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Broadband Delivered Entertainment Services: Forecasting Australian Subscription Intentions

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This study estimates a nested multinomial logit (NMNL) model of broadband delivered entertainment service subscription that allows for the impact of an installation fee and rental price, service attributes and household demographic variables on subscription. The model is estimated on stated-preference data obtained from an Australia-wide survey of capital cities and provincial centres. Nested multinomial logit model estimates are used to provide forecasts that suggest 65 per cent of separate residences passed are likely to subscribe at 2000. This percentage translates into 1237 744 subscribers.

I Introduction

Pay television (payTV) networks were prohibited by Australian government regulation until 1991. Subsequent deregulation allowed common carriers to deliver information and video service, and stimulate the development of broadband networks (van der Vlies 1996). With the issuance of payTV licenses, common carriers Optus and Telstra undertook separate largely overlapping broadband network rollouts. Deployment of fibre-optic, microwave and satellite infrastructure appeared based on a strategy of delivering a then unavailable broadband delivered entertainment service to capture customer loyalty and economies of scope. Network planners and marketing strategists implicitly assumed content providers would take advantage of enhanced network capacity, and that sufficient latent subscriber demand existed. The validity of the latter assumption rests on the economic relationship of subscriber demand and its pricing (Lee 1997; Quiggin 1998). The elasticity of demand for broadband delivered entertainment service and likely service subscription are unresolved questions.

This paper provides a detailed analysis of Australian broadband delivered entertainment service demand. Entertainment service is

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interesting, as it is believed to be a driver of early residential network access (Carey 1991). Diffusion models are often used to forecast entertainment (and communication) services (Bewley & Fiebig 1988; Meade 1989). Lengthy time-series on service adoption and information from analogous services (as in the case of not yet available service) are required to estimate models. As new services are likely to differ in their character from those currently available, diffusion model forecasts based on existing services are at best problematic. In this situation stated preference (SP) data are an attractive option to forecast subscription. The SP data are obtained from conjoint experiments where respondents choose among experimentally generated alternatives.

A nested multinomial logit (NMNL) model of broadband delivered entertainment service subscription is estimated on SP data obtained from an Australia-wide survey. The model provides a quantitative assessment of the impact of price, service attributes and household demographic variables on the demand for broadband delivered entertainment service with no revealed preference (RP) history. Model estimates are aggregated by sample enumeration to forecast Australian subscription. The approach adopted here follows Brownstone and Train (1999) who forecast on the basis of SP data. They combine SP data with sampled household characteristics to estimate an econometric model that yields household subscription probability estimates. To assess model reliability, forecasts are compared to RP subscription data at 2000. Hensher *et al.* (1999) propose the pooling of RP and SP data to improve SP forecast accuracy. To allow combination of these data they scale SP data by the ratio of the variances of RP and SP data. However, they report, 'Thus far, our results suggest that for these data sources, combination is not a statistically sound option even if we account for within-data source heteroscedasticity' (Hensher *et al.* 1999, 215). The issue remains unresolved.

A limitation of the NMNL model is the independence from irrelevant alternatives (IIA) property. That is, the model imposes equality of TWIG demand cross-elasticities for a BRANCH. Identification of the correct substitution pattern empirically is an important aspect of this study. The heteroskedastic extreme value (HEV) structure is employed to diagnose the appropriateness of the IIA property to the choice context. Independence from irrelevant alternatives is deemed reasonable when the random utility of alternatives have equal scale parameters.[1] The paper also allows for a non-linear income effect in the indirect utility specification. Standard utility specifications assume a negligible income effect or that income enters utility as a proxy for unobserved taste attributes (McFadden 1981; Small & Rosen 1981). Jara-Diaz and Videla (1989) and Jara-Diaz (1998) derive an indirect utility expression to show an income effect can be accommodated through a quadratic price argument. A significant non-linear income effect suggests the model should be estimated by income stratum or that indirect utility contain a purchasing power argument. Finally, the analysis shows a carefully integrated SP experimental design can yield sensible and useful forecast results when combined with a well-specified choice model.

