DRIVER'S LICENCE OWNERSHIP IN JAPAN: LONG TERM FORECASTING BY COHORT ANALYSIS

Tatsuhiko Kawashima and Hironobu Ogasawara*

CONTENTS

ABSTRACT

This paper, in the attempt of presenting a part of study examining the theoretical and empirical relationships between driver's licence ownership and passenger car ownership, shows the results of a long term forecast of the driver's licence ownership by sex and age-group in Japan. The method of cohort analysis is applied to Japan's data in order to estimate the future rates of driver's licence ownership. It has been found that, under assumptions set in this study, the marginal increment of total driver's licence ownership remains approximately six to eight times larger than that of population level until the beginning of the next century.

KEY WORDS

1 Introduction

A method that holds particular promise in making a long term forecast of driver's licence ownership, is a technique of cohort analysis which has been successfully employed in the field of quantitative population studies. The underlying basic framework of this technique is composed of two premises:

(1) Members of the same cohort would share identical attributes.
(2) Attributes of each cohort can be expressed at least as a function of time factor t.

The primary purpose of this paper is to show the results of a long term forecast of driver's licence ownership by sex and age-group. This forecasting work applies the method of cohort analysis to Japan's data, serving as a first phase of the study[1] to examine theoretical and empirical relationships between driver's licence ownership and passenger car ownership in order to get a better insight into the structure of dynamic interactions between the pattern of spatial distribution of population and the improvement of transport environments and security.

With the purpose mentioned above, this paper describes, in Section 2, the characteristics of data employed in our cohort analysis. Section 3 explains the formulation of functions to estimate the rates of driver's licence ownership by sex and age-group. The results of the forecasting on the driver's licence ownership for the 1990–2050 period are presented in Section 4, followed by brief concluding remarks stated in Section 5.

2 Data: Population and Driver's Licence Ownership

In this study, we use three sets of data: (1) actual population levels by sex and age-group for the years of 1975, 1980 and 1985, (2) projected population levels by sex and age-group for every five years from 1990 through 2050, and (3) driver's licence ownership (DLO) by sex and age-group for the years of 1975, 1980 and 1985. The data on actual population levels include sixteen age-groups: thirteen "five-year age-groups" to cover 0 to 14 years of age and 20 to 69 years of age, one "three-year age-group" to cover 15 to 17 years of age, one "two-year age-group" to cover 18 and 19 years of age, and one "open-ended age-group" to cover 70 years of age or over. The data on projected population levels encompass nineteen age-groups: eighteen "five-year age-groups" to cover 0 to 89 years of age, and one "open-ended age-group" to cover 90 years of age or over. The data on DLO contain twelve age-groups: one "two-year age-group" to cover 18 and 19 years of age, ten "five-year age-groups" to cover 20 to 69 years of age, and one "open-ended age-group" to cover 70 years of age or over.

Table 1 Population Projections

(unit: 1, 000 persons)

Sex	Age	1980[a]	1985[a]	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Male	Total	57, 594	59, 441	61, 054	62, 716	64, 543	66, 084	66, 861	66, 889	66, 543	66, 207	65, 950	65, 562	64, 933	64, 204	63, 557
Female	Total	59, 467	61, 585	63, 171	64, 849	66, 649	68, 163	68, 962	69, 049	68, 762	68, 436	68, 117	67, 571	66, 713	65, 812	65, 124
Both sexes	0– 4	8, 515	7, 509	7, 160	7, 809	8, 665	8, 735	7, 946	7, 236	7, 182	7, 692	8, 171	8, 090	7, 575	7, 181	7, 245
	5– 9	10, 032	8, 551	7, 441	7, 140	7, 788	8, 642	8, 714	7, 927	7, 219	7, 165	7, 673	8, 152	8, 071	7, 558	7, 164
	10–14	8, 960	10, 034	8, 532	7, 439	7, 138	7, 787	8, 641	8, 713	7, 926	7, 219	7, 164	7, 673	8, 151	8, 070	7, 558
	15–19	8, 272	8, 974	10, 036	8, 525	7, 433	7, 133	7, 783	8, 636	8, 707	7, 921	7, 214	7, 160	7, 668	8, 146	8, 065
	20–24	7, 841	8, 243	8, 950	10, 000	8, 495	7, 408	7, 110	7, 757	8, 608	8, 680	7, 897	7, 191	7, 138	7, 645	8, 121
	25–29	9, 041	7, 824	8, 170	8, 915	9, 963	8, 465	7, 382	7, 085	7, 730	8, 580	8, 651	7, 870	7, 167	7, 114	7, 618
	30–34	10, 772	9, 106	7, 798	8, 142	8, 885	9, 931	8, 438	7, 359	7, 064	7, 706	8, 554	8, 625	7, 846	7, 146	7, 092
	35–39	9, 202	10, 744	9, 022	7, 769	8, 114	8, 855	9, 897	8, 410	7, 336	7, 041	7, 682	8, 527	8, 597	7, 821	7, 123
	40–44	8, 338	9, 093	10, 679	8, 971	7, 728	8, 072	8, 812	9, 850	8, 370	7, 301	7, 008	7, 646	8, 487	8, 557	7, 784
	45–49	8, 090	8, 233	9, 046	10, 581	8, 891	7, 661	8, 005	8, 740	9, 770	8, 303	7, 243	6, 953	7, 586	8, 419	8, 488
	50–54	7, 200	7, 901	8, 100	8, 901	10, 422	8, 758	7, 552	7, 893	8, 620	9, 636	8, 188	7, 143	6, 857	7, 482	8, 304
	55–59	5, 614	6, 993	7, 734	7, 905	8, 696	10, 193	8, 567	7, 391	7, 729	8, 442	9, 435	8, 017	6, 995	6, 715	7, 327
	60–64	4, 465	5, 387	6, 740	7, 460	7, 638	8, 411	9, 873	8, 297	7, 163	7, 494	8, 187	9, 147	7, 770	6, 780	6, 510
	65–69	3, 965	4, 187	5, 100	6, 367	7, 065	7, 245	7, 989	9, 396	7, 892	6, 821	7, 138	7, 799	8, 708	7, 396	6, 455
	70–74	6, 683[b]	8, 208[b]	3, 801	4, 655	5, 821	6, 478	6, 660	7, 354	8, 675	7, 278	6, 296	6, 593	7, 204	8, 036	6, 821
	75–79			2, 987	3, 234	4, 003	5, 015	5, 608	5, 783	6, 399	7, 586	6, 345	5, 497	5, 760	6, 295	7, 010
	80–84			1, 825	2, 239	2, 476	3, 109	3, 904	4, 391	4, 547	5, 041	6, 019	4, 998	4, 342	4, 556	4, 983
	85–89			832	1, 108	1, 396	1, 581	2, 018	2, 535	2, 870	2, 983	3, 305	3, 982	3, 269	2, 852	3, 002
	90+			274	405	576	765	927	1, 185	1, 497	1, 758	1, 898	2, 073	2, 455	2, 247	2, 010
	Total	117, 060	121, 026	124, 225	127, 565	131, 192	134, 247	135, 823	135, 938	135, 305	134, 643	134, 067	133, 133	131, 646	130, 016	128, 681

[Note] (a)   actual population level
        (b)   70 years of age or over
Source: (1)   Bureau of Statistics, *1980 Population Census of Japan: Volume 2, Whole Japan,* Tokyo: Office of the Prime Minister.
        (2)   Statistics Bureau, *1985 Population Census of Japan: Volume 2, Whole Japan,* Tokyo: Management and Coordination Agency.
        (3)   Institute of Population Problems, 1987, *Population Projections for Japan: 1985–2085,* Tokyo: Ministry of Health and Welfare.

DRIVER'S LICENCE OWNERSHIP IN JAPAN (Kawashima and Ogasawara)
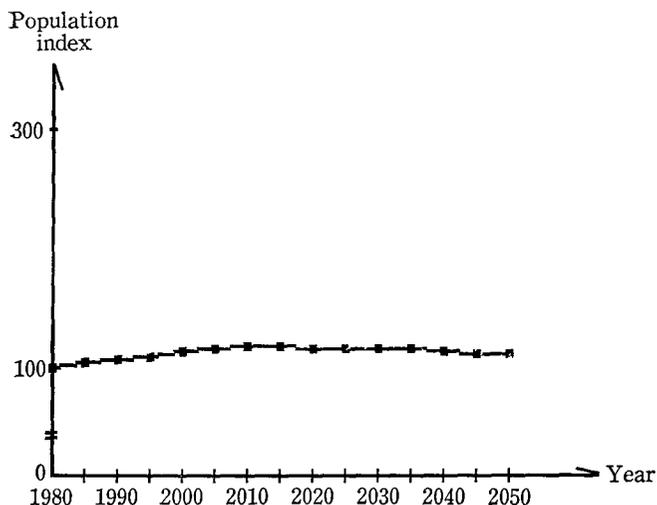
Population
index

(unit: 1,000 persons)

Year	Population (all ages)	Index
1980	117,060	100.00
1985	121,026	103.39
1990	124,225	106.12
1995	127,565	108.97
2000	131,192	112.07
2005	134,247	114.68
2010	135,823	116.03
2015	135,938	116.13
2020	135,305	115.59
2025	134,643	115.02
2030	134,067	114.53
2035	133,133	113.73
2040	131,646	112.46
2045	130,016	111.07
2050	128,681	109.93

300

100

0

1980 1990 2000 2010 2020 2030 2040 2050 → Year

Figure 1 Change in Both-sex Population (all ages)

## 2-1 Projected Population Levels for 1990-2050

We use the information provided by (i) Bureau of Statistics (1980) and Statistics Bureau (1985) as our basic data for actual levels of population, and (ii) Institute of Population Problems (1987a) for the data on projected levels of national population by sex and age-group[2]. A part of the data is furnished in Table 1 showing that the male population increases from 58 million in 1980 to 67 million in 2015 and that it then begins to decrease constantly to 64 million in 2050. The female population increases from 59 million in 1980 to 69 million in 2015, and then decreases to 65 million in 2050. Meanwhile, the both-sex population increases by 16%, as diagrammatically illustrated by Figure 1, from 117 million in 1980 to 136 million in 2015. It then begins to decrease continuously to 129 million in 2050. If we disaggregate the both-sex population to the age-brackets of (1) 20-54 years, (2) 55 years or over, and (3) 65 years or over, then we obtain Table 2 from which we can construct Figure 2. Both of them show changes in the levels of population for the three age-brackets. It can be pointed out that the population level for the age-bracket of 20-54 years increases by 5% during the 1980-1995 period and then proceeds along a path with gentle but rather steadily declining tendency to result in its 2050 level below its 1980 level by 10%. In contrast with this trend, the population for the age-bracket of 55 years or over rapidly increases until 2030 when it attains the level of more than twice (i.e., 235% level of) what it is in 1980. The increasing tendency of population level is more striking for the age-bracket of 65 years or over whose population level in 2020 is three times (i.e., 299% level of) what it is in 1980.

