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Motorists' Preferences toward Parking Space Management in the Capital City of Ulaanbaatar

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Abstract

Parking space management is among the strategic action areas towards a more sustainable transport system in Mongolia's fast-growing capital. To provide empirical evidence for upcoming decision support, this article adds recent disaggregate results on motorists' parking behavior and their stated preferences in extension of a 2016 count survey. The underlying data was generated by telephone interviews of car owners, whose vehicles were parked on a reporting date in a designated quarter in the very city center. Besides insights from descriptive analyses on car usage and parking behavior, part-worth utilities of parking facilities have been derived. Trade-offs between attributes such as parking search time, pedestrian egress distances to the trip destination and hourly parking rates, can be quantified. The case study results may be generalized for related metropolises in transition countries.

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Keywords: Parking space management; Mobility Survey; Parking Survey; Stated preference; Choice-Based Conjoint Measurement, Transition countries

1. Overview

1.1. Problem Statement

The transport system of Ulaanbaatar, the capital city of the emerging country of Mongolia, has to keep up with the tremendous population growth, positive labour market prospects, a corresponding building densification and mass-

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motorization of the past decades. Once designed for half a million inhabitants and low car ownership levels, Ulaanbaatar's transport capacity problems have become apparent throughout all modes and urban quarters, resulting in unstable service levels as well as an aggravation of existing environmental, social, and transport safety issues. The provision of new infrastructure for both flowing and stationary road traffic as well as the development of an adequate public transport offering appear to be more protracted than widely expected.

The parking situation in the central district is one of the key remaining problem areas, with focal points nearby shopping malls, administrative buildings, and larger employers. Over the course of one working day, particularly the side street network becomes overloaded with parked or search traffic. Outer traffic lanes on principal roads, pedestrian walkways and practically all car-accessible spaces are narrowed considerably or become completely blocked with (double) parked or stopped vehicles of all kind - regardless of other road users' interests or further consequences (Figure 1).

Fig. 1. a) to d) Tense parking situation in downtown Ulaanbaatar (Mares, 2018)

The enforcement of parking rules, a competency of the local police, is not pursued as frequently and as vigorously as possible. Even a 60.000 Tugrug (US-$24, about eight per cent of median monthly income) towing fee in combination with fines of another 30.000 Tugrug may not be dissuasive in all cases of parking offences or may question habits of chaotically obstructing each other. On the contrary, this behavior is generally taken for granted. Since the protection of personal data privacy does not receive any reflection at all, every car operator leaves a cell phone number behind the windshield in case the car has to be pulled away, even when parked correctly itself. Rather uncommon for Western countries, the procedure of notifying the car operator is likely to prolong a spontaneous return trip from a central location by typically at least several minutes. Automotive retailers have started to support this local custom, too, by selling specially designed marker carriers.

Besides the ordering and organizational function of selected, well-managed parking lots, the concept of an overall parking space management shall be conceived. This case study sets out to investigate the demand side in more detail.

1.2. Previous Work

After the political and economic opening of the county in the early 90-ies, the article of Akatsuka and Murray (1993) provided one of the first in-depth analyses of the challenges faced by Mongolia's transport subsectors. The transport developments have been given indirect consideration in research on the escalating seasonal air pollution (e.g. Guttikunda, 2008 or Bayasgalan & Matsumoto, 2017) and social issues (Terbish & Rawsthorne, 2016).

Prior to our investigation, only one recent external report on parking in Ulaanbaatar was known: Under the auspices of the Asian Development Bank, the quantity structure of the parking capacity shortage in Ulaanbaatar has been investigated by Brouwer (2016). This study served as the base and reference for this study. The 2016 count surveys give an overall picture of the tensed daytime parking situation downtown, caused by commuters and visitors. The peak utilization is reached in the afternoon of working days, around 3pm. The average peak utilization was specified with 122 per cent. On average, 22 per cent of all surveyed vehicles were parked illegally. During the night, there was no remarkable shortage of parking capacity. The study found than the acceptance of parking lots run be the municipality is particularly high. However, the revenue generated from parking fees is insufficient to amend capacity.

