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Long-distance travel patterns of rail users in Hungary - Findings of the new countrywide Origin-Destination (O-D) Survey

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Abstract

The paper gives a brief overview of the creation and methodology of elaborating the new nationwide Origin-Destination (O - D) survey of the passenger rail transport. Firstly presents the general transport conditions in Hungary with respect to long-distance railway transport. Then explain the harmonization methodology and the characteristics of the 4 different data source (ticketing statistics, passenger survey with over 33.700 respondents, traffic counting, household survey). The paper finally also presents the key findings of the survey and the main socio - economic factors which determine the rail user's long - distance travel patterns in Hungary.

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Keywords: O-D travel Survey; travel behaviour; rail transport; long-distance travel; Hungary;

1. Introduction

The long-distance travel patterns, in general, are a relative less researched area compared with the urban travel behaviour and suburban or metropolitan commuting patterns analysis. Since most persons' movement are taking place in and around their home and work settlements less attention is paid to long-distance travel patterns which have different constraints than their local or suburban counterparts. This paper focuses only human movements as the other kind of long-distance movements or flows as freight, information, money, etc. are completely different due to humans' natural constraints as travel time being one of the most cited ones (Fleischer and Tir, 2016). Despite the rapidly spreading telecommunication methods and the widespread use of social network websites, face-to-face human interactions are still considered an important aspect of long-distance spatial interactions. In other words "transport flows are used as a "proxy" to read the world" (Dobruszkes, 2012 p.2). In Western Countries, there is a

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growing academic literature from recent years about long-distance travel patterns (Dargay and Clark, 2012) particularly since the research made by Limtanakool et al (2007). Their research provided a possible theoretical framework for long-distance journeys, but they also note that there is not a single approach as countries and regions largely differ in what to consider long-distance travel. The unequal definitions for long-distance trip delimitations for instance above which trip length (from 50 km< till 160 km<) or journey time are far not the same around Europe as OPTIMISM FP7 (2012) research on European National Travel Surveys pointed out. Previous Research & Development (R & D) project work (Axhausen et al. 2003; Frei et al. 2010) has shown that the different purpose made surveys around Europe can result in comparable figures with some limitations particularly if it involves cross-border trips. In another research project (KITE) summary Kuhnimhof et al. (2009) concluded that there is a significant difference between the different surveys made either being household survey or a mobility diary the reporting period can range from latest trip until reporting all trips (sometimes with an overnight stay restriction) in the past 3 months which might contain more recall errors (Knudsen et al. 2014). In the current paper, two different approaches are being analysed the on-board workday latest trip passenger interview survey and the ticketing statistic database from rail O-D ticket sales. A similar combination of data sources took place in some Western Countries with relative bigger territorial extension namely in France, Germany and Italy (Beria and Laurino, 2016). Their research focus was on the recently liberalised bus (coach) transport by a combination of supply-side (timetable offer with fares) and researched tickets (demand proxy) with some socio-economic data on users profile (partly replacing surveys) analysis in which above a certain threshold (network/Euclidean distance or time) is considered long-distance according to the national regulations.

According to Dobruszkes, Dehon and Givoni, (2014) the data is growingly available to support demand-side analysis but confidentiality due to business interests is a growing issue. For this reason, the available data source is rare in Europe and only some recent works from China (Yang *et al.*, 2018) were able to obtain such a detailed O-D data in a country level. Despite being scarcely available the flow data on real people's flows seems to be a more exact indicator (Neal, 2010) than the service offer supply data which is normally freely available from timetables yet other factors e.g. occupancy rate, the capacity of the services are hardly accessible. The strength of the supply (schedule data) and demand (passenger flow) OD links might be greatly different and the current research paradigm prefers to use the demand (if available) or both to compare (Yang, Dijst, *et al.*, 2018). Another spatial configuration assessment methodology was developed by Iran (Dadashpoor, Afaghpoor and Allan, 2017) taking into account the passenger flows between provincial capitals for scheduled air, bus and the known private car flows, but not for passenger trains. The combination of a hardly available domestic full-scale OD rail ticket data combined with an onboard conducted relative high sampling of 8 % allows us to better understand the long-distance mobility patterns of the rarely analysed post-socialist country which has the highest domestic public transport modal share in Europe.

Due to this reason, a brief overview is given about the Hungarian Transport and Geographical characteristics which will be followed in Chapter 3 by the description of the latest Hungarian passenger railway travel survey aims and methods. Section 4 will show the results for the analysed long-distance transport data and provides conclusions for the last chapter.

2. Material and methods

In order to understand the national transport characteristics, the following subchapter will briefly present the transport situation in Hungary which is considered as one of the 10 "new" Member States joined to the European Union (EU) in 2004 after nearly half-century of communist-socialist socio-economic development.

