

## **ESTIMATION OF ORIGIN DESTINATION USING FRATAR METHOD: A PILOT STUDY IN JAYAPURA, INDONESIA**

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**Abstract:** This paper reports a study in estimating trip distribution based on a traditional method in a pilot study that involved home interview survey in Jayapura city Indonesia. The survey was conducted in October 2013 by Jayapura Planning Agency and successfully collected information pertaining to travel activities of 665 participants. Fratar method was then applied in duplicating the origin destination of travels. This pilot study demonstrated that the estimation results and the prediction from Fratar method reached a close similarity.

*Keywords:* Origin-Destination (OD) matrix, conventional analysis, home interview survey, Fratar method, traffic prediction.

### **1. INTRODUCTION**

Jayapura, as a fast developing city in Eastern Indonesia, transport planning is becoming a priority in stimulating economy growth, however Jayapura potentially has a traffic problems similar with others big cities such as Jakarta, Bandung, and Surabaya. In developing a healthy transport system, modelling on future travel is crucial in this city to archive well-planned transport planning. Therefore, transport forecast is necessary for future decision making. This paper reports the utilization of Fratar method in to develop origin destination (OD) matrix for travel pattern in Jayapura transport system. Basically Fratar method is using growth factor in scope city or region then attempt to forecasting the future travel demand based on number of trips that generated. As a pilot study, a survey particularly was particularly arranged to cover a small areas in Jayapura. In context transport modelling and planning purposes, reliable estimation of O-D matrices is a critical requirement. O-D traffic demand is one of the fundamental input data for transportation planning and traffic management.

The objective of this paper is to introduce the application of Fratar method on O-D estimation based on home interview surveys and may provide travel profiles in Jayapura, Indonesia. In this paper, Fratar model is utilized to look at trip productions, trip attractions, and network and socio- economic characteristics (Easa 1993). Fratar model is a simple, no calibration required, and it is suitable when travel time and travel friction factors between traffic analysis zones are not available such for a small urban area in particularly Jayapura city. In general, the history of demand modeling for personal trips has been dominated by the modeling approach that has come to be referred to as the four step model (McNally 2007).

To obtain the O-D information on travelers, a home interview survey was conducted in Jayapura city in October 2013 and involved approximately 665 participants. The survey was funded by Jayapura city Planning Agency.

## 2. O-D MATRIX ESTIMATION

Basically, there are two types of matrices, the first is production-attraction matrices and the second is origin-destination matrices. Trip distribution is a two-dimensional matrix that contains information about the amount of movements between traffic analysis zones within a certain area (Tamin 2000). Rows and columns declared zone of origin stated goal zones, so that the cell matrix states the amount of trips from the zone of origin to destination zone. A typical O-D matrix can be form as shown in Table 1.

Table1. O-D matrix

Zone	1	2	.....	13	O <sub>i</sub>	O <sub>j</sub>	F <sub>i</sub>
1					O <sub>1</sub>	O <sub>1,n</sub>	f <sub>i</sub> = 1
2					O <sub>2</sub>	O <sub>2,n</sub>	f <sub>i</sub> = 2
.....					....	.....	.....
13					O <sub>13</sub>	O <sub>13,n</sub>	f <sub>i</sub> = 13
D <sub>j</sub>	D <sub>j</sub>	D <sub>1</sub>	D <sub>2</sub>	D <sub>13</sub>	ΣO <sub>i</sub>		
D <sub>n</sub>	D <sub>n</sub>	D <sub>1;n</sub>	D <sub>2;n</sub>	D <sub>13;n</sub>	ΣO <sub>n</sub>		
f <sub>j</sub>	f <sub>j</sub>	F <sub>j</sub> = 1	f <sub>j</sub> = 2	f <sub>j</sub> = 13	F		

Easa (1993) stated that the trip distribution for a small area can be developed using direct method from base-year data, conducting an O-D survey from a sample of travelers to obtain information pertaining to origin and destination of trips and the time. Then, Fratar method can be applied to estimate the future trip distributions. Fratar method is developed based on some main assumptions. First assumption is the future trip distribution of origin zone is comparable to the existing trip distribution of origin zone, then the second assumption prediction of the future trip distribution can be modified by the value of the growth rate of destination zone (Tamin 2000). A basic Fratar method has then following form:

$$T_{i-j} = \frac{T_{i(G)}t_{i-j}E_j}{t_{i-j}E_j + t_{i-j}E_k + \dots + t_{i-n}E_n} \dots\dots\dots (1)$$