Apart from this special and regional case, there is a wealth of notable pieces on successfully implemented parking management and its theoretical foundations. To mention a few of them,

- Thomson and Richardson (1998) take the view of a motorist in their behavioral modelling framework of car park choice and subsequently represent it analytically.
- The final report of the European Commission's COST 342 project summarizes its findings from several Europe-wide studies of good practice in guidelines and recommendations (CEC, 2001)
- Coppola (2002) successfully integrated mode and parking choice realistically assuming elastic parking demand.
- Zhao et al. (2017) published comprehensive results on demand side determinants and quantifies user preference structures for the special case of park-and-ride lots.

1.3. Research Objectives and Article Organization

The study seeks contribute to ongoing efforts for the envisaged municipal parking management program. In extension of the macroscopic approach as of 2016, the paper aims to examine the motorists' behavior and preferences with regard to parking. The motivation of the underlying research was to add disaggregate empirical findings in order to decrease the present lack of understanding of how motorists choose car parks under the given special circumstances in Ulaanbaatar. Our research centers around the following questions:

- Taking a general view, which are the relevant choice criteria for a parking site?
- When presenting a specific, low-dimensional choice situation - which site would the drivers opt for?
- Giving motorists a say in things - what kind of wishes, requests and suggestions exist for the future parking concept of their city?

The remaining article has been organized as follows: Section 2 provides a background analysis on the development of socioeconomics, mobility, and the environmental situation in the Mongolian capital in the light of the special boundary conditions as a transition economy and the challenging climate. The survey methodology is documented in Section 3, whereas results to date are given in section 4. The final section provides conclusions and gives an outlook.

2. Background

Since 1990, the city of Ulaanbaatar has undergone a rapid development, accompanied by an urban sprawl. Since then, the population figure has risen from 560k to 1.4mn in 2018. The capital currently represents 41.5 per cent of the country's inhabitants. Waves of internal migration such as 2001/04 and the economic boom period 2010 through 2012 have visibly shaped the city and its ever-expanding fringes. As an effect of the ongoing urbanization and special demographics with a still comparatively high birth rates and a life expectancy of just 68.2 years, 64.3% of Ulaanbaatar's residents are 35 years and younger. The population consists of 48.1% males and 51.9% females. 94.9 per cent of the inhabitants are based in six residential districts, whereas only 5.1 populate the outskirts. The last census identified 386,218 households with an average size of 3.6, compared to 5.1 back in 1990 (see Appendix, Figure A.1).

In four years prior to 2017, the population density has risen by 9.3 per cent. As of 2016, Ulaanbaatar had 465.1 thousand employees (equaling 39.7% of Mongolia's workforce) and 46.4 thousand jobless people. The income situation has been analyzed in Table A.1. According to projections of the National Statistical Office, the country`s

population will be close to four million beyond 2030, while the capital's population will exceed two million people in the next decade.

Intra-urban travel according to household interview surveys conducted by Bataarzorig et al. (2018) amounts to 3.4 million trips per day, including non-motorized, with a modal split of walking (30.6%), car (24.2%), taxi (9.2%), bus (including micro bus and trolleybus, 33.4%), others (2.6%). The modal distribution of the 2.3 million motorized trips/day comprises car (34.8%), taxi (13.3%), bus (48.1%), and others (3.8%). A state-of-the art bus rapid transit network (Jellstrom et al., 2017) is planned for realization, to retain the transit modal share and avoid more car traffic.

The urban population's actual annual average household expenses for transportation as of 2002 were 35.3k for wealthier and 7.6k (2002) Tugrug for the poorer households. This represented just six per cent of the wealthier and about three per cent of the poorer households' incomes (NSO, 2017, p.108).