40

DRIVER'S LICENCE OWNERSHIP IN JAPAN (Kawashima and Ogasawara)

Table 2 Changes in Both-sex Population

(unit for population: 1,000 persons)

Year	Population (Age: 20–54)	Index	Population (Age: 55+)	Index	Population (Age: 65+)	Index
1980	60,484	100.00	20,726	100.00	10,647	100.00
1985	61,143	101.09	24,775	119.54	12,395	116.41
1990	61,765	102.12	29,293	141.33	14,819	139.18
1995	63,279	104.62	33,373	161.02	18,008	169.13
2000	62,498	103.33	37,671	181.76	21,337	200.40
2005	59,150	97.80	42,797	206.49	24,193	227.22
2010	57,196	94.56	45,546	219.75	27,106	254.58
2015	57,094	94.40	46,332	223.54	30,644	287.81
2020	57,498	95.06	46,772	225.67	31,880	299.42
2025	57,247	94.65	47,403	228.71	31,467	295.54
2030	55,223	91.30	48,623	234.60	31,001	291.16
2035	53,955	89.21	48,106	232.10	30.942	290.61
2040	53,678	88.75	46,503	224.37	31,738	298.08
2045	54,184	89.58	44,877	216.52	31,382	294.74
2050	54,530	90.16	44,118	212.86	30,281	284.40
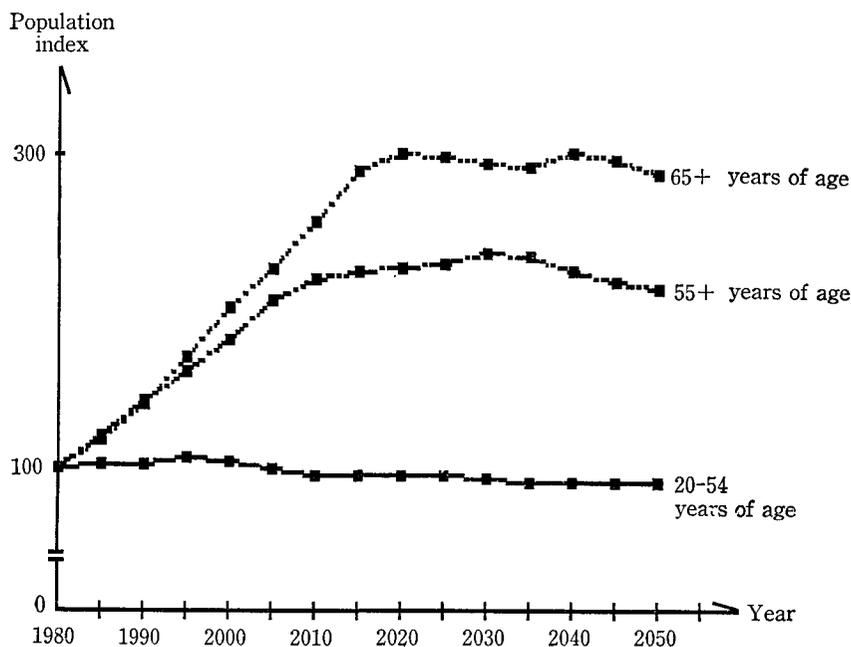
Figure 2 Changes in Both-sex Population (three age-brackets)

41

Table 3 Driver's Licence Ownership (Actual)　　　　　　(unit: persons)

Age	Male		Female		Both sexes	
	1980	1985	1980	1985	1980	1985
0- 4	0	0	0	0	0	0
5- 9	0	0	0	0	0	0
10-14	0	0	0	0	0	0
15-17	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
18-19	1,028,774	1,034,911	430,769	615,929	1,459,543	1,650,840
20-24	3,415,918	3,796,704	1,963,347	2,788,604	5,379,265	6,585,308
25-29	4,036,631	3,719,342	2,325,409	2,767,392	6,362,040	6,486,734
30-34	4,971,901	4,157,672	2,652,154	2,865,660	7,624,055	7,023,332
35-39	3,883,060	5,015,109	1,921,648	3,245,569	5,804,708	8,260,678
40-44	3,405,100	3,929,827	1,385,578	2,241,854	4,790,678	6,171,681
45-49	3,119,840	3,422,812	954,552	1,535,665	4,074,392	4,958,477
50-54	2,539,521	3,097,406	559,590	1,001,556	3,099,111	4,098,962
55-59	1,617,963	2,495,784	216,277	557,713	1,834,240	3,053,497
60-64	982,556	1,549,340	53,681	203,342	1,036,237	1,752,682
65-69	601,146	885,264	11,906	46,868	613,052	932,132
70+	333,948	692,291	2,248	10,514	336,196	702,805
Total	29,936,358	33,796,462	12,477,159	17,880,666	42,413,517	51,677,128

[Note]　(a)　See note 3) for reasons why figures for the age-group of 15–17 years are naughts.
Source: Japan Traffic Safety Association, 1981 and 1986, *Traffic Statistics*, (for 1980 and 1985), Tokyo.

Table 4 Rate of Driver's Licence Ownership (Actual)　　　　　　(unit: %)

Age	Male		Female		Both sexes	
	1980	1985	1980	1985	1980	1985
0- 4	0.000	0.000	0.000	0.000	0.000	0.000
5- 9	0.000	0.000	0.000	0.000	0.000	0.000
10-14	0.000	0.000	0.000	0.000	0.000	0.000
15-17	0.000	0.000	0.000	0.000	0.000	0.000
18-19	64.023	61.256	27.789	38.045	46.231	49.898
20-24	86.258	90.303	50.590	69.045	68.604	79.888
25-29	88.805	93.944	51.723	71.611	70.366	82.912
30-34	91.707	90.817	49.571	63.286	70.779	77.127
35-39	84.512	92.444	41.712	61.023	63.084	76.889
40-44	81.873	87.030	33.160	48.972	57.459	67.871
45-49	77.356	84.039	23.527	36.914	50.361	60.227
50-54	71.596	79.157	15.318	25.117	43.043	51.882
55-59	64.425	73.280	6.972	15.546	32.676	43.664
60-64	50.494	65.547	2.131	6.725	23.207	32.534
65-69	34.475	49.664	0.536	1.949	15.463	22.264
70+	12.117	21.051	0.057	0.214	5.031	8.562
Total	51.978	56.857	20.982	29.034	36.232	42.699

2-2 Driver's Licence Ownership for 1975, 1980 and 1985

The age-specific data on DLO (driver's licence ownership) by sex are available from Japan Traffic Safety Association (1976, 1981 and 1986). A part of these data is provided by Table 3[3]. It can be seen from this table that the male DLO increased by 13% from 29.9 million in 1980 to 33.8 million in 1985 and that the female DLO increased by 43% from 12.5 million in 1980 to 17.9 million in 1985. For the same five-year period, the both-sex DLO increased by 22% from 42.4 million to 51.7 million.

Based on the age-and-sex specific data on population and DLO, we can calculate the age-specific DLO rate[4] by sex. A part of the results of this calculation is shown in Table 4. As can be seen from this table, the DLO rate of male-total increased by around 4.9 points from 52.0% in 1980 to 56.9% in 1985, while the DLO rate of female-total increased by 8 points from 21.0% in 1980 to 29.0% in 1985. In consequence, the national DLO rate increased by 6.5 points during the same five-year period from 36.2% to 42.7%. Table 4 also shows that the highest DLO rate in 1985 is observed on the age-group of 25–29 years: 93.9% for male, 71.6% for female, and 82.9% for both sexes.

3   Estimation Functions: For Rates of Driver's Licence Ownership

The DLO rate can be regarded as a function of various socio-economic variables as well as of non-socio-economic variables. Among plausible explaining variables for DLO rate we adopt three variables; cohort code (i), sex code (j), and time factor (T). With these three variables, we fabricate a hyperbola function $R(i, j, T)$ as given by equation (1)[5] for the purpose of estimating age-and-sex specific DLO rate for a particular year T:

$$R(i, j, T) = -b_{ij}/(a_{ij}+mt)+s_j \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

where i : cohort code number ($i=3, 4, 5, ..., 24$),

j : sex code number ($j=1$ for male, and 2 for female),

T : year (Anno Domini) ($T=1990, 1995, ..., 2050$),

$t = (T-1985)/5$,

m : time-factor multipier,

s_j : saturation rate of driver's licence ownership, and

a_{ij}, b_{ij} : coefficients.

For the sake of Equation (1), we assign to each cohort, which is a cluster of driving licence holders who belong to the same age-group in a specific year, code number i as displayed in the first column of Table 5. In addition, we provisionally assume that $m=1$ as to the value of time-factor multiplier[6] and that $s=0.95$ for male and 0.80 for female as to the saturation level of DLO rate[7].

In the above setting, based on the DLO rates for 1980 and 1985 furnished in

Cohort			Coefficients of DLO rate function			
			Male		Female	
Code number (i)	Age group	In year	a_{i1}	b_{i1}	a_{i2}	b_{i2}
1	70+	1980	—	—	—	—
2	65–69	1980	—	—	—	—
3	60–64	1980	−53.6561	−24.325443	−429.3426	−335.104410
4	55–59	1980	27.2387	8.022558	−296.1757	−217.021620
5	50–54	1980	13.8969	3.018346	283.4217	182.675388
6	45–49	1980	9.7972	1.552193	35.5166	19.492461
7	40–44	1980	6.0614	0.664413	12.4760	5.375384
8	35–39	1980	4.1653	0.331988	5.2738	1.636351
9	30–34	1980	4.4662	0.114137	2.6571	0.504240
10	25–29	1980	3.0797	0.128839	2.4454	0.408725
11	20–24	1980	1.1374	0.012009	1.3991	0.117376
12	15–19	1980	1.1621	0.054581	1.2596	0.137988
13	15–19	1985	1.1100	0.035641	1.1937	0.080359
14	15–19	1990	1.0832	0.026420	1.1482	0.055787
15	15–19	1995	1.0668	0.020980	1.1191	0.042535
16	15–19	2000	1.0558	0.017393	1.0992	0.034312
17	15–19	2005	1.0479	0.014853	1.0850	0.028730
18	15–19	2010	1.0420	0.012959	1.0742	0.024700
19	15–19	2015	1.0374	0.011493	1.0659	0.021657
20	15–19	2020	1.0336	0.010325	1.0592	0.019278
21	15–19	2025	1.0306	0.009372	1.0538	0.017368
22	15–19	2030	1.0281	0.008580	1.0493	0.015802
23	15–19	2035	1.0259	0.007912	1.0454	0.014494
24	15–19	2040	1.0241	0.007340	1.0421	0.013386

[Note] (1) Bold-faced figures have been computed based on Table 4.

(2) Figures for cohorts 12 through 24 have been computed based on Tables 6 and 7.

Table 4, we obtain the values of coefficient a_{ij} and b_{ij} as shown in Table 5 for each of cohorts 3 through 11 by means of the following computational scheme[3]:

$$a_{ij} = (s_j - r_{ij,\,80}) / (r_{ij,\,85} - r_{ij,\,80}) \quad\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(2)$$

$$b_{ij} = a_{ij}(s_j - r_{ij,\,85}) \quad\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(3)$$

where $r_{ij,\,80} = R(i,\ j,\ 1980)$,

$r_{ij,\,85} = R(i,\ j,\ 1985)$,

$s_1 = 0.95$, and

$s_2 = 0.80$.