Where

$T_{i-j}$  is the predicted trips from zones  $i$  to  $j$  in the future;

$T_{i(G)}$  is the future trips generated in zone  $i$ ;

$t_{i-j}$  is the current trips from zone  $i$  to  $j$ ;

$E_n$  is the growth factor for zone  $n$

Shir-Mohammadli et al. (2011) claimed that properly planned conventional trip distribution models may perform better than a neural network model for the same purpose. The conventional planning four step modelling process consist of several procedures namely: Preparing input data, selecting a trip distribution model, calibrating the model and validating the model then forecasting.

### 3. DATA

#### 3.1 Data Collection

A survey was conducted in Jayapura city for 4 days and obtained 665 participants' feedbacks. Samples were selected based on five districts in Jayapura city. The samples are based on the total number of population in each districts and represent for sub districts. The population of Jayapura city in 2011 census is approximately 271.012 people, population growth rate in this city is 4.13% per year, with a population density of 285 people / km<sup>2</sup>. The population density is highest in the South Jayapura district with 1,628 people / km<sup>2</sup> and the lowest population density in the district of Muara Tami density 19 people / km<sup>2</sup>. Hyodo, Takahashi (2001) stated that appropriate number sample size and the distribution of those sample is necessity for pilot study.

The main information related to participant's trips activities in a week and some questions pertaining to their profiles such as education, ages, driver's license, and vehicle ownerships, for more detail on the sample questionnaires can refer to appendices.

In this paper, data extracted into spread sheet and analyzed uses SPSS 20 to obtain traveler's profiles, then using Fratar method for forecasting trip distributions in the future. Data gained from the survey is utilized for estimation process because it will represent trip activities in all districts.

Growth factors for each zone are different as it can be seen in Table 2, the factors E for each zone are based on assumptions made (source: RTRW BAPPEDA 2013).

Table 2. Growth factor in each district

Zone	Abepura	HERAM	Southern Jayapura	Northern Jayapura	Muara Tami
E	3.91	2.6	-0.63	1.63	-1.2

The percentage of growth factor is based on assumptions that related to growth factor in each sub districts. For Southern Jayapura area and Muara Tami, the growth factors are minus 0, 63 % and -1.2 % respectively because the number of population is decreasing every year.

#### 4. DISCUSSION

The method used to estimate the future trips is Fratar method. This method also can be called as a growth factor method. The O-D matrix demonstrated the number of trips between particular zones. In this case, there are five zones (districts) namely: Abepura, Southern Jayapura, Heram, Muara Tami and Northern Jayapura.

Table 3. O-D matrix for N =665

		Destination					Total
		ABEPURA	HEDAM	MUARA TAMI	NORTHERN JAYAPURA	SOUTHERN JAYAPURA	
Address Origin	ABEPURA	96	72	8	30	41	247
	HERAM	36	52	1	9	12	110
	MUARA TAMI	9	0	8	0	1	18
	NORTHERN JAYAPURA	10	15	3	123	34	185
	SOUTHERN JAYAPURA	12	15	2	31	45	105
	Total	163	154	22	193	133	665

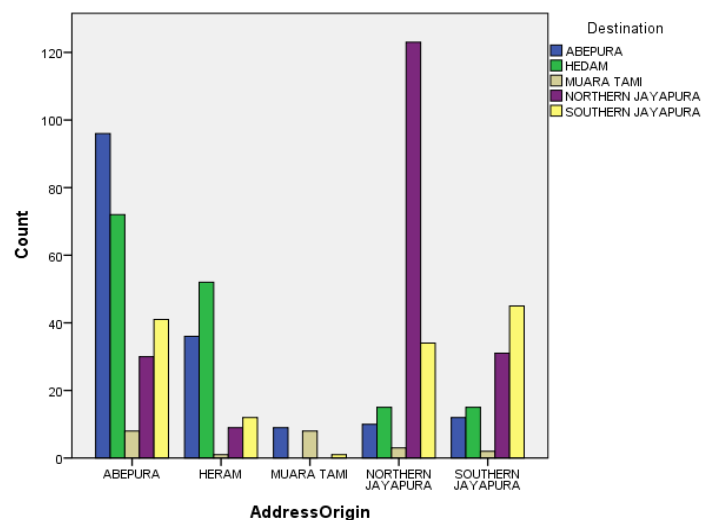


Figure 1. Total number of trips between each zone.