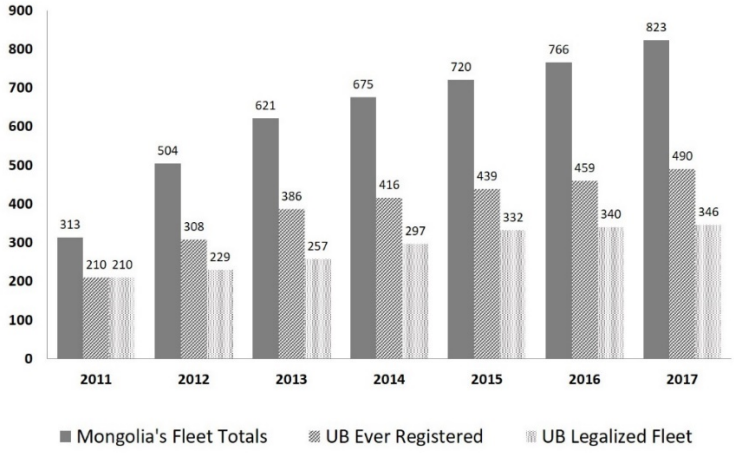

Fig. 2. Development of Passenger Fleet Sizes in Thousand Vehicles (UB Municipal Traffic Control Center, 2018)

In parallel to the population and wealth dynamics, a remarkable growth of the private car fleets has taken place. Since 2011, the car fleet has more than doubled (Figure 2). The current share of the legalized fleet, i.e. timely paid for with taxes and insurance coverage, and obeying one exclusion day per week, is about 71 per cent. Note that due to health and environmental protection considerations, the private car usage is restricted on a daily basis and depending on the license plate - according on the model of Beijing. Evidently, the contingent acquisition of second and third cars has increased the total fleet size, too. Regardless of prevailing right-hand traffic rules, about 50% of the capitals passenger car fleet are used left-hand traffic models from Eastern Asia - mainly gasoline-driven hybrids with defunct energy recovery system. More than 80% of the vehicles in operation are more than ten years old. The enforcement of vehicle admission and traffic rules, such as the often-ignore "No left turn" sign leaves considerable room for improvement and recapture of lost political scope.

Nonetheless, the more and more centralized city with new high-rise buildings attracts much road traffic. The Baga Toiruu districts hosts all major banks, along with public administration, business centers, universities, and shopping malls. Government institutions, banks and hotels are located around Sukhbaatar Square. Alongside the Peace Avenue and in Baga Toiruu districts a mixture of retail shops, gastronomic businesses, and residential areas can be found. These are the main destinations for commuters and visitors from fringe areas and other districts - besides considerable through traffic the main East-West axis has to bear, too. Travel times and corresponding services levels are unsatisfactory and impede the capital's productivity.

As previously mentioned, there is a shortage of daytime parking capacity along the boulevards. Arriving drivers experience saturated parking at uncertain parking attributes. In search of a (free) space, entering cars are crowding out

other uses of urban public space on practically all side streets and car-accessible backyards. Car parking and life of the neighborhoods is also affected by degraded safety and capacity during inclement weather conditions.

There is a growing concern of the air pollution situation during the extremely cold winters which pressures forces to act. Besides coal power plants and archaic heating in the yurt districts on most of the hills around, road transport – particularly heavy-duty vehicles aggravates the level of harmful substances in the basin's air. During the winter months, sulfur dioxide and nitrogene dioxide air contents regularly exceed the legal thresholds by the factor of 2.6 to 3.1. The non-compliance of the official limits of fine particle concentrations in breathing air, exemplary for PM2.5, is depicted in Figure 3.