The paper is organised as follows. Section II provides some background on payTV service provision in Australia and describes a NMNL model of entertainment subscription choice. Section III outlines the experiment design, survey method and sampling frame. Summary information, generated variables and estimation results are reported in Section IV. Subscription forecasts provided in Section V. Section VI contains concluding remarks.

II A Model of Entertainment Service Choice

As most capital expenditure is incurred in the construction of the transmission network payTV has mild economies of scale in additional subscribers and channels (Owen & Wildman 1992). In many countries traditional monopoly regulation and strategic cooperation has restricted facilities-based competition and so prevented duplication of infrastructure through network overbuild. To stimulate competition the Australian Broadcasting Authority initially issued 33 payTV licenses. The licences are valid Australia-wide when the

[1] A common practice when estimating NMNL models is to test the appropriateness of the IIA assumption (McFadden 1974; Hausman & McFadden 1984). Fry and Harris (1994) argue that care should be exercised when conducting these tests because conflicting inference can arise from different test statistics, particularly when using large sample critical values. Hensher *et al.* (1999) and Hensher (1998a) suggest that the HEV structure, attributed to Allenby and Grinter (1995) and Bhat (1995), be used to identify appropriate partitions of multinomial logit (MNL) models into nested structures, and to assess the appropriateness of the IIA assumption.

same programming is offered to all reception areas. At present most licenses remain inactive. New digital and compression technology have created substantial economies of scope and strategic advantage from the bundling of broadcasting, telephony and Internet service. Accordingly, the Australian market is dominated by vertically integrated communication companies Optus Vision, a joint venture between Optus Communications, Continental Cablevision and free-to-air (FTA) broadcasters Network 9 and Network 7 (launched in September 1995) and Foxtel, a venture between News Corporation and Telstra (started service in October 1995).[2] Clearly, both operators view cross-service marketing as important. For instance, payTV subscribers can be targeted for future delivery of on-line service such as datacasting, distance education, home banking, Internet telephony and video-on-demand (VOD).

When a household has access to broadband infrastructure (is passed by a cable system) it must decide whether or not to subscribe to payTV service. The choice depends on household characteristics, price and service offered. Random utility models (RUM) are useful in analysing such household decisions. A household is assumed to select an alternative with the highest utility (U). This utility is unobservable to the analyst and the RUM treats it as a random variable. In particular, a household maximises utility by considering service attributes and prices. The statistical design employed assumes households face choice among broadband delivered entertainment service alternatives $j = (1, 2, \ldots, 7)$ subject to the interest level for subscription $k = (0,1)$ per se. The household derives utility $U_{j|k}$, which is a function of the attributes of alternative j and household socio-demographic characteristics.

Utility is partitioned into deterministic (V) and stochastic (ε) components

$$U_{j|k} = V_{j|k} + \varepsilon_{j|k}, \tag{1}$$

where $V_{j|k}$ is a function of all measured characteristics and $\varepsilon_{j|k}$ is a residual. The conditional TWIG probability that defines the probability of choosing a particular entertainment service j, given that the household has indicated an interest in broadband delivered entertainment services ($k = 1$) is

$$P(j|k=1) = \frac{e^{\beta' x_{j|k}}}{\sum_{j=1}^{7} e^{\beta' x_{n|k}}} \tag{2}$$

where β is a parameter vector for the observations service attributes. The BRANCH probability of the household not interested in subscribing ($k = 0$) to entertainment services is,

$$P(k=0) = \frac{e^{\gamma' z}}{\sum_{j=1}^{7} e^{\gamma' z + \lambda J}} \tag{3}$$

where γ is a vector of parameters for the observations on the attributes of the indirect utility from not subscribing, $J = \ln \sum e^{\beta' x_i}$ is the inclusive value for interest in entertainment service, and λ is a measure of the independence of alternative sets of entertainment service. This term denotes the average utility that the household can expect from the alternatives within the subset. The 'independence' parameter λ at the node in the tree discounts the contribution of highly similar alternatives (McFadden 1984: 1422). λ may be used to test the consistency of the tree structure with household utility maximisation (Hensher 1986). $0 < \lambda < 1$ is required for global utility maximisation, and $\lambda = 1$ reduces the NMNL to a MNL.