Figure 1 shows the number of interzonal trips between districts. It can be seen that the interzonal trip of the distribution pattern is dominated by Northern Jayapura and followed by Abepura, pertaining to land use as these districts with many attractions, because many facilities are located in district such as offices, shopping malls, hospital, schools and ports.

Table 4a and 4b show the result of O-D matrix using Fratar method, using equation 1 for calculating the number of trips for each cell from the survey (N=665) and growth factor for each district that available in table 2.  $T_{i-j}$  is the predicted trips from zones i to j in 5 years in the future and use mean growth rate. Utilize geometrical increase method equation 2, as follow:

$$P_n = P(1 + IG / 100)^n \dots\dots\dots(2)$$

Where

IG is the geometric mean (%)

P is present trips

n is number of decades.

Table. 4a O-D Matrix calculation for each cell ( Fratar Method )

Number of cell	$T_i (G)$	$T_{i-j}$	$E_j$	$t_{i-j}.E_j$	$t_{ik}.E_k$	$t_{il}.E_l$	$t_{im}.E_m$	$t_{in}.E_n$	FRATAR
1_1	96	409	0.049	4.704	3.312	0.902	0.81	0.216	193.4771
1_2	72	409	0.046	3.312	0.902	0.81	0.216	4.704	136.2237
1_3	41	409	0.022	0.902	0.81	0.216	4.704	3.312	37.09956
1_4	30	409	0.027	0.81	0.216	4.704	3.312	0.902	33.31557
1_5	8	409	0.027	0.216	4.704	3.312	0.902	0.81	8.884151
2_1	36	182	0.049	1.764	2.392	0.264	0.243	0.027	68.45373
2_2	52	182	0.046	2.392	0.264	0.243	0.027	1.764	92.82388
2_3	12	182	0.022	0.264	0.243	0.027	1.764	2.392	10.24478
2_4	9	182	0.027	0.243	0.027	1.764	2.392	0.264	9.429851
2_5	1	182	0.027	0.027	1.764	2.392	0.264	0.243	1.047761
3_1	12	174	0.049	0.588	0.69	0.99	0.837	0.054	32.38746
3_2	15	174	0.046	0.69	0.99	0.837	0.054	0.588	38.0057
3_3	45	174	0.022	0.99	0.837	0.054	0.588	0.69	54.52991
3_4	31	174	0.027	0.837	0.054	0.588	0.69	0.99	46.10256
3_5	2	174	0.027	0.054	0.588	0.69	0.99	0.837	2.974359
4_1	10	306	0.049	0.49	0.69	0.748	3.321	0.081	28.13133
4_2	15	306	0.046	0.69	0.748	3.321	0.081	0.49	39.61351
4_3	34	306	0.022	0.748	3.321	0.081	0.49	0.69	42.94334
4_4	123	306	0.027	3.321	0.081	0.49	0.69	0.748	190.6615
4_5	3	306	0.027	0.081	0.49	0.69	0.748	0.738	9.022934
5_1	9	30	0.049	0.441	0	0.022	0	0.216	19.48454
5_2	0	30	0.046	0	0.022	0	0.216	0.441	0
5_3	1	30	0.022	0.022	0	0.216	0.441	0	0.972018
5_4	0	30	0.027	0	0.216	0.441	0	0.022	0
5_5	8	30	0.027	0.216	0.441	0	0.022	0	9.543446

From table 4a, it can be extracted into a new matrix based on Fratar calculations.