2.1. General factors influencing the mobility situation in Hungary

Due to the above mentioned different political system in the past, the Central European post-socialist countries have different modal-split, network development and partly travel patterns. The different priorities and opportunities of the transport policies for economic thus transport developments have contributed the have less private car use and ownership, fewer motorways and more public transport use in general combined with lower levels of general mobility by the 1990s' (Oszter, 2017). Since the societal changes made during the past more than 25 years in many fields this gap with the Western Countries decreased but the average use of public transport including railways remained among one of the highest in the EU (Figure 1 and Figure 2).

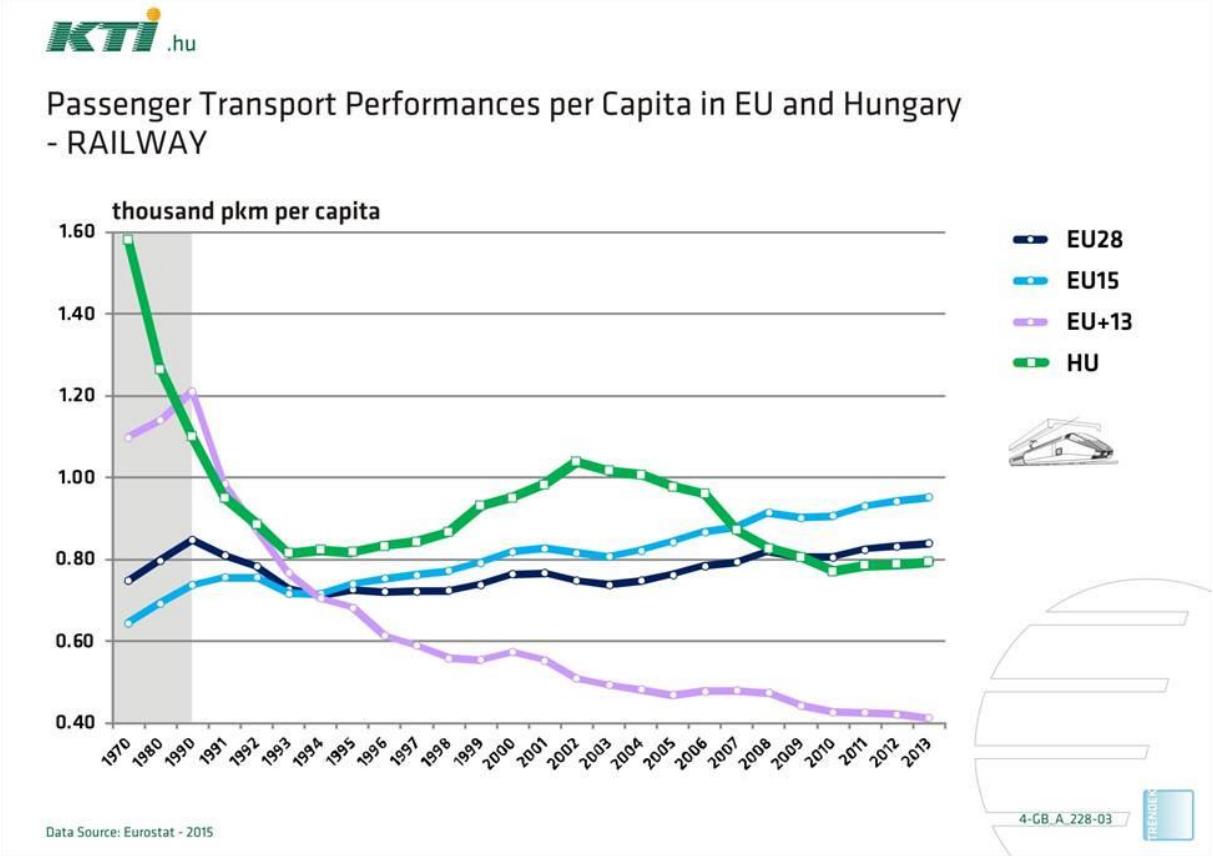

Figure 1. Railway Performance per Capita in EU and Hungary, 1970-2013. EU15 – the Member States before 2004, EU+13 New Eastern European Member states including Cyprus, Malta and Croatia. Data Source: Eurostat

