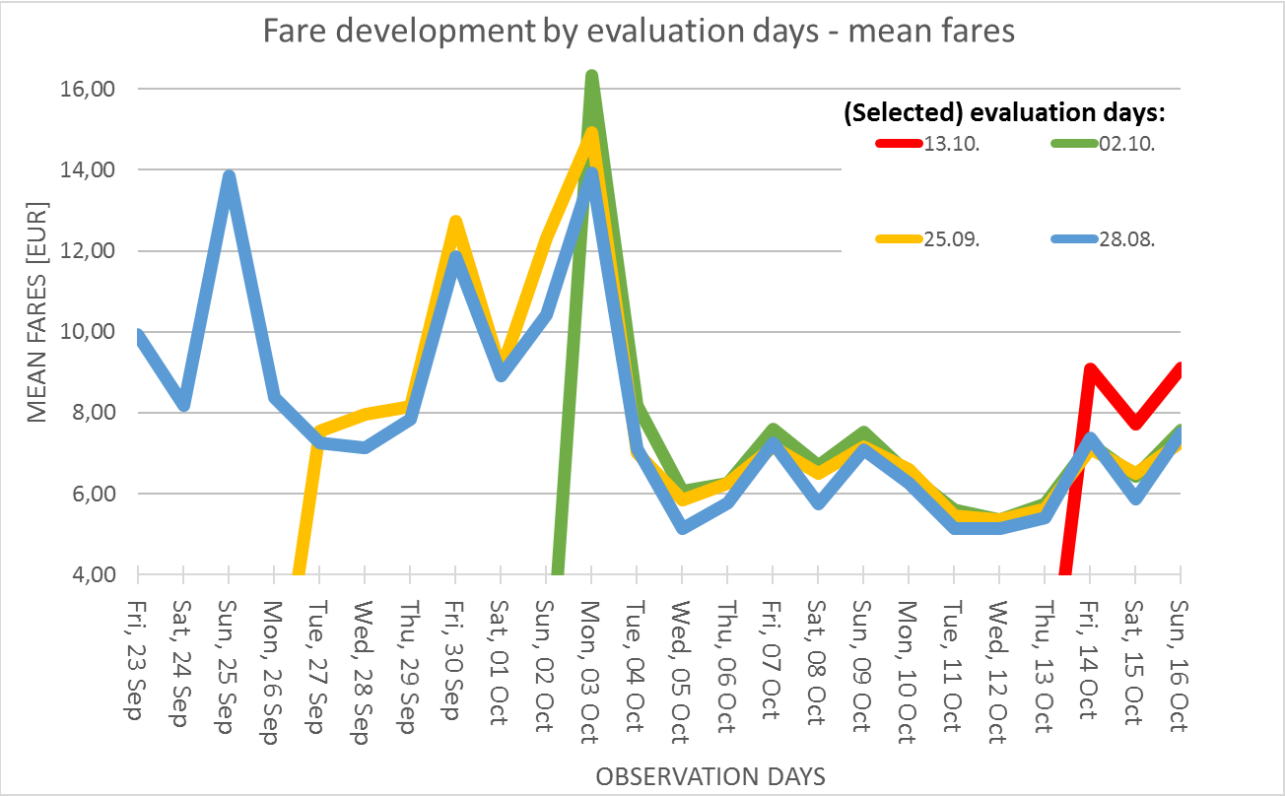


Figure 24: Mean fare development over selected (representative) evaluation days

The mean fare development in Figure 26 was though moderate in most cases. The mean was rising from evaluation day to evaluation day, but the increases were reaching about 1 EUR at maximum.

> *This is e.g. true for the development between the evaluation days 28.8. and 25.9 for the observed days 28.9., 2.10. 4.10.).*

An extraordinary fare increase could be recorded when the very first evaluation on 28.8. and the last evaluation on 13.10. were compared.

> *Here, the mean fare difference had increased by about 2 EUR over the seven weeks of evaluation.*

Figure 26 clearly points out that Fridays and Sundays were the most demanded weekdays, which can be read from the higher (mean) fares. Saturdays were less important, though still more costly than regular weekdays. In particular, Wednesdays were the least demanded days. The public holiday on 03 October is well recognizable among the price pattern.

Basically, the information in Figure 26 is related to Figure 25 above. New in Figure 26 are the graphs pointing out how many days before a bus departure the maximum fares were highest. In most cases, the suspicion that the fares were increasing while the departure days were approaching proved to be true. However, there were noticeable exceptions.

> *On the observed days Mon 26 September, Thu 29 Sept and Fri 30 Sept, the mean fares even decreased. E.g. tickets for rides on 29 September were most expensive two weeks in advance.*

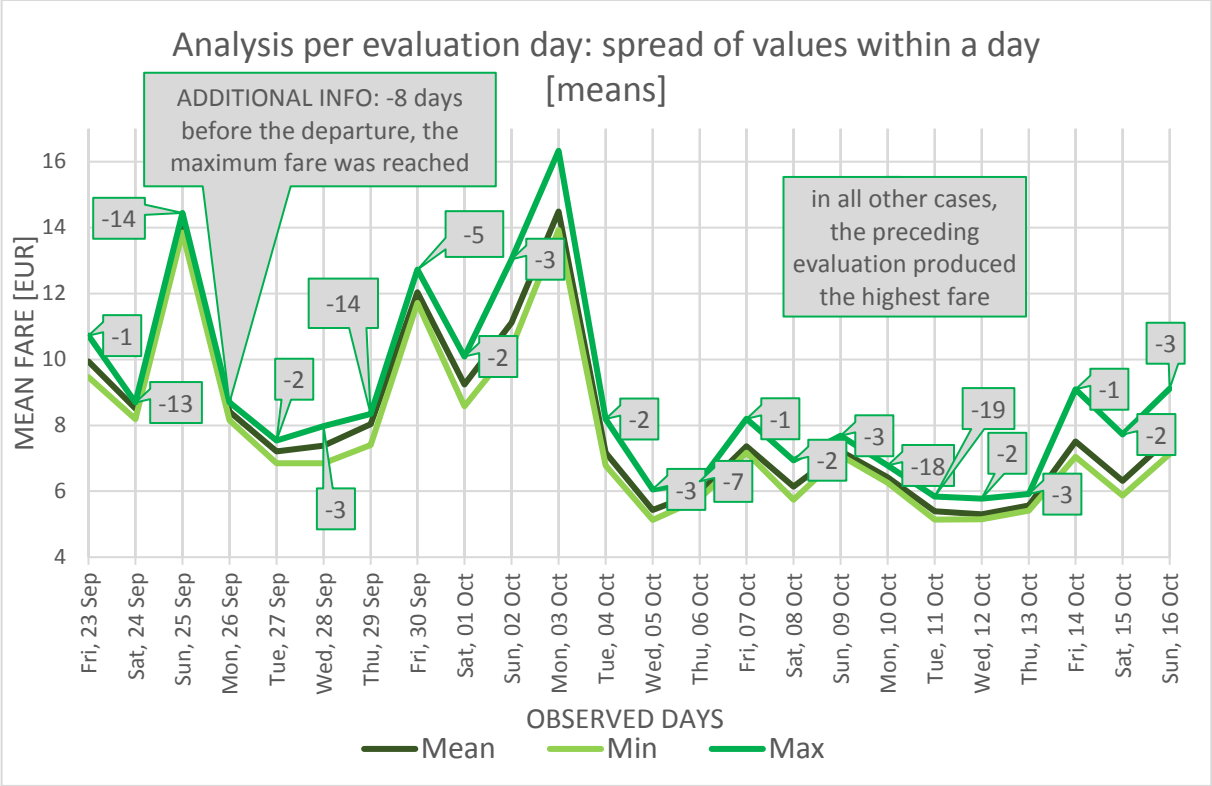


Figure 25: Mean fare development per day over all evaluation days

Most likely, the phenomenon was influenced from the price system adaptions of MFB in mid-September (see chapter C.6.1). Nevertheless, it was interesting to experience that MFB was readjusting its fares *downwards*, too. Since after 30 September no similar cases were observed and the reductions were only on small-scale, such events must not be overestimated though.

C.7. Intermediate Summary and Evaluation

On the Munich-Nuremberg line, passengers can choose between a variety of LDB lines. Also for other relevant Inner-Bavarian destinations which would encompass a MNx train connection (Bamberg, Bayreuth, Würzburg and Erlangen), single direct connections are available.

However, there is hardly any regularity in the bus schedule: around 9a.m., three lines go to Nuremberg (on Sundays), while there are bigger gaps at other daytimes. There are no frequent departure times. On weekdays, the number of buses dropped, decreasing the regularity further. On the other hand, LTs only operate in a 2-hour-frequency only, but stick to mostly recurring departure times that are easy to memorize for both weekends and weekdays.

Even though single bus lines need longer, most connections take 2:10 hours for going from Munich to Nuremberg. Most MNx trains are generally 30min faster (1:40).

The analyses from the chapters C.6.2.1 and C.6.2.2 have shown that MFB fares were dependent from the demand during the observation and evaluation period. Ticket prices were generally increasing while the evaluation days were progressing. However, the passenger demand is not the only regulating screw in the price setting strategy. Obviously, MFB had defined a base price prior to opening the booking process, in awareness of the expected demand.

The huge dataset could easily be subject to more evaluations. Looking at the data, it was for example interesting to see that sometimes single prices were set *down*. This happened for

numerous LDBs which fares were predefined by MFB and set to 19.50EUR for the observation day 03 October. The evaluation of this fare was e.g. met on the very first evaluation day, say 28 August. Together with the fare adaptions in mid-September, many of these prices were lowered (to either 13.90 EUR or 15.90 EUR). Even though this general effect was considered (through the mean values) in chapter C.6.2.2. as well, the development of *single* fares could be interesting, too.

However, it would be more important to repeat such an evaluation in order to collect new data. The LDB market has changed again and left MFB as the only considerable operator on the Munich-Nuremberg line. This had been different when the data were gathered. Therefore, MFB might have changed its price setting behavior again, a step which has been anticipated by experts anyway (see chapter B.1.2.3). It is therefore not sensible to recommend a further examination of the fare structures which were observed in September and October 2016.

The good news in this context is that, with the existing VBA tools, it is not complicated to record the price development again. In addition, evaluations meanwhile only have to consider the booking page of one operator (MFB) in the future. Developing this toolset was the actually time-consuming work for the data collection. The Excel sheets that are necessary for these evaluations can be requested from the author of the thesis.

D. MODULE D: THE SURVEY ON TRAINS AND BUSSES (LINE-DEPENDENT)

For better writing and understanding, the following two elements of the survey were abbreviated throughout Module D:

[location of surveying]	LT/CBS	survey on the MNx trains and at the CBS Munich
[version of the questionnaire]	V1.1 and V3.1	Version 1.1: pretest Version 3.1: final version

Further, other directional abbreviations from Module C were furtherly used, too (see first paragraphs of Module C)

D.1. DATA AVAILABILITY AND TARGETS

Understanding passenger behavior on the Munich-Nuremberg line naturally requires line-dependent data. However, the available data reflected limited information only.

Data availability - Passenger counts

The central department of DB Regio is in charge of analyzing the development of passenger numbers. Those numbers are then mainly used for negotiations with the sector entity BEG, tariff unions and competing operators. The regular data acquisition takes into account the following elements:

- Train composition: number of seats on the trains
- Season / Daytime / Weekday / Holidays
- First class / second class

Data is usually collected twice a year for every LT line. Passengers boarding and exiting trains are counted in every station, but they ignore the relationship of origins and destinations. Information that is crucial to understand the extent to which people are prone to either choose LDB or LT. (DB Regio AG 2016c)

> *It was thus impossible to make direct inferences from the data. People who had boarded the train in Munich could have exited in Nuremberg, but also in every station in between.*

However, the data were used for estimating the populations of both LT passengers travelling all the way between Munich and Nuremberg and for LDB passengers who would have taken the train if they had decided on this mode (see chapter C.1)

The organization of DB Regio would have enabled to submit special questions for surveys. However, this requires six-month lead-time. Given the limited time for writing the thesis, and also the volatility of the LDB market, it was not an option.

Data availability – Passenger shift estimation

In 2015, the regional division of the train operator DB Regio tried to estimate passenger demand shifts on the Munich-Nuremberg line. The basis was a mixture of published statistical data (e.g. share of former LT passengers who have then switched to LDBs instead) and calculations with regard to the revenue development after the market liberalization. The outcome confirmed DB

Regio's suspicion that LDB services have had severe impacts on LT passengers. (Mader, Uekötter 2015) Since it was a theoretical calculation only, more detailed information such as willingness-to-pay, the actual attractiveness of LDBs in comparison to LTs, and effective leverage items were not part of the examination.

Data availability – Missing information

Given the limited data availability, it was necessary to collect own data from both LDB and LT passengers. A survey should help understand the mobility choices of passengers on the Munich-Nuremberg line by collecting statistically relevant data. Since those specific, well-directed passenger interviews had never been carried out at DB Regio before, the survey was completely new designed and included several pre-test runs.

Question hierarchy

In order to maintain the relationship to the research question (chapter A.1) and the thesis topic, a three level hierarchy was defined and applied to the questionnaires. The accuracy of the questions increased from level 3 to level 1, whereas information content decreased. If applicable, the corresponding questions from the questionnaires (LT/CBS V3.1) are shown in round brackets.

3rd level questions: Derivations / Aggregations

- For what reasons did people choose LTs or LDBs, and through which factors could operators influence this behavior? (= research question)

2nd level questions: Intermediate step of aggregation

Univariate data analyses (chapter D.4/D.4.3.1)

- Distribution of LT passenger destinations
- Ticket type usage
- WiFi importance and age
- Alternative modes of LDB passengers
- Age structure on LTs and LDBs
- Shares and tendencies of group sizes per mode
- Mode choice criteria for LDB and LT passengers
- Average fare per person, per kilometer
- Stated comfort preference of LT and LDB passengers

Bivariate data analyses (chapter D.4/D.4.3.2)

- Profession (Age) ↔ statement: "less complicated"
- Profession (Age) ↔ LDB experiences
- Profession (Age) ↔ Fare per person, per km
- Profession (Age) ↔ Group size
- Comfort perception ↔ LDB experiences
- Ticket type ↔ group size (↔ travel distance)
- Willingness-to-pay

1st level questions

- Questions on the questionnaires (see questionnaire CBS/LT V3.1. in Attachment 10)

D.2. Survey Design

D.2.1. Survey Type

Miscellaneous kinds of travel surveys have been defined by literature for a better understanding of people's behavior with regard to travelling. They mainly differ in *where* the data is gathered, as shown in Figure 27:

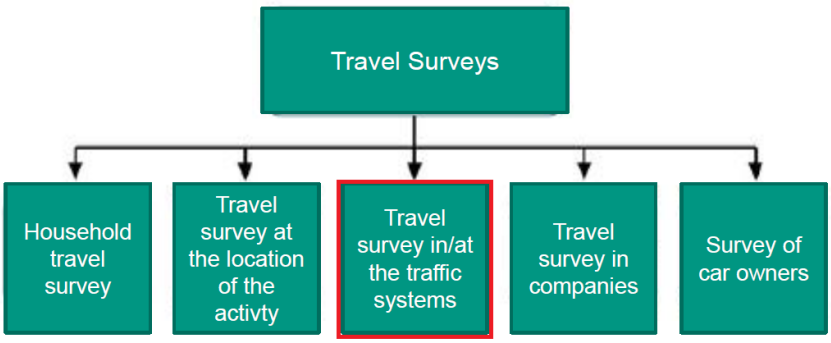


Figure 26: Different types of travel surveys

Source: (Kagerbauer 2015)

In general, travel surveys are generally examinations of (individual) travel behavior. (Kagerbauer 2015)

All data of the thesis was collected **in the traffic systems**, thus on (for LTs), respectively at the vehicles, when people were standing in front waiting for boarding (for LDBs).

Data collection was mainly taking place during October 2016, with several pre-test runs in August and September 2016. Here, the August test-runs were basically meant to develop and test the questionnaire. By early September, it has proven good quality and it was clear that the questions would be comprehensible for the interviewees. The main test-run purpose in September was to introduce the additional staff provided by DB Regio to the survey conditions and the questions (see chapter D.2.2).

Despite the relatively extensive time-frame of three months, the survey was considered as **cross-sectional:** its target was to get a snapshot impression of people's travel motivation on both LTs and LDBs.

Due to practical reasons, the poll was carried out in **paper,** rather than with electronic devices – for mainly two reasons. On the one hand, tablet computers were not available. Even if they were, programming would have been too extensive for the purpose of the survey. Most importantly, it would have reduced the information quality because travel choices are too multi-faceted to be predefined in a questionnaire. For that reason, all kinds of answers were not only gathered according to the form, but also numerous annotations were recorded as side comments. The open format left space for unexpected answers, as well as for complaints and recommendations from the passengers.