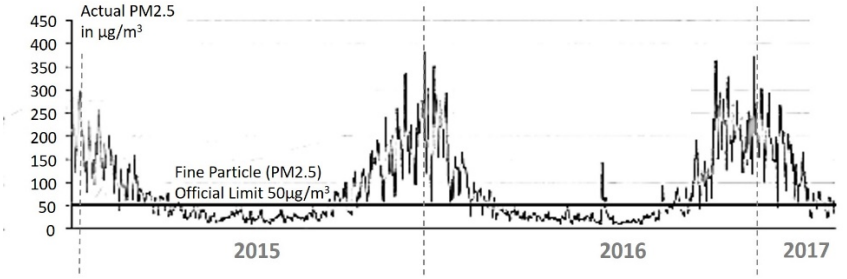

Fig. 3. Time Series of Fine Particle Emissions in Downtown Ulaanbaatar (Source: NAMEM, 2018)

In the light of a road-oriented transport policy of the past, the Municipality is concerned with curbing the growth traffic volumes as a measure to delimit its negative impacts. For example, the noise level exposure on main roads is 14.3 to 19.4 dB above limits.

The city`s ambitious "Master Plan 2030" of 2013 comprehensively addresses the problems of traffic congestion, transport safety deficits, saturated parking and avoidable environmental impacts in order to specify measures of improvement. (MUB, 2014). However, the first priority is given to the upgrading on the road network bottlenecks such as the extension of bridges across Tuul river rather than the development of modal alternatives. An uncertainty remains which of measures will affect the travel behavior in coherence with the overall objectives of the Master Plan. Moreover, the underlying problem is a lack of knowledge and respective data sources on the motorists' preferences with respect to pricing and clearer enforcement. This became the ultimate motivation of the present study.

3. Survey Design and Implementation

The unique situation of individual car holder's mobile numbers left behind windshields at parked cars offered the opportunity to solve the often critical steps of acquiring the affected persons as participants of telephone interviews.

The very center of the capital, between West of Sukhbaatar Square and State Department Store, was chosen as the sampling area (Fig.4). It is a subset of the investigation area of Brouwer's count survey as of 2016.

To obtain the user information, the survey questions were organized in several topic areas. The final questionnaire consisted of five parts A to E (Table 1), that is

- The car owner's characteristics and mobility profile,
- The characteristics the road trip the car was parked in connection with
- A pairwise comparison of the appreciation of parking site attributes
- Binary choice experiments for three parking duration scenarios, each with four hypothetical parking situations of pre-coded attributes, as specified in Table 2
- A comments box for issues and suggestions.

It has been transformed into an interview guide in Mongolian, considering appropriate levels of brevity and simplicity for the response categories.

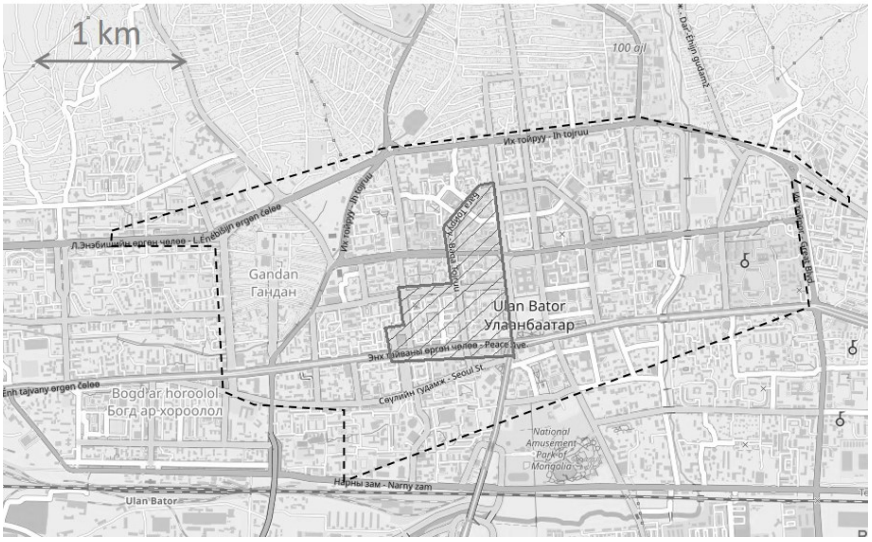

Fig. 4. Sampling Area as a Subset of Brouwer's Count Survey Investigation Area – dashed line (Mares, 2018 based on GOOGLE MAPS)