Table 4.b O-D Matrix (Fratat Method for 2018, n=5 years)

Zone	ABEPURA	HERAM	SOUTHERN JAYAPURA	NORTHERN JAYAPURA	MUARA TAMI	Total
ABEPURA	194	137	38	34	9	412
HERAM	69	93	11	10	2	185
SOUTHERN JAYAPURA	33	39	55	47	3	177
,NORTHERN JAYAPURA	29	40	43	191	10	313
MUARA TAMI	20	0	1	0	10	31
<b>Total</b>	345	309	148	282	34	1118

The new matrix provided information about the number of trips inter-zones in 2018. In addition, the profile of participant shows in Figure 2, a group age 41-55 years are the highest proportion travelled and in the long mean distance more than 30 Km compares to other age groups, and based on this profile the majority of traveller dis their travel for work.

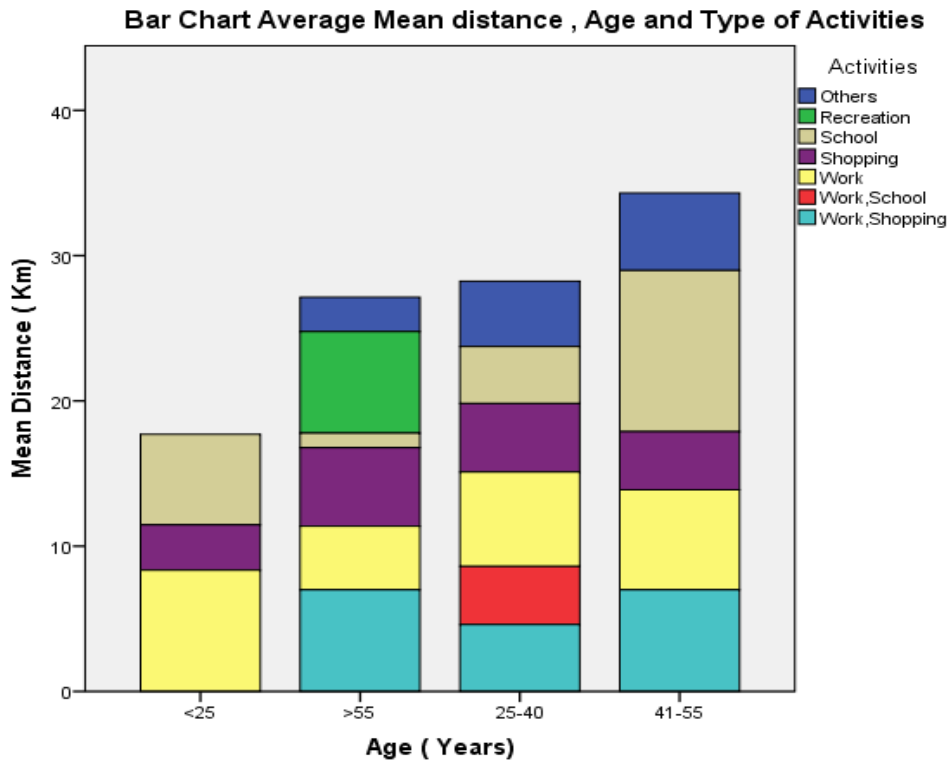


Figure 2. Number of travelers based on age groups and type of activities in mean distance (Km)

Tables 5 and 6 present the details of trip productions and attractions for the study areas if the growth rates are maintained at current levels.

Table 5 .Number of percentage of Attraction and production for districts

Zone	Attraction and Production			
	Trip production (O <sup>i</sup> )		Attraction (T <sup>d</sup> )	
	Total	%	Total	%
Abepura	22.252	37,14	14.685	24,51
Heram	5.572	16,54	7.800	23,16
Southern Jayapura	8.377	15,79	10.610	20,00
Northern Jayapura	14.452	27,82	15,076	29,02
Muara Tami	230	2,71	281	3,30
Total	50.883	100	48.452	100