It should be noted in Table 5 that male cohort 3 and female cohorts 3 and 4 have

DRIVER'S LICENCE OWNERSHIP IN JAPAN (Kawashima and Ogasawara)

Table 6 Rate of Driver's Licence Ownership
for 1980-2050: Age-Group of 18-19
Years

(unit: %)

Year	Male	Female
1980	61. 3220	26. 8517
1985	62. 6090	38. 5092
1990	63. 2296	42. 3569
1995	63. 5940	44. 2745
2000	63. 8340	45. 4229
2005	64. 0041	46. 1876
2010	64. 1308	46. 7333
2015	64. 2289	47. 1424
2020	64. 3071	47. 4604
2025	64. 3710	47. 7147
2030	64. 4240	47. 9228
2035	64. 4688	48. 0961
2040	64. 5071	48. 2427
2045	64. 5403	48. 3683
2050	64. 5693	48. 4772

Table 7 Rate of Driver's Licence Ownership
for 1980-2050: Age-Group of 20-24
Years

(unit: %)

Year	Male	Female
1980	86. 258	50. 590
1985	90. 303	69. 045
1990	91. 789	73. 268
1995	92. 561	75. 141
2000	93. 033	76. 199
2005	93. 353	76. 879
2010	93. 583	77. 352
2015	93. 756	77. 701
2020	93. 892	77. 968
2025	94. 001	78. 180
2030	94. 091	78. 352
2035	94. 165	78. 494
2040	94. 229	78. 614
2045	94. 283	78. 716
2050	94. 331	78. 804

coefficients a_{ij} and b_{ij} with negative signs[9]. This might suggest that the saturation level of DLO rate would begin to dwindle after a certain advanced age due to the development of old age impediment in health conditions[10].

Coefficients a_{ij} and b_{ij} for cohorts 12 through 24 in Table 5, are obtained on the basis of Tables 6 and 7. Table 6 shows male and female DLO rates for the age-group of 18–19 years in every five years from 1980 to 2050. They are estimated by going through the next four steps:

Step-1: By means of the ordinary least squares (OLS) method, we get the following two regression equations based on the data on male and female DLO rates for the age-group of 18–19 years in 1975, 1980 and 1985[11]:

$$Q_{18-19}(1, T) = 0.60035 + 0.01287(T - 1975)/5$$
$$Q_{18-19}(2, T) = 0.15194 + 0.81657(T - 1975)/5$$

where $Q_{18-19}(j, T)$ denotes the estimated male ($j=1$) or female ($j=2$) DLO rate in year T (*Anno Domini*) for the age-group of 18–19 years.

Step-2: Computing $Q_{18-19}(j, T)$ for $j=1$ and 2 and for $T=1980$ and 1985, we

45

obtain the male and female DLO rates in 1980 and 1985 for the age-group of 18–19 years as shown in Table 6.

Step-3: Define $RCF(., j, T)$ as a "cohort-free" version of $R(i, j, T)$ expressed by Equation (1). That is, $RCF(., j, T)$ is the same function as $R(i, j, t)$ except that $RCF(., j, T)$ is independent of cohort code number i. Then, calculating values of $a_{.j}$ and $b_{.j}$ of $RCF(., j, T)$ with $m=1$, $s_1=0.65$ and $s_2=0.50$[12] on the basis of the figures obtained at Step-2, we get the following two functions to estimate future male and female DLO rates for the age-group[13] of 18–19 years:

$$R_{18-19}(1, T) = RCF(., 1, T)$$
$$= -0.0683/\{2.8578 + (T - 1985)/5\} + 0.65$$
$$R_{18-19}(2, T) = RCF(., 2, T)$$
$$= -0.2282/\{1.9857 + (T - 1985)/5\} + 0.50$$

Step-4: Computing $R_{18-19}(j, T)$ for $j=1$ and 2 and for $T=1990, 1995, ..., 2050$, we obtain figures in Table 6 for every five years from 1990 to 2050.

Table 7, meanwhile, shows male and female DLO rates for the age-group of 20–24 years in every five years from 1980 to 2050. Rates for 1980 and 1985 are actual ones, while rates for the 1990–2050 period are to be estimated through the next two steps:

Step-1: Calculating values of $a_{.j}$ and $b_{.j}$ of the "cohort-free" function of $RCF(., j, T)$ with $m=1$, $s_1=0.95$ and $s_2=0.80$ using the actual DLO rates for the age-group of 20–24 years in 1980 and 1985, we get the following two functions to estimate the future male and female DLO rates for the age-group[14] of 20–24 years:

$$R_{20-24}(1, T) = R(., 1, T)$$
$$= -0.10151/\{2.16124 + (T - 1985)/5\} + 0.95$$
$$R_{20-24}(2, T) = R(., 2, T)$$
$$= -0.17457/\{1.59358 + (T - 1985)/5\} + 0.80$$

Step-2: Computing $R_{20-24}(j, T)$ for $j=1$, 2 and for $T=1990, 1995, ..., 2050$, we obtain figures in Table 7 for every five years from 1990 to 2050.

4 Forecast Results: Driver's Licence Ownership for 1980–2050

Assume that the DLO rate of any cohort would remain at the same level once the cohort arrives at the age-group of 70–74 years. Then, from Tables 4 through 7

and Equation (1), Tables 8 and 9 are constructed to show the male and female DLO rates for each age-groups (except figures for the total) in every five years from 1980 to 2050[15].

Based on the DLO rates furnished in Tables 8 and 9 as well as on projected population levels provided by Institute of Population Problems (1987a), Tables 10 and 11 are constructed to show the male and female DLO levels for each age-groups (except figures for the total) in every five years from 1980 to 2050. Figures for the total in these two tables are calculated as the sum of DLO levels over age-groups. We then in turn get the DLO rates for the total in Tables 8 and 9 by dividing the total DLO levels shown in Tables 10 and 11 by their corresponding population levels provided in Table 1.

From Tables 10 and 11, Table 12 is constructed to show both-sex DLO levels for each age-groups in every five years from 1980 through 2025. Dividing age-specific DLO levels in Table 12 by their corresponding population levels in Table 1, Table 13 is constructed to show both-sex DLO rates in every five years for the 1980–2050 period.

As can be seen from Table 8, the male-total DLO rate in 1980 is 52.80% with the age-specific rate increasing as the year of age advances from 24.53% for the age-group of 15–19 years up to the maximum rate of 91.71% for the age-group of 30–34 years. It then begins to decrease. In 1985 when the male-total DLO rate is 57.67% with the maximum rate of 93.94% for the age-group of 25–29 years, the rate is greater than in 1980 for every age-group except that of 30–34 years. As shown in Table 9, the female-total DLO rate, on the other hand, is 21.18% for 1980 and 29.34% for 1985 with the respective maximum rates of 51.72% and 71.61% both for the age-group of 25–29 years. It should be noted that, in our model, both male and female DLO rates tend to increase with time for every age-group as shown by Figures 3 and 4. It is, however, also to be noted as clearly illustrated by Figure 5 that there exists a significant difference between male and female on the DLO rate for any given age-group, but that such a difference tends to converge to a certain extent as time goes on. Table 13 shows that the both-sex DLO rate is 36.73% in 1980 with the maximum rate of 70.78 for the age-group of 30–34 years and 43.25% in 1985 with the maximum rate of 82.91 for the age-group of 25–29 years. The general tendency of the changes in the both-sex DLO rate is diagrammatically displayed in Figure 6[16].

Turning our eyes from the DLO rates to the DLO levels, it follows from Tables 10 and 11 that the male DLO level increases from 29.9 million in 1980 to 48.9 million in 2025 and then begins to decrease to 46.7 million in 2050. The female DLO level which is 12.5 million in 1980 increases to 42.1 million in 2030 followed by its decrease to 41.0 million in 2050. The comparisons between DLO and population levels for male and female by age-group are graphically shown in Figure 7 for years 1980, 1985, 2010, 2030,[17] and 2050.

Table 8 Rate (%) of Driver's Licence Ownership for Male: 1980-2050

Age	1980	1985	1990	1995	2000	2005	2010	2015
0- 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5- 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10-14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-19	24.529	25.044	25.292	25.438	25.534	25.602	25.652	25.692
20-24	86.258	90.303	91.789	92.561	93.033	93.353	93.583	93.756
25-29	88.805	93.944	92.476	93.854	94.353	94.586	94.713	94.789
30-34	91.707	90.817	94.438	93.274	94.133	94.480	94.654	94.753
35-39	84.512	92.444	91.842	94.617	93.689	94.303	94.566	94.703
40-44	81.873	87.030	92.912	97.464	94.710	93.943	94.417	94.627
45-49	77.356	84.039	88.573	93.235	92.881	94.766	94.114	94.499
50-54	71.596	79.157	85.591	89.615	93.471	93.180	94.804	94.238
55-59	64.425	73.280	80.624	86.758	90.367	93.652	93.405	94.832
60-64	50.494	65.547	74.738	81.843	87.668	90.934	93.794	93.581
65-69	34.475	49.664	66.590	76.013	82.871	88.396	91.378	93.909
70-74	12.117[a]	21.051[a]	48.803	67.562	77.137	83.750	88.993	91.734
75-79			21.051	48.803	67.562	77.137	83.750	88.993
80-84			21.051	21.051	48.803	67.562	77.137	83.750
85-89			21.051	21.051	21.051	48.803	67.562	77.137
90+			21.051	21.051	21.051	21.051	48.803	67.562
Total	52.798	57.666	61.871	66.180	68.398	69.352	70.230	71.553

Age	2020	2025	2030	2035	2040	2045	2050
0- 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5- 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10-14	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-19	25.723	25.748	25.770	25.788	25.803	25.816	25.828
20-24	93.892	94.001	94.091	94.165	94.229	94.283	94.331
25-29	94.839	94.873	94.897	94.915	94.929	94.939	94.948
30-34	94.815	94.857	94.885	94.906	94.922	94.934	94.944
35-39	94.784	94.836	94.871	94.896	94.914	94.928	94.939
40-44	94.740	94.808	94.852	94.883	94.905	94.921	94.933
45-49	94.673	94.769	94.827	94.866	94.892	94.912	94.926
50-54	94.561	94.709	94.792	94.843	94.877	94.901	94.918
55-59	94.331	94.609	94.738	94.810	94.856	94.886	94.908
60-64	94.852	94.404	94.647	94.762	94.826	94.867	94.894
65-69	93.722	94.869	94.463	94.679	94.781	94.839	94.876
70-74	94.005	93.837	94.882	94.511	94.706	94.798	94.851
75-79	91.734	94.005	93.837	94.882	94.511	94.706	94.798
80-84	88.993	91.734	94.005	93.837	94.882	94.511	94.706
85-89	83.750	88.993	91.734	94.005	93.837	94.882	94.511
90+	77.137	83.750	88.993	91.734	94.005	93.837	94.882
Total	73.042	73.893	73.727	73.090	72.759	73.030	73.524

