Paper for HESG (YORK) 26th-28th July 2006

Alternative approaches to modelling Discrete Choice Experiment Responses

Michela Tinelli[1,2], Mandy Ryan[1]
[1] Health Economics Research Unit, University of Aberdeen
[2] Department of General Practice and Primary Care, University of Aberdeen

Summary
Whilst Discrete Choice Experiments (DCEs) often apply conditional logit model for multiple-choice experiments, the importance of considering alternative approaches has been recognised. This paper models DCE response data, using conditional, nested and mixed logit models (with a flexible substitution pattern) within the context of a study looking at preferences for extending the role of the pharmacist. Each choice presented three options, and four substitution patterns were investigated. Consideration was given to the goodness of fit and marginal rates of substitution (MRS) generated from the different models. The inclusion of socioeconomics and their impact on MRS was also considered. Results were compared across 3 groups (‘*control*’, ‘*intervention all*’ and ‘*intervention still receiving the treatment*’). The results highlight the importance of identifying patterns of substitution between alternatives when estimating welfare gains.

1. Introduction

Discrete Choice Experiments (DCEs) are a stated preference technique increasingly used in health economics to elicit individual preferences. The technique is based on the premise that individuals derive benefit from the attributes of the good or service. Further, if a price proxy is included, willingness to pay (WTP), a monetary measure of benefit, can be estimated. Whilst most applications of DCEs apply forced choices, the importance of allowing for multiple options is being recognised (Ryan and Skatun 2004). The standard approach to estimating welfare with multiple alternatives, using the conditional logit model, assumes that options available are perfect substitutes. If alternatives are not perfect substitutes, a partial solution is to use the Nested Logit Model (NLM). Here options are grouped such that the assumption of perfect substitution is valid within groups (or nests), but not between groups (Hensher and Greene 2001; Louviere et al, 2000; Knapp et al, 2001; Hanemann, 1999; Puig-Junoy et al, 1998). When using the NLM the researcher must specify the appropriate nesting structure. Another generalisation of standard logit model is the Mixed Logit (ML) or Random Parameter Logit (RPL), introducing heterogeneity across individuals and allowing for multiple observations for each respondent (Train, 2003).

Different nesting structures or mixed logit models may result in different parameter estimates. This aim of this paper is to consider issues raised when relaxing the IIA assumption to estimate parameter estimates, and to compare parameter estimates from the conditional, nested and mixed logit models. This is discussed within the context of a DCE concerned with patient preferences for extending the role of the pharmacist. In the next section the DCE is described. Following this, the next section describes econometric analysis issues raised in the analysis of multiple option DCE data, and then the different utility functions cross models are presented. Consideration of the estimation of WTP in such models are then presented, and concluding comments are then made.

2. The Discrete Choice Experiment: extended role of the pharmacist in the management of drug therapy

Pharmacists' expertise in medicines has been demonstrated in a Randomised Controlled Trial (RCT), which showed that pharmacy review of repeat prescriptions could identify drug interactions and adverse events, and reduce drug costs (Bond, 2000). This enhanced role for pharmacists was subsequently incorporated into the strategies for pharmacy in England (Department of Health 2000), Wales (Audit Commission: A Spoonful of Sugar 2001), Northern Ireland and Scotland (Scottish Executive, The Right Medicine). The new community pharmacy contracts, and other recent regulatory changes (for example, supplementary prescribing for continued prescribing in chronic conditions, and independent pharmacy prescribing) are all likely to increase the contribution of pharmacists to the management of medicines for chronic conditions, in both the general practice and community pharmacy settings. The Community Pharmacy Medicines Management Project (Jaffray, 2005) was a large national, multi-centre (RCT) to evaluate the introduction of a medicines management service by community pharmacists for patients with coronary heart disease (CHD).

The DCE was a cross-sectional postal survey. Participants to the Community Pharmacy Medicines Management study who replied to the 12-month follow-up survey (879 intervention; 470 control) were sent a DCE self-completion questionnaire for eliciting preferences for a community-pharmacist based provision of medicines management. The study randomized patients to both the intervention (medicines management service from pharmacy) and control group (usual care). Results from Medman study (Jaffray, 2005) and a previous DCE (Tinelli et al, 2004) were used to derive the attributes and their levels. The Medman patient survey included 19 statements on what patients would like to receive when they visit the pharmacy for prescription medicines. Exploratory Factor Analysis (EFA) with varimax rotation was used to assess any underlying main domains and define possible suitable attributes (Tucker and MacCallum, 2003). The six attributes included are shown in Table 1. Information was also collected on age sex and income (to identify sources of individual heterogeneity).

Each choice offered three options: the current scenario; a novel community pharmacist and general practitioner review medicines (CP&GP); and a GP only medicines review (GP). An example of choice is presented in Figure 1. Generally, the patients could be dealing with four different current scenarios: intervention group still receiving the medman service (A); intervention group not receiving the treatment any more (B) or who never received it (C); control patients (D). Before being presented the DCE choices each subject was asked to define their current situation in terms of attributes levels. Intervention group patients were also asked if they were still receiving the Medman service from their pharmacist. For the purpose of the analysis three different groups were compared, including control and intervention group (intention to treat approach) versus intervention still receiving the service (per protocol or on treatment approach).