Table 6. Distribution of number of inter-zonal trips in 5 districts

<b>Prediction of number of trips production and trips attraction</b>					
Zone	Production(O <sup>i</sup> )				
	2013	2018	2023	2028	2033
<b>Abepura</b>	22.252	26.956	32.654	39.558	47.92
<b>Heram</b>	5.572	6.335	6.336	6.941	6.942
<b>Southern Jayapura</b>	8.377	8.116	7.864	7.619	53
<b>Northern Jayapura</b>	14.452	15.669	16.988	18.419	18.544
<b>Muara tami</b>	230	217	204	192	181
<b>TOTAL</b>	50.883	57.293	64.047	72.728	73.64
Zone	Attraction (T <sup>d</sup> )				
	2013	2018	2023	2028	2033
<b>Abepura</b>	14.685	17.789	21.55	26.106	31.624
<b>Heram</b>	7.8	8.868	8.869	9.474	9.475
<b>Southern Jayapura</b>	10.61	10.28	9.96	9.65	9.35
<b>Northern Jayapura</b>	151	16.988	18.419	19.969	20.095
<b>Muara tami</b>	281	265	249	234	221
<b>TOTAL</b>	48.452	54.19	59.047	65.434	70.766

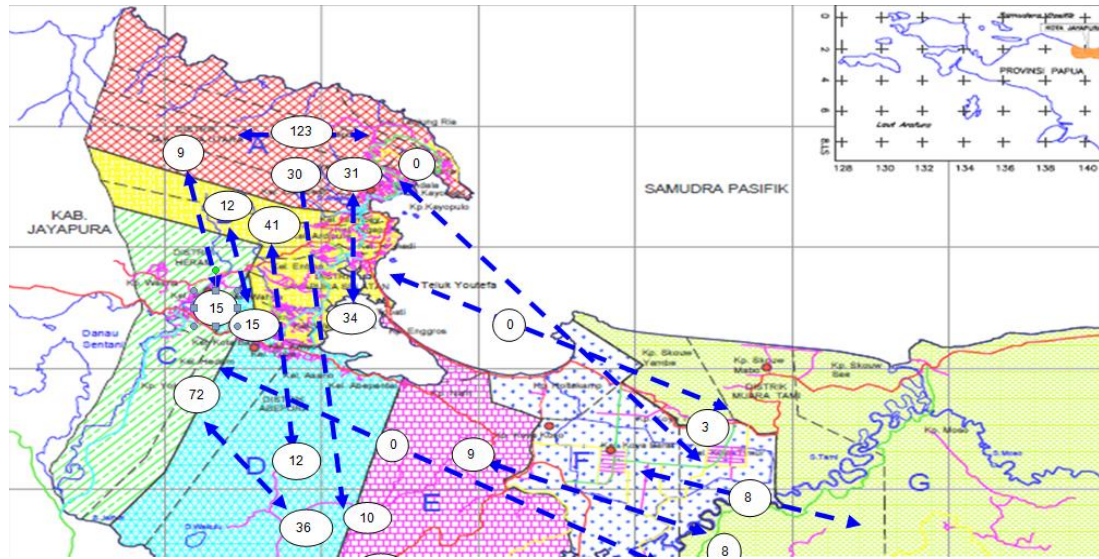


Figure 3. Trips distributions based on survey N= 665

## 5. CONCLUSION

This paper utilized a home interview survey on travelers' O-D movements as the base year data, and applied Fratar method to estimate the future O-Ds. A sample of 665 home interview were conducted, and some new O-D matrices can be developed. This information might use by transport planning authorities in their road network planning process. This study is only a pilot study, and more and large scale of surveys and modelling should be conducted in the near future to get even more convincing results in Jayapura city.