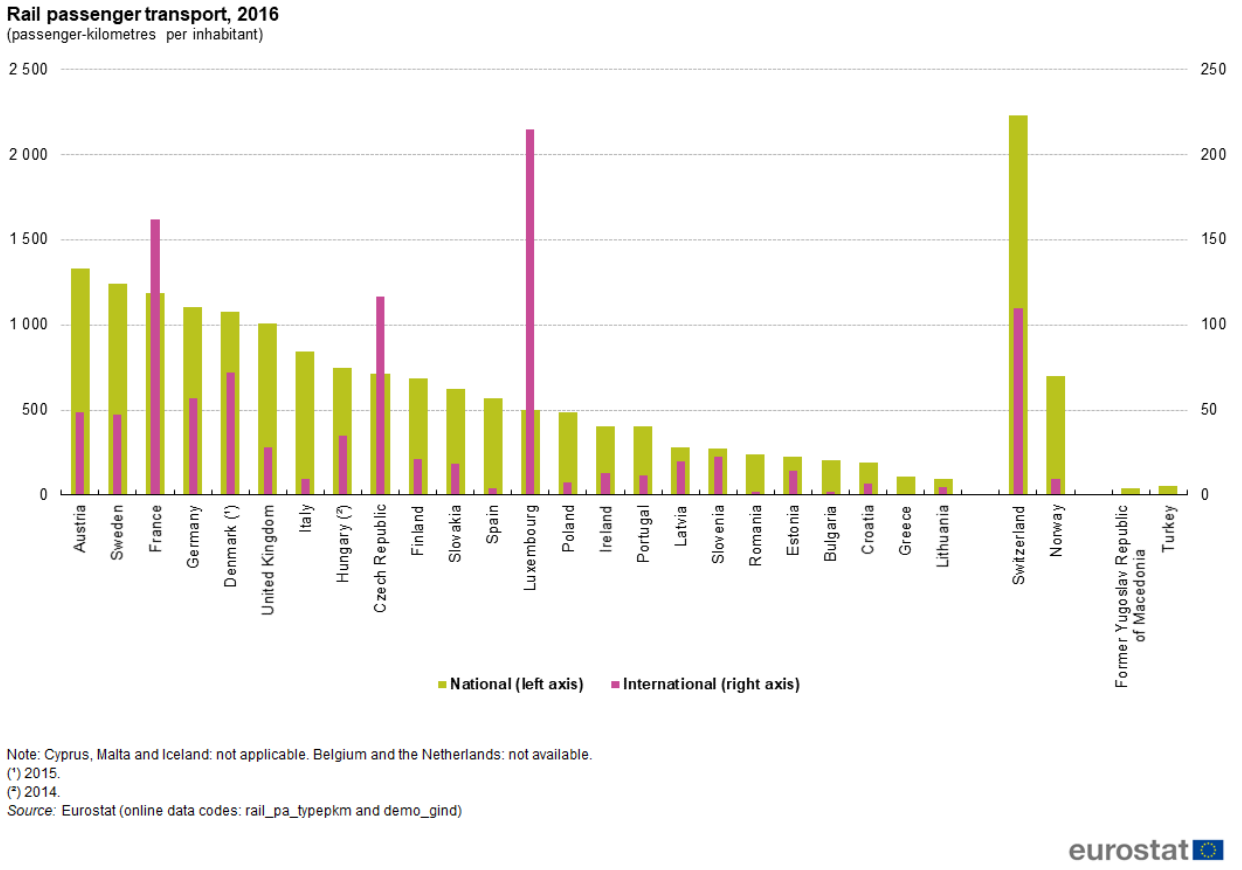

Figure 2. Railway Performance per Capita in the EU Member States (including pre-accession and EFTA countries – Switzerland, Norway) and Hungary in 2014-2015 (passenger-km per inhabitant) Source: Eurostat

Based on the passenger-km per inhabitant indicator of Figure 2. the intensity of using passenger rail services in Hungary is higher than in the Czech Republic which has the densest railway network in Central Europe (CE) and follows Italy's case among the more rail oriented Western countries.

The general modal split for all motorised trips in Hungary is also favourable for public transport as ca. 39 % of all motorised trips are made by public transport in Hungary. According to Figure 3. the modal-split based on passenger-km for private cars in Hungary was 68,2 % in 2015 which is the lowest value in the EU. This situation can be briefly explained with the good network coverage of public transport system (including 99,9 % of the settlements with at least 3 daily services) combined with the generous social tariff discounts (e.g. free travel to any EU citizen above 65 years age). At the same time, the motorisation rate is the second lowest in the EU level (325 cars per 1000 inhabitants in 2015) being far from the EU's average around 500 cars per 1000 inhabitants. On the other hand, the bad average condition of both road and rail infrastructures are problematic with many speed restrictions and ageing vehicles and rolling stock.

