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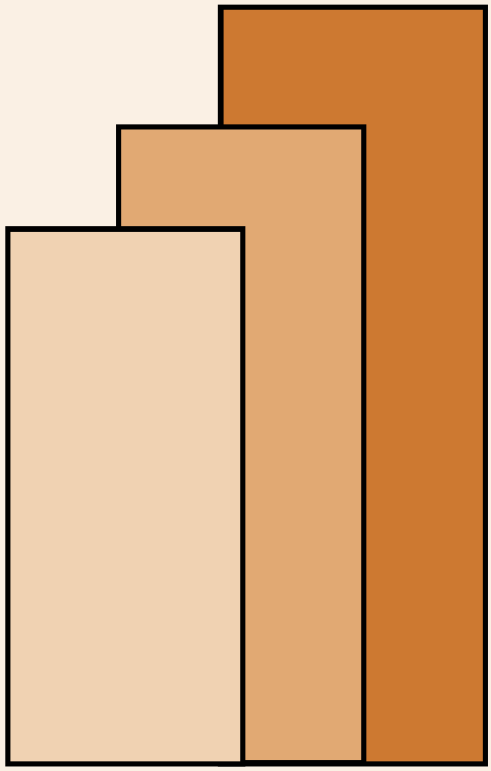

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Understanding Household Water Demand for Metro Cebu [*]

F. Largo, A. Inocencio, and C. David[**]

Introduction

The widening gap in demand and supply for water amidst a rapidly growing urban population and rising cost of developing new sources of water supply has led to greater attention on water demand management strategies which are less costly and more consistent with environmental objectives than water supply expansion activities.[1] In Metro Cebu, such an approach is long called for given the naturally limited groundwater supply, high cost of surface water development, and rapid urban growth. Metro Cebu's population almost doubled over the last 20 years. Also, the growing pollution of underground aquifers (which are the main source of water for Metro Cebu) and surface water bodies, affects not only the quality but also the quantity of water supply for urban and other uses. The current drought exacerbated the water shortage, particularly for the poor people dependent on artesian wells.

The key instrument for more efficient use of water is on the adoption of an optimal pricing framework, i.e., the price of water and its related wastewater must reflect not only the financial cost of water production and distribution, but also the opportunity or scarcity cost of water, and the environmental or cost of externalities associated with water production and

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[1] Demand management strategies are geared towards a more economical allocation of water across sectors and water across sectors and water conservation through more efficient use, reuse, or recycling of water.

consumption. Freshwater has ceased to be plentiful and thus should not continue to be treated as a free good. And consumers of water must, in principle, be responsible for the cost of mitigating the negative externalities incurred in the production and consumption of water. It is therefore critical for water resource management to understand the factors affecting household demand for water, especially its demand response to changes in water price, and the potentials for adopting water conserving practices and technologies.

Information on household water demand is also important in demand projections. Infrastructure planning makes use of demand forecasts. Erroneous demand projections results in inappropriate supply responses. It has been shown in the literature that simplistic extrapolation of trends in per capita water consumption has often overestimated future water use. However, in the Metro Manila case, David (1997) has shown water demand projection to be underestimated. Given the large contribution of household demand in total urban water demand, studies which closely examine its characteristics and nature will be very useful.

This study examines the nature and determinants of household water demand in Metro Cebu in order to provide the much needed information for more accurate demand projections and designing effective demand management strategies. The paper is organized into two sections. The first section characterizes the household's supply and demand for water. In the second section, the econometric estimates of the household demand function for water are presented.

The Data

A household survey was conducted in Metro Cebu with a total sample of 466 households from 75 barangays spread among the eight cities and municipalities of the MCWD service area. The sampling criteria were based on the source of water, quality of water service in terms of water pressure and time availability, and income levels. To be able to meet these criteria and obtain a representative cross-section of water users within each barangay and municipality, a rapid reconnaisance survey of the barangays was conducted and

then households were chosen based on the sampling criteria. For the barangay level survey, data on the different sources of water, the nature of private water vending, and the general economic status of the residents were collected. Table 1 shows the distribution of sample households and the number of barangays per municipality. Depending on the area and size of population of each barangay, at least five households representing the different sources of water and income levels were interviewed. The highly urbanized cities of Cebu, Mandaue, and Lapu-lapu comprise the bulk of the sample households.