The unconditional probability,

$$P(j, k) = P(j|k)P(k), \tag{4}$$

represents the joint probability of the household indicating an interest in subscription and selecting alternative j.

III Experimental Design and Survey Method

Survey respondents are provided with a description of the generic entertainment service likely to be delivered by Foxtel and Optus Vision.[3] Content include sport, news, motion pictures, VOD and interactive video games. The BRANCH level subscription requires respondents indicate

[2] Australis began providing MDS services in January 1995 through several subsidiaries, but has since exited the market. At April 1999, Austar provided satellite TV and radio services to regional areas in the eastern states.

[3] Proprietary data show only two companies provided cable service at February 1999.

TABLE 1
Service Description

Alternative	Price	Interactivity	Ease of use	Market diffusion
A	Medium	Distributive	Programming same as VCR	Most friends subscribe
B	Low	Distributive	Programming easier than VCR	Few friends subscribe
C	Medium	Selective	Programming easier than VCR	No friends subscribe
D	Low	Selective	Programming harder than VCR	Most friends subscribe
E	High	Communicative	Programming easier than VCR	Most friends subscribe
F	Medium	Communicative	Programming harder then VCR	Few friends subscribe
G	Low	Communicative	Programming same as VCR	No friends subscribe

their interest in subscribing or otherwise. Respondents with no interest in entertainment service subscription are excluded from the experiment. Interested respondents are provided with a list of service packages (choice sets) that vary by service attribute and price. Choice sets are structured so as to require respondents to trade off attributes and price when selecting a service package. Attributes and their levels are identified from consumer demand, technology and price studies (Carey 1991; Minoli & Keinath 1994). Focus groups and a pilot survey provided feedback on service descriptions, the definitions of attributes and their levels.[4] The choice experiment includes rental price and service attributes, interactivity, ease of use and community adoption.

The monthly rental (subscription) price variable has low ($10, $20, $30, $40), medium ($50, $60, $70, $80) and high ($90, $100, $110, $120) price bands. An alternative is defined by attribute and price levels. The interactivity attribute identifies household control of service delivery and content. Distributive (fixed) content allow receipt of broadcast service. Selective (set menu) service provides features such as pause, rewind and fast-forward. A communicative (personalised) menu enables interactive communication among subscribers. Ease of use indicates the user friendliness of service. Broadband consumer-premise equipment can be very easy (less technical than a VCR), quite easy (technically similar to a VCR) or not easy (more technical than a VCR) to use. Finally, the service diffusion variable captures both network externality and demonstration effects.

Four three-level factors (attributes and price) define 3^4 (or 81) alternatives. However, such a large number of alternatives will present too complex a choice task for careful evaluation by respondents. This may lead respondents to use simpler decision-making rules, such as making choices lexicographically (Louviere & Woodworth 1983; Louviere 1988; Carson *et al.* 1994; Adamowicz *et al.* 1998). As a result, Table 1 contains only nine alternatives out of this 81 alternative set are retained by using a fractional factorial design (Louviere 1988). Simply put, an interaction between any pair of attributes occurs when household preferences for the levels of an attribute depends on the level of the other. This design only takes into account the 'main effects' and ignores 'interaction effects'. These 'effects' refer to the impacts of different levels of the factors on the overall choice outcome. Furthermore, out of the remaining nine alternatives, two are clearly dominated by, or dominating, the others, and hence are eliminated from the choice set. This is because if the respondent is presented with too easy a choice, then the response will not contain sufficient information for estimating the trade-off between the various attributes (Krieger & Green 1991; Carson *et al.* 1994). Alternative A, for example describes a service that has set programming content (as with FTA television), priced in the medium price ($50 through $80) band, is of similar programming difficulty to a VCR and most friends are subscribers.