In order to achieve comparable answers and again for practical reasons, the survey was designed for **personal interviews, together with simultaneous paper and pencil recording**. In some cases, exemptions were made (e.g. partially deaf / dumb persons, people who preferred an auto-guided form of participating). As a consequence of the extensive pretest runs, the comprehensibility of all questions could eventually be presumed, since the interviewer would also ask the same questions as written on the form.

Information about who filled out himself or who was interviewed was not recorded though. (Kagerbauer 2015)

D.2.2. Preconditions

Human resources and timeframe

According to the General Examination and Study Regulations applying for the Master's thesis and authored by TUM, a Master's thesis has to be finished within six months after official beginning. This timeframe must not be exceeded but for convincing reasons. (Technische Universität München 5/6/2009)

Consequently, the data acquisition process should not take too long in order to leave enough time for data analyses. The pretest run was limited to August and September, while the mass data collection was scheduled for October. However, unforeseen influences slightly hindered the execution in the early phases:

- Impossibility to ask passengers at the CBS Nuremberg: At the beginning of the pre-test, the actual aim was to ask people at the CBS at Nuremberg. People boarding there would virtually exclusively go to Munich, as most of the buses terminated there. However, in practice the idea was not sensibly executable. Unlike the CBS in Munich, there were no information screens (see images in Attachment 6). Drivers could choose any bus bay available. In general, the administration of the CBS Nuremberg was poor in comparison to Munich.
  Consequently, it was extremely hard to find passengers to Munich, since the whole ridership of all lines was scattered throughout the station and would only rush to the bus when it was approaching. Then, it was naturally too late to interview passengers. To ask *everybody* at the station in advance and filter out the relevant passengers was too time-consuming though. In addition, there were sometimes simply few people travelling from Nuremberg to Munich.
  For all these reasons, the survey location at the CBSs was compromised and diverted to Munich in the early stages of the pre-test phase. There, it was not possible to filter out passengers to Nuremberg only, causing profound adaptions to the data acquisition process (see chapter D.2.3)
- Unclear permission for the CBS station survey: As described in chapter C.4, the CBS Munich is private property. "Marketing activities" are generally not allowed without explicit permission of the operator. (Rot Kreuz Betriebe 2013) The operator (Rot Kreuz Betriebe) was eventually asked and agreed to the survey on 12 September 2016 (see document in Attachment 9)

- Staff availability: DB Regio disposed three young trainees for the survey. In September and October, they were helping carry out the survey on both the CBS Munich and on LTs. Their availability was though limited as they had only begun working there in early September, and had either other tasks to do (e.g. projects, exams, school) or were on vacation. Therefore, mass data collection was only possible in October.
- Oktoberfest München: In 2016, the Oktoberfest was taking place from 17 September till 03 October. During Oktoberfest periods, load factors, mode choices and destinations – thus travel behavior as a whole – are completely different than under "normal" circumstances. Even though these passenger streams would have been of great interest for DB Regio too, it was not the actual scope of the thesis. When the main part of data acquisition was launched on 03 October, the first day was nevertheless within the Oktoberfest period. This certainly influenced the results to a certain extent, but was seen as the representative day for any kind of special events, which *do* regularly take place at Nuremberg and Munich.

With three people to coordinate, it was necessary to draw up a schedule in order to plan data collection in line with the personal availability. The plan was updated regularly; its latest version was attached to the thesis in Attachment 11.

Basic data of all interviewers mentioned (with the names abbreviated with initial letters for privacy reasons):

- Interviewer #1: LS, male, from Munich (author of this thesis)
- Interviewer #2: FW, female, from Töging am Inn
- Interviewer #3: AW, female, from Ingolstadt
- Interviewer #4: YT, female, from Dachau

With the underage Interviewer #4, flexible rearrangements of the schedule were impossible. Further, she was not allowed to go without an adult person. It was therefore decided to do all survey runs with at least two people each. Positive effects were bigger data volumes per LT and LDB, as well as higher motivation when working in a group.

Sample Size

Beyond the pure scientific question about the appropriate, significant size of a sample, there were other restraining factors, which basically had the same background as the ones mentioned earlier in this chapter (staff availability, limited time frame, etc.). In addition, there was also data loss due to practical problems. About 40 datasets from the pre-test had to be sorted out since they were just not comparable to the bigger part. Further, some answers were deemed invalid, for various reasons. See chapter D.4.1.1 to learn more about the practical impacts on the survey.

Apart from these limitations, statistical directed literature with regard to surveying was laid as base before starting the survey. Here, Fowler (2009, p. 43ff.) delivered a useful practical approach. Fowler chose an unusual guidance in which he excluded common, but obviously wrong approaches of how to decide on sample sizes:

- **DO NOT:** choose a certain percentage of a population. The result would be misleading since it totally ignores the actual size of the population. Example: In a big population, increments of the sample size will result in a negligible gain of accuracy.
- **DO NOT:** choose any kind of standardized sample size. Evidently, some surveys were made based on comparisons: If e.g. a researcher in one city had carried out a survey, other researchers simply adopted the value for other cities of comparable size, too. However, samples in general are hardly the same in any kind of study and have thus to be defined on a case-by-case basis.
- **DO NOT:** infer from the desired level of accuracy, say confidence interval, to the sample size. And even though this is not per se wrong, it provides little guidance in practice: in most cases, the sample size will not be calculated on the basis of *one single* estimate. More important, the level of precision is seldom definable in advance. And even if it could, the value then ignores other faulty influences which do not originate in sampling.

Fowler instead highlighted that researchers have to know what they are seeking for *before* they launch their investigations. In other words, it is crucial to have an overview about the subgroups of interest. Depending on what should be evaluated, it is less important to link the sample to the population size, but rather to identify the minimal acceptable sample size which is still capable to represent the subgroup of interest. Moreover, Fowler eventually provided numeric assistance for the size: One of his core statements in this context was that the gain of accuracy is negligible if one added 50 more samples to a sample of 500. (Fowler 2009, 43ff.)

> *In retrospect, it was thus important to have been actively involved in the interviews: Referring to Fowler's statements, this enabled to get an overview of the passengers of interest and to consider previously unforeseen statements, influences and developments.*

For the evaluations to come in the subsequent chapters, these thoughts were taken as basis. In addition, statistical tools (especially confidence intervals and values of central tendencies) have checked the validity of the data.

Types of Error to be dealt with

Sampling is not the only source for errors. In the different stages of data collection and aggregation disturbing influences can lead to wrong conclusions.

The first deviation can occur when the answers of people do not **meet the actual target of the question**. This can happen for various reasons, such as misunderstanding, unwillingness to answer or social desirability of an answer. The answer is then biased. For that reason, the evaluation should distinguish two categories: subjective and objective measurements, with the first being more prone to manipulations (Fowler 2009, p. 49ff.).

Application to the survey

In case of the survey on LTs and at the CBS Munich, this influence type was low, yet not totally excludable. While people were being asked, their neighborhood was often listening carefully, with the chance of being influenced by the answers of other people. Social desirability was however not a perceivable issue. Neither the general questions nor the ones on LDB / LT usage were filled with socially sensitive content. There were individual cases, when people refused to

answer single questions. An example was question (1.2) about the profession. However, the amount of affected questionnaires was less than five. Those unwilling to participate were not part of the survey anyway.

Fowler (2009) also addresses two more problematic criteria that are related to the individual answers: it is about *who* answers and about *who has better chances of being chosen.*

Latter was not seen as an issue: everyone on the train had the sheer chance to be chosen. However, influences in this context were

- Departure, respectively train circulation time (season, daytime, and others)

Since it was barely impossible to cover all trains with the survey, it was decided to focus on several groups instead. These were influenced by various data:

- Validity of the BT and other similar offers
- General bias resulting from surveys on certain departure times only
- Crowdedness of the means of transports, in order to see the decision in suboptimal conditions, i.e. demand peaks (crowded trains, but stable price vs. guaranteed seating on buses which are then more expensive though)
- Public and school holidays (higher share of families)

For a more detailed view on this issue see chapter D.2.3

- People unwilling to answer, who, in a certain sense, did not have the "chance" to become part of the sample.
  - While asking people, the questioners had the chance to get a – admittedly subjective – impression about those persons who declined to be interviewed. Accordingly, there was no recognizable age, profession or other pattern among them (e.g. employees being stressed and thus unwilling, in contrary to students who might be more willing to talk to interviewers of equal age). All in all, the acceptance of the survey was very good among passengers.

Questionnaires were filled out per ticket (=per group). If a questionnaire covered more than one person, aggregated answers were assumed. This step was based on the assumption that within a group, opinions would be transferred to other group members.

> *In particular, negative opinions and experiences with a transport mode were supposed to be communicated within the group.*
>
> *If a group consisted of e.g. 20 people travelling with 4 BT tickets, this was however also recorded in one questionnaire only. Those cases were rare though.*

There was mostly one respondent in representation of all others. However, there were often short discussions within the group before answers to items were given.

Interviewer FW eventually turned to occasionally change the survey mode towards self-guided interviewing (on LTs only). She therefore asked people directly whether they would agree and provided roller-pens. The only qualitative cut was that people would deliver less additional background information or perceptions. On the other hand, the participants were able to ponder the questions for longer.

LDBs to destinations beyond Nuremberg

Inner-Bavarian LDB connections past Nuremberg were also included in the survey. Comparability to LTs was granted though, as these relations would also use MNx trains if LTs were chosen instead of LDBs (they are the second cheapest option after bus). These destinations had to be included, as people on LTs were often travelling to more distant parts of Bavaria, too. (for more information on the topic see chapter D.2.3 and Attachments 7 and 12)

Response rates on LDBs and LTs

With 1:40 hours travel time, it was easy to collect data on LTs. When people were waiting for their bus at the CBS Munich, it was much more difficult to reach them. Therefore, there was a considerable lower response rate per bus than per train (see number of respondents in chapter D.4.1.1).

LTs: Exclusion of all internal trips on the line

There were absolutely no LDBs which were serving stations in between Munich and Nuremberg. As a consequence, all passengers with origin or destination of such stations were simply irrelevant for the survey. For that reason, the very first question of *all* interviews on LTs was whether people would travel all the way between the two cities. **Only those who were travelling all the way between the two cities Munich and Nuremberg were interviewed.**

> *Nevertheless, the original dataset still contained single distorting cases by the end of the survey, as sometimes misunderstandings or language problems had occurred. Those data were eventually sorted out prior to evaluation.*

D.2.3. Time and Distance issues

Schedules, departures and daytimes had to be harmonized. Undesirable effects such as biases resulting from daytime had to be avoided while at the same time, staff availability had to be granted. In addition, coherent bundles of suitable departing LDBs had to be identified and integrated in the overall roster.

Choosing suitable LDB connections for the survey (MFB)

As explained in chapter D.2.2, the initial plan to collect data at the CBS Nuremberg did not work out as planned and the location was diverted to Munich instead. Since virtually no LDBs went to Nuremberg and not further, it was necessary to decide on suitable connections for the interviews: it would have taken too long to ask all passengers on LDBs whether they would go to Nuremberg, and the output per bus was expected to be very low.

> *Example: only a small percentage of all bus passengers of an LDB to Berlin would exit in Nuremberg. In addition, those passengers would have had to be sorted out prior to start asking the actual questions from the questionnaire.*

The acceptable passenger destinations for the survey were thus adapted by making another assumption: <u>If bus passengers had to take the train, their journey had to include MNx trains between Munich and Nuremberg.</u>

Buses to very distant targets were thus unfavorable, as passengers would turn over to LDTs instead. Eventually, and based on these thoughts and preconditions, buses to the following destinations were included in the survey (Table 10):

Origin/ Destination	Shortest travel time [daytime]		Nr of transfers (LTs only)	Faster LT connections*	Nr of questionnaires in survey (V2.6)		
	LDB	LT	LT	LT	LDB	LT**	
					Munich to…	Munich to…	From … to Munich
Nuremberg	2:10	1:42	0	No	95	165	182
Erlangen	2:50	2:21	1	No	44	15	13
Bamberg	3:25	2:48	1	No	10	11	19
Würzburg	3:50	3:11	1	No	13	33	43
Bayreuth	2:40	2:56	1	No	2	19	14
Dresden	6:30	6:58	2	Yes	22	0	1
) faster regular LT connections available via other routes** *) both directions (destination MN and origin NM)**					100% (186)	69% (243/352)	72% (258/360)

Table 10: MN_LT, NM_LT and MN_LDB (dataset: "total"): important origins/destinations

The last destination, Dresden, was definitely a borderline case. Train rides to Dresden would require several transfers (at Nuremberg and Hof) and did not bring an advantage in terms of travel time. In addition, LT fares were extraordinary expensive because the BT ticket is not sufficient. Nevertheless, it was decided to include this destination, since the actual passenger volumes on MNx LTs with regard to this city were unclear. In addition, the departures at CBS Munich fitted well into the departure pattern of LDBs to other destinations listed above. LDTs were also not a sensible option for this destination, neither with regard to price, nor duration.

However, the low practical relevance became only clear when the passenger numbers were compared. On LDBs, the city pair connection Munich-Dresden was well-accepted among passengers. On trains, there was though only one (!) questionnaire.

For those reasons, all questionnaires with regard to Dresden were eventually removed prior to deeper evaluation and analysis (see chapter D.4.1.1 also).

Choosing suitable LT connections for the survey (MNx LTs)

The departure times in Table 11 and Table 12, and its graphical counterpart in Figure 28 clearly show that there was a particular emphasis on rather early trains from Munich to Nuremberg for the survey. In all cases, the interviewers returned immediately with the next train. This was however not made intentionally, but resulted from the personal availability of the survey staff:

MN_LDB						
#	time	**Day**	**to**	**Particularties**	**Nr of questionnaires**	**Nr of people**
1	**10:45**	Monday, 10 October 2016	Erlangen		2	2
2	**10:50**	Monday, 10 October 2016	Bamberg		4	7
3	**14:50**	Friday, 16 September 2016	Erlangen		5	6
4	**16:30**	Sunday, 28 August 2016	Erlangen	(School) holidays	4	5
5		Sunday, 9 October 2016	Erlangen		12	14
6		Sunday, 16 October 2016	Erlangen		20	21
7		Sunday, 23 October 2016	Erlangen		9	9
8	**16:35**	Tuesday, 30 August 2016	Bamberg		3	3
9		Friday, 30 September 2016	Bamberg	Oktoberfest, extended weekend	5	6
10		Thursday, 13 October 2016	Bamberg		13	17
11		Thursday, 20 October 2016	Bamberg		3	3
12	**16:50**	Sunday, 28 August 2016	Bamberg		5	9
13	**17:00**	Sunday, 9 October 2016	Dresden		15	17
14		Sunday, 16 October 2016	Dresden		15	18
15		Sunday, 23 October 2016	Dresden		12	18
16	**17:15**	Tuesday, 30 August 2016	Erlangen		3	4
17		Friday, 30 September 2016	Würzburg	Oktoberfest, extended weekend	17	22
18		Friday, 7 October 2016	Würzburg		17	17
19		Thursday, 13 October 2016	Würzburg		8	9
20		Thursday, 20 October 2016	Würzburg		7	7
21	**18:50**	Sunday, 28 August 2016	Bamberg		4	5
22	**19:30**	Sunday, 28 August 2016	Bayreuth		3	4
				Σ	**186**	**223**

Table 11: MN_LDB: questionnaires per daytime, day and LDB destination

Sunday evenings were thus avoided, as were Friday evenings. Since the bus schedule proposed afternoon times, where many relevant buses could be reached at once, it was not possible to be on the train at the same time. There was one attempt to change this schedule and do LDB interviews in the morning, where at least two suitable buses could be reached (Table 11 above, MN_LDB, ##1-2). The result was though disappointing, as the number of passengers was very low. On the other hand, one survey took place on board of a Sunday evening train (Table 12, MN_LT, #10), which was actually a suitable train to survey. Nevertheless, it remained the only train of the evening hours, due to the reasons mentioned above.

Morning trains at 7:05 (MN) were considered on two days only due to the low number of passengers going all the way to Nuremberg. The passenger pattern was initially deemed interesting since the BT ticket and similar flat-rate offers are not valid at this daytime.

As LDB passengers were mainly asked in the afternoon or evening hours, people were not likely to travel long distances any more. Since the focus was on Inner-Bavarian connections (plus the buses to Dresden), there was no negative qualitative impact on the response rate.

Table 12 below shows the departure times of trains which were part of the survey.