[Note] (a) 70 years of age or over

Table 9 Rate (%) of Driver's Licence Ownership for Female: 1980–2050

Age	1980	1985	1990	1995	2000	2005	2010	2015
0– 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5– 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10–14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15–19	10.741	15.404	16.943	17.710	18.169	18.475	18.693	18.857
20–24	50.590	69.045	73.268	75.141	76.199	76.879	77.352	77.701
25–29	51.723	71.611	73.893	77.484	78.655	79.169	79.437	79.594
30–34	49.571	63.286	75.107	75.767	78.084	78.916	79.305	79.517
35–39	41.712	61.023	68.137	76.547	76.761	78.453	79.093	79.403
40–44	33.160	48.972	66.212	70.806	77.332	77.376	78.703	79.220
45–49	23.527	36.914	53.918	69.173	72.494	77.826	77.796	78.883
50–54	15.318	25.117	40.111	57.504	71.087	73.659	78.166	78.099
55–59	6.972	15.546	26.620	42.867	60.223	72.426	74.510	78.414
60–64	2.131	6.725	15.773	28.043	45.266	62.355	73.415	75.160
65–69	0.536	1.949	6.477	15.998	29.392	47.374	64.073	74.175
70–74	0.057[a]	0.214[a]	1.767	6.227	16.222	30.673	49.241	65.485
75–79			0.214	1.767	6.227	16.222	30.673	49.241
80–84			0.214	0.214	1.767	6.227	16.222	30.673
85–89			0.214	0.214	0.214	1.767	6.227	16.222
90+			0.214	0.214	0.214	0.214	1.767	6.227
Total	21.175	29.343	35.488	41.225	45.407	48.635	51.693	54.987

Age	2020	2025	2030	2035	2040	2045	2050
0– 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5– 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10–14	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15–19	18.984	19.086	19.169	19.238	19.297	19.347	19.391
20–24	77.968	78.180	78.352	78.494	78.614	78.716	78.804
25–29	79.694	79.761	79.808	79.843	79.869	79.889	79.905
30–34	79.645	79.728	79.785	79.826	79.856	79.879	79.897
35–39	79.576	79.684	79.755	79.804	79.840	79.867	79.888
40–44	79.476	79.623	79.715	79.777	79.821	79.852	79.876
45–49	79.315	79.534	79.660	79.741	79.795	79.834	79.863
50–54	79.019	79.390	79.580	79.691	79.762	79.811	79.846
55–59	78.329	79.126	79.450	79.617	79.716	79.780	79.824
60–64	78.603	78.510	79.212	79.500	79.649	79.738	79.796
65–69	75.673	78.751	78.655	79.282	79.541	79.676	79.757
70–74	74.779	76.087	78.871	78.774	79.341	79.576	79.699
75–79	65.485	74.779	76.087	78.871	78.774	79.341	79.576
80–84	49.241	65.485	74.779	76.087	78.871	78.774	79.341
85–89	30.673	49.241	65.485	74.779	76.087	78.871	78.774
90+	16.222	30.673	49.241	65.485	74.779	76.087	78.871
Total	58.227	60.643	61.790	62.045	62.120	62.445	62.929

[Note] (a) 70 years of age or over

Table 10 Driver's Licence Ownership for Male: 1980–2050

(unit: persons)

Age	1980[a]	1985[a]	1990	1995	2000	2005	2010	2015
0– 4	0	0	0	0	0	0	0	0
5– 9	0	0	0	0	0	0	0	0
10–14	0	0	0	0	0	0	0	0
15–19	1,028,774	1,034,911	1,300,758	1,111,369	971,298	936,763	1,024,040	1,138,136
20–24	3,415,918	3,796,704	4,203,027	4,737,261	4,045,092	3,535,262	3,409,215	3,726,813
25–29	4,036,631	3,719,342	3,834,034	4,276,926	4,806,338	4,094,625	3,570,671	3,438,006
30–34	4,971,901	4,157,672	3,715,196	3,852,211	4,272,689	4,795,816	4,082,435	3,559,888
35–39	3,883,060	5,015,109	4,168,706	3,705,210	3,853,412	4,263,417	4,780,295	4,068,446
40–44	3,405,100	3,929,827	4,981,008	4,166,412	3,684,208	3,838,496	4,242,141	4,755,006
45–49	3,119,840	3,422,812	3,981,345	4,939,582	4,137,841	3,645,657	3,805,038	4,202,358
50–54	2,539,521	3,097,406	3,425,350	3,942,174	4,853,028	4,068,246	3,577,915	3,739,360
55–59	1,617,963	2,495,784	3,056,461	3,356,672	3,848,719	4,714,433	3,954,784	3,472,738
60–64	982,556	1,549,340	2,420,029	2,952,885	3,234,937	3,698,292	4,518,069	3,790,031
65–69	601,146	885,264	1,462,321	2,278,108	2,776,173	3,033,765	3,462,304	4,225,925
70–74	333,948[b]	692,291[b]	758,889	1,307,997	2,046,435	2,492,398	2,721,419	3,101,530
75–79			249,449	607,111	1,062,748	1,671,551	2,047,686	2,243,524
80–84			142,933	170,720	424,587	758,044	1,200,246	1,479,861
85–89			58,520	76,624	94,096	239,135	437,800	695,772
90+			16,419	24,418	34,312	44,837	122,496	223,629
Total	30,408,233	34,277,091	37,774,445	41,505,680	44,145,913	45,830,737	46,956,554	47,861,023

Age	2020	2025	2030	2035	2040	2045	2050
0– 4	0	0	0	0	0	0	0
5– 9	0	0	0	0	0	0	0
10–14	0	0	0	0	0	0	0
15–19	1,149,040	1,046,414	953,733	94 7,175	1,015,084	1,078,855	1,068,751
20–24	4,141,579	4,181,169	3,807,846	3,469,994	3,446,889	3,694,017	3,926,036
25–29	3,753,722	4,167,763	4,203,941	3,825,075	3,483,881	3,458,637	3,703,908
30–34	3,427,578	3,741,147	4,154,087	4,190,118	3,812,071	3,472,690	3,446,452
35–39	3,547,768	3,415,038	3,727,479	4,139,357	4,174,326	3,798,072	3,459,571
40–44	4,045,394	3,526,854	3,395,708	3,706,115	4,115,060	4,149,936	3,775,493
45–49	4,708,095	4,005,869	3,492,479	3,362,035	3,669,488	4,073,616	4,107,466
50–54	4,128,512	4,623,699	3,932,903	3,428,562	3,300,761	3,603,377	3,999,849
55–59	3,634,584	4,012,358	4,491,527	3,819,912	3,330,384	3,206,203	3,500,196
60–64	3,326,474	3,485,405	3,847,419	4,304,072	3,659,340	3,190,369	3,072,676
65–69	3,543,621	3,109,791	3,261,803	3,600,649	4,024,415	3,419,910	2,982,909
70–74	3,790,264	3,173,572	2,785,721	2,926,060	3,230,411	3,606,118	3,061,785
75–79	2,563,051	3,152,913	2,629,317	2,313,211	2,432,713	2,687,747	2,992,774
80–84	1,628,579	1,864,037	2,315,332	1,914,278	1,689,840	1,781,532	1,970,825
85–89	864,299	954,899	1,091,635	1,370,586	1,119,477	993,409	1,051,907
90+	351,743	461,462	532,180	601,775	740,756	673,750	609,139
Total	48,604,303	48,922,390	48,623,110	47,918,974	47,244,896	46,888,238	46,729,737

[Note] (a) actual level of driver's licence ownership
(b) 70 years of age or over

Table 11 Driver's Licence Ownership for Female: 1980-2050

(unit: persons)

Age	1980[a]	1985[a]	1990	1995	2000	2005	2010	2015
0- 4	0	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0	0
15-19	430,769	615,929	829,009	736,019	659,358	641,822	708,664	793,123
20-24	1,963,347	2,788,604	3,202,543	3,668,399	3,159,974	2,783,772	2,681,792	2,938,640
25-29	2,325,409	2,767,392	2,973,468	3,376,744	3,829,719	3,274,433	2,869,280	2,752,377
30-34	2,652,154	2,865,660	2,902,153	3,039,762	3,393,522	3,831,389	3,271,326	2,864,190
35-39	1,921,648	3,245,569	3,054,589	2,949,350	3,071,190	3,400,142	3,829,664	3,266,619
40-44	1,385,578	2,241,854	3,521,157	3,161,475	2,967,995	3,084,226	3,399,163	3,822,343
45-49	954,552	1,535,665	2,453,802	3,654,393	3,215,840	2,968,283	3,082,261	3,386,444
50-54	559,590	1,001,556	1,643,763	2,588,812	3,717,830	3,235,089	2,953,101	3,065 395
55-59	216,277	557,713	1,049,640	1,730,107	2,672,076	3,736,433	3,228,535	2,924,044
60-64	53,681	203,342	552,372	1,080,222	1,787,112	2,708,709	3,711,849	3,192,062
65-69	11,906	46,868	188,096	539,135	1,091,916	1,806,386	2,691,051	3,631,628
70-74	2,248[b]	10,514[b]	39,691	169,317	513,898	1,074,160	1,773,671	2,601,735
75-79			3.851	35,167	151,321	461,989	970,180	1,606,251
80-84			2,449	3,051	28,381	123,734	380,881	804,853
85-89			1,183	1,590	2,028	19,280	85,312	264,897
90+			418	617	882	1,179	11,946	53,180
Total	12,592,150	18,070,644	22,418,184	26,734,160	30,263,042	33,151,026	35,648,676	37,967,781

Age	2020	2025	2030	2035	2040	2045	2050
0- 4	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0
15-19	804,928	736,142	673,410	670,843	720,552	767,508	761,480
20-24	3,272,327	3,308,578	3,016,545	2,751,999	2,735,752	2,933,729	3,119,833
25-29	3,006,060	3,339,598	3,368,710	3,065,966	2,793,013	2,772,943	2,970,056
30-34	2,746,943	2,999,359	3,331,815	3,360,661	3,058,481	2,786,176	2,766,027
35-39	2,859,178	2,741,121	2,993,198	3,323,848	3,352,487	3,050,917	2,779,286
40-44	3,258,520	2,851,296	2,732,634	2,983,658	3,313,349	3,341,822	3,040,895
45-49	3,804,756	3,241,787	2,835,905	2,718,364	2,967,592	3,294,759	3,323,094
50-54	3,361,479	3,774,209	3,214,222	2,811,493	2,694,369	2,941,038	3,265,702
55-59	3,036,046	3,324,080	3,729,395	3,175,144	2,777,319	2,661,475	2,904,813
60-64	2,873,707	2,984,942	3,265,105	3,660,955	3,115,073	2,724,649	2,610,925
65-69	3,110,907	2,790,154	2,898,438	3,168,112	3,549,109	3,019,711	2,640,742
70-74	3,471,968	2,964,351	2,650,075	2,754,743	3,009,403	3,367,643	2,863,575
75-79	2,360,749	3,164,628	2,695,763	2,412,672	2,509,755	2,742,817	3,066,051
80-84	1,337,886	1,970,456	2,659,125	2,250,654	2,019,893	2,104,066	2,302,475
85-89	563,765	940,508	1,385,016	1,887,410	1,579,567	1,423,626	1,488,050
90+	168,866	370,220	640,136	927,928	1,246,558	1,163,370	1,078,959
Total	40,038,085	41,501,429	42,089,492	41,924,450	41,442,272	41,096,249	40,981,963

[Note] (a) actual level of driver's licence ownership
(b) 70 years of age or over

51

Table 12 Driver's Licence Ownership for Both Sexes: 1980-2050

(unit: persons)