Next, in presenting these alternatives to a respondent to solicit a response, there are in total 2^7 ($= 128$) combinations (2 indicates whether or not an alternative is to be presented, and there are 7 alternatives to be decided upon). Clearly this is a

[4] Discussion with Optus Communications and Telstra suggest the alternatives used here represent well those considered by Foxtel and Optus Vision.

TABLE 2
Choice Sets

Choice set	A	B	C	D	E	F	G
Alternative							
1				Null set			
2				+	+	+	+
3		+	+			+	+
4		+	+	+	+		
5	+		+		+		+
6	+		+	+		+	
7	+	+			+	+	
8	+	+		+			+

+ indicates the alternative is included in the choice set.

huge choice set. Therefore, to reduce the set to a manageable size, another fractional factoral design is used. In this design, only eight out of 128 combinations are chosen, and this is to take account only the 'main effects' and some selected interaction effects. An 'effect' refers to the potential impact of the level of an attribute (price, interactivity, ease of use or market diffusion) – or the interaction these attributes – on the choice outcome. The eight alternative choice sets are reported in Table 2 (see Louviere *et al*. 2000: 83–127 for a comprehensive discussion concerning the design of choice experiments).

(ii) Response task

Given an interest in BRANCH subscription, the respondent must choose from five alternatives, namely four entertainment services from the seven (TWIG) alternatives (A through G) and the alternative of not subscribing. When an alternative is selected the respondent is notified of an installation fee (from $0 to $600). The fee varies by household and trial.[5] When respondents consider experiment expenditure as reasonable, the choice experiment is complete. However, when the trial expenditure is deemed unreasonable (more than household willingness to pay) the experiment is terminated. The SP method allows several experiments to be carried out from the same household by repeating the same experiment but with a different choice set. The experiment is in fact repeated three times in this study. In repeating trials it is assumed households evaluate choice sets in an experiment without regard to earlier choice (Hensher *et al*. 1992; Madden 1995; Revelt & Train 1998).[6] This implies the assumption of path independence in household decision-making process, and so the three choices made by the same household can be treated as three independent observations. To take account of fixed experiment effects, three dummy variables are included: C_1 (if experiment number 1, and 0 otherwise), C_2 (if experiment number 2, and 0 otherwise) and C_3 (if experiment number 3, and 0 otherwise). The definition of C_1 to C_3 can be arbitrary (any of these three experiments be regarded as 'experiment number 1' and so on). However, to capture the 'order effects' of the experiments, C_1 to C_3 were labelled according to the order in which the three experiments were presented to each individual household. It is expected that the estimated coefficients associated with these three index variables will be similar. Furthermore, and more importantly, the correlation matrix between the estimated coefficients of the variables is expected to be close to being diagonal. Next, and more importantly, to capture the individual-specific effects, we have included an extensive series of dummy variables that stand for the observed socioeconomic characteristics of these individual households that are assumed to have a significant influence on their choice decisions.[7] To account for the unobserved characteristics, one possibility is to use the 'random-coefficient' or 'mixed' logit specification, which allows for some of the parameters of the model to be estimated as a random distribution rather than a fixed coefficient. However, to do this efficiently, we need more repeated choices per individual household relative to the total number

[5] For example, for a trial containing a low-price alternative, a price is extracted from listed prices. In the next trial that contains a low-price alternative the procedure continues by selecting the next listed price. A similar procedure is adopted for the installation fee.

[6] Further, Revelt and Train (1998: 647) argue that mixed logit allows efficient estimation when there are repeated choices, as occurs in our application.

[7] These dummy variables are (see Table 3): INCOME, BCOLLAR, FT, HHLESS25, HH3544, HIGHED, KIDS, MALE, REGION, RENT, ADOPT.

of observations.[8] Given that there were only three repeated choices per individual household in a sample of 1009 individual households, and together with the fact that we have included a substantial number of socioeconomic variables in the model to capture much of these individual-specific effects, we have not adopted the random-coefficient logit approach.