MN_LT					
#	**time**	Day	Particularties	Nr of questionnaires	Nr of people
1	**07:05**	Tuesday, 4 October 2016		3	4
2		Monday, 24 October 2016		8	13
3	**09:01**	Tuesday, 23 August 2016	(School) holiday	16	51
4		Friday, 16 September 2016		31	47
5		Friday, 30 September 2016	Oktoberfest, extended weekend	36	65
6		Friday, 21 October 2016		29	75
7	**11:05**	Friday, 7 October 2016		42	91
8		Friday, 14 October 2016		73	155
9		Friday, 28 October 2016		30	84
10	**13:00**	Sunday, 9 October 2016		25	96
11		Sunday, 16 October 2016		30	50
12	**18:06**	Sunday, 23 October 2016		29	62
			Σ	**352**	**793**
NM_LT					
#	**time**	Day	Particularties	Nr of questionnaires	Nr of people
1	**09:10**	Tuesday, 4 October 2016		23	49
2	**11:10**	Friday, 16 September 2016		58	111
3		Friday, 30 September 2016	Wiesn, extended weekend	41	129
4		Friday, 7 October 2016		43	66
5		Friday, 14 October 2016		44	77
6		Friday, 21 October 2016		49	89
7		Friday, 28 October 2016		22	45
8	**13:10**	Sunday, 9 October 2016		26	44
9		Sunday, 16 October 2016		40	74
10	**17:10**	Tuesday, 23 August 2016	(School) holiday	14	27
			Σ	**360**	**711**

Table 12: MN_LT and NM_LT: questionnaires per daytime, day and LDB destination

The travelled distances for MN_LT, NM_LT and MN_LDB, with regard to daytime, can be read from Figure 28 below and were illustrated in the maps in Attachment 7.

The reference lines for city pairs in Figure 28 are however not true for all cases, since the distances would be misleading for origins other than Munich or Nuremberg.

Example: passengers travelling from a city south of Munich (e.g. Salzburg) to a north Bavarian town cannot be referenced to the lines. However, the unreferenced distances (y-axis) are true for every case.

To learn more about the underlying distance calculation, see chapter D.4.1.1. The figure was based on the generally smoothened dataset "total" (see also chapter D.4.1.1 for more information).

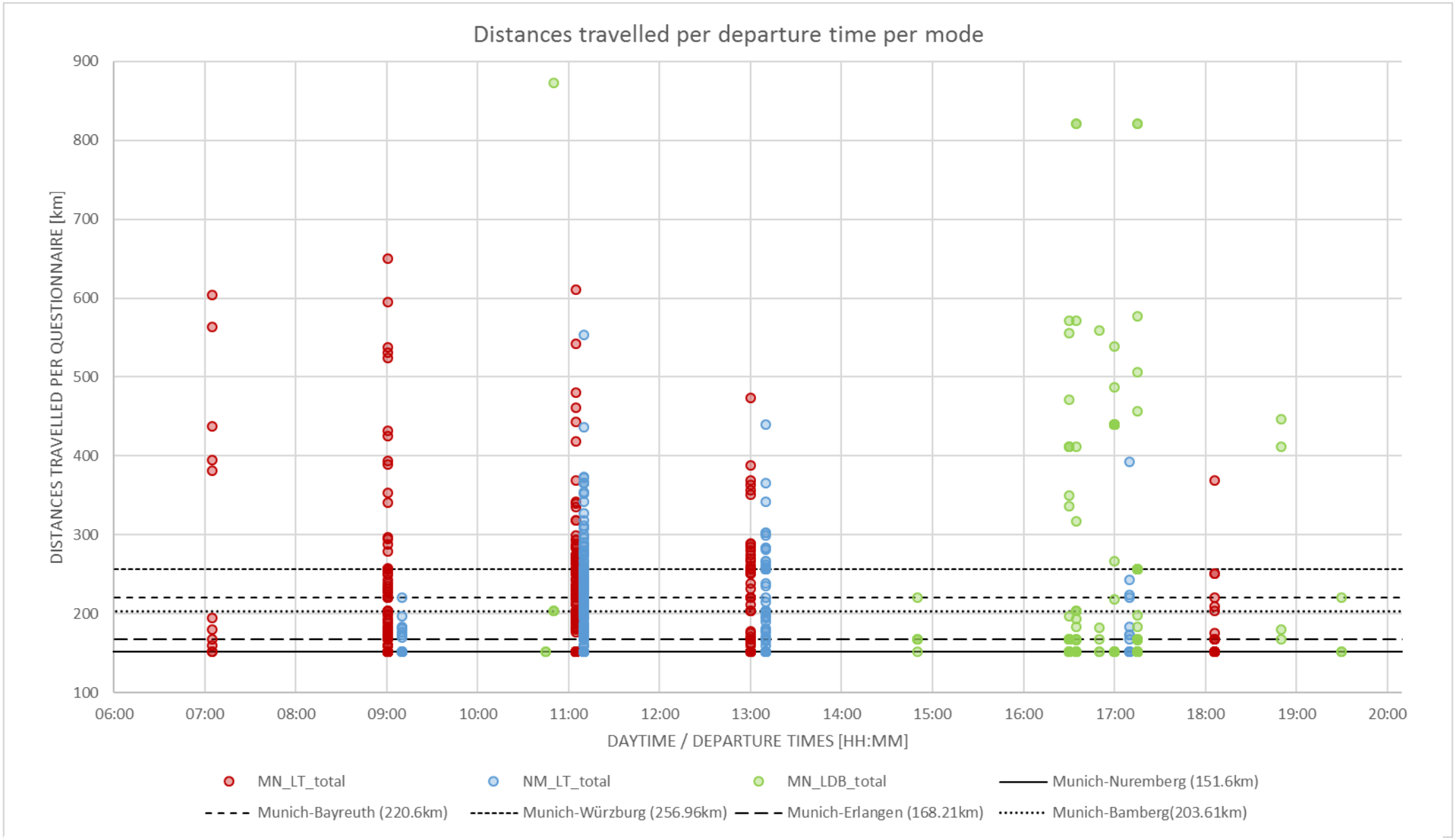


Figure 27: Distances travelled per mode, per questionnaire and daytime

D.3. QUESTIONNAIRE DESIGN

Virtually all literature sources agree on the same approach in terms of how a questionnaire should me made up: concise questions, no unnecessary questions, contained in a short questionnaire.

The initial idea to offer incentives for the participation in the survey was dropped due to rather negative experiences of the marketing department at DB Regio. In their opinion, people would not participate more willingly and enthusiastically when material benefits were luring. Instead, people would be more motivated to take part in a survey when they felt that their opinion was valuable and that it could provoke a positive change. Further, the considerably limited length of the questionnaire, respectively the short duration, would not require any incentives.

Questions were asked in both closed and open way. Specification for version LT/CBS_V3.1:

- Open questions: 1; 2.1.; 2.2; 3
- Half-open questions: 1.1.; 2.7; though virtually every question contained or caused individual statements which were than recorded
- Closed questions: 1.2.; 1.3.; 2.3; 2.4; 2.5; 2.6.; 2.8.

The printing format of the questionnaires was initially A4, but was eventually changed to the smaller A5 layout for better handling.

Version LT/CBS V1.1. (pre-test)

The original draft of the questionnaire, named LT/CBS V1.1, was first brought into action on 08 August 2016. The translated form and the original (German) version are part of Attachment 10. LT/CBS V1.1. was already designed differently for LDB and LT interviews, trying to ask as many equal, thus comparable questions as possible.

The basis for the questions asked in LT/CBS V1.1. were the aggregated 3rd level questions mentioned in chapter D.1. Windpassinger (2014b) – and the few other authors available in context of this topic, too – had already listed the most prominent decision factors in their publications. These were partially adopted for the survey. Carrying out the survey in the early stages with LT/CBS V1.1, other points of views were stated by passengers and taken over in the later questionnaire versions.

However, LT/CBS V1.1 already stressed the most pressing issues, such as price, trip duration, sociodemographic data like age and profession, to just name a few.

The changes towards version V3.1.

Doing the first interviews on trains and at the CBS, several systematic problems of LT/CBS V1.1 occurred in practice and were changed in the subsequent versions:

- There was no sense in filling out the basic data (printed in red color) for every questionnaire. For example, one interview series of course always reflected the same LT/LDB.
- The numbering of questions was missing.
- Two obsolete questions were identified and removed from the questionnaires:

  - The reason for travelling was soon deemed irrelevant. In other words, there were little grounds to infer from travel reasons to mode choice, willingness-to-pay or other trip characteristics.
  - BC discounts (see also chapter 0) was seldom pertinent in practice and thus removed from the questionnaire. If passengers were using BC, this was noted in context of the ticket type.
- The number of people per group (=number of people per questionnaire) was contained in two different questions.
- The question "Do you think that trains are more reliable than buses" was asked in a suggestive way and changed accordingly.
- In practice, bus passengers could not distinguish whether their alternative mode would have been a LT or a LDT service. The question was rephrased.
- The proposed answer possibilities with regard to why passengers decided on a certain mode, were reduced. The actual reasons were too diverse as if to be covered by closed questions only. Moreover, it was hard to quickly assign the answer to the appropriate check boxes during the interviews.
  Another consequence was to only ask for reasons which LDBs and LTs fulfilled in different ways.

  Example: drinks and snacks were available on both trains and buses, and were thus not deemed an influencing criterion for the mode choice. Such preference statements from passengers would thus only reveal a (wrong) subjective perception.

  Eventually, predefined qualitative mode choice criteria were derived from passenger statements from the pretest and taken over in the questionnaire:
  - WiFi: clearly advantageous for bus
  - View/sight: rather advantageous for train
  - Freedom to move / spacing: rather advantageous for train

  Passengers were asked to rank these three comfort characteristics (1=very important, 3=least important)

- The question about the willingness-to-pay was clarified and extended. Different (theoretical) prices were eventually proposed to passengers randomly. The calibration was however done during the pre-test phase, when it became obvious that bus passengers would never accept a +15EUR additional fare for trains compared to LDBs. The level was consequently set down. For train passengers, the original format proved suitable. See chapter D.4.3.3 for additional information.
- Layout changes were made, with DB / CBS and TUM logos placed on top of the questionnaires

Both LT/CBS V1.1 and LT/CBS V3.1 (translated and original German versions) are part of the Attachment 10

D.4. STATISTICAL EVALUATION

D.4.1. Methodology

D.4.1.1. Datasets

Various impressions and observations pointed out that further data smoothening would be required.

Aggregation Level 0: raw, untreated set of answers from the survey (dataset: "raw")

This dataset contained the untreated answers from the survey and was not subject to any evaluation. The shift from the dataset "raw" to the subsequent dataset "total" was just based on cleaning, clarification and logical smoothening. The single steps can be traced in Attachment 14.

Number of questionnaires contained in the dataset "raw":

MN_LT	n = 377
NM_LT	n = 374
MNNM_LT (=combination)	n = 751
MN_LDB	n = 186

Aggregation Level 1: consideration of groups and long-distant destinations (dataset: "total")

A first data analysis after having cleaned the raw data set proved that the passenger movements were unbalanced. The survey had mostly taken place with a certain emphasis on one direction with regard to daytime. In the morning, Munich to Nuremberg was focused, while the other direction was surveyed directly afterwards in the noon or early afternoon hours. This led to the following distortions which are still part of the dataset "total":

- The (comparably few) passengers travelling long distances on LTs were reached on MN_LT mainly, since they were prone to start in the morning in order to reach their long-distant destination at the same day. The respective impacts were retrievable in context of ticket types and distances. Eventually, this was one of the main reasons for different outcomes in the datasets MN_LT and NM_LT, which were harmonized in the dataset "reduced" later (see below). As only northbound LDB passengers with regard to mainly Inner-Bavarian destinations were asked at the CBSs, the train dataset had to be smoothened accordingly in order to prevent misleading results.
- Another disturbing influence was identified in bigger groups on LTs, which were unlikely to travel on LDBs. If they had decided on taking the bus, it would have been more sensible to order charter buses, since group tariffs are not available for MFB. Consequently, a group size threshold was drawn at a group size of ≥10 people. Those groups were then removed in the dataset "reduced".

Number of questionnaires contained in the dataset "total" (with regard to "raw"):

MN_LT	n = 352 (-25)
NM_LT	n = 360 (-14)

MNNM_LT (= combination)	n = 712 (-39)
MN_LDB	n = 186 (±0)

Aggregation Level 2: omission of groups and distant destinations (dataset: "reduced")

The dataset "total" was thus interesting to see where people are going – and that there is a considerable, though not dominant, transport flow towards long-distance targets on MNx LTs. However, these long-distance travelers are not the "typical" customers of LTs. The negative influence was the distortion of several of the recorded numbers: average travel distance, fare per person, per km, mode choice decisions and even more.

In order to obtain a harmonic, more homogenous dataset, it was necessary to concentrate on mass data which was available for both buses and trains, independently from the direction (LTs only): **Inner-Bavarian trips without consideration of groups of ≥10 people.** Two groups of 25 people each, and each one group of 10, 14, 28 and 50 members were affected. Since the questionnaires were filled out per group and not per person, the effect on the dataset was not as big as the figures could let guess.

Number of questionnaires contained in the dataset "reduced":

MN_LT	n = 322 (-30)
NM_LT	n = 346 (-14)
MNNM_LT (combination)	n = 668 (- 44)
MN_LDB	n = 145 (-41)

Map illustrations of both datasets "total" and "raw" are available in Attachment 7.

Introducing a standard distance

For a meaningful comparison of both distances and thus fares per person per kilometer, it was necessary to introduce a standardized distance. For passengers it was indifferent whether the distance of the route was longer – as long as travel times, fares etc. were acceptable. Consequently, the route was standardized for both LTs and LDBs in the same way. This standard distance was the direct line distance, though it was *not* measured from a trip's origin to its destination, but in three steps instead:

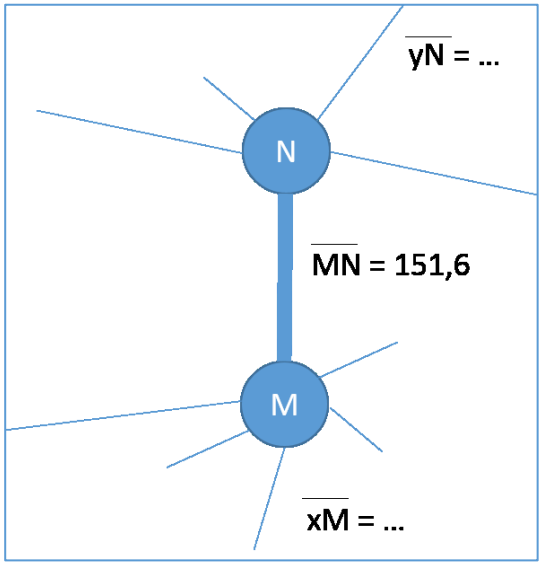


Figure 28: Principle of the unified distance calculation

- Origin to Munich $\overline{xM}$
- Munich to Nuremberg, constant 151.6km $\overline{MN}$
- Nuremberg to the trip destination $\overline{yN}$

The principle was illustrated in Figure 29. For all opposite trips the calculation was done accordingly. All measurements were carried out individually per dataset based on an *.xlsm tool which allowed distance calculations based on post codes. (Weinert 2008) For foreign or ambiguous place names, manual reworking was necessary. Eventually, all three distance elements were summed up and (automatically) assigned for each trip of all questionnaires of the dataset "total" and "reduced". The procedure thus lay a valid database for relational comparisons, in which distances could be included (see e.g. chapters D.4.2 and D.4.3).

Particularly interesting city pairs are shown in Table 13.

Distance from Munich to… [km]				
Nuremberg	Erlangen	Bamberg	Würzburg	Bayreuth
151.61	168.21	203.61	257.96	220.60

Table 13: Unified distances for the most relevant destinations

For the number of questionnaires (and people) for these destinations refer to chapter D.2.3

Analysis tools and background information

For each analysis there was a reference to the underlying dataset in the following form *[direction_mode, "dataset"]*

For some analyses, cross tables and correlations were drawn up. Correlations were measured with the Bravais-Pearson coefficient. It ranges between **-1 (perfect negative correlation) and +1 (perfect positive correlation)**. The value 0 constitutes no correlation.

The coefficient requires at least ordinal scale data. For that reason, the codes from attachment 13 were taken. In addition, the Pearson coefficient is sensitive to outliers. Since the dataset "reduced" did not contain any outliers anymore, this effect could not occur. (Riepl 2011) In addition, trials with the Spearman rank coefficient produced very similar values.

For cross tables, both percentages and absolute values were listed. Depending on the context, the tables were drawn up for either **column sums = 100% and/or row sums = 100%**. The most meaningful values were colored in red shades in the background.