Household Water Situation

Sources of Water

Although nearly all water used for urban purposes in Metro Cebu originate from groundwater sources, and Table 2 indicates the wide variety of means by which households obtain access to that groundwater. About two-thirds of the sample households rely solely on MCWD piped water connection. In addition, another 3 to 4 percent of households also have MCWD connections but because of rationed supply, they also use other sources primarily its own wells.[3] In fact, about 20% of households have two or more sources of water. As shown in Appendix Table 1, these households typically use own well or vended water to supplement limited MCWD water supply or purchase MCWD water for drinking and cooking from neighbors to supplement the less potable water from artesian wells and other vended water.

The relatively high percentage of households with MCWD connection may be due to the fact that most of interviewed respondents were located not far from the public transportation routes where incidentally most of the MCWD water lines are, so the chances of getting MCWD served households were higher. This implies that the role of other private providers and self-supply must be much underestimated.

Aside from MCWD, small private waterworks catering primarily to residential subdivisions provide tap water to another 4% of households. A greater proportion of

households (18%) are fully self-supplied using primarily deepwells; and another 6% of households use own well-water in conjunction with other sources of water supply.

A significant number of low-income households have been provided by public faucets (10%). However, the number of families relying solely on vended water is higher, accounting for at least 12% of households. If households partially dependent on vended water are included, private water markets easily cater to at least 30% of Metro Cebu households. The most common practice of water vending is to purchase from the source using containers such as pails and gallons. It is interesting to note that the majority of households buying water (20% of total households) actually purchase water from neighbors with MCWD water connections. It would not be surprising if MCWD water sold by households form a significant part of the non-revenue water as sellers try to avoid payment of the higher water tariffs charged due to the progressive tariff structure.

Levels of Water Consumption

Table 3 shows the average water consumption and distribution of sample households by water consumption brackets and source of water. Average water consumption is highest among households dependent on private waterworks (160 lcpd), although that of MCWD household customers is only slightly lower at (140 lcpd). About 70% of households served by MCWD consume less than 30 cum/month while up to 50% of households using private waterworks system have consumption rate way beyond that level. It should be noted that because of water rationing of tap water from both sources, actual average water consumption is effectively suppressed, estimated as only 85% of demand in other studies (Electrowatt 1991; Expertelligence 1996). Average water service is 21 hours for MCWD[3] and even lower (18 hours) for private waterworks (Table 4).

[3] This is also higher than the 1995 number of hours of MCWD water service reported in the ADB Water Utilities Data Book.

Nearly all households dependent on vended water consume less than 10 cum per month or a low per capita consumption of about 30 to 40 liters per day

Cost of Water

The cost of water may be expected to vary widely across different sources. And for MCWD, and private water works, the tariff structure is progressive, i.e., increasing at higher rates of water consumption (see Appendix Table 2).

Table 5 presents the average price of water and average household income by source of water. The lowest price of water is enjoyed by households connected to the MCWD distribution system and private waterworks, averaging ₱12/cum. The effective cost of water from these sources may be somewhat higher if the costs of coping with water rationing (eg., booster pumps, storage containers, and waiting time) are included. The two average prices are similar because private waterworks often intentionally follow the MCWD rates. At that price, at least the cost of operation and maintenance or private waterworks will be covered; the capital cost of water supply development would likely be charged as part of the property development cost and thus reflected in the price of land. The MCWD charges a much higher rate (₱30/cum) for large water users to cover capital cost of investments and perhaps also some cost of ineffeciencies.

In contrast to household with piped water connections, households relying on vended water pay about five times (₱60-80/cum) for water that has to be picked up from a neighbor source or transported through a hose. When the vended water is delivered by tricycle, carts, jeeps or trucks, the price of vended water is more than ₱100/cum, almost ten times the price of water for households with tap water from MCWD or private waterworks.

The cost of self-supplied water from deepwells using electric pump is higher than the MCWD water, but still way below that of vended water. While the direct cost of water from

the artesian well may be lower, this does not include the cost of inconvenience of hauling up and down rope tied cans or pails and of not having tap water. Moreover, ability to install own well generally require ownership of land and dwelling. Hence, low income households particularly squatters have to rely on the more expensive vended water or on the generosity of neighbors or other households who own wells.