The survey was conducted on weekend and weekday evenings during 1 April through 9 April, 1995. Eighty per cent of interviews were on weekends between 10 am and 6 pm, the remainder were conducted on weekday evenings between 4 pm and 8 pm. A total of 1010 person-to-person interviews were conducted at separate residences located in Australian capital cities and provincial centres (population less than 100 000 persons). Cluster sampling is used to locate households. Around a randomly drawn starting point in a sampling area a cluster of five households are interviewed. All households have an equal chance of being a start point. Full details of survey administration, interviewer instructions are contained in Madden and Simpson (1996: 135–139).

[8] In Revelt and Train (1998), for example there were 401 surveyed customers with each customer providing at least 12 and up to 16 repeated choices. Furthermore, there were no observed socioeconomic dummy variables included in the Revelt and Train model to capture any of the individual customer-specific effects. Finally, as stated by the authors (Footnote 8, p. 650), identification of the model will be empirically difficult if all coefficients were allowed to vary. In the end, the main coefficient of the model (price coefficient) was kept fixed. In the current model, there is only one coefficient that can be allowed to vary across individual households in the Branch level (INSTALL) and only three coefficients that can be varied randomly in the TWIG level (RENTAL*, EASE, and INTERACT). This implies in the extreme, only the EASE and the INTERACT coefficients can be allowed to vary randomly across individual households. However, with only three repeated choices per household, and furthermore, together with the fact that we have already included a substantial number of socioeconomic variables in the model to capture a significant proportion of these individual-specific effects, it can be said that if there were still any individual-specific effects left to be captured in the two remaining coefficients (EASE and INTERACT), these would most likely to be small.

IV Data and Model Estimation

Seventy-nine percent of households interviewed were interested in subscription. Survey data suggest subscription interest increased with household income. The converse is true for respondent age. Households with three to five occupants show substantial interest, as do males, employed persons and students. Pair-wise correlations show negative relationships between subscription and rental price ($\rho = -0.197$) and installation fee ($\rho = -0.090$).

The variables used to estimate the NMNL model are provided in Table 3. Subscription depends on household and respondent characteristics. As these characteristics do not change with the alternative chosen they are entered at the BRANCH level. Variables entering at this level are household size and composition, and respondent characteristics including age, gender, education, employment status and occupation. The installation fee is also included at the BRANCH level. Service attributes and rental price enter at the TWIG level as they vary among alternatives.

The NMNL model can be estimated sequentially or simultaneously via full information maximum likelihood (FIML). For sequential estimation, the conditional choices are estimated as MNL models. Inclusive values are then calculated for a universal choice set and included as exogenous variables in the marginal choice, which is also estimated as an MNL model. The TWIG parameter estimates are efficient for the subset of the data used in estimation. The BRANCH parameter estimates are consistent but not fully efficient because of the inclusive value parameter used in estimation (Hensher 1986). The FIML estimates both BRANCH and TWIG parameters simultaneously by maximising the unconditional log-likelihood $\sum \log P_n(I|k) + \log P_n(k)$. Further, FIML estimation is the more efficient procedure as the information matrix is not block diagonal in β and s (Greene 1997).

Parameter estimates indicate that subscription probability declines with the installation fee and rental price, and increases with interactivity and ease of use. Subscription is more likely for younger (less than 45 years old respondents), males and full-time employed persons. Households with more than one child under 15 years are more likely to subscribe, while households located in regional areas are less likely to subscribe.