Age	1980[a]	1985[a]	1990	1995	2000	2005	2010	2015
0- 4	0	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0	0
15-19	1,459,543	1,650,840	2,129,767	1,847,388	1,630,656	1,578,585	1,732,704	1,931,259
20-24	5,379,265	6,585,308	7,405,570	8,405,660	7,205,066	6,319,034	6,091,007	6,665,453
25-29	6,362,040	6,486,734	6,807,502	7,653,670	8,636,057	7,369,058	6,439,951	6,190,383
30-34	7,624,055	7,023,332	6,617,349	6,891,973	7,666,211	8,627,205	7,353,761	6,424,078
35-39	5,804,708	8,260,678	7,223,295	6,654,560	6,924,602	7,663,559	8,609,959	7,335,065
40-44	4,790,678	6,171,681	8,502,165	7,327,887	6,652,203	6,922,722	7,641,304	8,577,349
45-49	4,074,392	4,958,477	6,435,147	8,593,975	7,353,681	6,613,940	6,887,299	7,588,802
50-54	3,099,111	4,098,962	5,069,113	6,530,986	8,570,858	7,303,335	6,531,016	6,804,755
55-59	1,834,240	3,053,497	4,106,101	5,086,779	6,520,795	8,450,866	7,183,319	6,396,782
60-64	1,036,237	1,752,682	2,972,401	4,033,107	5,022,049	6,407,001	8,229,918	6,982,093
65-69	613,052	932,132	1,650,417	2,817,243	3,868,089	4,840,151	6,153,355	7,857,553
70-74	336,196[b]	702,805[b]	798,580	1,477,314	2,560,333	3,566,558	4,495,090	5,703,265
75-79			253,300	642,278	1,214,069	2,133,540	3,017,866	3,849,775
80-84			145,382	173,771	452,968	881,778	1,581,127	2,284,714
85-89			59,703	78,214	96,124	258,415	523,112	960,669
90+			16,837	25,035	35,194	46,016	134,442	276,809
Tatal	43,000,383	52,347,735	60,192,629	68,239,840	74,408,955	78,981,763	82,605,230	85,828,804

Age	2020	2025	2030	2035	2040	2045	2050
0- 4	0	0	0	0	0	0	0
5- 9	0	0	0	0	0	0	0
10-14	0	0	0	0	0	0	0
15-19	1,953,968	1,782,556	1,627,143	1,618,018	1,735,636	1,846,363	1,830,231
20-24	7,413,906	7,489,747	6,824,391	6,221,993	6,182,641	6,627,746	7,045,869
25-29	6,759,782	7,507,361	7,572,651	6,891,041	6,276,894	6,231,580	6,673,964
30-34	6,174,521	6,740,506	7,485,902	7,550,779	6,870,552	6,258,866	6,212,479
35-39	6,406,946	6,156,159	6,720,677	7,463,205	7,526,813	6,848,989	6,238,857
40-44	7,303,914	6,378,150	6,128,342	6,689,773	7,428,409	7,491,758	6,816,388
45-49	8,512,851	7,247,656	6,328,384	6,080,399	6,637,080	7,368,375	7,430,560
50-54	7,489,991	8,397,908	7,147,125	6,240,055	5,995,130	6,544,415	7,265,551
55-59	6,670,630	7,336,438	8,220,922	6,995,056	6,107,703	5,867,678	6,405,009
60-64	6,200,181	6,470,347	7,112,524	7,965,027	6,774,413	5,915,018	5,683,601
65-69	6,654,528	5,899,945	6,160,241	6,768,761	7,573,524	6,439,621	5,623,651
70-74	7,262,232	6,137,923	5,435,796	5,680,803	6,239,814	6,973,761	5,925,360
75-79	4,923,800	6,317,541	5,325,080	4,725,883	4,942,468	5,430,564	6,058,825
80-84	2,966,465	3,834,493	4,974,457	4,164,932	3,709,733	3,885,598	4,273,300
85-89	1,428,064	1,895,407	2,476,651	3,257,996	2,699,044	2,417,035	2,539 957
90+	520,609	831,682	1,172,316	1,529,703	1,987,314	1,837,120	1,688,098
Total	88,642,388	90,423,819	90,712,602	89,843,424	88,687,168	87,984,487	87,711,700

[Note] (a) actual level of driver's licence ownership

(b) 70 years of age or over

Table 13 Rate (%) of Driver's Licence Ownersh p for Both Sexes: 1980–2050

Age	1980	1985	1990	1995	2000	2005	2010	2015
0- 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5- 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10–14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15–19	17.644	18.395	21.221	21.670	21.938	22.131	22.263	22.363
20–24	68.604	79.888	82.744	84.057	84.815	85.300	85.668	85.928
25–29	70.366	82.912	83.323	85.852	86.681	87.053	87.239	87.373
30–34	70.779	77.127	84.860	84.647	86.283	86.871	87.151	87.296
35–39	63.084	76.889	80.063	85.655	85.341	86.545	86.996	87.218
40–44	57.459	67.871	79.616	81.684	86.079	85.762	86.715	87.080
45–49	50.361	60.227	71.138	81.221	82.709	86.333	86.037	86.828
50–54	43.043	51.882	62.582	73.374	82.238	83.390	86.481	86.213
55–59	32.676	43.664	53.092	64.349	74.986	82.909	83.849	86.548
60–64	23.207	32.534	44.101	54.063	65.751	76.174	83.358	84.152
65–69	15.463	22.264	32.361	44.248	54.750	66.807	77.023	83.627
70–74	5.031[a]	8.562[a]	21.010	31.739	43.984	55.056	67.494	77.553
75–79			8.480	19.860	30.329	42.543	53.814	66.571
80–84			7.966	7.761	18.294	28.362	40.500	52.032
85–89			7.176	7.059	6.886	16.345	25.922	37.896
90+			6.145	6.181	6.110	6.015	14.503	23.359
Total	36.734	43.253	48.455	53.494	56.718	58.833	60.818	63.138

Age	2020	2025	2030	2035	2040	2045	2050
0- 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5- 9	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10–14	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15–19	22.441	22.504	22.555	22.598	22.635	22.666	22.694
20–24	86.128	86.287	86.418	86.525	86.616	86.694	86.761
25–29	87.449	87.498	87.535	87.561	87.580	87.596	87.608
30–34	87.408	87.471	87.513	87.545	87.568	87.586	87.598
35–39	87.336	87.433	87.486	87.524	87.552	87.572	87.587
40–44	87.263	87.360	87.448	87.494	87.527	87.551	87.569
45–49	87.133	87.290	87.372	87.450	87.491	87.521	87.542
50–54	86.891	87.151	87.288	87.359	87.431	87.469	87.495
55–59	86.307	86.904	87.132	87.253	87.315	87.382	87.417
60–64	86.558	86.340	86.876	87.078	87.187	87.242	87.306
65–69	84.320	86.497	86.302	86.790	86.972	87.069	87.121
70–74	83.714	84.335	86.337	86.164	86.616	86.781	86.869
75–79	76.946	83.279	83.926	85.972	85.807	86.268	86.431
80–84	65.240	76.066	82.646	83.332	85.438	85.285	85.758
85–89	49.758	63.540	74.936	81.818	82.565	84.749	84.609
90+	34.777	47.308	61.766	73.792	80.950	81.759	83.985
Total	65.513	67.158	67.662	67.484	67.368	67.672	68.162

[Note] (a) 70 years of age or over

53

Driver's licence
ownership rate (%)
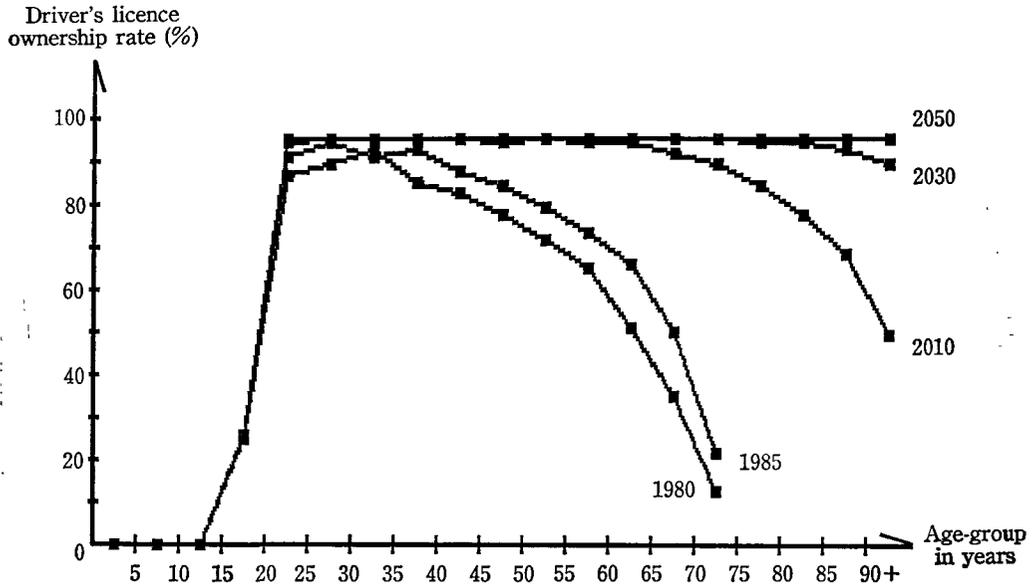
Figure 3 Changes in Rate of Driver's Licence Ownership 1980-2050: Male