Indeed, Table 5 also shows that average income of households with tap water for MCWD or private waterworks is at least twice as much most of those dependent on vended water, public faucets and those self-supplied from artesian wells. The regressive character of the actual water price structure in Metro Cebu is clearly reflected in Table 6 which reports the average price, water consumption, and ratio of water bill to income by income class. Average price of water increases from about ₱10/cum for high income households with access to piped water, up to ₱30 – ₱35/cum for low income households largely dependent on vended water. Clearly, the progressive nature of the MCWD tariff structure has not benefitted the poor in terms of water price, since the poor actually pay a much higher price for water than rich households. To the extent that the water pricing policy has prevented the improvement or expansion of the potentially more economical piped water service, it has had perverse effects on equity as greater cost is incurred by the ad hoc extensions of water distribution to ineligible households or to areas outside the pipe distribution network.

Consumption and Income

As to be expected, Table 6 shows average consumption of water increasing at higher income levels, as richer households would have a greater effective demand than poorer households. However, the regressive pattern of average water price would further widen the difference in average water consumption because demand for water may be expected to decrease as price of water rises. Because of the wide disparities of average incomes as well

as the regressive pattern of average water prices, the ratio of water bill to income of richer households is typically less than 1% in contrast to 4 to 8% for low income households, despite the more than four-fold water consumption per capita of the former.

In the next section, we quantify econometrically the separate effects of water price and household income on demand for water.

Demand Function Estimates

Methodology

Following the consumer theory of utility maximization given income constraint, household demand function for water was estimated econometrically based on the following specification:

$$D = f (Pw, Y, N, T, Q)$$

where D is monthly consumption (cum/month) P is the price of water (₱/cum), Y is monthly household income (₱ thousand), N is number of persons in the household, T represents household characteristics and water-related technologies, and Q are quality indicators of water supply. Water quality variables included are dummy variables indicating taste (TST = 1 if the taste is satisfactory and 0 otherwise); turbidity (TRD = 1 if no tubidity is observed and 0 otherwise); and odor (SML = 1 if water is odorless and 0 otherwise). Household characteristic is indicated by residential tenure as denoted by three dummy variables, i.e., RENT = 1 if renting house and lot and 0 otherwise, SQOWPV = 1 if l squatting on private land and owns the house and 0 otherwise, and OWNCNST if squatting with owner's consent and not paying any rent for the house and lot. Water-related technologies are represented by a dummy variable for use of shower for bathing (SHWR = 1 and 0 otherwise) and a variable

to reflect the type of sanitation system (SPTYP) with values ranging from 1 to 9 with (1) representing more water using technology and 9 with the least use for water.

Because of difficulties in obtaining accurate consumption and cost data for self-supplied water, econometric estimation of the demand function was limited to the sub-sample of households obtaining water from MCWD, private waterworks, and water vendors. Morever, a two-stage least square method was used to estimate the demand function to minimize possible biases due to simultaneity problems. Although the water price of MCWD and private waterworks may be considered exogenous variables, their progressive block rate structure may lead to a two-way feedback as consumers choose the amount to be consumed based on the price, while the actual price paid will in turn depend on the quantity of water consumed. In the case of vended water, the price is determined simultaneously by market demand and supply factors, though the use of household level data may largely mitigate the identification problem associated with demand function estimation.

In the first stage, a price equation is estimated with source of water, water quality and tenure dummies and water using technologies as independent variables. Based on the parameters of the price equation, a predicted price is calculated for each household sample and used as the instrumental variable for price in the demand equation. In this way, the parameter estimates will be unbiased and consistent.

Results

Table 7 reports the empirical estimates of household demand function specified in both linear and logarithmic forms. In general, the results are statistically reliable, particularly the logarithmic specification. About 70% of the variations of water use may be explained by the independent variables, while the coefficients have the correct signs and are mostly statistically highly significant. As expected, demand for water is negatively correlated with

its own price and positively correlated with income. In fact, it appears that water demand is more responsive to price (-0.72) than to income (0.15) suggesting that optimal pricing as a demand management strategy may be expected to be an effective means of addressing the growing scarcity of freshwater. Furthermore, the significant coefficients for type of sanitation and bathing indicate that policies which influence choice of water-using technologies for activities will likewise be worthwhile demand management strategies.