The parameter estimates contained in Table 4 cannot be interpreted as marginal effects as the choice probability is non-linear in attributes and

TABLE 3
Variables

Variable	Description
BRANCH	
INCOME	= Household before tax income (10^{-4})
INSTALL	= Installation fee ($)
BCOLLAR	= 1, Respondent employed as a trades person or assistant; = 0 otherwise
FT	= 1, Respondent full-time employed; = 0, otherwise
HHLESS25	= 1, Respondent aged less than 25 years; = 0, otherwise
HH2534	= 1, Respondent aged 25 through 34 years; = 0, otherwise
HH3544	= 1, Respondent aged 35 through 44 years; = 0, otherwise
HIGHED	= 1, Respondent completed a degree; = 0, otherwise
KIDS	= 1, Household has more than one child aged under 15 years; = 0, otherwise
MALE	= 1, Respondent is male; = 0, otherwise
REGION	= 1, Household located outside metropolitan areas; = 0, otherwise
RENT	= 1, House is rented; = 0, otherwise
TWIG level	
RENTAL	= Subscription price ($10–$120 monthly, $10 increments)
RENTAL*	= Subscription price ($10–$120 monthly, $10 increments) deflated by household income
ADOPT	= 1, No friends use service; = 0, few or most friends use the service
EASE	= 1, Service is not very easy to use; = 0, service is very or quite easy to use
INTERACT	= 1, Service is distributive; = 0, service is selective or communicative

price. In Table 5 the marginal effect of RENTAL*, INTERACT and EASE on the subscription probability show substantial variation across alternatives. The effect of RENTAL* is greatest for alternatives B, D and G (see Table 5). While there is no monotonic map between marginal effect magnitudes and the mean price of an alternative (mean values of other variables are not identical across alternatives) alternatives B, D and G describe low-price services ($10 through $40) while the price of the other alternatives vary from $50 to $120. The marginal effects of INTERACT and EASE show less variation by alternatives.

Own- and cross-rental price elasticities are reported in Table 6. The elasticities vary over households and depend on price and service attributes. Own-price elasticity is the effect on the probability of selecting j due to a change in the rental price of service j. The RENTAL* elasticity measures the impact on the service j subscription probability from a change in the monthly rental to household income ratio. For example, the elasticities for alternative A (Row 1 in Table 6) suggest a 10 per cent increase in the ratio of rental price of A to household income (or 10 per cent decrease in affordability) results in a 6.86 per cent decline in the alternative A choice probability, a 1.47 per cent increase in the probability of choosing other alternatives, and a 0.19 per cent increase in the probability of not subscribing. Own-price elasticity estimates for monthly rental price are similar in magnitude and inelastic. That own-price is inelastic is not unexpected as alternatives describe entertainment service. Small cross rental-price elasticities indicate little substitution among alternatives. Further, the relatively small cross-elasticity estimates between subscription and no subscription branches (compared to the within subscription branch) suggest households are more likely to substitute between services than to unsubscribe in response to an alternative's rental price increase. The estimated subscription probability elasticity for the installation fee is -1.185. Comparison of the installation fee and monthly rental price elasticities suggest the subscription probability is more sensitive to this one-off fee. The installation fee range used in the choice experiment ($0 to $600) reflects the prices charged by payTV providers at the time of the survey. An observed decrease in installation fees charged by payTV operators in the period since the survey (to about $50) correlates well with the large elasticity found in this study.

Model estimates (see Table 6) show λ lies in the unit interval that satisfies McFadden's (1978) condition for the maintained nested structure, namely, the model is consistent with household utility

TABLE 4
FIML Choice Model Estimates

	Parameter	Standard error
TWIG level		
RENTAL*	–0.741	0.047
ADOPT	–0.082	0.112
EASE	–0.249	0.120
INTERACT	–0.489	0.080
Branch level		
INSTALL	–1.306	0.257
BCOLLAR	0.177	0.110
FT	0.230	0.119
HHLESS25	0.798	0.159
HH2535	0.863	0.133
HH3545	0.324	0.120
HIGHED	0.057	0.109
KIDS	0.349	0.109
MALE	0.319	0.092
REGION	–0.222	0.099
RENT	–0.014	0.103
Diagnostics		
Log likelihood function	–4347	
Restricted log-likelihood	–4677	
χ^2statistic	660.1	
$\hat{\lambda}$	0.198	0.072
Scale parameters (ALT G = 1)		
NOSUB	0.216	0.119
ALT A	2.337	1.185
ALT B	2.476	1.353
ALT C	1.637	0.131
ALT D	2.330	1.373
ALT E	1.805	0.946
ALT F	1.901	0.999