Driver's licence
ownership rate (%)
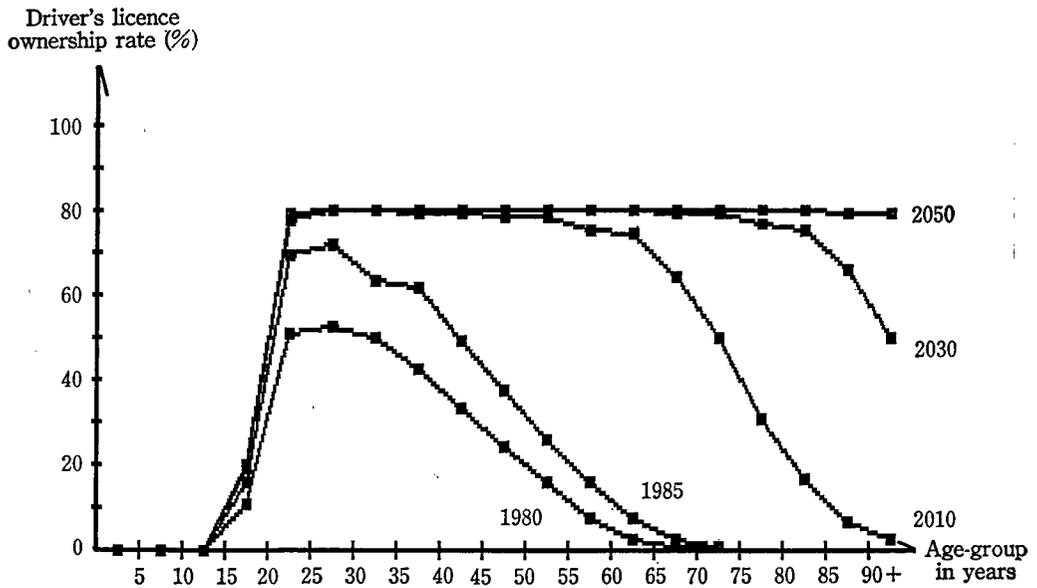
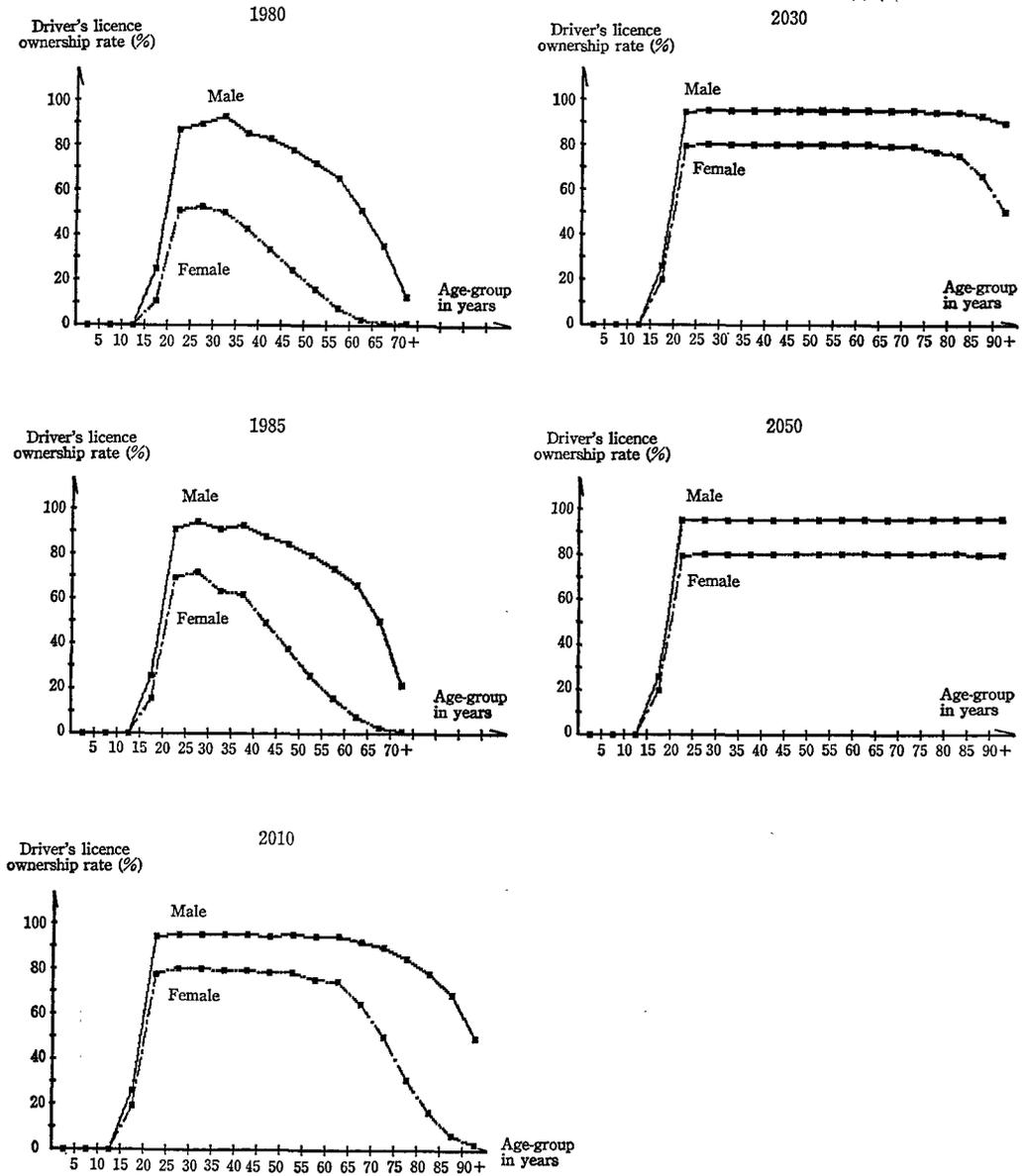**Figure 4** Changes in Rate of Driver's Licence Ownership 1980-2050: Female

Figure 5 Changes in Rate of Driver's Licence Ownership 1980–2050:
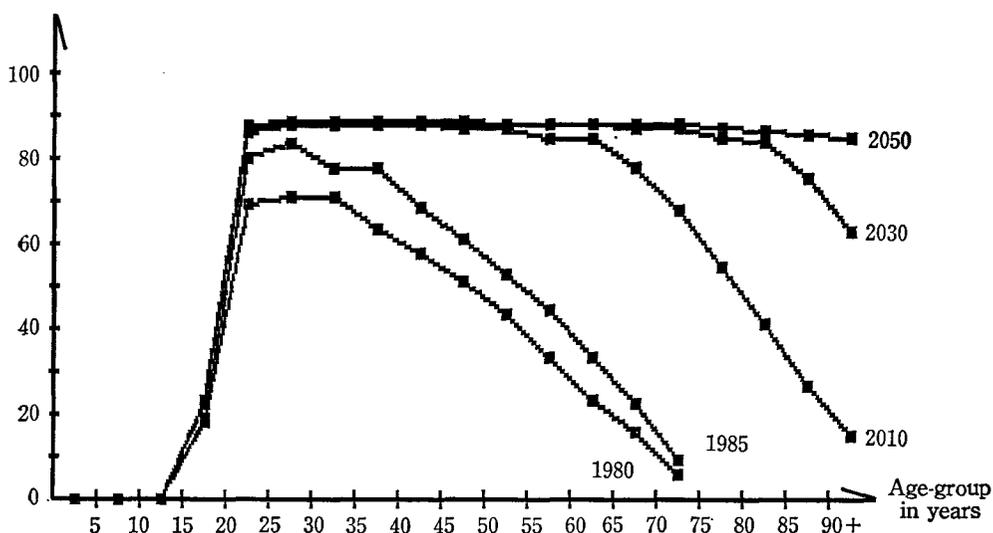Comparison between Male and Female

Driver's licence
ownership rate (%)

Figure 6 Changes in Rate of Driver's Licence Ownership 1980-2050: Both Sexes

Table 14 Driver's Licence Ownership (DLO) Index: Male, Female and Both Sexes

Year	Male		Female		Both sexes	
	D L O	DLO index	D L O	DLO index	D L O	DLO index
1980	30, 408, 233	100. 00	12, 592, 150	100. 00	43, 000, 383	100. 00
1985	34, 277, 091	112. 72	18, 070, 644	143. 51	52, 347, 735	121. 74
1990	37, 774, 445	124. 22	22, 418, 184	178. 03	60, 192, 629	139. 98
1995	41, 505, 680	136. 49	26, 734, 160	212. 31	68, 239, 840	158. 70
2000	44, 145, 913	145. 18	30, 263, 042	240. 33	74, 408, 955	173. 04
2005	45, 830, 737	150. 72	33, 151, 026	263. 27	78, 981, 763	183. 68
2010	46, 956, 554	154. 42	35, 648, 676	283. 10	82, 605, 230	192. 10
2015	47, 861, 023	157. 39	37, 967, 781	301. 52	85, 828, 804	199. 60
2020	48, 604. 303	159. 84	40, 038, 085	317. 96	88, 642, 388	206. 14
2025	48, 922, 390	160. 89	41, 501, 429	329. 58	90, 423, 819	210. 29
2030	48, 623, 110	159. 90	42, 089, 492	334. 25	90, 712, 602	210. 96
2035	47, 918, 974	157. 59	41, 924, 450	332. 94	89, 843, 424	208. 94
2040	47, 244, 896	155. 37	41, 442, 272	329. 11	88, 687, 168	206. 25
2045	46, 888, 238	154. 20	41, 096, 249	326. 36	87, 984, 487	204. 61
2050	46, 729, 737	153. 67	40, 981, 963	325. 46	87, 711, 700	203. 98
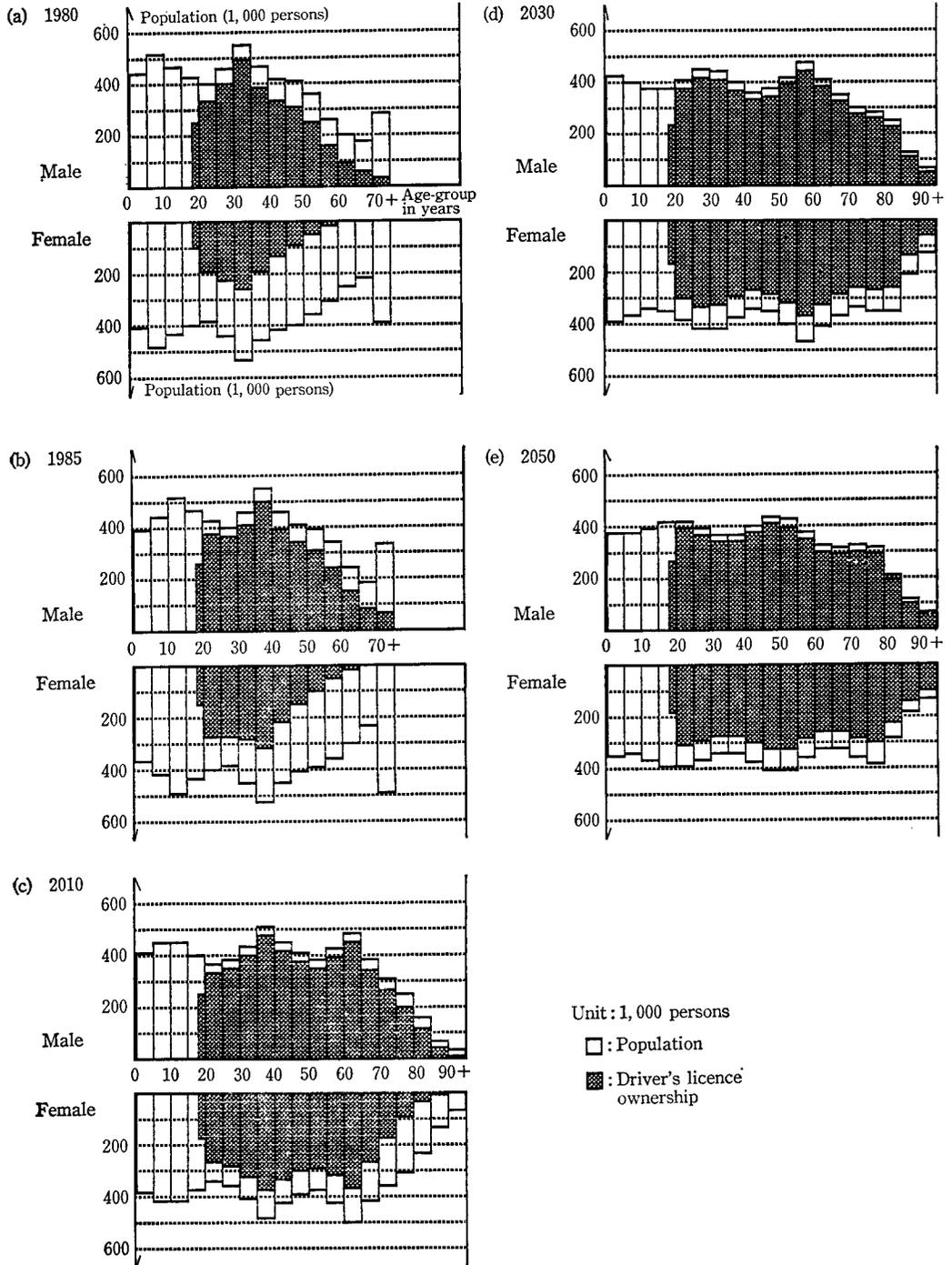
Figure 7 Driver's Licence Ownership as Compared with Population by Sex and Age-group