It should be emphasized that the high water prices observed in the sample households refer to vended water. These prices reflect not only the higher cost of distribution but some monopoly profits which could have been minimized through an expanded and more accessible central distribution system. Unfortunately, those higher costs are borne mostly by the poor households. The fact that demand elasticity with respect to price is substantially greater than income elasticity suggests that the very high price of water paid by the poor rather than low incomes largely explain their low levels of water consumption with adverse impact on their health and welfare.

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Table 1. Location and number of sample households, Metro Cebu, 1998.

Cities/municipalities	No. of barangays	No. of households
Cebu City	33	207
Mandaue City	13	61
Lapu-Lapu City	9	77
Cordova	3	20
Consolacion	3	23
Lilo-an	2	16
Compostela	5	18
Talisay	7	44
Total	75	466

Table 2. Distribution of sample households by source of water, Metro Cebu, 1998.

Source	No. of households	% of households
MCWD	158	33.9
Private waterworks (PWW)	19	4.1
Self-suplied		
Deepwell	74	15.9
Artesian	11	2.4
Public faucets (PF)	45	9.7
Private water vendors		
MCWD		
Pick-up	43	9.2
Hose (cont.)	5	1.1
Hose (fixed)	1	*
Delivered	1	*
Pick-up (fixed)	1	*
TBW water		
Pick-up	10	2.1
Hose (cont.)	0	-
Hose (fixed)	0	-
Delivered	1	*
Pick-up (fixed)	1	-
Combinations**	95	20.4
Total***	466	100

* Share is less than 0.5%.
** Entries may not add up to 100 percent due to rounding off errors.
*** Total includes a household who obtain water from spring.

Table 3. Distribution of sample households by water source and by levels of water consumption, Metro Cebu, 1998 (%).

Water consumption (cu.m./hh/month)	MCWD	Self-supplied			PF	Water vendors				
		PWW	Deepwell	Artesian		Deli-vered	HF	HC	PU	PUF
1-10	6	32	57	73	84	92	100	100	100	100
11-20	26	26	27	27	16	6	-	-	-	-
21-30	39	5	9	-	-	-	-	-	-	-
31-40	14	16	-	-	-	-	-	-	-	-
41-50	7	10	-	-	-	-	-	-	-	-
51-60	4	5	-	-	-	2	-	-	-	-
61-70	2	-	1	-	-	-	-	-	-	-
71-80	1	-	-	-	-	-	-	-	-	-
81-90	1	-	-	-	-	-	-	-	-	-
91-100	-	5	-	-	-	-	-	-	-	-
Over 100	-	-	5	-	-	-	-	-	-	-
Average consumption										
in cu.m./hh/month	27.1	27.7	18.0	7.7	6.8	5.8	4.0	3.8	3.0	5.2
in cu.m./capita/month	4.2	4.8	2.6	1.4	1.1	1.2	1.1	1.2	0.4	1.0
(liters/capita/day)	(140.0)	(160.0)	(86.7)	(46.7)	(36.7)	(40.0)	(36.7)	(40.0)	(13.3)	(33.3)

Table 4. Distribution of sample households by time availability of water from MCWD and private waterworks, Metro Cebu, 1998 (%).

No. of hours	MCWD	PWW
1-4	2.5	10.5
5-8	3.2	15.8
9-12	5.7	-
13-16	3.2	5.3
17-20	3.8	-
21-23	1.3	-
24	80.2	68.4
Average no. of hrs.	21.0	18.0

Table 5. Average price of water, income per capita, and ratio of water bill to household income by source of water, Metro Cebu, 1998.

Source	Average price (P/cu.m.)	Monthly income (P/capita)	% of water bill to income
MCWD	12.0	2503.2	3.6
Private waterworks (PWW)	12.6	7645.7	2.0
Self-supplied			
Deepwell	-	2772.1	-
Artesian	-	1273.8	-
Public faucets (PF)	14.1	1427.2	1.0
Water vendors			
MCWD			
Pick-up	76.3	1189.0	7.3
Hose (cont.)	59.8	1696.7	4.4
Hose (fixed)	53.2	1200.0	5.6
Delivered	106.4	750.0	6.3
Pick-up (fixed)	66.5	4000.0	1.0
TBW water			
Pick-up	56.5	1370.8	4.8
Hose (cont.)	-	-	-
Hose (fixed)	-	-	-
Delivered	132.9	1025.0	3.8
Pick-up (fixed)	3.4	1100.0	0.5

Table 6. Average price of water, water consumption, and ratio of water bill to income by annual household income, Metro Cebu, 1998.