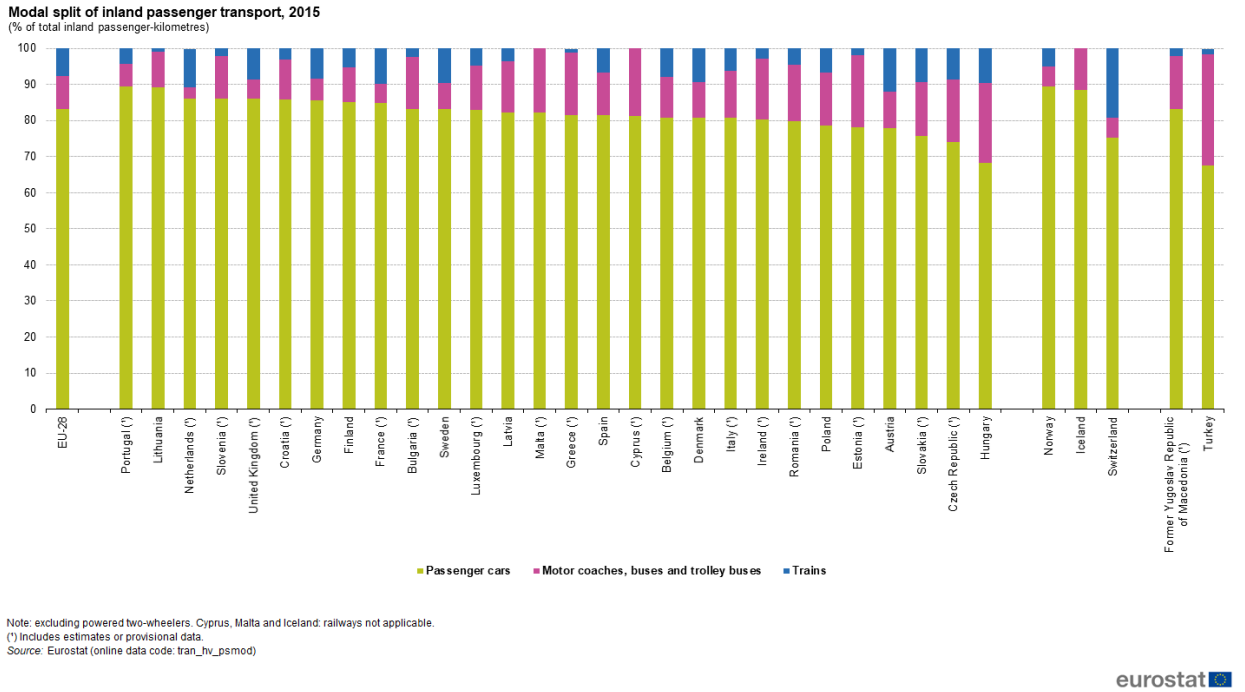

Figure 3. Modal split of inland passenger transport, (including pre-accession and EFTA countries) and Hungary in 2015 (% of total inland passenger-km) Source: Eurostat

2.2 Previous research for long-distance transport in Hungary

Previous researches concerning long-distance mobility in Hungary were carried out by some operators company or by the Ministry who ordered the services but in most cases, the results were not published. The lack of suitable and accessible data made only the Census commuting database the only reliable form for running analyses (Kiss and Szalkai, 2014). Nevertheless, the daily (mostly work and education related) commuting system possess a different travel pattern than the long distance travels. Frisnyák (2016) archive research from ticketing statistics of the 1880s till WWI showed the gradual increase of the use of the railways (with shorter average trips) however long-distance traffic was in most cases still under 10 % by the end of the period (1914) too. Only the capital city and some of the largest cities could achieve higher shares. Early research in the area dates back to the period of WWII when Márton (1942) analysed that time available railway passenger traffic arrivals based on ticket sales and timetable information by service offer and average travel speed. Based on an early population potential with some functional indicators of the analysed cities he has identified a roughly 100 km (2-3 hour journey time) intensive catchment radius for a city with a population of at least 100.000 populations. His representations of early location accessibility along rail corridors are one of the first known researches in the area in Hungary. Later on, it is worth to point out Krajkó et al (1969) who analysed the long-distance passengers' flow (that time roughly 50 % rail modal share among weekly commuters) from a socialist industrial macro-regions perspectives. They work extended to the private car and road truck vehicles OD patterns from the 1963 OD survey. From publicly available data which meant transport timetable offers, journey and travel times Ács (2011) made an evaluation for the network connectivity of the micro-regions. In his work assessed only the bus network and not passenger rail services. He concluded that in areas where the railway service is not competitive in journey time or the location of the railway station is inconvenient at the destination the long distance bus services has an absolute market share within public transport flows. Erdősi (2002) also analysed the publicly available timetable offers and found out that regional disparities in the bus services which could be explained by the different settlement structure as due to historical reasons the average settlement size and settlement density varies among the regions.

From statistical analysis until today the most reliable data sources were the ticketing statistics provided by Hungarian Central Statistical Office (KSH, 2018) which included the different km categories and average travel

distances (for all trips in 2017 it was 52,2 km) by train categories (higher service Inter-City was used by 6,8 % of the passengers in 2017). It also stated the share of "socially free" travellers which was 20,9 % in 2015.
As Table 1. shows below more than half of the railway passengers in Hungary travels up to 30 km and just 12,7 % travels between 50 and 99 km while only 16,4 % (with a slightly decreasing trend) can be considered as truly long-distance traveller in Hungary as their travel distance exceeds 100 km which is the limit defined by the national regulation (Passenger Service Act of 2012) for suburban services and regional services which crosses county boundaries.

Km-range / Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
0–30 km	54,9	54,8	54,3	55,8	54,0	54,0
31–49 km	17,4	17,0	17,2	18,0	17,0	16,9
50–99 km	11,9	12,0	12,3	11,5	12,4	12,7
100–299 km	15,3	15,8	15,7	14,3	16,2	16,0
300 km and above	0,5	0,5	0,5	0,4	0,4	0,4

Table 1. Share of passengers per tariff km zones in Hungary between 2012 and 2017 (in % of sold tickets) Data source: KSH

3. Theory/calculation

Based on the previously presented literature and several unpublished works for the Ministry responsible for transport in Hungary KTI Institute for Transport Sciences Non Profit Ltd. In January 2016 has started to elaborate the new nationwide Origin and Destination matrix which was financed from Connecting Europe Facility (CEF) in order to map the traffic flows across the Hungarian section of the Trans-European Networks (TEN-T) corridors. The results will serve as a database for assessing future infrastructure investment. For the first time, it includes not just several road traffic components (e.g. private cars, minivans, trucks, buses) but also air, inland waterways and railway transport modes including freight and passenger services (Albert, 2017).