In the analysis chapters, screenshots of computed data in R were included. Two elements of the display have to be explained:

- Unlike the rest of the document, the direction-mode abbreviations like e.g. MN_LT could not be processed by R. Therefore, the format was changed to e.g. MNT (Munich-Nuremberg Train) or MNB (Bus accordingly). A "y" was used for separation, followed by the underlying dataset "red" ("reduced") or "tot" ("total").
- The Pearson correlation value is the very last number (at the bottom of each R extraction).

D.4.1.2. Parametric processing

A basic prerequisite for many standard evaluations is the normal distribution of the underlying dataset. A plot of histograms confirmed that there is mainly no normal distribution among the dataset "reduced", which was the basis for most analyses.

> *e.g. the distances were not equally distributed. Most passengers were travelling to Nuremberg, Erlangen or relatively close places around Nuremberg. As a matter of fact, the histogram was left-skewed. Among most other items there were similar irregular patterns.*

However, various sources (Sullivan 2016; Mordkoff 2016; Scibilia 2016) suggest non-parametric tests only for small sample sizes. The number of 30 seems to be a well-accepted threshold among researchers. Accuracy for bigger samples is still granted with regard to the Central Limits Theorem. The smallest dataset (MN_LDB "reduced") however still included 145 cases.

For the dataset "reduced", overlaid Histograms for MNNM_LT and MN_LDB were computed in R and added to Attachment 16. For the same dataset, also Boxplots were extracted for all items containing applicable (and useful) data (see Attachment 15).

D.4.2. Preliminary Evaluation 1: dataset "total"

As announced in chapter D.4.1, the dataset "total" was only subject to general evaluations. The summary of statistical values in Attachment 12 shows that the accuracy (e.g. standard deviations, confidence intervals, etc.) of the dataset "total" is way lower compared to the dataset "reduced". This was true for almost all items of the survey.

However, for the following single items it was sensible to do the evaluation with this dataset as they contained data of *all* customer groups of MNx passengers going from Munich to Nuremberg (or vice versa).

Distribution of LT passenger destinations [MN_LT and NM_LT, "total"]

It is interesting to see the categorical destinations of passengers, i.e. with regard to the cities Munich and Nuremberg, Bavaria and other. Figure 30 shows the distribution for both MN_LT and NM_LT, for origins and destinations. Nuremberg was roughly the origin / destination of 50% of all trips, while Munich used to play a bigger role (75-80%). The share of long-distant destinations was small, though not always negligible. The offset between MN_LT and NM_LT with regard to those destinations was ca. 5%, an observation that again justified the differentiation of the datasets "total" and "reduced".

> *The share of passengers going from Munich to Nuremberg was 37.8% (133/352), from Nuremberg to Munich 41.4% (149/360). See also table Table 10.*

Despite those differences, the parity of traffic streams was on a good level.

An equivalent graph could have been drawn for LDB passengers too. However, since the sample size was much smaller and the buses were selectively chosen, this graph would not contain any robust information. LDBs to Bamberg and Würzburg will seldom carry people to beyond Bavaria. Moreover, the destinations of LDB customers always depended on the actual connections at the CBS. For LTs, connections were similar from hour to hour and offered numerous recurring transfer possibilities at the terminus of the train (Munich or Nuremberg).

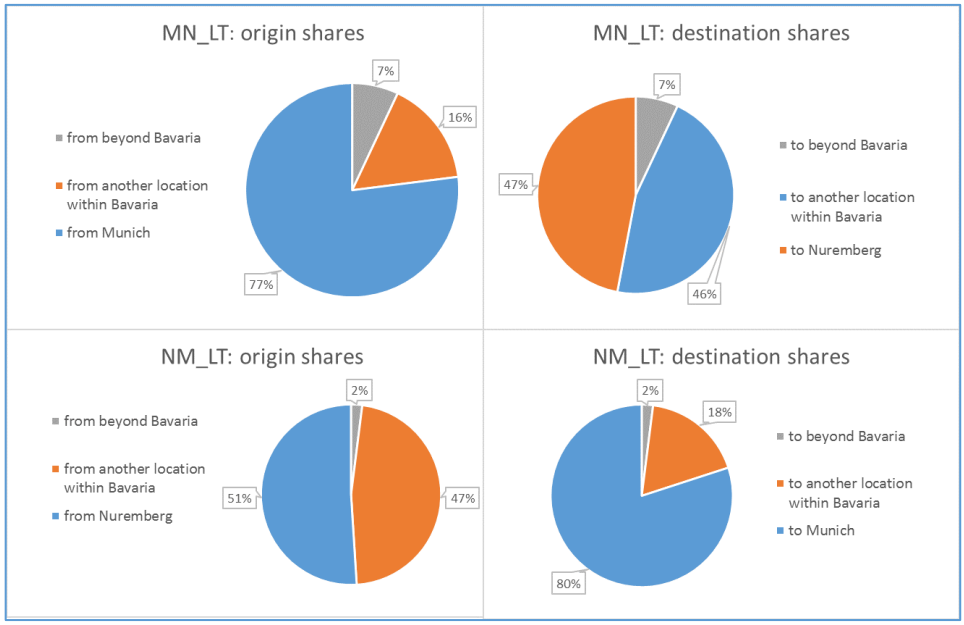


Figure 29: MN_LT and NM_LT: categorical origins / destinations per questionnaire

> *On 13 October there were for example four questionnaires with destination Amsterdam. Obviously, one of the chosen LDBs provided suitable transfers to another LDB at Nuremberg CBS. However, these were individual cases and rather met by coincidence.*

Ticket type usage [MNNM_LT "total"]

Figure 31 shows the overall (direction-independent) shares of tickets of LTs. The BT ticket was the most well-demanded and accepted offer. For MN_LT, the percentage was 78%, for NM_LT it numbered 88%. The direction-dependent offset again confirms the disharmony in terms of travel

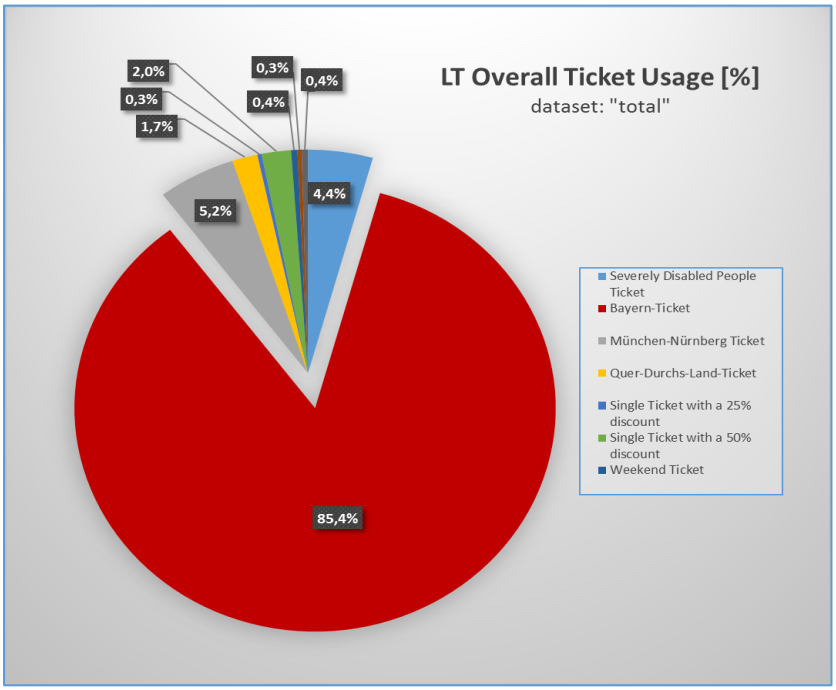


Figure 30: MNNM_LT: shares of tickets that were used among passengers

distance (BT is not valid outside Bavaria). It can also be connected with the fact that MN_LT had 7% passengers to places beyond Bavaria while NM_LT only contained 2% (Figure 30 above).

WiFi importance and age [MNNM_LT and MN_LDB, "total"]

Using cross-tabs, the interrelation of these two items was measured based on the dataset "total", too. This was possible as the responses for WiFi-importance did practically not differ between the two datasets "total" and "reduced" (see statistical values in Attachment 12).

MNNM_LT	Importance of WiFi over profession									
	pupil	*trainee student*	*employed*	*retired*	*other*	*pupil*	*trainee student*	*employed*	*retired*	*other*
	NUMBERS					*PERCENTAGES*				
Very important	11	76	95	6	4	78,60%	45,50%	26,00%	4,00%	25,00 %
Somewhat important	2	60	129	14	4	14,30%	35,90%	35,20%	9,40%	25,00 %
Not important	1	31	142	129	8	7,10%	18,60%	38,80%	86,60%	50,00 %
Col sums = 100%						100	100	100	100	
Very important	Row sums=100%					5,70%	39,60%	49,50%	3,10%	2,10 %
Somewhat important	Row sums=100%					1,00%	28,70%	61,70%	6,70%	1,90 %
Not important	Row sums=100%					0,30%	10,00%	45,70%	41,50%	2,60 %

Table 14: MNNM_LT: WiFi importance over profession

Table 14 shows the ranking of WiFi over the professions, which also indirectly reflected age. The evaluation was done per questionnaire, not per person. Since there was a difference for when column sums or row sums held, both versions were shown in the graph. Furthermore, it was very important to be aware of the number of questionnaires behind each percentage (see left part of Table 14). The subgroup "other" did not contain any valuable information.

```
        Pearson's product-moment correlation

data:  c(MNTytot$WiFi, NMTytot$WiFi) and c(MNTytot$Profession, NMTytot$Profession)
t = 12.774, df = 710, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.3705911 0.4902004
sample estimates:
      cor
0.4322953
```

Figure 31: MNNM_LT: Pearson coefficient for WiFi&Profession Calculated with (R Studio 2016)

A calculation of the Pearson coefficient in R (Figure 32) showed a moderate positive correlation.

Some core statements from Table 14:

- *"41.5% of all people on the train who rated 'WiFi' as less important (rank 3), were retired (elderly people), 45.7% were employed"*

- *"86.6% of all retired people on the train rated 'WiFi' as less important, but 78.1% of all pupils and 45.5% of all trainees / students rated WiFi as very urgent (rank 1). However, the absolute numbers of pupils are rather low.*

On LDBs, the distribution became less accurate due to the smaller sample size, (e.g. "retired" over "WiFi is very important" numbered 0.0%, say not a single such statement). WiFi can be considered necessary for younger people – those who were the main customers of LDBs.

The same table was eventually drawn for the LDB survey too:

MNNM_ LDB	Importance of WiFi over profession									
	pupil	*trainee student*	*employed*	*retired*	*other*	*pupil*	*trainee student*	*employed*	*retired*	*other*
	NUMBERS					*PERCENTAGES*				
Very important	4	37	18	0	1	33,3%	43,0%	24,7%	0,0%	6,3%
Somewhat important	5	31	37	0	2	41,7%	36,0%	50,7%	0,0%	12,5%
Not important	3	18	18	11	1	25,0%	20,9%	24,7%	100,0 %	6,3%
Col sums = 100%						100	100	100	100	
Very important	Row sums=100%					6,7%	61,7%	30,0%	0,0%	1,7%
Somewhat important	Row sums=100%					6,7%	41,3%	49,3%	0,0%	2,7%
Not important	Row sums=100%					5,9%	35,3%	35,3%	21,6%	2,0%

Table 15: MN_LDB: WiFi importance over profession

The high share of young people also made the Pearson correlation coefficient drop. The respective correlations were:

Some core statements from this table:

- *"61.7% of all people on the buses who rated 'WiFi' as very important (rank 1), were students."*
- *"50.2 of all trainees/students and pupils on the bus rated 'WiFi' as most important (rank 1).*

```
        Pearson's product-moment correlation

data:  MNBytot$Profession and MNBytot$WiFi
t = 3.4007, df = 184, p-value = 0.0008242
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.1029008 0.3739744
sample estimates:
      cor
0.2431798
```

Figure 32: MN_LDB: Pearson coefficient for WiFi&Profession Calculated with (R Studio 2016)

The figures for LDBs must however be handled with caution. The small number of retired people and few pupils actually relativize the validity of inferences with regard to this group. The figure for the students can be seen as more precise though.

D.4.3. Detailed Evaluation 2: dataset "reduced"

The more detailed analyses were based on the dataset "reduced", as it contained a more homogenous data structure. A big numerical overview of the dataset was computed by Excel and R and is part of the thesis in Attachment 12.

Moreover, a graphical overview on the data structure was evaluated in R. The results were Boxplots and Histograms which are part of the Attachments 15 and 16.

D.4.3.1. Univariate Analyses

The following figures were mainly based on mean values. For additional information the median value was added to some figures, too.

Alternative modes of LDB passengers [MN_LDB, "reduced"]

Line-independent statistics for the entire country (see chapter B.1.2.1) differed greatly from the line-dependent numbers: while the overall image is that former LT and LDT passengers form ca. 43% of all LDB passengers, the value is considerably higher on the Munich-Nuremberg line.

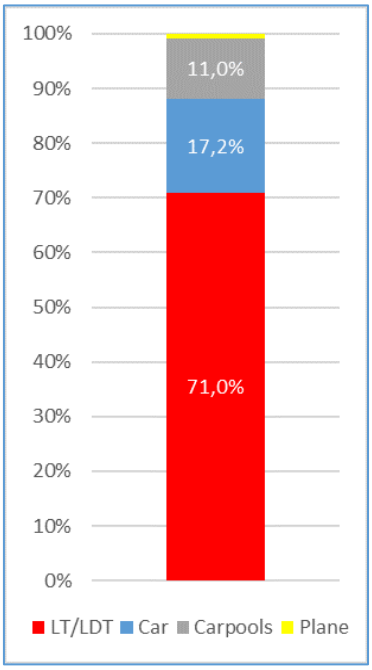


Figure 33: MN_LDB: alternative modes

In the questionnaire, there was no differentiation between LDTs and LTs. However, there are signs that LTs are more severely affected than LDTs: For LDB passengers on Inner-Bavarian lines, LDTs are not as attractive as LTs because of the big fare offset.

The statement was based on the assumption that in most cases special offer tickets for LDTs (ideally 14.25 EUR with BC25, or 19 EUR) would be available for some passengers only. The step from LDBs to LDTs was therefore deemed more drastic since they are much more expensive than LTs.

Therefore, most of the 71% of LDB passengers from the dataset "reduced" might have chosen LTs if LDBs were not available at all. The number would possibly range between 40-50% - however, the data did not allow any exact inferences.

Age structure on LTs and LDBs [MNNM_LT and MN_LDB, "reduced"]

Evidently, LDBs predominantly attracted young students, rather than any other person group. The two diagrams (Figure 35) basically reflect the same statement, as the attributes of both age and employment fit well together. The vast absence of children (0-14 years) on LDBs can be explained by the tariff and convenience structure:

- The fare structures of LTs allow free transport of own children in this age class while children cannot travel free of charge on LDBs.
- Freedom to move and short travel times are particularly important when children are taken on a journey. This could be observed on the survey, too (on the basis of group size, fare per person, per km, comfort perception).

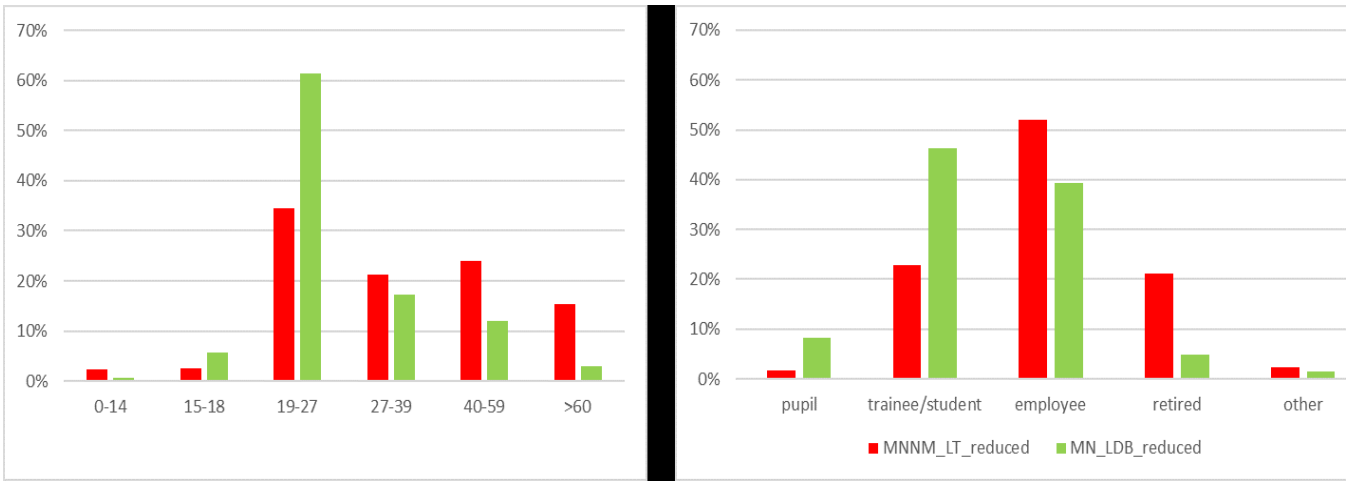


Figure 34: MNNM_LT and MN_LDB: age and profession of passengers

However, the high share of students among bus passengers might be slightly overestimated, since the survey times at the CBS Munich were often right at the weekend commuter hours (Thu, Fri and Sun afternoons and early evening). On LTs, the surveys had mostly taken place earlier in the day (see chapter D.2.3). Nevertheless, the tendency was certainly true.