Income Class	Average price (P/cu.m)	Water consumption (cu.m/hh)	Water consumption (liters/capita/day)	% water bill to income
Under P30,000	34.96	2.49	53.00	8.78
P 30,000-39,999	30.59	1.40	107.00	4.07
P 40,000-59,999	22.37	2.04	133.00	4.03
P 60,000-99,999	24.68	2.42	123.00	3.22
P 100,000-149,999	17.02	3.30	133.00	2.50
P 150,000-199,999	17.50	2.94	160.00	1.84
P 200,000-249,999	10.72	2.81	193.00	1.67
P 250,000-499,999	10.50	2.91	180.00	0.82
P 500,000-749,999	7.06	6.83	260.00	0.53
P 750,000-999,999	8.67	7.10	453.00	0.34
P1,000,000 and over	11.88	7.65	447.00	0.78

Table 7. Regression estimates (2SLS) of water demand functions based on households obtaining water from MCWD, private waterworks, public faucets, and water vendors, Metro Cebu (1998).

Variable	Linear	Double Log
P	-0.229 (-6.275)*	-0.717 (-11.953)*
Y	0.295 (5.770)*	0.146 (2.998)*
N	0.866 (4.137)*	0.473 (6.448)*
SML	-2.153 (-0.726)	-0.161 (-1.204)
TRD	-1.911 (-0.932)	-0.137 (-1.481)
TST	18.592 (5.137)*	0.499 (2.970)*
RENT	-2.087 (-0.987)	-0.199 (-2.106)**
SQOWPV	2.973 (1.835)***	0.078 (1.065)
OWNHCNST	-0.178 (-0.044)	-0.182 (-0.989)
SHWR	2.280 (0.937)	0.237 (2.271)*
SPTYP	-1.033 (-1.669)***	-0.089 (-3.216)*
Intercept	4.347 (1.497)	2.513 (5.030)*
R^2	0.526	0.704
Adjusted R^2	0.507	0.692
Durbin-Watson	2.044	2.018

Appendix Table 1. Number of sample households using more than one source of water, Metro Cebu.

Source	# of HHS	%
MCWD & Owned PTW	7	7.4
MCWD & not-owned PTW	1	1.1
MCWD & owned Artesian Well	2	2.1
MCWD & pickup from hh w/ PTW	1	1.1
MCWD & PFP	4	4.2
MCWD & Spring Water	2	2.1
PWW & owned PTW	1	1.1
Owned PTW & PFP	1	1.1
Owned Artesian Well & PFP	3	3.2
Not Owned Artesian Well & PFP	2	2.1
PFP & pickup from hh w/ MCWD	22	23.2
PFP & pickup from hh w/ PTW	6	6.3
PFP & delivered MCWD water	2	2.1
PFP & Spring Water	1	1.1
Pickup from hh w/ MCWD & River Water	1	1.1
Owned PTW & pickup from hh w/ MCWD	3	3.2
Not owned PTW & not owned Artesian Well	1	1.1
Not owned PTW & pickup from hh w/ MCWD	3	3.2
Owned Artesian Well & not owned PTW	1	1.1
Owned Artesian Well & pickup from hh w/ MCWD	9	9.5
Owned Artesian Well & pickup from hh w/ PTW	2	2.1
Owned Artesian Well & delivered TBW	1	1.1
Not owned Artesian Well & pickup from hh w/ MCWD	11	11.6
Not owned Artesian Well & pickup from hh w/ PTW	1	1.1
Pickup from hh w/MCWD & pickup from hh w/ PTW	1	1.1
Pickup from hh w/ MCWD & delivered TBW	4	4.2
Pickup from hh w/ PTW pays fixed & pickup from hh w/ MCWD	1	1.1
Not owned Artesian Well & pickup from hh w/ MCWD & delivered MCWD water	1	1.1
Total	95	100.0

Appendix Table 2. Water Rate Structure of Metro Cebu Water District as of February 1998.

Bracket	Without Discount	With Discount
First 10 cu.m.		
Meter Size		
1/2	90.64	86.11
3/4	147.00	139.65
1	287.87	273.48
1 - 1/2	735.00	698.00
2	1,825.00	1,733.00
3	3,283.00	3,118.00
4	6,566.00	6,237.00
6	9,842.00	9,350.00
11 - 20 cu.m.	10.00	9.50
21 - 30 cu.m.	11.76	11.17
Over 30 cu.m.	32.25	30.65

Appendix Table 3. Distribution of sample households by water source and by quality of water, Metro Cebu, 1998 (%).