## ACKNOWLEDGEMENTS

BAPPEDA KOTA JAYAPURA, Jayapura city Planning Agency Papua, INDONESIA

Samuel Rorong, ST.MT

Team Surveyor University Cenderawasih



# APPENDICES

KUISIONER 1										
Nama Kepala Keluarga	: .....									
Alamat	: Perumahan .....			: Kel. ....			: Kec. ....			
Kepemilikan kendaraan	: Mobil .....		: Unit Motor .....		: Unit Sepeda .....		: Unit			
Status rumah	: Milik sendiri <input type="checkbox"/>		: Sewa <input type="checkbox"/>		: Lainnya <input type="checkbox"/>					
Umur	: < 25 Th		: 25 - 40 Th		: 40 - 55 Th		: > 55 Th			
Pendidikan Terakhir	: SMA		: D3		: S1		: S2			
Pekerjaan	: PNS		: 1		: TNI/Polri		: 2		: PEG Swasta	: 3
	: Pedagang		: 5		: Pelajar		: 6		: Mahasiswa	: 7
	: Lainnya:		: 8							
Ayah			Ibu		Anak 1		Anak 2		Anak 3	
Anak 4			Anak 5		Keluarga 1		Keluarga 2		Keluarga 3	
Penghasilan/Bulan	: 0 s/d 1,5 jt		: 1,5 s/d 3 jt		: 3 s/d 5 jt		: ≥ 5 jt			
Alamat Rumah	: Perumahan .....			: Kelurahan .....			: Distrik .....			
Kepemilikan kendaraan	: Mobil		: unit		: Motor		: unit			
1. Jenis aktivitas sehari-hari										
Bekerja	: 1		: Belanja		: 2		: Sekolah		: 3	
Hiburan	: 4		: Lainnya		: 5					
Ayah			Ibu		Anak 1		Anak 2		Anak 3	
Anak 4			Anak 5		Keluarga 1		Keluarga 2		Keluarga 3	
2. Jarak tempat aktivitas dari rumah (km)										
Ayah			Ibu		Anak 1		Anak 2		Anak 3	
Anak 4			Anak 5		Keluarga 1		Keluarga 2		Keluarga 3	
3. Frekuensi perjalanan ke tempat aktivitas dalam seminggu (....X dalam seminggu)										
Ayah			Ibu		Anak 1		Anak 2		Anak 3	
Anak 4			Anak 5		Keluarga 1		Keluarga 2		Keluarga 3	
4. Moda yang digunakan										
Mobil	: 1		: Spd Motor		: 2		: Ang. Umum		: 3	
Ayah			Ibu		Anak 1		Anak 2		Anak 3	
Anak 4			Anak 5		Keluarga 1		Keluarga 2		Keluarga 3	
5. Lokasi Tujuan Perjalanan										
nama kawasan/tempat : .....										
Distrik :										
Jayapura Utara	: 1		: Jayapura Selatan		: 2		: Abepura lainnya:		: 3	
Muara Tami	: 4		: Heram		: 5					
Ayah			Ibu		Anak 1		Anak 2		Anak 3	
Anak 4			Anak 5		Keluarga 1		Keluarga 2		Keluarga 3	
6. Waktu berangkat dari rumah sampai kembali ke rumah										
Ayah	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Ibu	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Anak 1	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Anak 2	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Anak 3	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Anak 4	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Anak 5	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Keluarga 1	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Keluarga 2	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					
Keluarga 3	: Berangkat Pukul :		: Kembali kerumah Pukul:		: :					

7.	Lama perjalanan dari rumah ke tempat aktivitas (bagi pengguna kendaraan pribadi) = .....menit				
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
	Jalan yang dilalui responden dalam menuju tempat aktivitas				
		1		2	
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
8.	Frekuensi parkir kendaraan setiap hari (bagi pengguna kendaraan pribadi) = .....kali				
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
9.	Rata-rata biaya parkir yang dikeluarkan setiap harinya (bagi pengguna kendaraan pribadi)				
	Rp.				
10.	biaya operasional kendaraan pribadi/hari (bagi pengguna kendaraan pribadi)				
	Rp.				
11.	jumlah muatan kendaraan pribadi				
	1 Orang	2 Orang	3 Orang	4 Orang	≥ 5 Orang
12.	Frekuensi berganti moda (pengguna Angk. Umum) = .....kali				
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
13.	biaya operasional menggunakan angkutan umum (Taxi)				
	Rp.				
14.	Alasan memilih moda				
	Aman	Nyaman	Cepat	Murah	lainnya:
15.	Frekuensi perjalanan belanja responden dalam seminggu = .....kali				
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
16.	Tempat belanja				
	Kota	1	Pinggir kota	2	
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
17.	Frekuensi perjalanan rekreasi/hiburan responden dalam seminggu = .....kali				
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
18.	Tempat tujuan rekreasi/hiburan				
	Kota	1	Pinggir kota	2	Luar kota
				3	
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
19.	Frekuensi perjalanan tujuan silaturahmi responden dalam seminggu = .....kali				
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3
20.	Tujuan silaturahmi				
	Kota	1	Pinggir kota	2	Luar kota
				3	
	Ayah	Ibu	Anak 1	Anak 2	Anak 3
	Anak 4	Anak 5	Keluarga 1	Keluarga 2	Keluarga 3

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