Shares and tendencies of group sizes per mode [MNNM_LT and MN_LDB, "reduced"]

Figure 37 clearly proves a high share of alone travelling passengers, while the group size LT clients happened to distributed more equally.

> *Notice: the term "group" must not be mixed up with the description "big groups of ≥ 10 people", which are no longer part of the dataset "reduced". Here the term "group" rather describes the number of people per questionnaire (=people per ticket).*

The most common group sizes on LTs were 1 and 2 people (see Figure 36). The share of people travelling alone was 49.7%. However, there were considerable shares for 3-5 people, too.

On LDBs, most passengers were travelling alone (in 125 questionnaires out of 145 samples; = 86%). Group sizes >3 were hardly met at all.

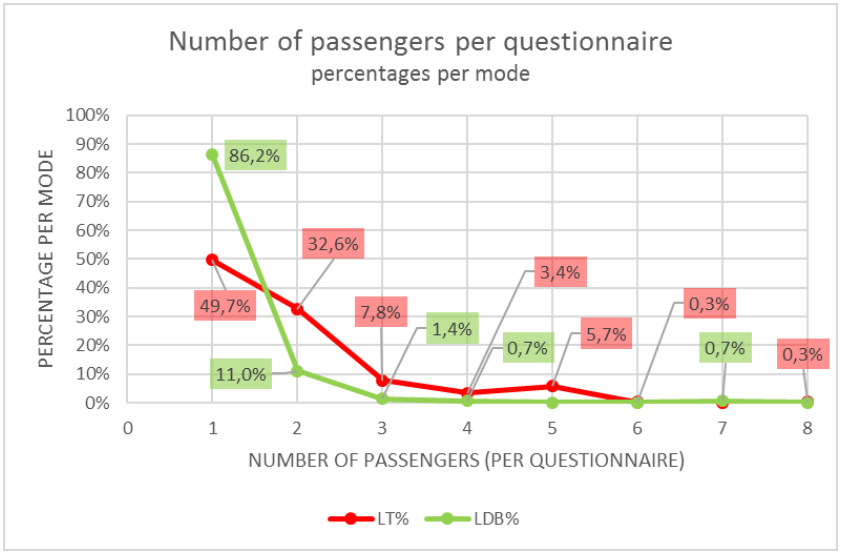


Figure 35: MNNM_LT and MN_LDB: group size distribution per mode

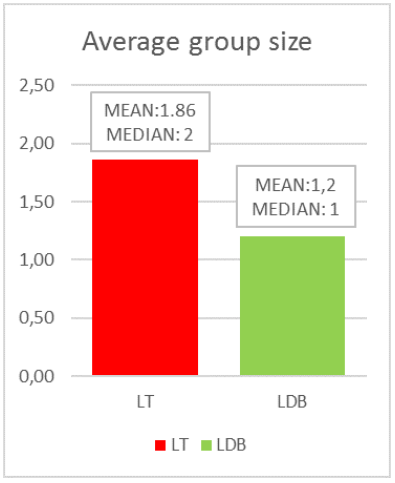


Figure 36: MNNM_LT and MN_LDB: average group size

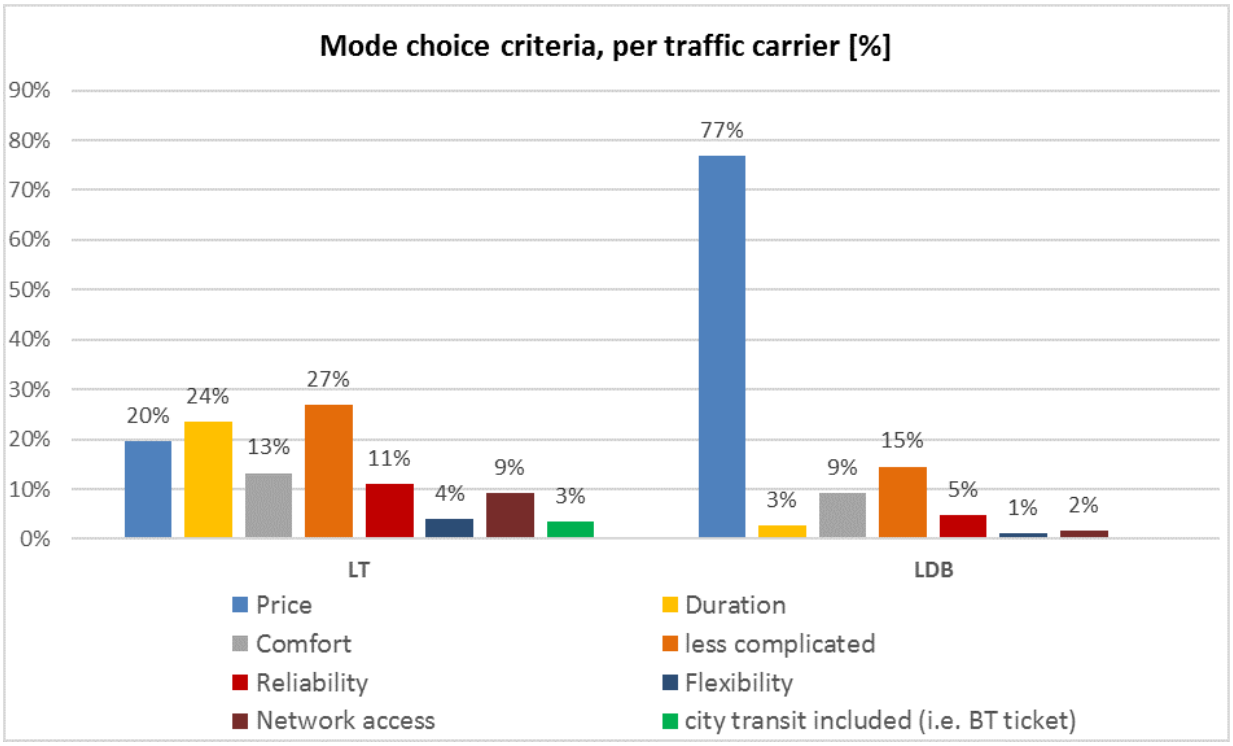


Figure 37: MNNM_LT and MN_LDB: mode choice criteria per mode

On trains, the mean group size was 1.86 persons per group while the number for buses was much lower (1.2).

Since it is not only the mean values, but also the medians which prove a considerable offset between the modes, the tendency is very clear here. However, one must not neglect that also group sizes on LTs tended to be small.

Mode choice criteria for LDB and LT passengers

The associated question 2.5 of LT/CBS V3.1 allowed multi-referencing, but most passengers still stuck to one or two statements. The general perception that LDBs attracted people with their low fares was vastly proven in the survey. For 77% of all LDB users, the fare was the main decision criterion, as shown in Figure 38. Most LT customers voted in favor of three categories: fare (which in most cases had its break-even for group sizes of 2-3 people), duration (which is virtually always faster on LTs), and the description "less complicated". Latter contained also habitual reasons: the regular, memorable departure frequencies and the familiar booking procedures, to just name a few. "Less complicated" could thus mean that elderly people chose the train because they do not want to purchase tickets online or that they were less prone to try new mobility offers at all. However, for younger people, online booking is a feature of uncomplicatedness.

LTs seemed to be perceived more reliable than LDBs, which is rather seldom a decisive criterion for the mode choice though. Indeed, sentences like the following were frequently heard while doing LT surveys: "I normally take the bus, but today I've got an appointment where I need to be on time. That's why I'm taking the train".

The BT also included free city transport in most cities, also in Munich and Nuremberg (see chapter 0). This advantage was sometimes mentioned among LT passengers, but is certainly often an "unspoken" part of the attribute "fare" or "less complicated".

Average fare per person per kilometer [MNNM_LT and MN_LDB, "reduced"]

The paid fares for LDBs were indeed fundamentally lower than what people paid for LTs. The rather theoretical number can be highlighted with the aid of a simple example: Recalculated for the unified distance from Munich to Nuremberg (151.6km), LDB passengers pay 8.49 EUR, while an average LT trip cost 13.80 EUR. The difference of more than 5 EUR on the average (!) fare is remarkable. What even made things more extreme is that the peak prices of the extended Oktoberfest weekend (03 October) *were* included in the data. During the survey on this weekend, LDB fares were two-digit without exceptions (see chapter C.6.2) while the fare system of LTs is *always* constant. Consequently, the fare offset in "normal" conditions, say weekend or even during the weeks, is deemed even slightly bigger than mentioned above.

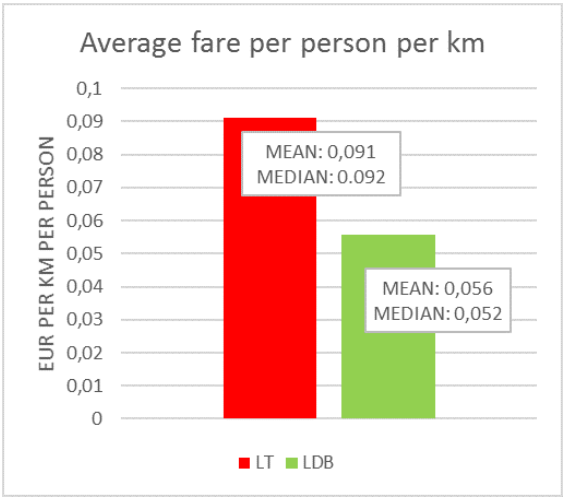


Figure 38: MNNM_LT and MN_LDB: average fares per person, per km

Stated comfort preference of LT and LDB passengers [MNNM_LT and MN_LDB, "reduced"]

On the first glance, the diagram in Figure 40 might not be intuitively comprehensible. The most important characteristic is that y=2 indicates an indifferent attitude of passengers towards comfort in LDBs and LTs. In awareness of this it is then easy to see that LT passengers are actually very convinced of the comfort of LTs (=1). On the other hand, even LDB passengers still have a strong tendency towards the train, as their answers even fell below the threshold of indifference, thus slightly voting in favor of trains.

Another interpretation is that even though trains were considered more comfortable among bus passengers, their attitude towards the bus is much more positive than for train passengers.

However, the data needs to be seen with reservations, as the question on the CBS did not distinguish between LTs and LDTs (!). This might have led to an overestimation of the train comfort perception of LTs among bus passengers.

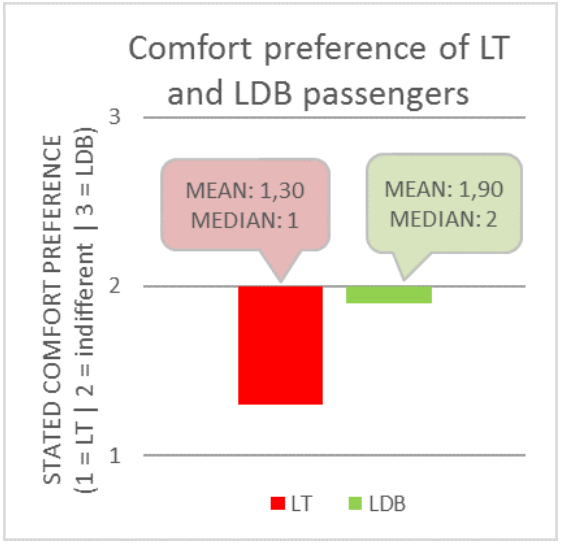


Figure 39: MNNM_LT and MN_LDB: stated comfort preferences

D.4.3.2. Bivariate Analyses

Unlike single-item analyses, the following paragraphs sought to find relationships between two different items in order to find deeper insights. Since "age" and "profession" were supposed to have big influences on many other items, many of the following bivariate analyses were made based on the item "profession". The interrelationship between age and profession in the dataset "reduced" was already proven in Figure 35.

MNNM_LT and MN_LDB: Profession (containing ~Age) ↔ **statement: "less complicated"**

		PERCENTAGES				NUMBERS			
		Pupil	Student/ Trainee	Employed	Retired	Pupil	Student/ Trainee	Employed	Retired
MN _LDB	"less complicated" was not a criterion	66,7%	89,6%	91,2%	71,4%	8	60	52	5
	"less complicated" was a criterion	33,3%	10,4%	8,8%	28,6%	4	7	5	2
	Column sums	*100,0%*	*100,0%*	*100,0%*	*100,0%*				
MNNM _LT	"less complicated" was not a criterion	63,6%	71,2%	74,4%	73,8%	7	109	258	104
	"less complicated" was a criterion	36,4%	28,8%	25,6%	26,2%	4	44	89	37
	Column sums	*100%*	*100%*	*100%*	*100%*				

Table 16: MNNM_LT and MN_LDB: profession and "less complicated"

Despite the small absolute numbers for LDBs, there is a light tendency that young people are more prone to rate LDBs as less complicated. On trains, rather more settled people and elderly had the impression that trains were less complicated. The group "other" was omitted.

```
        Pearson's product-moment correlation

data:  MNTNMTyred$`less complicated` and MNTNMTyred$Profession
t = -0.95647, df = 666, p-value = 0.3392
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.11257898  0.03893036
sample estimates:
        cor
-0.03703715
```

```
        Pearson's product-moment correlation

data:  MNByred$`less complicated` and MNByred$Profession
t = -1.001, df = 143, p-value = 0.3185
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.24311719  0.08069276
sample estimates:
        cor
-0.08341367
```

Figure 40: MNNM_LT and MN_LDB: Pearson coefficient for Profession &"less complicated"

Calculated with (R Studio 2016)

The Pearson correlation coefficient hardly showed a considerable relationship: on LDBs, young people tended to rate buses as less complicated while on LTs there was practically no correlation. Latter statement is interesting, as one would have expected elderly people and employees to rather take the train due to people's habits.

MNNM_LT and MN_LDB: Profession (containing ~Age) ↔ **LDB experiences**

have you ever tried LDBs so far?		PERCENTAGES				NUMBERS			
		Pupil	Student/ Trainee	Employed	Retired	Pupil	Student/ Trainee	Employed	Retired
MN_LDB	no	8,3%	9,0%	8,8%	14,3%	1	6	5	1
	yes	91,7%	91,0%	91,2%	85,7%	11	61	52	6
	Column sums	100,0%	100,0%	100,0%	100,0%				
MNNM_LT	no	63,6%	23,5%	57,3%	81,6%	7	36	199	115
	Yes	36,4%	76,5%	42,6%	18,4%	4	117	148	26
	Column sums	100,0%	100,0%	100,0%	100,0%				

Table 17: MNNM_LT and MN_LDB: Profession and LDB experiences

It was the first ride on LDBs for only a vast minority of bus passengers. However, most train passengers had never tried LDBs. One would expect that the older people are, the less interested and open they are for LDBs. The numbers for pupils are low and have thus to be seen as less representative.

```
        Pearson's product-moment correlation

data:  MNTNMTyred$Profession and MNTNMTyred$`LDB_experienced?`
t = -9.6324, df = 666, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.4145471 -0.2812889
sample estimates:
       cor
-0.3496854
```

Figure 41: MNNM_LT: Pearson coefficient for Profession & LDB experiences

Calculated with (R Studio 2016)

On the other hand, there were also students/trainees on the LTs who had made good experiences with LDBs. Further investigations on this group found out that they were travelling in big group sizes above-average (2.16 instead of the dataset's mean of 1.90). Their main mode choice reasons were "Price" (35%) and "less complicated" (38%; multi-referencing was possible). These statements confirmed that the fare of LTs tends to be quite attractive for groups of young people.

MNNM_LT: Profession (containing ~age) **↔ Price per person, per km**

The graph in Figure 43 was evaluated in order to find out whether younger people, respectively people with generically lower income (especially pupils and students) pay less per person. This could be the case for e.g. students who find fellow travelers (e.g. Internet, App), or organize in groups in other ways. However, such a pattern is not recognizable. The mean value does however indicate a tendency that employees are more likely to spend more money per km per person than all other groups.