3.1 Elaboration of the domestic Origin-Destination Travel Survey (OCF) for Passenger Railway Services

As mentioned before numerous travel survey has been developed in the past in order to monitor the passenger flow of which the most recent took place in 2007 and 2008. Albert et al (2008) organized onboard passenger count and passenger interviews during autumn and spring workdays and Sundays. Virtually all the rail services were monitored on regional sequence within a 2 year period. Since then the global financial crisis has significantly changed the travel patterns due to passenger's changing demand and needs as well as the financial need in 2009 to suspend railway passenger services on 40 secondary lines of which 10 has been re-started 1 year later. By 2015 the economic conditions improved and the Ministry of National Development (that time responsible for transport issues in Hungary) ordered to elaborate the new nationwide survey. Due to budgetary reasons and time-constraints, several alternative new solutions had to be found for the successful elaboration of the O-D project.
Concerning passenger railway services this meant that there were less financial resources to organise personal passenger interviews thus following a long public procurement procedure during October and November 2016 with some extra days in early December. Passengers were asked on board of the trains by the hired workforce (mostly university students). The survey took place on Tuesdays, Wednesdays and Thursdays on Budapest suburban railway network from noon till 10 pm while on long-distance and regional services full day nearly all train services except for 4 lines of which 2 were under reconstruction with bus replacement services. During this two month period, more than 33.700 trips have been recorded which is roughly 7-8 % of the total passengers. Out of the total, roughly 11.000 trips can be considered as a suburban trip around Budapest. It is important to note that in 2016 there was no need for passenger count as since 2011 gradually the two passenger railway operator companies in Hungary (MÁV-START and GYSEV) introduced electronic based ticket system which contains information about the OD of the passengers not just the discount type and travel distance as it was the case before. Nevertheless, the exact use of season tickets (monthly ticket) and the unregistered free travellers (elderly people above 65, young children, socially discounted persons) needed to be exactly adjusted by several algorithms based on 2011 statistics when it was mandatory to anyone to ask at least a free registration ticket. On the basis of the 2011 full ticketing statistics, free travellers share was adjusted for each OD pair as Berényi and Oszter (2017) summarised the technical details. It should be noted

that the season ticket users travel 90 % on workdays and at the same time long-distance services experience the highest demand on Fridays and Sundays.
Other important data sources what feed rail travel survey is the nearly similar questionnaire asked on the most important domestic bus stations and on some bus lines and contained information about multimodal trips what involved at least one railway leg. The aim of the harmonised survey was to measure the multimodal trips and to prepare a multi-modal passenger transport OD matrix. The domestic bus travel survey asked more than 68.000 trips during the same period which contained 2,5 % railway connections as well (Munkácsy and Vass, 2017). The general low number of bus-rail connections can be explained by the lack of tariff integration and in many cases the inconvenient interchange options. On the other hand locally in some suburban stations with harmonised timetables, the multimodal passenger can be 40 % of certain feeding suburban bus services.
In some isolated minor cases were still not fully electronic ticketing system works KTI has got passenger count data realised by ticket controllers on the lines of GYSEV regional railway operator from Western Hungary and also a 3.000 households representative survey made parallel in 2016 which refreshes the 51.500 trip household survey on travel patterns from 2008 (Siska, 2015).

4. Results & Discussion

4.1 Ticketing statistics for long-distance rail trips

From the updated and extended ticketing statistics it turns out that out of the total 859 settlements 46.280 OD links had at least 1 passenger per day in a 2 month period and 28.890 had at least 0,1 passengers on an average workday but only 790 had more than 100 passenger/workday and just 82 more than 1000 passengers per workday.
Concerning trips over 100 km which can be considered as a truly long-distance trip in Hungary (Passenger Service Act, 2012) the number of 1000 persons per direction OD pairs restrict to the relations between the capital city of Budapest and the 2-4th most populated city pairs with the exception that the 6th biggest city Győr is having the top number of passengers as it is the closest and best served by railway on the halfway of Budapest-Vienna elevated speed (140-160 km/h) mainline.
Regarding long-distance trip 433 OD relations has more than 10 passengers per workday of which 294 originates or finishes in Budapest.
The TOP30 long-distance relations exclusively leaving or end in the capital city with a minimum threshold of 200 workday passengers and up to TOP75 OD relation can be count more than 100 passengers per direction on a workday.
The population and economic size of the capital city Budapest with nearly 1,76 million inhabitants explain the huge contrast with the following second biggest city Debrecen with around 205 thousand population and only 8 bigger provincial cities reach the 100.000 population (KSH).