Table 1: Questionnaire at a Glance

A Car Owner's Characteristics/ Mobility Profile	**B** Trip Characteristics	**C** Pair-wise Comparison/ Part Worths	**D** Choice-Based Conjoint Measurement
Age	Trip Purpose	Optional Transfer to Public Transport	Parking Duration Scenarios (i)-(iii) and Respective Choice Sets
Gender	Parking Search Time	Safekeeping of Vehicle	(i) 30 minutes
Household Size	Usual Parking Frequency	Weather-Proof Garage	(ii) 4 hours
Household Fleet Size	On-site Parking Space Availability	Cheap / Free Parking	(iii) entire day (10h)
Main Purpose for Driving	**E** Suggestions for Improvement of UB's Parking Situation	Barrier-Free Access	(i) P1/P4, P2/P3, P1/P3
Public Transport Availability		Short Egress Distance	(ii) P1/P2, P2/P4, P2/P3
Approximate Location		No/Short Parking Search Time	(iii) P2/P4, P2/P3, P1/P3

Table 2. Hypothetical Choice Options of Parking Situations (kMNT is 1000 Tugrug)

Type	Description	Egress Distance Walk [min]	Maximum Stay [h]	PST [min]	Hourly Tariff [kMNT]	Eventual Fine [kMNT]
P1	Roadside, paid	3	2	5	1.5	15
P2	Public lot, free	10	24	1	0	0
P3	Private lot, paid	5	24	3	1.8	0
P4	Illegal parking	1	0	0	0	30

4. Results

The survey was conducted in November 2017. Within the set narrow locational boundaries, the relevant study group of motorists could be explored to a relatively high extent. As preconceived, most of the recorded car owners could be reached the same day by mobile phone.

Without any handout material at the respondents' side, especially choice experiment in the part D demanded some imagination and endurance. With the help of a small local team of interviewers and the citizens' readiness to provide information, *n*=201 car owners could be questioned in total.

The planned geocoding of household locations in part A proved to be difficult to perform because of missing or imprecise address data for a too high proportion of records. The classification by residential type was therefore infeasible.

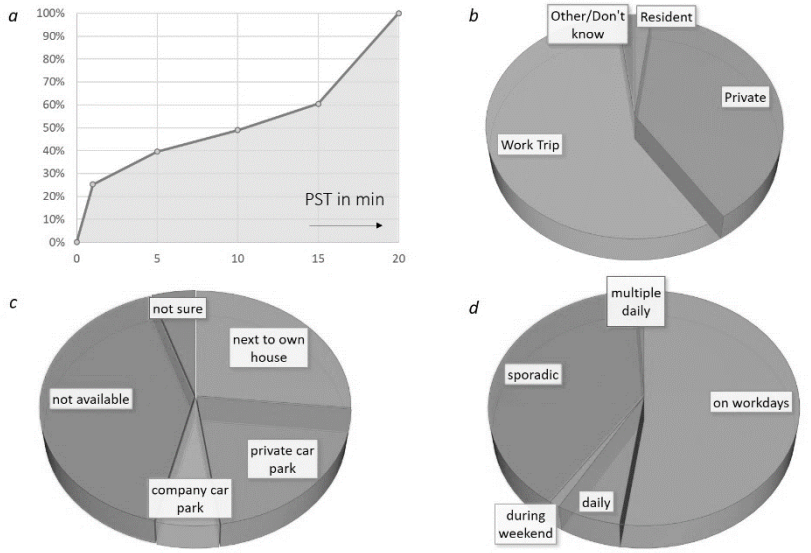

Fig. 5. Descriptive results regarding parking search time (a), trip purpose (b), availability of parking site (c), parking frequency (d)

Figure 5 a) to d) highlights several descriptive results.