Mean values were [EUR per person, per km]: 0.0857 (pupils), 0.897 (students/trainees), 0.0958 (employees), 0.0835 (retired)

The low value of retired persons is though influenced by another factor: severely disabled people were part of the mean, even though their fare was 0. Ignoring those tickets, the value surges back to 0.093 EUR per person, per km.

However, even without counting the 0 values of "fare per person, per km", R only produced a correlation of 0.015 (see lower part of Figure 44 – which is better than before the adjustment (-0.055), but still did not imply any considerable correlation.

```
        Pearson's product-moment correlation

data:  MNTNMTyred$Profession and MNTNMTyred$Fare_per_person_per_km
t = -1.4329, df = 666, p-value = 0.1523
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.13074818  0.02050445
sample estimates:
        cor
-0.05543992
```

```
data:  MNTNMTyredoSBH$Profession and MNTNMTyredoSBH$Fare_per_person_per_km
t = 0.37659, df = 643, p-value = 0.7066
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.06242153  0.09194401
sample estimates:
       cor
0.01484972
```

Figure 43: MNNM_LT: Pearson coefficient for Profession & Price per person, per km

Calculated with (R Studio 2016)

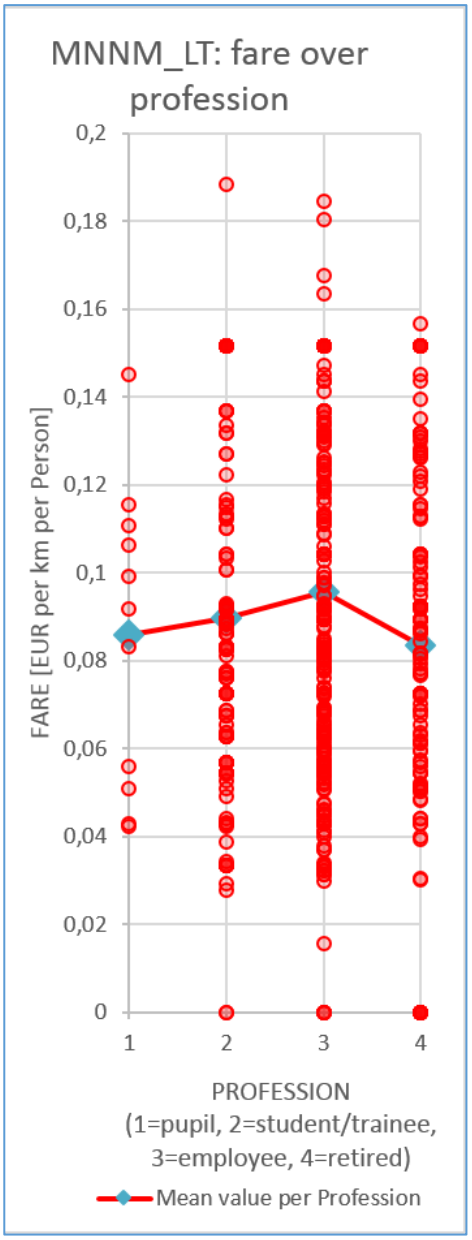


Figure 42: MNNM_LT: fare & profession

> *In this context it should be pointed out that correlation coefficients are not sensitive to different scales like the graph had on the x-axis (1-4) and on the y-axis (0.08-0.095). Only the covariance would be.*

MNNM_LT and MN_LDB: Group size ↔ profession

No considerable changes of group size per profession (=age) could be observed. The few cases per cell on LDBs were hindering a meaningful evaluation for this mode.

For LTs, there was only a light deflection for students travelling in groups of 5 people – and in groups > 1 person in general.

```
        Pearson's product-moment correlation

data:  MNTNMTMNByred$Group_Size and MNTNMTMNByred$Profession
t = -1.5878, df = 811, p-value = 0.1127
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.12395318  0.01313755
sample estimates:
        cor
-0.05567019
```

```
        Pearson's product-moment correlation

data:  MNTNMTyred$Group_Size and MNTNMTyred$Profession
t = -2.3812, df = 666, p-value = 0.01753
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.16657769 -0.01613492
sample estimates:
        cor
-0.09188059
```

Figure 44: MNNM_LT: Pearson coefficient for Group size & Profession

Calculated with (R Studio 2016)

In Figure 45, the Pearson correlation coefficients were calculated. On the left, the figure shows the correlation for all modes (MNNM_LT and MN_LDB), while the right part only shows the value for MNNM_LT. The coefficient confirmed the weak inferences: the small negative figure can be vaguely interpreted as follows: the bigger a group is, the younger the people (because retired

was coded "4" and pupil/student "1" and "2"). However, the extent of correlation is not reliable. For the LT dataset, the coefficient becomes slightly clearer.

MN_LDB	PERCENTAGES				NUMBERS			
Group size:	Pupil	Student/Trainee	Employed	Retired	pupil	student/trainee	employee	retired
1	91,7%	89,6%	84,2%	71,4%	11	60	48	5
2	8,3%	10,4%	8,8%	28,6%	1	7	5	2
3	0,0%	0,0%	3,5%	0,0%	0	0	2	0
4	0,0%	0,0%	1,8%	0,0%	0	0	1	0
5	0,0%	0,0%	0,0%	0,0%	0	0	0	0
6	0,0%	0,0%	0,0%	0,0%	0	0	0	0
7	0,0%	0,0%	1,8%	0,0%	0	0	1	0
8	0,0%	0,0%	0,0%	0,0%	0	0	0	0
Column sums	100,0%	100,0%	100,0%	100,0%				
MNNM_LT								
	Pupil	Student/Trainee	Employed	Retired				
1	54,5%	45,8%	50,1%	56,0%	6	70	174	79
2	18,2%	28,1%	32,6%	35,5%	2	43	113	50
3	18,2%	11,1%	7,2%	5,7%	2	17	25	8
4	9,1%	3,9%	4,0%	0,7%	1	6	14	1
5	0,0%	11,1%	4,6%	2,1%	0	17	16	3
6	0,0%	0,0%	0,6%	0,0%	0	0	2	0
7	0,0%	0,0%	0,3%	0,0%	0	0	1	0
8	0,0%	0,0%	0,6%	0,0%	0	0	2	0
Column sums	100,0%	100,0%	100,0%	100,0%				

Table 18: MNNM_LT and MN_LDB: Group sizes & Profession

MNNM_LT and MN_LDB: Comfort perception ↔ LDB experiences

Before the interrelation of this items can be interpreted, one has to be aware the questions were slightly different for LT and LDB customers. While LDB passengers only had to state whether the upcoming trip would be their first, LT passengers had another differentiation. In case they had already gathered experiences on buses, they should say whether they had made good or rather negative experiences.

Table 19 shows the percentage comfort perceptions vs. LDB experiences.

	PERCENTAGES			NUMBERS		
MNNM_LT (col sums = 100%)	**not experienced**	**experienced**		**not experienced**	**experienced**	
Train	79%	74%		289	220	
indiff	19%	13%		72	40	
Bus	2%	13%		8	39	

Column sums Σ	100%	100%		369	299	668
MNNM_LT (row sums = 100%)	**not experienced**	**experienced**	**Row sums Σ**	**not experienced**	**experienced**	**Row sums Σ**
Train	57%	43%	100%	289	220	**509**
indiff	64%	36%	100%	72	40	**112**
Bus	14%	86%	100%	8	39	**47**
MN_LDB (col sums = 100%)	**not experienced**	**experienced**		**not experienced**	**experienced**	
Train	28%	24%		7	60	
indifferent	24%	18%		3	23	
Bus	48%	58%		4	48	
Column sums Σ	**100%**	**100%**		**14**	**131**	**145**
MN_LDB (row sums = 100%)	**not experienced**	**experienced**	**Row sums Σ**			**Row sums Σ**
Train	10%	90%	100%	7	60	**67**
indifferent	12%	88%	100%	3	23	**26**
Bus	8%	92%	100%	4	48	**52**

Table 19: MNNM_LT and MN_LDB: comfort perception and LDB experiences

Some core statements to improve the comprehensibility of Table 19:

- *79% of all LT passengers who had not made any experiences with LDBs yet rated trains as more comfortable. At the same time, 74% of those who had made experiences on LDB rides still felt that trains were more comfortable.*
- *On the other hand, 58% of all LDB passengers who had made LDB experiences before (91% of all) stated that buses were more comfortable than trains. This confirmed that bus passengers were relatively convinced of the bus offer. However, one must not overlook that 24% of all LDB passengers would have favored a train ride – but were still bound to buses, despite longer travel times, apparently due to the low fares (see Figure 38 for respective information)*
- *While only 9% of LDB customers had not tried LDBs before, this was true for 55% of all LT customers.*

```
        Pearson's product-moment correlation

data:  MNTNMTyred$`LDB_experienced?` and MNTNMTyred$Comfort_Better_In
t = 3.3972, df = 666, p-value = 0.0007212
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.05520251 0.20434906
sample estimates:
      cor
0.1305141

data:  MNByred$`LDB experienced / not first ride on bus` and MNByred$`Comfort better in`
t = 0.48183, df = 143, p-value = 0.6307
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.1235600  0.2019441
sample estimates:
       cor
0.04026016
```

Figure 45: MNNM_LT and MN_LDB: Correlation of Comfort perception & LDB experiences
Calculated with (R Studio 2016)

The second bullet point still leaves space for ambiguous interpretations: were LDB customers positively surprised by LDBs? Or did they just rely on other criteria, such as WiFi, plugs etc., which they did not associate with the term "comfort"? Since the questions were asked in a very general way, it was not possible to go into the details, especially because the values are not totally clear here. It was an interesting phenomenon that LDB passengers, who are generally familiar to both modes, have a more positive image of LDBs than LT passengers have. From this tendency arise possible issues for LT operators: once passengers have tried LDBs, their recovery might be difficult.

The Pearson correlation of 0.039 is slightly positive only, while the tendency for LTs is clearer: people on LTs who had tried LDBs before had a more positive perception of buses than passengers without experiences.

> *The value for LDBs (0.039) is basically meaningless since it was not the first trip on a LDB for the vast majority of passengers (91%). Therefore, the value which is very close to zero anyway, does not contain important information.*

And there was another influencing factor which originated in the way of asking the question: for many LDB passengers, a "train" was associated with LDTs instead of LTs.

> *The question was intentionally designed in this way, as many LDB passengers would not have had any particular idea of the quality of LTs on the line. With regard to this item, the statements from LT passengers were deemed more reliable, as they could naturally associate the question to the LT train they were on and apparently everyone was generally familiar with the comfort of a bus.*

Consequently, if passengers would have been asked for LTs more specifically, even more people would have tended to rate the comfort of LDBs higher, rather than the one on LTs.

MNNM_LT: Ticket type ↔ group size (↔ travel distance)

The shares of ticket types were already part of the univariate analysis in chapter D.4.2. The upcoming bivariate examination was meant to deepen the view of the univariate analysis

mentioned, linking it to the group size. Since the BT ticket was the far-and-away most relevant ticket, travel distances were added using the secondary y-axis for this ticket.

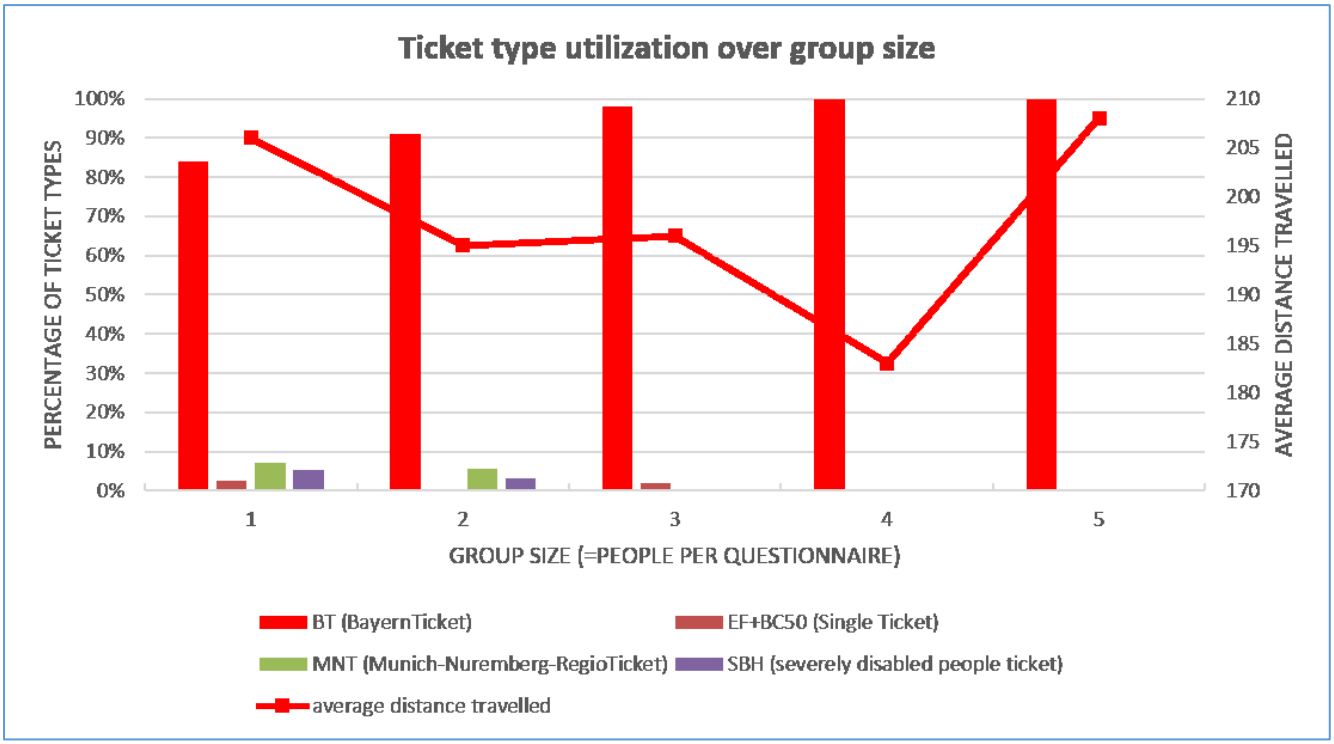


Figure 46: MNNM_LT: attractiveness of the BT ticket over group size

Calculated with (R Studio 2016)

Additional information: number of cases in which BT tickets were used:

People per group	Number of cases	People per group	Number of cases
1	332	4	23
2	218	5	38
3	52	≥ 6	5 *(not displayed)*
		Σ	668

Table 20: MNNM_LT: BT ticket usage with regard to the group size (absolute numbers)

Some core statements for better understanding of Figure 47:

- *84% of people who were travelling alone had chosen the BayernTicket (23 EUR). On average, those people were travelling 204km.*
- *With group size, the BT ticket became more and more attractive, even when the distances were declining. The surge of distances from 4 to 5 people per group using the BT ticket is deemed rather coincidental, since the number of cases was comparably low (23 and 38).*

The visible correlation from Figure 47 is also reflected by Pearson's correlation coefficient (0.17). For its calculation, the BT was coded as "1" while all other tickets were "2". Consequently, the bigger a group is, the more important became the BT ticket. However, one must not forget that also for small groups (e.g. 1-3 people) the BT was still the most relevant ticket.

D.4.3.3. Theoretical willingness-to-pay

The theoretical willingness-to-pay (wtp) was recorded among both LDB and LT passengers. The questions for bus passengers and LT passengers were different though:

- Questionnaire CBS V3.1: *"Using the train, the journey between Munich and Nuremberg is about 30min shorter compared to this bus. Would you accept the increased fare, if the train cost 3 / 5 / 8 / 10 EUR more than what you paid for this bus (total cost for all passengers)?"*
- Questionnaire LT V3.1: "*Using long-distance buses, the journey between Munich and Nuremberg is about 30min longer compared to this train. Would you accept the extended travel time, if the bus was 5 / 8 / 10 / 15 EUR less costly than this train (total cost for all passengers)? "*

The different fare increments were asked randomly. Calibration of the increments was taking place during the pretest in August 2016 (see chapter D.4.1. for more information).

The equal distribution of the fare steps throughout the questionnaires was aimed at, though not totally attained. It had thus to be weighed in order to reach 25% each. However, the derivations were marginal, as displayed in Table 21:

Fare increments	LTs	LDBs
3 EUR	--	27.1%
5 EUR	26.7%	23.6%
8 EUR	24.3%	25.7%
10 EUR	25.4%	23.6%
15 EUR	23.6%	--

Table 21: MNNM_LT and MN_LDB: achieved distributions of theoretical fares

After weighing, the responses were transferred into Figure 48. The left circle diagram shows the overall responses of "yes" (willing to change) and "no" (not willing to change) independently from the fare. Latter was set into context on the right side of each of the two diagrams.