4.2 Travel survey data for long-distance rail trips

As presented in Chapter 3. the qualitative information about the passenger's background was obtained by the elaboration of passenger surveys in order to get information about their socio-economic background, travel habits and potential multimodal trips which do not appear in railway ticketing statistics.
On Figure 4. can be clearly seen the long-distance sample composition by age and gender. From the total sample 33.733 rail trips, only 6954 trips (20,6 %) belongs which is slightly higher than the 14,7 % share from ticket statistics shown in Table 1 above. The main reason is that due to crowded trains and relatively short journey times on the suburban services meant less sample (2-4 %) but on the other hand, long-distance trains and regional services with longer journey time and usually less crowd meant a higher share of questioned passengers. In certain cases, secondary regional lines with weak passenger demand were asked nearly 100 % of the onboard passengers. Looking on Figure 4. it can be seen the higher share of women travellers with the exception of the 31-45 years age group which is the time for most women in Hungary to deal with small children and the length for maternity leave (rarely with part-time job) is among the highest (up to 2 years per baby) in Hungary.

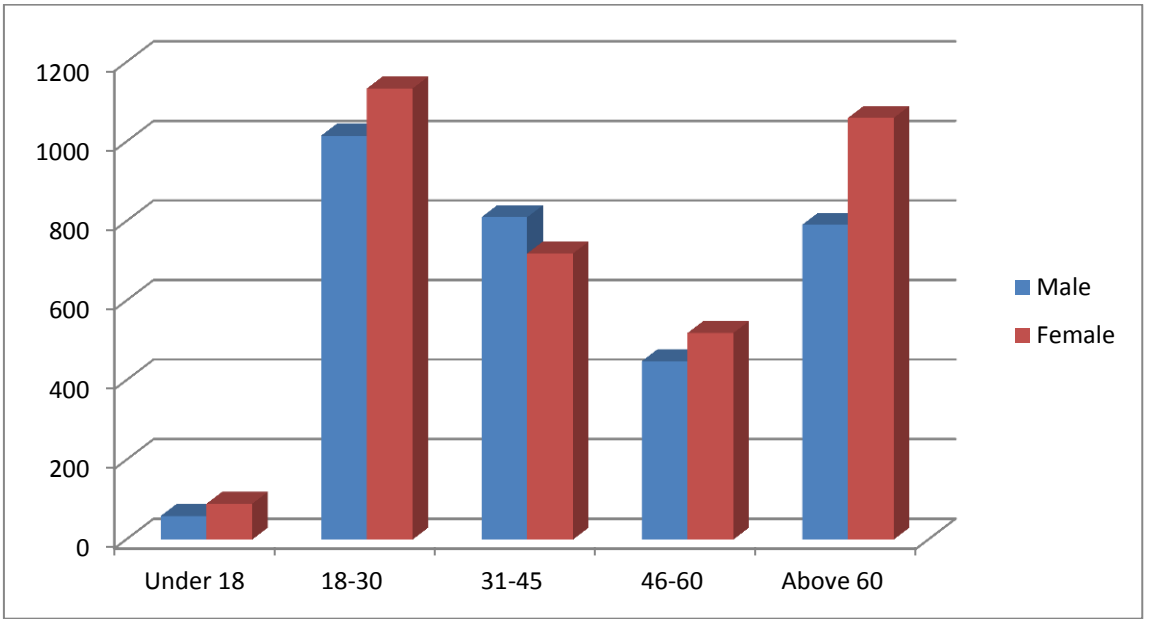

Figure 4. Long-distance rail travellers by age and gender in Hungary (2016) Source: KTI OD Questionnaire

The lower share of young passengers under 18 years old in long-distance transport on weekdays is not surprising as the travel survey was made on mandatory school days and younger children under 14 years old weren't ask separately from their fellow family members who travelled with. The 46-60 age group has also a lower share in long-distance travels by railway but other surveys made by Hungarian Touristic Agency (MTÜ, 2016) showed that the population is choosing less the railway for long-distance several day trips (9,3 %) compared to the private car (78,5 %). Concerning the access mode for long-distance rail travels (Figure 5.) nearly one-third of the respondents walk only while other one-third uses urban public transport means. Combined with the metro users in Budapest (14 %) all public transport access mode has a 47 % share. The use of the private car is 11 % on the general sample but for long-distance users, this figure climbs up 17 % including many cases when the traveller was only as a passenger in someone else's private car. Bikes and motorbikes are not significant access modes.