- Part A:
  - The dominant age category is 30-39 years, living in a three- or four person households.
  - 70% of the respondents' households own one car, 26% two cars and 4% more than two cars.
  - 64% are car captives, 29% have availability of public transport but obviously did not use it that day, and 7% are unaware of it.
  - 41% have no designated parking space, 27% possess a space next to the site of residence, 21% at a private car park and 6% at their company (Fig.5c)

- Part B:
  - The trip purpose was 52% private (inkl. work commute), 6% commercial and 42% mixed private/commercial. Just about two per cent were residents. (Fig.5b)
  - For 36% of the interviewed their parking space search took more than 16 minutes, whereas 23% found one in less than a minute (legal or illegal). (Fig.5a)
  - 52% use this location on all workdays, 39% park only sporadically, 1% during weekends only, 1% multiple times a day (Fig.5d)

- Part C

Table 3. Part-Worths of Parking Facilities by Pairwise Comparison

Optional Transfer to Public Transport	.049
Safekeeping of Vehicle	.176
Weather-Proof Garage	.118
Cheap / Free Parking	.120
Barrier-Free Access	.202
Short Egress Distance	.167
No/Short Parking Search Time	.168

- Part D Choice Experiments

Table 4. Relative Frequency of Binary Choices in favour of Types P1 to P4

Segment	Choice Set	P1 [%]	P2 [%]	P3 [%]	P4 [%]
	P1/P4	98.1			1.9
	P2/P3		53.0	47.0	
(i) 30 minutes	P1/P3	37.0		63.0	
(ii) 4 hours	P1/P2	6.5	93.5		
	P2/P4		98.1		1.9
	P2/P3		45.9	54.1	
(iii) entire day (10 hours)	P2/P4		97.1		2.9
	P2/P3		43.1	56.6	
	P1/P3	9.8		90.2	
(i) + (ii) + (iii)	(balanced)	19.9	41.8	37.1	1.2

Table 4 shows the relative frequencies obtained for the twelve choice situations. The stated preferences differ considerably from the behaviour revealed daily.

In the next step, the part-worth utilities were derived by choice-based conjoint measurement. The size of the usable choice dataset was 1,067 observations (58.9% of all addressed). The specification of the generic linear logit function of a parking site was:

$$U_i = \beta_{0,i} + \beta_1 \cdot DUMLEG_i + \beta_2 \cdot EGRDIST_i + \beta_3 \cdot MAXSTAY_i + \beta_4 \cdot HRLYTAR_i + \beta_5 \cdot EVTLFINE_i + \beta_6 \cdot PSTIME_i \quad (1)$$

The maximization of the likelihood function was conducted with MS EXCEL Solver. Results are given in Table 5.

Table 5. Partworth utilities obtained by CBCM for three parking duration segments and all segment

PARTWORTH	UNIT	(i)+(ii)+(iii) ALL SEGM	(i) 0.5h SEGM	(ii) 4h SEGM	(iii) 10h SEGM
DUMLEG	-	3.7849	6.8360	5.9062	5.8511
EGRDIST	Min	-5.5262	5.5583	-9.4848	-6.6247
MAXSTAY	H	4.4987	9.0705	6.7062	7.5368
HRLYTAR	kMNT	-2.2110	-6.1089	-3.1531	-1.1289
EVTLFINE	kMNT	-5.5278	-6.5829	-4.8278	-9.4747
PSTIME	Min	-0.2106	-5.1834	-0.1370	6.1213
Final LL	-	807	256	284	276

The resulting tradeoffs (Table 6) exhibit a high sensitivity towards parking-search times. The surveyed motorists place a rather low value on saving pedestrian egress time to reach the desired destination point.