Quality of water	MCWD	PWW	TBW		PF	Water vending				
			Deepwell	Artesian		Delivered	HF	HC	PU	PUF
Turbidity										
W/o particles	78	95	85	91	87	91	80	100	100	100
W/ particles	5	5	8	-	4	6	-	-	-	-
Inconsistent	17	-	7	9	9	4	20	-	-	-
Taste										
Good	98	89	91	82	89	100	100	100	100	100
Poor	2	11	7	9	2	-	-	-	-	-
Salty	-	-	3	9	9	-	-	-	-	-
Smell										
Odorless	88	100	97	100	98	96	100	100	100	100
Foul odor	1	-	1	-	2	2	-	-	-	-
Inconsistent	11	-	1	-	-	2	-	-	-	-
Color										
Clear	96	95	95	100	98	98	100	100	100	100
Rusty	3	5	4	-	2	-	-	-	-	-
Yellowish	1	-	1	-	-	2	-	-	-	-

Appendix Table 4. Distribution of sample households by water source and tenure of residence, Metro Cebu, 1998 (%).

Tenure	MCWD	PWW	Self-supplied		PF	Water vendors				
			Deepwell	Artesian		Deli-vered	HF	HC	PU	PUF
Own H & L*	58	37	89	73	47	21	-	-	50	100
Rent H & L	28	53	4	27	38	45	-	-	50	-
Own house but squatting on private land	2	-	3	-	7	4	20	-	-	-
With owner's consent	12	10	4	-	9	30	80	100	-	-

* H = house; L = lot; Del = delivered by carts/bicycles/jeeps/trucks; HF = hose with fixed charges; HC = hose by containers; PU = pick-up by containers; PUF = pick-up fixed.

Appendx Table 5. Distribution of sample households by degree of water pressure in MCWD and private waterworks (PWW) connection, Metro Cebu,1998 (%).

Water pressure	MCWD	PWW
Low	5	-
Moderate	54	47
High	41	53

Appendix Table 6. Number of households, population, land area and population density in the MCWD service area.

City/Municipality	No.of Households	Population	Land Area (sq.km.)	House service connections (March 1998)	Density	Connections/ HH
Cebu City	134,986	662,299	280.9	49,307	2,358	0.37
Mandaue City	40,941	194,745	11.7	9,305	16,645	0.23
Lapu-Lapu City	33,741	173,744	58.1	2,389	2,990	0.07
Cordova	5,172	26,613	11.7	317	2,275	0.06
Talisay	22,928	120,292	86.4	1,064	1,392	0.05
Consolacion	9,996	49,205	32.6	1,339	1,509	0.13
Liloan	10,264	50,973	52.1	2,587	978	0.25
Compostela	5,163	26,499	53.9	713	492	0.14
MCWD Service Area	*263,191*	*1,304,370*	*587.4*	*67,021*	*2,221*	*0.25*

Sources: Population-NSO Population Census, 1995
Land Area-Cebu Provincial Profile, 1990
Service Connections, March 1998 -MCWD Corplan

Appendix Table 7. Distribution of sample households by water source and by annual household income bracket, Metro Cebu, 1998 (%).

Income Class	MCWD	PWW	Self-supplied		PF	Water vendors				
			Deepwell	Artesian		Deli-vered	HF	HC	PU	PUF
Under P30,000	1	10	4	9	2	9	-	-	-	-
P 30,000-39,999	2	5	1	18	16	13	-	-	-	-
P 40,000-59,999	9	5	12	27	20	23	40	100	-	-
P 60,000-99,999	24	10	20	9	22	28	60	-	100	50
P 100,000-149,999	25	10	24	18	20	19	-	-	-	-
P 150,000-199,999	13	-	9	18	4	8	-	-	-	-
P 200,000-249,999	9	10	9	-	9	-	-	-	-	50
P 250,000-499,999	11	16	8	-	7	-	-	-	-	-
P 500,000-749,999	2	10	4	-	-	-	-	-	-	-
P 750,000-999,999	-	16	1	-	-	-	-	-	-	-
P1,000,000 and over	4	5	5	-	-	-	-	-	-	-