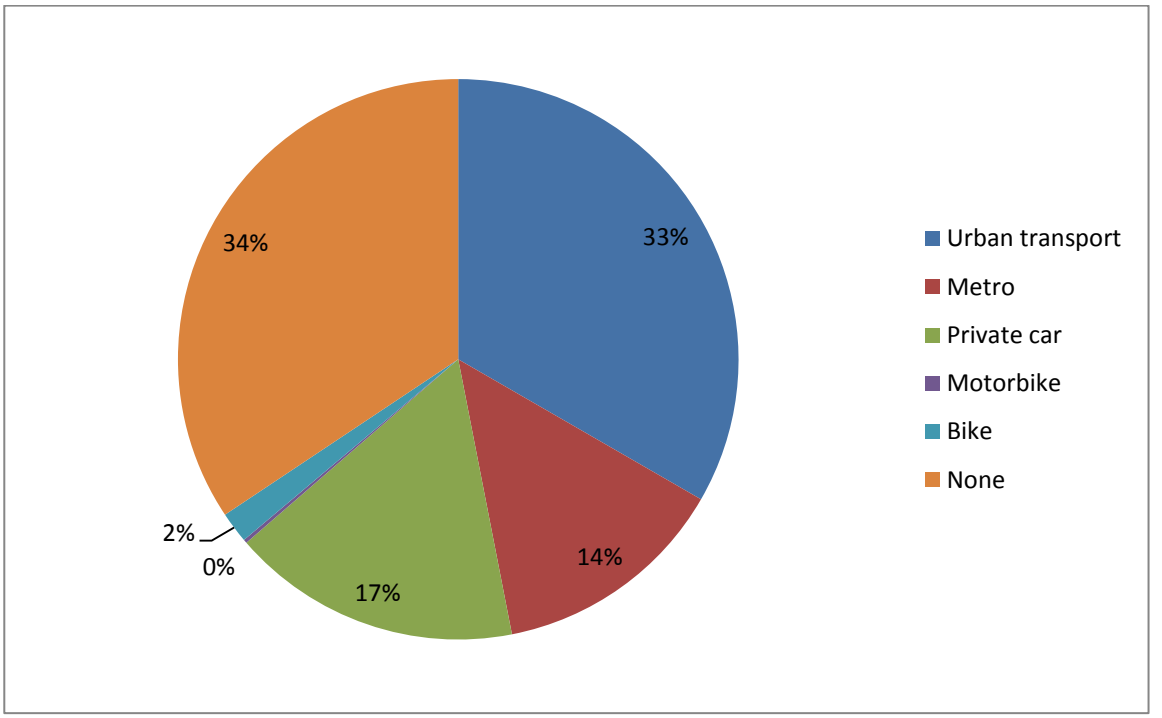

Figure 5. Access mode of long-distance rail travellers in Hungary (2016) Source: KTI OD Questionnaire

Figure 6. shows the relationship between the travel purpose and the frequency of the trips. Long-Distance travel is not used often by any travel purpose. Several respondents use long-distance rail for work relative frequently some of them are commuters from 120-130 km to Budapest where there is short journey time and also several private railway staff is using it daily for longer distances. The students are usually travelled by long-distance by rail weekly or several times per month for visiting friends and family members (VFR) in their home far from the university. Other purposes include tourism and general VFR but these trips have a relatively high share but they realised less often only. Some higher level position office jobs require work trips less often and in case of no or no willingness to use private cars, they appear as classic business passengers.

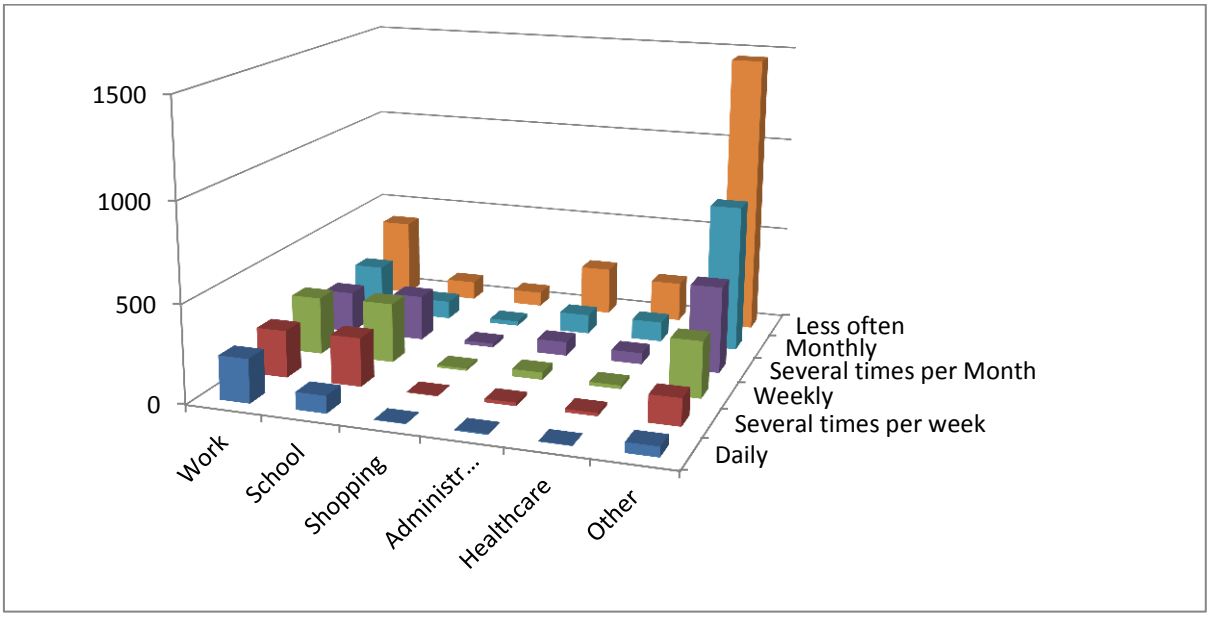

Figure 6. Travel purpose and frequency of the trips of long-distance rail travellers in Hungary (2016) Source: KTI OD Questionnaire