Table 6. Substitution Rates of an Hourly Parking fee of 1kMNT (~USD 0.40)

Segment	Parking Search Time [min]	Duration of Walk to Destination [min]
(i) 30 minutes	1.2	1.1
(ii) 4 hours	23.0	0.3
(iii) entire day (10 hours)	-	0.2
(i) + (ii) + (iii) all	10.5	0.4

The model was tested by performing simultaneous choices between all four options P1 to P4 (rather than two). This gives a ranking of parking site concepts (Table 7).

Table 7. Relative Frequency of Quarternary Choices in favour of Types P1 to P4

Segment	P1 [%]	P2 [%]	P3 [%]	P4 [%]
(i) 30 minutes	1.5	60.7	37.2	0.6
(ii) 4 hours	7.2	35.4	53.6	3.7
(iii) entire day (10 hours)	3.5	37.7	58.2	0.6
(i) + (ii) + (iii) all	8.8	38.6	48.6	4.0

- Part E Comments and Suggestions

The six most common answers were itemized. Respondents underscore the desire for ordering principles and called for

- more parking lots and parking garages,
- a consistent parking management,
- the improvement of public transport as a modal alternative or part of the intermodal transport chain,
- the provision of more safety and security
- demand-responsive parking fees, and
- a parking guidance system, preferably with real-time mobile and on-site capacity information.

5. Conclusions

Resolving the parking-related issues of the unavoidable car traffic plays a key role in the strategic and operational transport policy.

The municipality is at an early stage of development of effective measures of enforcement and control, toward a more sustainable and reliable parking system. The is still a chance to integrate land use and transport planning (e.g. Kodukula, 2008)

As confirmed by the survey respondents, there is much awareness of the unsatisfactory quality of life from the motorists' side too, as well as a broad desire for a change to Western standards in the transport sector and to overcome the partially chaotic parking situation.

The conducted survey provides new insights into the preference structure of motorized residents. A general willingness-to-pay for adequate qualified parking exists, providing the basis for the commercial viability of new infrastructure pre-financed by the private sector. Most value is placed on barrier-free pedestrian access and the reduction of uncertainty regarding parking search times.

The interdependency of parking and transit-oriented developments and interplay with alternative modes, such as new digital mobility services of floating cars without parking requirements, are of much importance and have to be further investigated.

5. Appendix

A.1. Socioeconomic Data

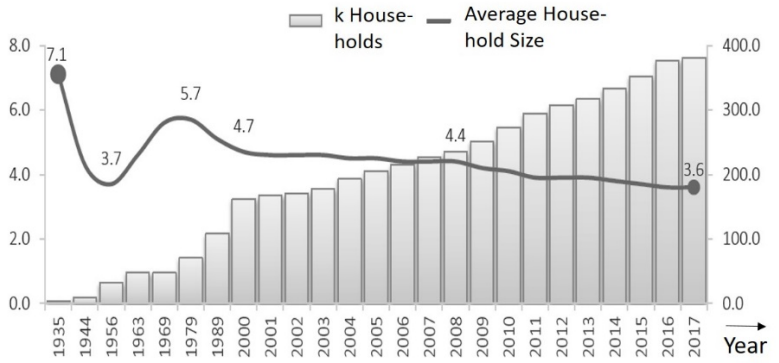

Fig. A.1. Time Series of Ulaanbaatar's Households and Their Size (Source: , 2018)

Table A.1. Distribution of Income (Source: Survey of Mongolian General Social Insurance, 2018)

Monthly Per-Capita Income Bucket	Share %	Comment
240k MNT (US-$ 94.5)	7.4	Minimum Income
>240k – 500k MNT (– US-$ 197)	21.4	
>500k – 900k MNT (– US-$ 355)	35.4	Median Income
>900k – 1,300k MNT (– US-$ 512)	18.0	Average Income
>1,300k – 1,500k MNT (– US-$ 590)	4.5	
>1,500k MNT (US-$ 590 –)	13.3	Miner's Salary: 2,500k MNT
Nationwide Sample	100.0	636,5k Employees

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