Both diagrams show stunningly similar numbers: general willingness-to-change (left) was about 70% "no" and 30% "yes". However, these kinds of direct comparisons were not meaningful since the fare increments differed. The general and expectable trend was though met: the cheaper an LDB was, the more willing LT passengers were to change – and vice versa.

Obviously train passengers were less willing to change than bus passengers (this was already stated in the pretest of the survey and led to the different increments). This is mainly based on two characteristic of a train ride:

- In the questions mentioned above, the bus ride was always defined to take 30min longer than a train ride; **LTs are thus temporally advantageous** anyway (see chapter C.2.1).
- The general **comfort perception is better on LTs** than on LDBs (see chapter D.4.3.1).

It was both impossible to separate these two on the basis of the collected data, and it was not relevant. The actual statement of interest was the extent of the monetary benefit which would have to be offered in order to make someone change mode.

One could thus also expect that it is more “financially” effortful to make LT passengers change to LDBs.

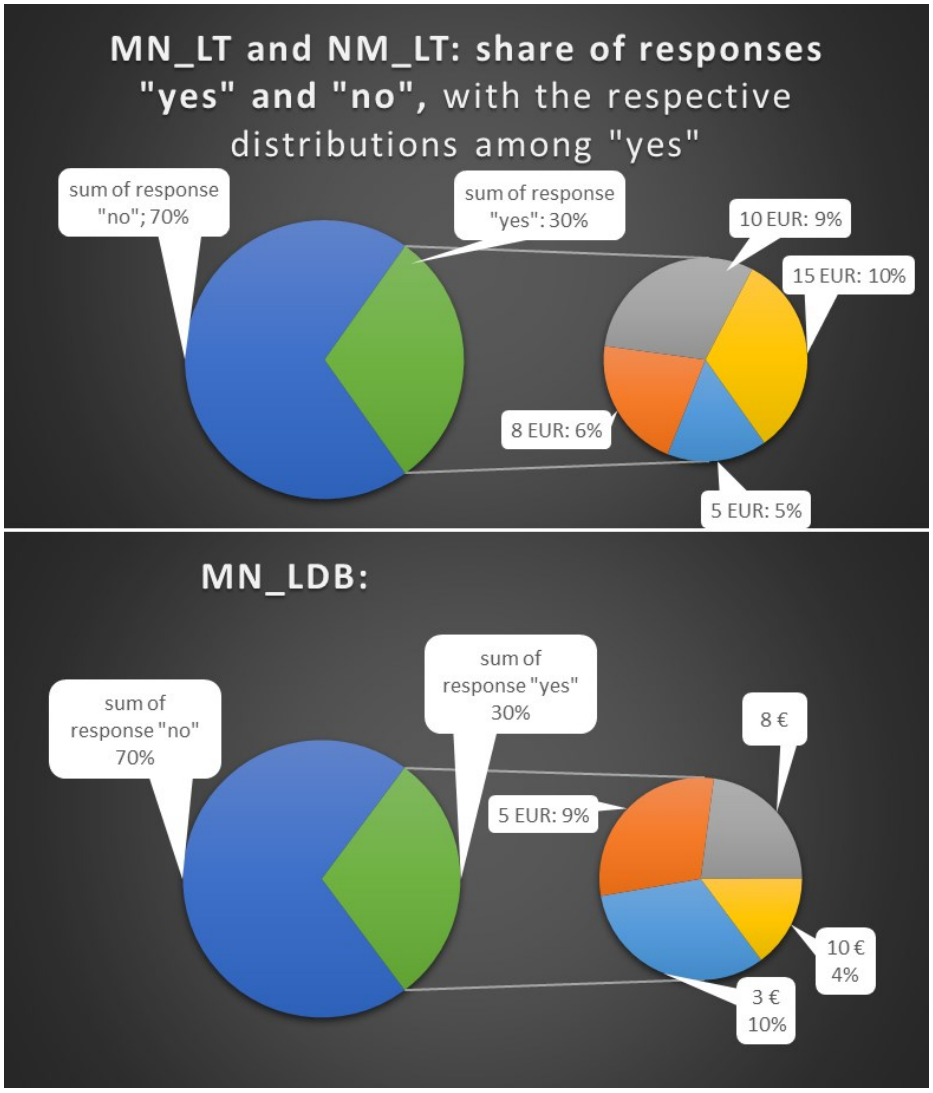


Figure 47: MNNM_LT and MN_LDB: share of answers regarding wtp

The upper figure shows the combined data of MNNM_LT, enclosing all 813 valid questionnaires from the dataset “reduced” (MNNM_LT = 668 + MN_LDB = 145).

Another component had to be taken care of. The 70% “no”-respondents of both LTs and LDBs would partially have switched mode if they were offered better incentives (Moeckel 2016c). More bus passengers were assumed to change for 1€ additional fare, while train passengers would have needed a 20€ benefit in order to answer “yes”.

Consequently, the trend line in Figure 49 below was interpolated for these two values, which were displayed transparent. The estimations showed that both figures would match another 10% each of former “no”-respondents. On both traffic carriers, about 60% would thus stay on “their” mode. Such an equal distribution was stunning, as one would expect a higher willingness-to-change among LDB passengers – also in memory of the survey item “general comfort perception” (see chapter D.4.3.1). In this context, it is again important to remember the different fare increments, which have caused an offset with regard to the answers from the very beginning.

However, the "yes"-responses were calculated independently from the travelled distance and the group size. It was therefore necessary to furtherly process the values to obtain the resulting *fare per person, per km* (contained in Attachment 12).

The impact became visible with the calculation of the *resulting fare per fare increment [EUR per person, per km].* In other words, the acceptable amount of money LDB passengers had to pay in average (per person, per km) in order to switch to LT transport (and accordingly vice versa for LT passengers who should switch to LDBs). The results are shown in Table 22 below. The base was the fare and the number of item "yes"-respondents over the sum of "yes"-respondents. Interpolated values from theoretical fare increments were marked in light orange.

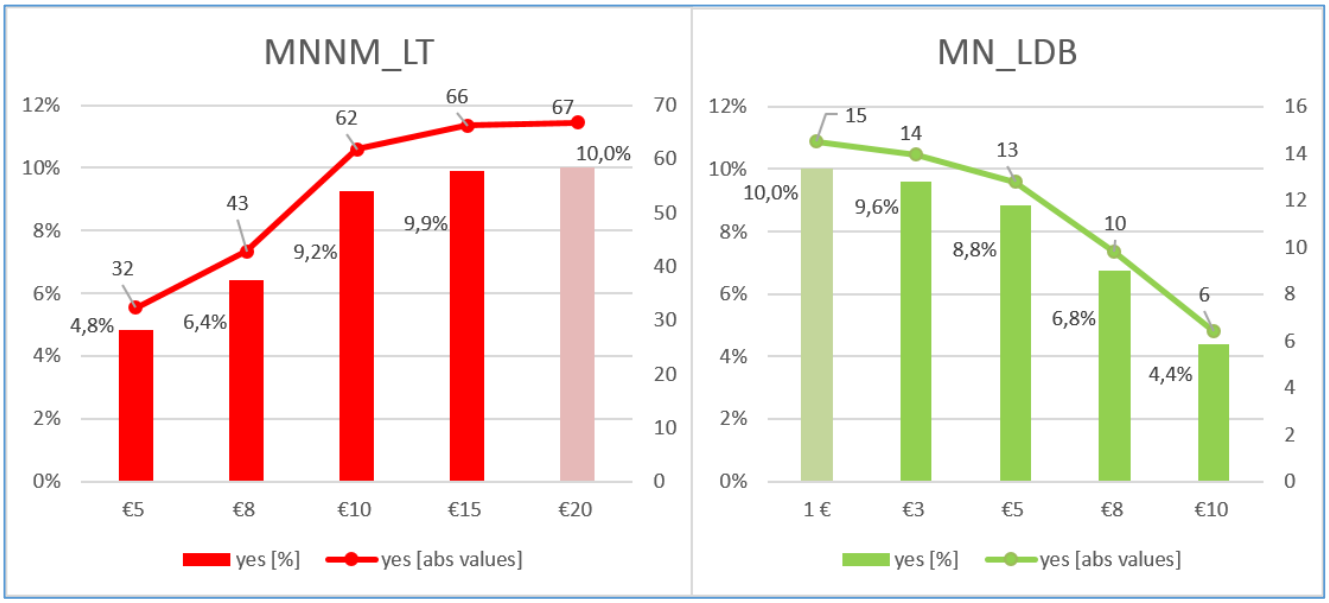


Figure 48: MNNM_LT and MN_LDB: likelihood of all "yes"-respondents to change modes

	nr of "yes"-respondents	current average payment (EUR per person, per km)	resulting average wtp [EUR per person, per km]	difference	e.g. Munich-Nuremberg (151,6km)	annotations	**to retrieve xx % of all**
LT → LDB							
-5,00 €	33	0,0865	0,0684	-0,0181	10,37		**4,94%**
-8,00 €	40	0,0920	0,0636	-0,0284	9,65		**10,93%**
-10,00 €	62	0,0871	0,0527	-0,0344	7,99		**20,21%**
-15,00 €	66	0,096176484	0,037224822	-0,0590	5,64		**30,09%**
-20,00 € (interpolated)	67	n/a	0,01997819	n/a	3,0286935		**40,12%**
LDB → LT							
+1,00 € (interpolated)	15	n/a	0,05362906	n/a	8,13016506		**40,00%**
+3,00 €	14	0,0587	0,0723	+0,0136	10,97	group of 7 people included	**29,66%**
+5,00 €	13	0,0423	0,0701	+0,0287	10,63		**20,00%**

	nr of "yes"-respondents	current average payment (EUR per person, per km)	resulting average wtp [EUR per person, per km]	difference	e.g. Munich-Nuremberg (151,6km)	annotations	**to retrieve xx % of all**
+8,00 €	10	0,0664	0,1050	+0,0386	15,96		**11,03%**
+10,00 €	6	0,0574	0,1090	+0,0516	16,52		**4,14%**

Table 22: MNNM_LT and MN_LDB: willingness-to-pay of "yes"-respondents

Some concluding statements to improve the comprehensibility:

- *MFB could attract up to about 30% of LT customers with their current fares. The extended trip duration and the generally lower comfort perception of LDBs are included in this number. However, the real share of passengers is lower because LDBs do not serve all destinations of trains. The dense LT network coverage over the country is an important advantage of LT operators.*
- *Between Munich and Nuremberg, LT operators could attract up to 40% of LDB passengers if tickets were available for 8.13EUR per person. This shift could be achieved in most cases. However, for some destinations (e.g. Bayreuth) the assumption in the question (30min faster) would not be true.*

Table 22 derived a more precise, practically applicable value for the willingness-to-pay for LTs and LDBs. However, there is no indication to which extent it originates from the shorter travel time or from other characteristics such as comfort, reliability, or other criteria.

Shortcomings

The size of the LDB dataset is not as big as the one of LTs, causing reduced accuracy. However, the table in Attachment 12 (summary of statistical values) does not suggest any sign of sheer invalidity of this dataset.

All trips except city pair connections cannot be substituted by LDB services. The attempt to only analyze answers which *could* in reality be substituted by LDBs failed though, as there were not enough such datasets.

The linearity of the fare estimation for the theoretical additional fares 1EUR and 20EUR was a simplification, as for the curves would possibly follow a non-linear course. More precisely, a non-linear approach with regard to distance would have possibly been more appropriate.

In general, questions where people are asked to pay more for something lead to underrepresentations, as individuals always misestimate their actual willingness-to-pay. (Kagerbauer 2015) Therefore, the figures might contain underestimations.

The question structure was not very intuitive to understand: 30min time difference measured from where to where? What if buses were not available in the hometown of a passenger? Since passenger did not have a lot of time to ponder the question, their answers may have contained some uncertainties. Prior to the analysis, the question was thus subject to serious doubts whether the results would be useful. The more surprising were the relatively clear outcomes and the conclusive distribution of the answers, as well as the apparently realistic inferences on the willingness to pay.

D.5. LESSONS LEARNED AND FURTHER EXAMINATION NEEDS

Neither can dataset evaluations be global for every single aspect and correlation, nor can questionnaires contain all interesting information. Therefore, this chapter should help understand shortcomings and future evaluation needs.

Lessons learned

Even though the pretest had greatly contributed to the improvement of the questionnaires, the final version LT/CBS V3.1. still contained single inaccuracies.

For the survey on LTs, it would have been an interesting question whether the interviewees would go back on the same day. In this case, flat-rate day passes such as the BT, Munich-Nuremberg Ticket etc. are widely advantageous. Bus passengers would have to pay per trip in those cases.

The assumption that the opinion of all group members can be aggregated in *one* questionnaire was a questionable simplification. However, no better solution could have been thought of until to the end of the thesis.

The question 2.6 in LT/CBS V3.1. was phrased in a complicated way and asked for a distance which was not accurately specified.

With regard to LDB customers, the questions 2.5, 2.6, and 2.8 of CBS V.3.1 did not make any distinction between LTs and LDTs. However, such a separation was hardly achievable since it could not be expected that LDB passengers were totally familiar to all characteristics of LT and LDT trips (e.g. fares, trip duration, comfort, etc.). Consequently, even a new survey would follow a similar approach again.

Future examination needs

Even though the questionnaires LT/CBS V3.1 contained a question on the trip frequency of passengers, this item was never considered in any analysis. The existing dataset(s) would therefore hold potential for additional such evaluations. The information could e.g. used for calibrating the importance of answers, giving regular riders a higher weight compared to uniquely travelling passengers.

The statements of LDB passengers were evaluated with no regard to their alternative mode. Consequently, the answers of someone whose alternative mode would have been e.g. private car were used for inferences on the competitive behavior of LTs and LDBs. This is actually a simplification, but given the high share of potential train users (70%) and a generally common, mode-independent sensitivity regarding comfort, fare and trip duration, it appeared tenable.

The population estimations for LTs (chapter C.1) could be improved using a logit model, where the two base factors (city population and passenger counts) can be leveled off. However, for the scope of this thesis, such an improvement of accuracy was simply not necessary.

In addition to the (most important) univariate analysis and its bivariate counterpart, multivariate analyses could produce more relationships. However, given the limited sizes of the datasets, the success of those evaluations seems doubtful.

Sometimes, passengers had an objectively wrong perception of their mobility choice. For example, there were LT passengers travelling alone, who thought that the LT trip would be less costly than a LDB ride from Munich to Nuremberg. The dataset(s) still contain the data, but would have to be filtered out. However, there were few cases only.

D.6. SIDE COMMENTS ON THE SURVEY

Public Transport is known to be a microcosm for all levels of the society. Carrying out the survey, this became visible. As shown in Module D, there were miscellaneous types of people and groups travelling for completely different reasons. At the very beginning of the poll during the pretest phase in August 2016, many families were on their way to visit relatives, grandparents went on city trips with their grandchildren, workers on week-end trips. These and numerous other occasions were the base for many friendly conversations. Many travelers deeply started thinking about the bus competition and the questions, bringing up totally new aspects of why people actually travel on buses or trains. In this context, it was stunning to see the (subjective) perception of single people towards these two means of transport: some passengers claimed to stay away from buses for safety reasons – a statement that is hard to prove with statistics ((Die Welt 2014a). On the other hand, the ecological footprint of busses was sometimes estimated too negative, as it actually dependent from the load factor. Nevertheless, some single train passengers were convinced that buses would always be more harmful for the environment than trains.

Other interesting similar statements were made on the allegedly poor social standards applied upon bus drivers.

There were many occasions in which the individuality of people became evident: A man refused to participate in the survey when the first questioner on the one side of the aisle asked him to. However, when another questioner was approaching on the other side of the aisle, he actively asked him whether he could take part, with a surprising explanation: the second questioner simply seemed more sympathetic to him.

This man, together with a lot of other people, would not stop talking once a conversation had started. Sometimes, the following minutes would reveal a wrap-up of the person's whole life, with sometimes even intimate stories.

Another person was deliberately filling out the form when he suddenly ripped it apart and threw it in the bin. He severely complained about the survey and said that it denigrated LDBs – an unfair treatment he did not want to support.

Numerous passengers were unaware of the differences between interviewers and qualified conductors. It was often necessary to not only work through the questionnaire but also to listen to daily "passenger problems". Toilets out of service, malfunctions of the air conditioning, capacity problems of single trains and many more issues were projected on the interviewers. Elderly people and mothers with babies frequently asked for help with luggage or baby carriages; help that was of course deliberately provided.