Driver's licence
ownership index
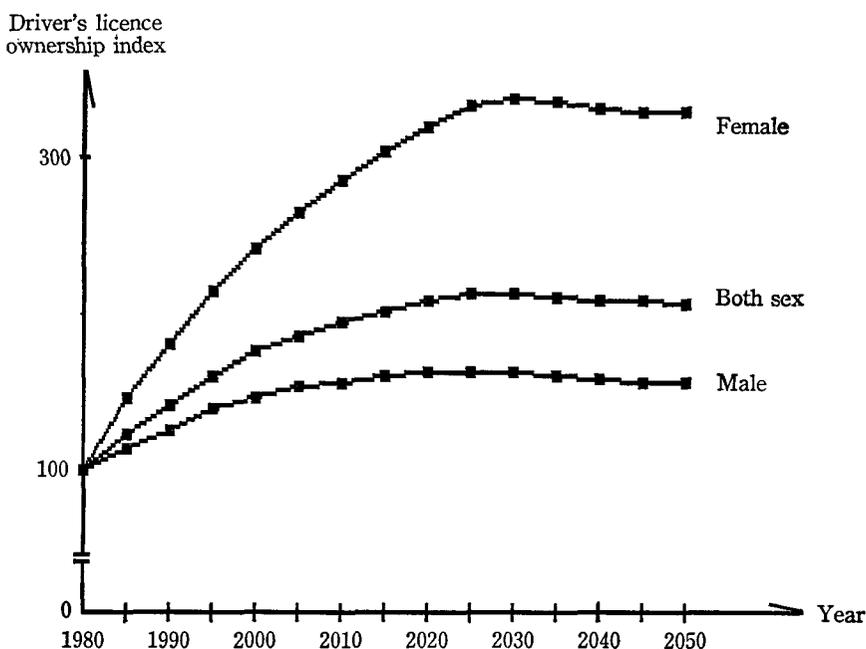
Figure 8 Driver's Licence Ownership (DLO) Index:
Male, Female and Both Sexes

For the both-sex DLO level, Table 12 shows that the level increases from 42.4 million in 1980 to 90.7 million in 2030. It then begins to decline to 87.7 million in 2050. Referring to the index with 100.0 for 1980 as shown in Table 14, the both-sex DLO level grows to be approximately doubled (increase by 111%) in fifty years from 1980 to 2030. The female DLO level becomes more than tripled (increase by 234%) during the same period, while the male DLO level in its peak year 2025 is around one and a half level of the year 1980. Figure 8 illustrates these changes of DLO levels for male, female and both sexes during the 1980–2050 period.

If we aggregate the both-sex age-specific DLO levels into the age-brackets of (1) 20–54 years[18], (2) 55 years or over, and (3) 65 years or over, we can construct Figure 9 showing the both-sex DLO index for these three age-brackets. It can be pointed out from this table that the DLO for the age-bracket of 20–54 years increases by 42.75% between 1980 and 2000 with the increase by 28.41% between 1980 and 2050. For the age-bracket of 55 years or over, the DLO level increases by 418% before 2000, by 975% between 1980 and 2035 and by 900% between 1980 and 2050. The age-bracket of 65 years or over increases its DLO level by 767% before 2000, by 2760% between 1980 and 2035 and by 2651% between 1980 and 2000.

(a) 20–54 Years
Driver's licence
ownership index
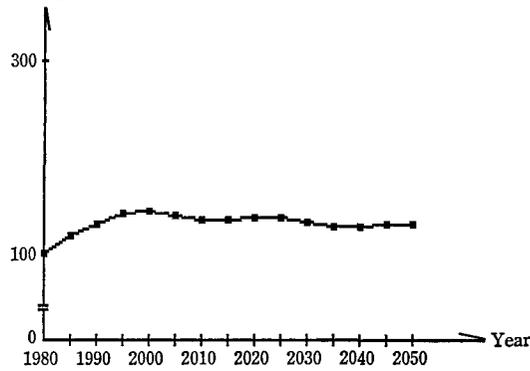
Year	D L O	DLO index
1980	37, 134, 249	100. 00
1985	43, 585, 172	117. 37
1990	48, 060, 141	129. 42
1995	52, 058, 711	140. 19
2000	53, 008, 678	142. 75
2005	50, 818, 853	136. 85
2010	49, 554, 297	133. 45
2015	49, 585, 885	133. 53
2020	50, 061, 911	134. 81
2025	49, 917, 487	134. 42
2030	48, 207, 472	129. 82
2035	47, 137, 245	126. 94
2040	46, 917, 519	126. 35
2045	47, 371, 729	127. 57
2050	47, 683, 668	128. 41

(b) 55 Years or Over
Driver's licence
ownership index
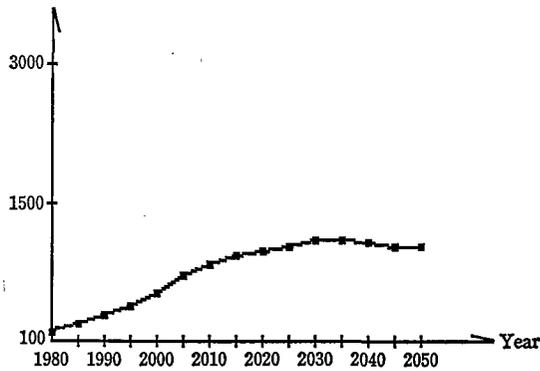
Year	D L O	DLO index
1980	3, 819, 725	100. 0
1985	6, 441, 116	168. 6
1990	10, 002, 721	261. 9
1995	14, 333, 741	375. 3
2000	19, 769, 621	517. 6
2005	26, 584, 325	696. 0
2010	31, 318, 229	819. 9
2015	34, 311, 660	898. 3
2020	36, 626, 509	958. 9
2025	38, 723, 776	1013. 8
2030	40, 877, 987	1070. 2
2035	41, 088, 161	1075. 7
2040	40, 034, 013	1048. 1
2045	38, 766, 395	1014. 9
2050	38, 197, 801	1000. 0

(c) 65 Years or Over
Driver's licence
ownership index
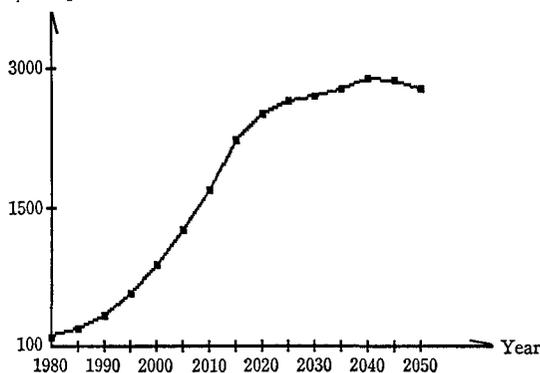
Year	D L O	DLO index
1980	949, 248	100. 0
1985	1, 634, 937	172. 2
1990	2, 924, 219	308. 1
1995	5, 213, 855	549. 3
2000	8, 226, 777	866. 7
2005	11, 726, 458	1235. 3
2010	15, 904, 992	1675. 5
2015	20, 932, 785	2205. 2
2020	23, 755, 698	2502. 6
2025	24, 916, 991	2624. 9
2030	25, 544, 541	2691. 0
2035	26, 128, 078	2752. 5
5040	27, 151, 897	2860. 4
2045	26, 983, 699	2842. 6
2050	26, 109, 191	2750. 5

Figure 9 Driver's Licence Ownership (DLO) Index for Both Sexes:
Age-brackets of 20-54 Years, 55 Years or Over, and 65 Years or Over

From the above observations, we can extract the following findings concerning the elasticity of the DLO level with respect to population level, which is defined as the ratio of the marginal increment of DLO index and that of population index. The both-sex DLO elasticities with respect to population for the 1980–2000 period are:

(1) 6.05 for all-ages,

(2) 12.84 for the age-bracket of 20–54 years,

(3) 5.11 for the age-bracket of 55 years or over, and

(4) 7.64 for the age-bracket of 65 years or over.

The both-sex DLO elasticities for the 1980–2030 period are:

(1) 7.64 for all-ages,

(2) −3.46 for the age-bracket of 20–54 years,

(3) 7.21 for the age-bracket of 55 years or over, and

(4) 11.66 for the age-bracket of 65 years or over.

5 Conclusion

This paper has presented (1) the method of formulation of functions to estimate sex-and-age specific DLO rates, (2) the procedures to obtain the parameters for those functions, and (3) the results of the long term DLO forecasts conducted through the means of cohort analysis.

We have used extremely crude functions, *i.e.*, a family of hyperbola functions, to estimate DLO rates. The empirical results of our work, however, may hopefully provide useful clues which may lead to prolific studies in investigating relationships between driver's licence ownership and passenger car ownership. Perhaps, one of the most interesting results of this study would be that the national DLO elasticity with respect to population is 6.05 for all-ages and 12.84 for age-bracket of 20–54 years during the 1980–2000 period. This would imply that in Japan the speed of the increment of DLO is around six times faster than that of population until 2000 for all-ages and thirteen times faster for the age-bracket of 20–54 years. This message would address, in case it can be justified that there would be a reasonable magnitude of correlation between DLO and car ownership[19], that the supply of large-scale, high-quality and safe highway services will become increasingly indispensable to the society and that the demand for passenger cars will remain relatively strong from a long term point of view until the beginning of the next century.

NOTES
1) In amplifying, this study attempts to investigate the *relationships* of the urbanization-suburbanization phenomena and their consequent leisure development by car-use *with* the characteristics of the urban-rural transport systems and patterns. The primary research interests of this study are associated with those expressed in Altshuler *et alii*

(1984), Banister (1985), Button and Pearmen (1985), Kawashima and Nakamura (1986), Sheffi (1985), Werner (1985), Button and Gillingwater (1986), Dupree (1987), Kawashima (1987), and Watanatada *et alii* (1987).

2) See Institute of Population Problems (1987b) for the spatially disaggregated population projections by prefecture. Meanwhile, among other interesting works for the long-term population projection in Japan, see Kawashima, Ohhira, Ohshika and Kimura (1982) in which the projection technique of multiregional population dynamics is applied to Japanese data for population projections for the 1980-2070 period. For detailed explanation of the multiregional population dynamics, see Rogers (1985). For related quantitative approaches of population analysis, see also for example Keyfitz and Flinger (1971), Rogers (1975), Keyfitz (1977a, b), Willekens (1978), and Johnson and Lee (1987).

3) In Japan those who are of the age of 18 years or over are qualified for examination to get a passenger car driving licence, while those who are of the age to 15-17 years are qualified for driver's licence examination only for motor cycles but not for passenger cars. For this reason, DLO figures are naughts in Table 3 for the age-group of 15-17 years.

4) The age-specific DLO rate is defined as the quotient of "age-specific DLO" divided by "its corresponding age-specific population."

5) We choose the hyperbola function given by Equation (1) simply because of its mathematical tractability. More deliberate considerations would perhaps enable us to formulate a more significant function. Among other possible types of functional form is, for example, the family of logistic function as expressed by:

$$\text{DLO Rate} = m/[n\{1+\exp(-mt+c)\}] \quad\cdots\cdots\cdots\text{(N-1)}$$
   where t: time, and
         m, n, c: coefficients.