As it was mentioned before the Hungarian tariff system has a wide range of social discount mandatory by the law. The largest group belongs to pensioners who travel free of charge above 65 years of age. Some of them travel weekly for long-distance using the free transport opportunity but most of them only travel long-distance less often or monthly (Figure 7.). Still, they are the 3rd largest group of long-distance rail users.

Reduced season ticket users are typically students who travel home often (weekly) or in case of some schools they travel to the university for only 2 days for courses and it is cheaper to buy a discounted season ticket than pay for student residence.

Full price season ticket users are those long-distance commuters who travel to works from distances around 120-130 km.

The largest group of long-distance travellers is entitled to a discount on the social basis or sometimes they are holders of the rail operator's 50 % discount card which worth to buy if someone travels at least several times per month more than 100 km. The second largest group belongs to the full fare long-distance travellers who are travelling less often or only monthly.

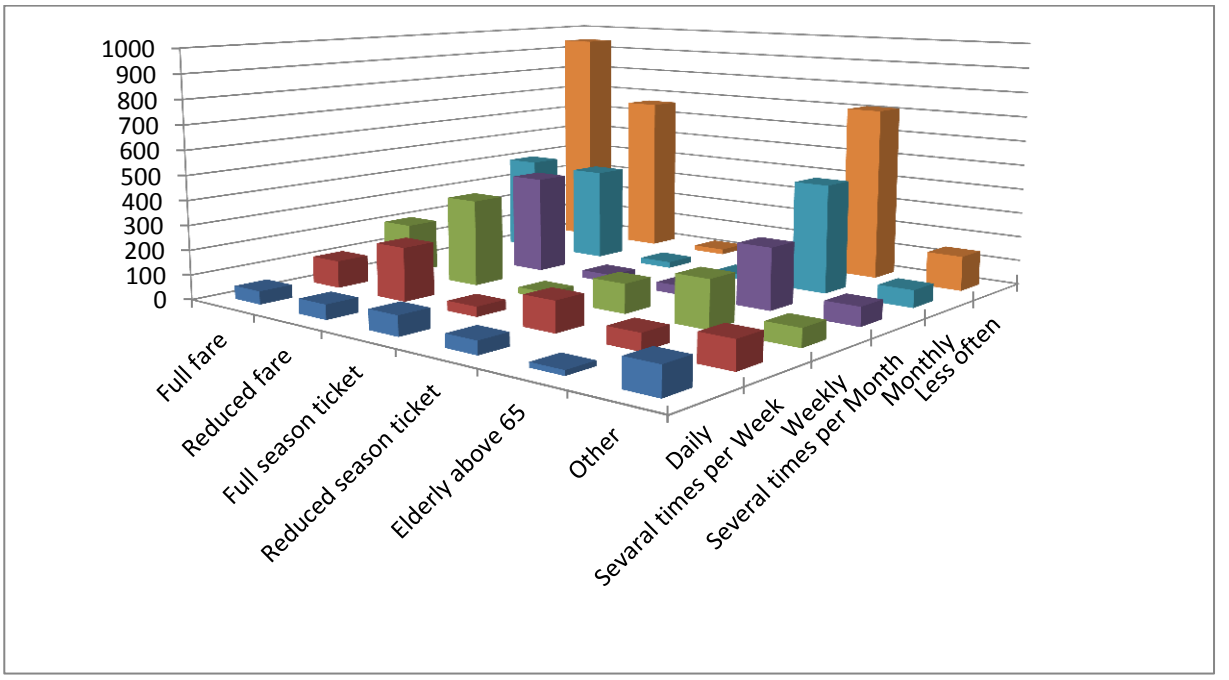

Figure 7. Tariff discounts and frequency of trips of long-distance rail travellers in Hungary (2016) Source: KTI OD Questionnaire

5. Conclusions

As one could see above there are many research options in long-distance travel surveys in order to prepare solutions for better services offer and to operate services more economically. The need to understand human travel behaviour cannot be done without a proper and deeper analysis of what has been started only in this paper. Spatial interaction research is a growing interest for many scholars and travel survey data combined with other available regional statistics can serve as a useful tool.

For further research one direction should the complex analysis of the case of polycentric development and spatial structure in Hungary as Burger and Meijers (2012) expressed the need to compare their results with other countries of development grade. Concerning Central Europe, relevant works have already been done by Kraft (2014) from the Czech Republic with travel survey data. Also, the accessibility measurement of long-distance transport as it was analysed by (Beria et al. 2017) could be a further step ahead.

6. Acknowledgement

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