maximisation. While Hausman and McFadden's (1984) test ($\chi^2_{calc}(4) = 3.3 < \chi^2_{crit} = 9.49$), does not reject the IIA structure imposed on household choice the test is of low power (Fry & Harris 1994). Following Hensher *et al.* (1999) the estimated scale parameters from the HEV model are compared to assess the appropriateness of the IIA property and the alternative groupings in the NMNL. The scale parameters of alternatives fall within a standard deviation of the mean parameter estimate (the scale parameter for G is normalised to 1), while the scale parameter for no subscription is an order of magnitude lower than other alternatives, and is almost 2 standard deviations from the mean parameter estimate. The estimated scale parameters imply the IIA property holds within branches but not between the subscription and no subscription branches, adding further support to the maintained tree structure.

TABLE 5
Marginal Effects

Alternative	RENTAL*	INTERACT	EASE
A	−0.00580	−0.02409	−0.01224
B	−0.26641	−0.05473	−0.02780
C	−0.03485	−0.03380	−0.01717
D	−0.21507	−0.05703	−0.02897
E	−0.01737	−0.02674	−0.01359
F	−0.03465	−0.03069	−0.01559
G	0.14205	−0.05682	−0.02859
Average	−0.13700	−0.04900	−0.02400

TABLE 6
Rental Price Elasticity Estimates

Alternative	Own-price	Cross-price	Cross-price
A	−0.686	0.147	0.019
B	−0.595	0.147	0.019
C	−0.661	0.147	0.019
D	−0.587	0.147	0.019
E	−0.679	0.147	0.019
F	−0.669	0.147	0.019
G	−0.592	0.147	0.019

As such, the cross rental-price elasticities are equal.[9] Finally, the Jara-Diaz and Videla, 1989) and Jara-Diaz (1998) test indicates a non-linear income effect in the indirect utility function. Accordingly, the model is estimated with an affordability variable RENTAL* argument in place of rental price. Further, the estimated coefficients of the index variables, included to capture any unobserved effects, were insignificant. This result held whichever of the two dummy variables were included. Also the corresponding off-diagonal elements contained in the variance-covariance matrices were less than 0.10 and suggests this source of error is not of concern. Finally, in no case do the estimated coefficients of the non-index variables exhibit substantial variation, with no variable changing sign or significance.[10]

[9] A test of the appropriateness of the NMNL model nested as opposed a single-level MNL model structure is made. The likelihood ratio test ($\chi^2_{calc} = 99.46 > \chi^2_{crit} = 3.84$) suggests the MNL specification is unduly restrictive.

[10] All results are available from the corresponding author on request.

TABLE 7
Sociodemographic Variable Projections at 2000

	Sample proportions (%)	2000 projection (%)
Household income		
Less than $14 999	14	18
$15 000–$24 999	12	15
$25 000–$34 999	15	13
$35 000–$49 999	17	16
$50 000–$79 999	22	14
$80 000 +	10	13
Refused	10	11
Total	100	100
Respondent age		
15–24	13	19
25–34	23	20
35–44	23	20
45–54	21	16
55–64	9	10
65 +	11	15
Total	100	100

Source: ABS (1993, 1997).

V Subscription Forecasts

Providing projections for all survey sociodemographic variables is impractical. Hensher *et al.* (1992) suggest weighting by selected variables. Household income and respondent age are chosen as they explain subscription and their population values are likely to change. Table 7 shows sample proportions for variables and population projections to 2000 based on extrapolation of ABS (1993, 1997) data.

The sample is weighted to reflect differences in sample proportions and projected population characteristics at 2000. Market forecasts are computed by applying the rule,

$$MF = \sum_{g=1}^{G} \left(\frac{N_g}{N_T}\right) \frac{1}{N_{Eg}} \sum_{g=1}^{N_{Eg}} P(i|z,S), \qquad (5)$$

where N_g is the projected population of households in the g^{th} income or respondent age group, N_T is projected population and N_{Eg} are the participants from the g^{th} group.