6) Arbitrarily, but circumspectly taking it into consideration that the sign of time-factor multiplier m has to be positive, we set $m=1$ since there is no other expedient means to prescribe the value of m within the scope of limited data available to authors at the time of conducting this study. In case adopt Equation (N-1) with $t=(T-1985)/5$, as the functional form to estimate the DLO rate, we could obtain the value of time-factor multiplier m appearing in Equation (N-1) by solving the following simultaneous equation system for m_{ij}:

$$\begin{cases} R(i, j, 1980) = (m_{ij}/n_{ij})/\{1+\exp(m_{ij}+c_{ij})\} \\ R(i, j, 1985) = (m_{ij}/n_{ij})/\{1+\exp(c_{ij})\} \end{cases}$$
      where $m_{ij}/n_{ij}=s_j$

The solutions for m_{ij} and c_{ij} in this system turn out to be:

$$m_{ij} = \log_e[\{s_j/R(i, j, 1980)-1\}/\{s_j/R(i, j, 1985)-1\}]$$
$$c_{ij} = \log_e\{s_j/R(i, j, 1985)-1\}.$$

7) We prescribe DLO saturation rate $s=0.95$ for male and 0.80 for female in the light of the results of analytical work by Wigan (1987). His work indicates, as shown in Figure N-1, that the saturation rate of driving licence holders in Australia would be at around 95% for male and between 80% and 90% for female. More justifiable values of

%
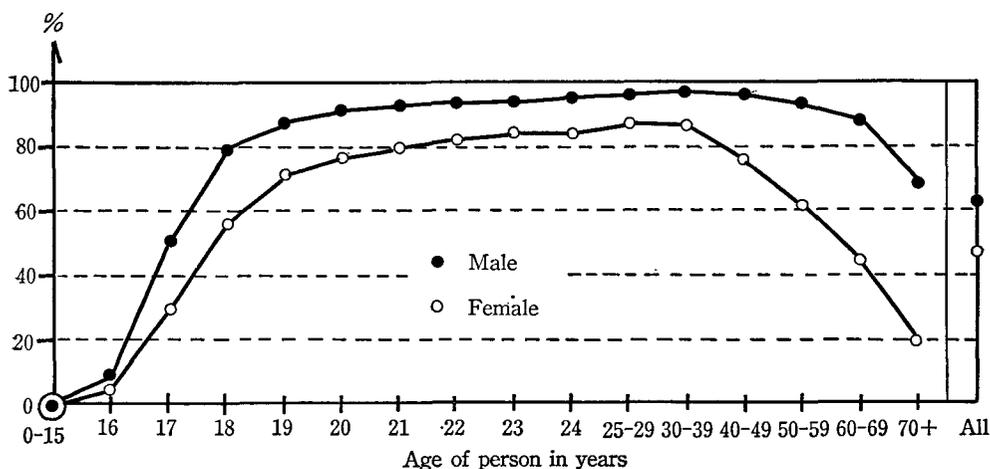
Source: M. R. Wigan, 1987, *Australian Personal Travel Characteristics,* Special Report No. 38, Victoria, Australia: Australian Road Research Board (p. 26).

Figure N-1 Percentage Holding of Driving Licences by Age and Sex: Australia 1978

saturation rate for Japan's case should be, however, empirically explored.

8) We get Equations (2) and (3) by solving the following simultaneous equation system for a_{ij} and b_{ij} $(i=3, 4, 5, \ldots, 11; j=1, 2)$:

$$\begin{cases} R(i, j, 1980) = -b_{ij}/(a_{ij}-1)+s_j \\ R(i, j, 1985) = -b_{ij}/a_{ij}+s_j \end{cases}$$

where $s_1=0.95$, and

$s_2=0.80$.

For the male cohort 11 (*i.e.,* $i=11$, $j=1$), for example, the coefficients a_{ij} and b_{ij} are respectively calculated as follows:

$a_{11,1} = (0.95-0.86258)/(0.93944-0.86258)$
$\quad = 0.08742/0.07686$
$\quad = 1.1374$
$b_{11,1} = (0.08742/0.07686) \times (0.95-0.93944)$
$\quad = 0.08742 \times 0.01056/0.07686$
$\quad = 0.0120$

9) It might also be worthwhile to notice that the values of a_{ij} and b_{ij} both decrease as the cohort number decreases except $a_{12,1}$, $b_{9,1}$ and $b_{11,1}$.

10) In the light of this implication, it would be desirable for us to revise our model in such a way that the saturation level of DLO rate starts dropping after a certain advanced age.

11) Since the male DLO rate decreases during the 1980–1985 period, we take this approach as a desperate measure taken under the pressure of necessity that the DLO rate for the age-group of 18 and 19 years should be supposed to increase as time goes on.

12) We tentatively set $s_1=0.65$ and $s_2=0.50$ by taking it into consideration (1) that the

saturation level of DLO rate for the age-group (*not* "cohort") of 18–19 years would be considerably lower than that for its elder age-groups due to the fact that the age-group of 18–19 years corresponds to the ages of the third-year senior high school students and the first-year university students, and (2) that the difference between s_1 and s_2 (*i.e.*, 0.15) is to remain the same as for the case presented by Equations (2) and (3).

13) Note that this is *not* "cohort."

14) Note that this is *not* "cohort."

15) In Japan, those persons who are under eighteen years are not qualified for examination to obtain driver's licences for passenger cars. Therefore, DLO rate for the age-group of 18–19 years provided in Table 6 are to be multiplied by 2/5 in order to obtain the DLO rates in Tables 8 and 9 for the age-group of 15–19 years.

16) It would be interesting to know that some of the both-sex cohorts start to decrease their DLO rates at their rather younger age level. For example, the both-sex cohort 20 (cohort of 15–19 years of age in 2020) starts to decrease its DLO rate at the age level of 35–39 years.

17) The both-sex (*i.e.*, national) DLO level has its peak in 2030.

18) This aggregation would perhaps generate useful information for those who have research or policy interests in the ageing society and public policy associated with the improvement of highway environments for elderly drivers. For the issues of ageing and public policy, see for instance Browne (1983), Guilleward (1983), Kawashima (1983), and McPherson (1983).

19) The extent of the possible correlation between DLO and car ownership shall be empirically investigated in the second phase of this study.

REFERENCES

Adler, H. A., 1987, *Economic Appraisal of Transport Projects: A Manual with Case Studies*, Baltimore: Johns Hopkins University Press.

Altshuler, A., Anderson, M., Jones, D. and Womack, J., 1984, *The Future of the Automobile*, Cambridge: MIT Press.

Banister, D., 1985, *Rural Transport and Planning: A Bibliography with Abstracts*, London: Mansell.

Browne, W. P. and Olson, Y. K. (Eds), 1983, *Aging and Public Policy: The Politics of Growing Old in America*, Westport, Connecticut: Greenwood.

Bureau of Statistics, (1980), *1980 Population Census of Japan: Volume 2, Whole Japan*, Tokyo: Office of the Prime Minister.

Button, K. J. and Pearmen, A. D. (Eds), 1985, *Applied Transport Economics: A Practical Case Studies Approach*, New York: Gordon and Breach.

Button, K. J. and Gillingwater, D., 1986, *Future Transport Policy*, London: Groom Helm.

Dupree, H., 1987, *Urban Transportation: The New Town Solution*, Aldershot, England: Gower.

Guilleward, A. (Ed.), 1983, *Old Age and the Welfare State*, London: Sage.

Institute of Population Problems, 1987a, *Population Projections for Japan: 1985–2085*, Tokyo: Ministry of Health and Welfare (in Japanese).

————, 1987b, *Population Projections by Prefectures: 1985–2025*, Tokyo: Ministry of Health and Welfare (in Japanese).

Japan Traffic Safety Association, 1976, 1981 and 1986, *Traffic Statistics (Kohtsuh Tohkei)*,

(for 1975, 1980 and 1985), Tokyo (in Japanese).

Jansson, J. D., 1988, "Car Ownership Entry and Exit Propensities of Different Generations: A Key Factor for the Development of the Total Car Fleet," Presented at the Oxford Conference on Travel and Transportation, Oxford, England.

Johnson, D. G. and Lee, R. D. (Eds), 1987, *Population Growth and Economic Development: Issues and Evidence*, University of Wisconsin.

Kawashima, T., 1983, "Age Structure Change in Regional Population of Japan: Elasticity Analysis," *Gakushuin Economic Papers* (*Gakushuin Daigaku Keizai Ronshuh*), Vol. 20, No. 1, pp. 13–48, Tokyo: Gakushuin University (in Japanese).

————, 1987, "Is Disurbanisation Foreseeable in Japan?: A Comparison between US and Japanese Urbanisation Processes," *Spatial Cycles*, L. van den Berg, L. S. Burns and L. H. Klaassen (Eds), pp. 100–126, Aldershot, England: Gower.

Kawashima, T., Ohshika, T., Ohhira, S. and Kimura, F., 1982, "Multiregional Population Forecasting for Japan: Application of IIASA Model," *Gakushuin Economic Papers* (*Gakushuin Daigaku Keizai Ronshuh*), Vol. 18, No. 2, pp. 3–69, Tokyo: Gakushuin University (in Japanese).

Kawashima, T. and Nakamura, K., 1986, "Future Traffic Demand for Highway Services and Economic Loss Caused by Traffic Congestion," *Present Problems of Highway Traffic Conditions and Alternative Possible Policy for Solving Them* (*Dohro Kohtsuhnan no Genjoh to Taisaku*), pp. 14–26, Tokyo: Japan Research Center of Transport Policy (in Japanese).

Keyfitz, N., 1977a, *Applied Mathematical Demography*, New York: John Wiley.

————, 1977b, *Introduction to the Mathematics of Population (With Revisions)*, Reading, Massachusetts: Addison-Wesley.

Keyfitz, N. and Flieger, W., 1971, *Population: Facts and Methods of Demography*, San Francisco: Freeman.

McPherson, B. D., 1983, *Ageing as a Social Process*, Toronto: Butterworths.

Sheffi, Y., 1985, *Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods*, New Jersey: Prentice-Hall.

Rogers, A., 1975, *Introduction to Multiregional Mathematical Demography*, New York: John Wiley.

Rogers, A., 1985, *Regional Population Projection Models*, Beverly Hills: Sage.

Statistics Bureau, (1985), *1985 Population Census of Japan: Volume 2, Whole Japan*, Tokyo: Management and Coordination Agency.

Van den Broecke, A. A. J., 1988, "Long Term Forecasting of Car Ownership with the Cohort Processing Model," Presented at the Oxford Conference on Travel and Transportation, Oxford, England.

Watanatada, T., Dhareshwar, A. M. and Lima, P. R. S. R., 1987, *Vehicle Speeds and Operating Costs: Models for Road Planning and Management*, Johns Hopkins University Press.

Werner, C., 1985, *Spatial Transportation Modelling*, Beverly Hills, California: Sage.

Wigan, M. R., 1987, *Australian Personal Travel Characteristics*, Special Report No. 38, Victoria, Australia: Australian Road Research Board.

Willekens, F. and Rogers, A., 1978, *Spatial Population Analysis: Methods and Computer Programs*, Research Report 78–18, Laxemburg, Austria: International Institute for Applied Systems Analysis.