With the DB app on the smartphones, the questioners frequently assisted people in finding their connection trains, buses, or simply the arrival time of a train.

Doing the survey, also politically induced issues became prominent: one of the most shocking moments was a young Eritrean refugee who was carrying all his possessions with him. His English skills were on a good level though, allowing a short conversation: he was on his way to Switzerland and was not in possession of a valid ticket – and did not care at all since he had more severe problems to face. He simply could not afford to buy one and there were no considerable consequences for him to fear. It was the bare attempt to find a better life, after having made bad experiences in his home country, as well as in German refugee homes. It was a moment where worlds collided, and an instance where issues such as humanity, helpfulness and social commitment became striking.

E. Recommendations, Final Conclusion and Outlook

On 09 November 2016, the underdog candidate Donald Trump was elected for President of the United States and proved all opinion analysts wrong. Hardly any statisticians had predicted him to win the struggle for presidency. Even their extreme scenarios had not expected his victory.

Even though the consequences would have deeper impacts than the results of the examination of the Master's thesis, it revealed that there are always uncertainties among surveys. In particular, the volatility of the LDB market, the limited size of the sample and constraints by time, money and manpower, were the most vulnerable conditions for the validity of this study.

Nevertheless, the survey in Module D, together with the line-dependent analysis in Module C, have brought up miscellaneous important insights which are illustrated in the following SWOT analysis. They were subsequently translated into specific action proposals.

SWOT-Analysis

In general, the strengths / opportunities of one mode are the weaknesses / threats of the other. Therefore, duplicates were avoided in the SWOT analysis in Table 23. However, there are still such parts in the table in case that one aspect had to be pointed out particularly. Most elements are not limited to the Munich-Nuremberg line, but all aspects mentioned in the table are true for the line.

Advice: here in the SWOT analysis, the green and red colors are not related to LDBs / LTs. They only underline the labels "harmful" (red), respectively "helpful" (green)

LTs:		
	HELPFUL	**HARMFUL**
INTERNAL	• Economies of scale / synergies in a big company	• No quick adaptions due to extensive internal organization • Stiff, inflexible pricing scheme with no chance to control the load factors • Most lines are not as affected as Munich-Nuremberg → less interest of LT operators to intervene • Hardly any detailed info about passengers / trips available • Cannibalization effects resulting from new special offers of LDTs which resulted from the LDB competition

LTs:		
	HELPFUL	**HARMFUL**
EXTERNAL	• Better image / comfort perception of LTs compared to LDBs • Inhibitions of some passenger groups to try LDBs • big influence of DB on the market • trains are well-known among all passenger groups • dense network (nationwide) • memorable frequency *future:* • new trains will soon provide better comfort and improve frequency without intermediate transfers	• No quick adaptions due to many external influences (tariff unions, sector entities, politics…) • Numerous LDB lines throughout the day between Munich and Nuremberg *future:* • Young people are more open to LDBs, rather than older people → a long-term problem! • MFB attempts to extend and densify its network • Call of LDB operators to set the tempo limit to 120km/h instead of 100km/h (Frankfurter Allgemeine Zeitung GmbH)
LDBs:		
	HELPFUL	**HARMFUL**
INTERNAL	• Comprehensive information about passengers available from the booking process → valid database for changes of all kinds • Lean company structures, quick adaptions possible	• Lack of profitability up to now, expectations of investors are expected to cause price increases • Dependency from subcontractors
EXTERNAL	• low infrastructure costs • attractive booking environment for young people (smartphone, refunding regulations, etc.) • strikes at LDT/LT operators • few restrictions with regard to pricing, routes, schedule design etc. only • dynamic pricing helps to control the load factor • WiFi availability helps to bind young clients	• Competitiveness with regard to travel times • Attractiveness is limited to point-to-point connections (e.g. Munich-Nuremberg) *future:* • Sensitive reactions of passengers to (expected) fare increases • Political changes (toll, oil price, etc.) • Call of LT operators for law adaptions of PBefG in order to change the thresholds (e.g. 100km instead of 50km)

Table 23: SWOT analysis for LTs and LDBs

Consequences and recommendations

With the conclusions from the SWOT analysis and the single insights from the Modules C and D, it was eventually possible to formulate recommended measures. The following proposals were written from the LT operator's point of view, for mainly two reasons:

- The Federal government has always been trying to foster rail transportation, rather than road transport. (Presse- und Informationsamt der Bundesregierung 2014)
- The legal framework has proven outdated with regard to modern, long LT lines such as MNx. The laws are actually trying to limit private competition of LTs, as latter are publically subsidized.

However, the last paragraph briefly addressed LDBs in order to assure the neutrality of the thesis. Moreover, inverting the arguments, one could also derive suited approaches for the LDB operator's perspective.

The subsequent recommendation did not take into account the self-sufficiency / profitability for the operator, but rather provides guidance on which levers could be moved effectually.

Recommendations for the LT operator on the Munich-Nuremberg line:

1. **Introduce student tickets / student discounts:** even though reduced BCs can be purchased by students, they are practically not used for trips on MNx trains from Munich to Nuremberg. Given the negligible share of tickets where BC discounts are applicable at all, this is not surprising. Those ticket types were hardly used by any passenger.
   Most students are in possession of a semester ticket in Munich, Nuremberg or other Inner-Bavarian cities that were relevant for the MNx connection. Therefore, only one of the two ways (either to the CBS at one town or from the CBS in the other) has to be paid. With regard to LDBs, this diminishes the attractiveness of a BT ticket too, as one way to/from the CBS is free anyway. The decisive point here is the offset between the BT ticket (for 1-2 people) and LDB tickets.

   The latest edition of a nationwide survey among students on social standards showed that expenses for rent were rising continually while the budget was growing disproportionately low and transport expenses remained constant (Frankfurter Allgemeine Zeitung GmbH 2013). The survey dates back to 2012 when LDB transport was not an option at all. Consequently, the tendency of students to diminish transport expenses using LDBs is comprehensible. The fact that students tend to have more time than other population groups and that they are thus willing to accept long travel times seems logical as well.

   Student trips are often related to trips back home and forth to their university town. Those trips are mainly made alone. In these cases, cheaper LT group tickets can hardly be chosen. LDBs perfectly attract *exactly these* customers – whose cheap trips are even improved by free WiFi and an entertainment offer.

   Moreover, the regular home-university trips withdraw money from LTs *periodically.*

   The implementation of student tickets would be feasible since students can prove the status with their ID-card.

   However, the actual price setting for such student tickets, e.g. per person, per km or similar, cannot be defined here. Given the availability of semester tickets at one "end" of a trip mentioned above, it appears desirable to optionally encompass public transport.

2. **Restructuring of the pricing scheme:** LDB operators are highly aware of both the expected and actual demand of their customers and apply this knowledge to the fares. The LDT operator DB FV has introduced a similar system for its special offer tickets. However, the fare system of LTs vastly neglects the demand and the load factors. Most regionwide / line-dependent tickets only exclude departures earlier than 9a.m. in order to prevent interferences to the commuter rush hours.

   The ticket system dates back to the last century and has hardly seen any profound adaptions up to now. This seems inappropriate in times of smartphones, online booking processes and yield management. Improved information about passengers and their trips would be an additional positive effect.

   However, the LT fare system is difficult to change, and such a step would be seen as revolutionary. Further, all parties involved have to agree.

   A first step could be to sell reduced tickets for trains with low demand. On the Munich-Nuremberg line, this would impact the load factor of very early and late MNx trains.

   Also the load factor of other connections to Nuremberg, such as via Treuchtlingen ("Ring West", travel time: ca. 2:43 hours), could be improved while the well-demanded "classic" MNx line (travel time: ca. 1:40 hours) would be relieved.

3. **Low effect of line-dependent ticketing:** Line-dependent tickets (like the MNT for the MNx trains) are cheaper by some Euros and easier to implement than other tickets which have to be coordinated among other operators and tariff unions. On the other hand, those tickets have little power to improve the position of LT operators with regard to the LDB competition.

   E.g. the MNT was not playing a considerable role in the survey between Munich and Nuremberg in general. More specifically, the ticket simply seemed unattractive for both LT and LDB passengers: it is valid on exactly the same connection as those served by buses. The price reduction compared to the global valid BT ticket is marginal. As most passengers do not want to go from central station to central station only, it would be more sensible to augment the range of validity either by location or by time.

4. **The 9a.m. restriction:** Both BT and MNT, together with some others, are only valid after 9a.m. on weekdays. The reason, say the separation of rush hours and validity hours is certainly not generally wrong. However, opposite to commuter streams the limitation is useless. Especially in case of the MNx trains, the commensurability is questionable: the MNx connections at 7:05 (MN) and 7:32 (NM) had little demand only, according to the passenger counts of DB Regio and the survey days 04 October and 24 October. Admittedly, for the last couple of stations of each trip when commuters are boarding, the load factor may surge. However, it does not seem appropriate to prohibit the usage of these trains for the whole journey.

   Again, it is clear that the implementation would be hard: how to exempt single trains from a general, regionwide rule?

The solution could maybe be found in the MNT ticket. Here, less passengers compared to the BT ticket would cause little influence on commuter trains. Implementation would be easy since only own tickets would be affected. Eventually, the (currently low) attractiveness of the ticket would be improved.

5. **Advertisement at the central bus stations:** Trains are a very well-known mean of transport in Germany. However, it is doubtful whether everyone is aware of the short trip duration from Munich to Nuremberg on *LTs* (instead of LDTs only). A normal, unfiltered inquiry on the booking page of DB only recommends LDT trips which are mostly expensive. Many passengers might be startled and think of other modes, rather than taking into account a specific search for LTs on the same (!) booking page. Even if they did, they might encounter other trains on the Ring East / Ring West which trip duration is about 2:43 hours. The MNx trip duration of 1:40 hours is extraordinary fast for LT trains. Many passengers are supposed to be unaware of this.

   It is possible that those misjudgements can be avoided with well-directed advertising activities. The CBS Munich offers billboard advertisements (Figure 50).

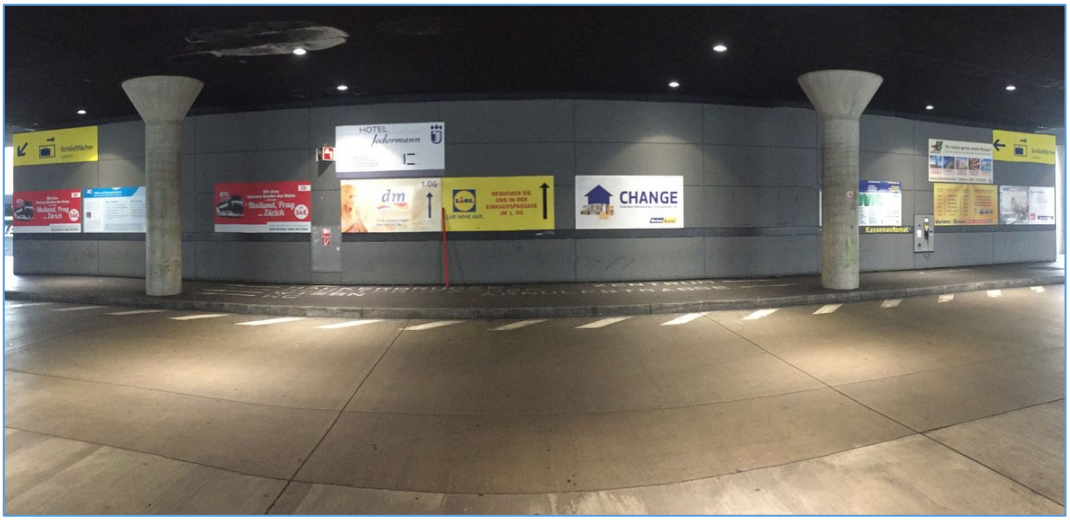


Figure 49: Billboard advertisements at the CBS Munich

Both the BT and the MNT ticket, together with new student tickets or discounts, seem to be the most important levers for the competition with LDBs on the Munich-Nuremberg line. Price rises should be avoided by all means necessary – a claim that is certainly easier to put into practice for the MNT than for the BT.

WiFi is desirable, though evidently not decisive for the short trip. LT operators should therefore rather focus on the implementation of the other improvements mentioned above.

LDB operators could basically convert the proposed measures. The most pressing issue apparently are also with regard to pricing: families and (small) groups are not adequately considered by the LDB operators, suitable tickets are inexistent. The observation that elderly people were rather unwilling to try LDBs could be overcome, e.g. by advertising bus rides and improving sales activities. The advantages for this group is that drivers will help to load luggage on the bus and seating is secured. Elderly people tend to have the time to accept longer trip durations. However, one must not forget about other elements which are particularly important

for this person group: toilet accessibility without steps, seat spacing and freedom to move are more relevant for elderly passengers.

The cooperation of LDB operators with tariff unions could help improve the catchment area of the bus stations. Monetary benefits for passengers are important, but also the inclusion of annoying ticket purchases would improve the quality of the journey chain. A wider collaboration, e.g. with LT operators can though be deemed unrealistic.

Outlook

The topic of the thesis was highly motivating, as it addressed an up-to-date topic. The big interest of DB Regio was similarly important for both the survey and the results. Moreover, it was obviously one of the first analyses of a certain line for LT and LDB competition, applied to one of the most affected lines in Germany.

The case-study was important to examine passenger's behavior with regard to mode choice in a small scale and in a defined environment. The results are thus never directly applicable to other cases. However, the tendencies and the scientific approach may be very useful for any kind of similar examination – also for other modal comparisons.

Evidently, LDBs will remain an integer part of mobility in the 21st century in Germany. For most political and economic actors, the liberalization has proven successful, especially for the Minister of Transport, Alexander Dobrindt (Die Welt 2014b). And even though the market consolidation seems to be over, there are still open discussions of regulative issues:

- The **law on renewable energies (EEG)** contains an extra burden cost for train operators. While LDBs are not affected, LT operators are obliged to pay respective cost shares. The CEO of DB has been fighting for years to change this unequal treatment and eventually imposed a reduction of the cost share. However, the European Union has been trying to intervene (Frankfurter Allgemeine Zeitung GmbH 2014)
- The discussion about the **toll integration of LDBs** is still not over either. Politicians of virtually all parties have tried to impose respective law adaptions, but were stopped by the Minister of Transport. However, the impact on LDB fares would be very low. Calculations of the Ministry of Transport estimated an extra burden of 0.2 cents per person, per km. (Die Zeit 2016a) Also LT companies have agreed that the fare advantage of LDBs can hardly be contested by tolls (mofair e.V. 2016, p. 59).
- Other political debates are still going on, e.g. on **emission trading, taxation and infrastructure cost coverage** according to causative principles
- Both LT and LDB operators keep trying to **impose law changes** in order to improve their competitiveness. While LTs try to change the threshold within LDB services are forbidden (50km) to 100km, LDBs attempt to increase the speed limit.

(Deutsche Bahn AG 2016h)

Even with those discussions looming, there is little doubt that the new mobility segment will continue to establish. For train operators, this means that they have to contemplate their pricing systems and sales channels, as well as their traditional way of carrying out their business in general.

An attempt to find an answer to the research question

The research question asked at the very beginning of the thesis asked…

"for what reasons people choose LTs or LDBs, and through which factors can operators influence this behavior?"

Naturally, it cannot be answered in one global sentence, but the response rather consists of multiple influences.

First of all, and little surprising, the fare is the most important part of the mode choice. Travel time still is another crucial aspect, but however differs between population groups. Especially students and young people are less sensitive here.

The dense rail network and the comprehensive ticket structure of the BT diminishes the probability of choosing the bus. The further people's origins / destinations are away from the next CBS, the more attractive are trips on LTs.

The bigger a group is, the bigger the likelihood to decide on LTs. The basis of the fare system of LDBs are single trips, which diminishes their attractiveness for groups. This behavior is even increased by comfort reasons: LTs are even more convenient for group travels.

The low fares, modern booking procedures, free WiFi and entertainment on board are the main elements that attract young, alone-travelling people. The first two reasons mentioned rather inhibit elderly people from taking the bus though.

Even among LDB passengers, the predominant opinion prefers the trains with regard to comfort. However, bus passengers are mostly generally happy with LDBs. This implies that once passengers have experienced a LDB, they are harder to reacquire than to make someone stick to LTs.

Eventually, an old proverb of Mahatma Gandhi has again proven true – not only for Donald Trump, but also for LDB operators:

"First they ignore you, then they laugh at you, then they fight you, then you win"

(izquotes.com 2015)

In context with Ulrich Homburg's statement mentioned in the very first chapter of the thesis, DB is currently in the "fight "-status, while LDB operators still keep winning.

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