Table 8 shows 65 per cent of Australian households are forecast to subscribe to broadband delivered entertainment service. While the duopoly assumption preclude explicit forecasts predicated on market structure changes it is possible to proxy competition scenarios by examining the penetration of low-price alternatives. Forecast demand is clearly greater for low-price alternatives B, D and G and suggest price competition between Foxtel and Optus Vision could accelerate penetration. Forecast penetration rates by income and age are calculated by summing household subscription probabilities within subpopulations. The product of these probabilities and projected household numbers within subpopulations provide forecasts of Australian diffusion for income and age groups. Almost 60 per cent of low-income (less than $20 000 per annum) and 70 per cent of high-income households (above $80 000 per annum) are forecast to subscribe. This pattern is apparent for all subscription alternatives. Less than 50 per cent of respondents aged over 55 years and more than 70 per cent of respondents aged less than 25 years are forecast to subscribe. For both income and age subscription interest at 2000 is likely to be greater for the low-price

TABLE 8
Forecast Subscription at 2000

		Income ($ thousand)			Age (years)		
Choice	Households	< 20	40–50	> 80	< 25	35–45	> 55
No subscription	35.1	40.0	35.1	32.0	27.9	35.0	50.7
Subscription	64.9	60.0	64.9	68.0	72.1	65.0	49.3
Alt A	5.05	4.69	5.01	5.22	5.60	5.02	3.82
Alt B	12.7	11.7	12.4	13.2	14.4	12.7	9.61
Alt C	7.34	6.77	7.27	7.66	8.14	7.30	5.59
Alt D	13.7	12.7	14.0	14.7	15.2	13.8	10.6
Alt E	5.70	5.25	5.71	5.97	6.30	5.70	4.32
Alt F	6.60	6.09	6.66	6.88	7.27	6.62	4.97
Alt G	13.8	12.8	13.9	14.4	15.3	13.9	10.4
Total households	100	100	100	100	100	100	100

alternatives, B, D and G. Finally, the reliability of model projections is assessed by comparison with actual payTV subscription. Based an estimated 1904 222 separate residences passed, the NMNL model forecasts 1237 744 subscribers at 2000.[11] This forecast compares well with actual pay TV subscribers of 1100 000 at 1999, and projected subscribers, based on RP data, of 1300 000 at 2000 (Budde 1999).

VI Conclusions

A NMNL model of broadband delivered entertainment service subscription is estimated on SP data from an Australia-wide survey. The model provides a quantitative assessment of the impact of price, service attributes and household demographic variables on demand for as yet delivered entertainment service with no RP history. Rental price elasticity is negatively related to subscription interest and generally inelastic. The cross-price elasticity is positive, inelastic and equal across alternatives suggesting substitution between alternative service offerings is small. Furthermore, the subscription probability installation fee elasticity is elastic indicating subscription is more sensitive to an installation fee than monthly rental price.

Forecasts obtained from the NMNL model suggest 65 per cent of separate households passed are likely to subscribe to broadband delivered entertainment service by 2000, which translates into 1237 744 subscribers. The forecast compares well with actual payTV subscribers at 1999, and projected subscription (based on RP data) of 1300 000 at 2000. Comparison of RP and SP forecasts show a carefully integrated SP experiment can yield sensible and useful forecasts when combined with a well-specified choice model. Finally, forecast interest in entertainment service at 2000 increases with household income, but declines with respondent age. The results have important implications for both service provider marketing strategy and provide useful input into public policy on universal access to advanced communications services.

[11] While public information on network roll-out is proprietary media releases indicate Optus Vision passed 2 million and Foxtel 1.5 million households at 1997 (Deutsche Morgan Grenfell 1997). Effective residences passed is calculated by assuming roll out ceased in 1997 (Lee 1997), network overbuild is 60 per cent of Optus Vision network (Deutsche Morgan Grenfell) and 83 per cent of passed households are separate residences (ABS 1997).

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