Table 1: Summary of attributes, levels and socioeconomics

Attributes	Levels	Variable names	Coding
1) Advice [advice on **medicines** and **health&life style**]	**- No advice** **- Only on medicines** **- Only on health/lifestyle** **- On medicines & health/lifestyle**	**(Compared to no advice)** **ADVMED** **ADVHL** **ADVMH**	**Dummy**
2) Time [time spent **travelling to**, **waiting** in the pharmacy]	**- 10 min** **- 20 min** **- 30 min** **- 40 min**	**TIME**	**10** **20** **30** **40**
3) Privacy in the pharmacy [consultation with your pharmacist is in a **private area**]	**- No** **- Yes**	**(Compared to no privacy)** **PRIVD**	**Dummy**
4) Satisfactory replies to your question	**- No** **- Yes**	**(Compared to no reply)** **REPLD**	**Dummy**
5) The chance of receiving the "most appropriate" treatment	**- Very poor** **- Poor** **- Good** **- Very good**	**CH0** **CH1** **CH2** **(Compared to Very good)**	**Dummy**
6) How much you have to pay [cost of the medicine + the cost of the medicines review and advice received+ the cost of any travel]	**- £0** **- £10** **- £20** **- £30**	**COST**	**0** **10** **20** **30**
Socioeconomics			
Age	**Continuous**	**AGE**	
Sex	**-Female** **-Male**	**SEX** **(Compared to female)**	**Dummy**
Income	**-Up to 20'000** **-20'000-40'000** **-Over 40'000**	**IN1** **IN2** **(Compared to over 40000)**	**Dummy**

Figure 1: Example of choice

	Medicines review by GP& pharmacist	Medicines review by GP only	
ADVICE	No advice	Only on medicines	
PRIVATE DISCUSSION	Yes	No	
SATISFACTORY REPLIES	No	Yes	
CHANCE OF APPROPRIATE TREATMENT	Good	Very good	
TIME (Travelling to + waiting in the pharmacy)	20 min	10 min	
HOW MUCH YOU HAVE TO PAY (Consultation + medicines + travelling)	£0	£10	
WHICH SERVICE WOULD YOU CHOOSE? (Tick one box only)	**MEDICINES REVIEW BY GP& PHARMACIST** ☐	**MEDICINES REVIEW BY GP ONLY** ☐	**YOUR CURRENT SITUATION** ☐

Experimental design techniques were used to design a set of choices for which preferences were elicited. Three alternative orthogonal labelled choice designs were created from design catalogues using a fold-over approach (main effects) and from a computer optimisation procedure (main effects and interactions) (Louviere et al, 2000; Ryan and Gerard 2003; Hanley et al, 2001, Carlsson and Martinsson 2001). The three designs were piloted, asking patients attending two surgeries in Aberdeen, Scotland. DCE experiments ability of capturing patients' preferences was estimated using the D-efficiency measure, and consideration was given to how efficiency was being estimated (Carlsson and Martinsson, 2001; Maddala et al, 2003; Zwerina et al, 1996). Following this, parameters were estimated using conditional logit modelling and welfare estimates generated. These were compared for the different experimental designs. The preferred catalogue design was adopted for the main study. It presented lower D-error referred to the others when considering the overall survey data. Results from the pilot phase are available from the authors on request (Tinelli et al, 2005 (2)). The questionnaire used in the main phase included 32 choices, allocated into 4 blocks[1] using the computer software SAS (Kuhfeld, 2000), with all blocks orthogonal to the all attribute levels. Consistency of responses was checked using Sen's contraction consistency principle (San Miguel et al, 2005).

The survey was sent to 1349 patients (879 intervention; 470 control). 73% (643/879) of intervention and 67% (314/470) of control returned a questionnaire. Data eligible for analysis came from 53% (468/879) of intervention and 52% (243/470) of control. 51% (245/483) of intervention were still receiving the service. 76% (540/714) provided consistent responses. Intervention group still receiving the Medman service were likely to be older than other groups (72.56 yrs versus 70.73 yrs in intervention all versus 71.04 yrs in control; P<0.05). Their current situation was significantly better for advice received (P<0.001), privacy in the premises (P<0.001), replies to questions (P<0.001) and change of receiving appropriate treatment (P<0.001) than other groups.

[1] A pre-pilot work asking a group of PhD students to complete the original 32 choices questionnaire, indicated that that choices were too many for subjects to respond to.

Preferences for the collaboration between CP&GP in medicines review increased when moving from the control (16.65%, 328/1969), intervention all (17.45%, 655/3752) to the intervention still experiencing the service (35.28%, 501/1982). 43.3% (308/711) of reported a constant choice. Their preferred current choice was the current (27%, 192/711), followed by the GP only review option (9.0%, 64/711) and innovative collaboration between CP&GP (7.3%, 52/711).

3. Econometric analysis of DCE data with multiple options

DCEs are a stated preference technique being increasingly used in health economics to elicit individual preferences. The technique is based on the premise that individuals derive benefit from the attributes of the good or service. Further, if a price proxy is included, willingness to pay (WTP), a monetary measure of benefit, can be estimated.

3.1. Conditional Logit approach

Whilst most applications of DCEs apply forced choices, the importance of allowing for multiple options is being recognised (Ryan and Skatun, 2004). The standard approach to estimating welfare with multiple alternatives, using the conditional logit model, assumes that options available are perfect substitutes. This model assumes that the ratio of probabilities for any two alternatives is independent of the attribute levels of the third alternative (cross-elasticity of substitution across alternatives or IIA assumption); the coefficients are fixed in the population, and that repeated choices made by a respondent are independent (Louviere et al, 2000; Train 2003). However, if this assumption is not true, experimental findings may be biased and lead to incorrect predictions. Therefore it is important to examine whether some options compete with some more than with others, thereby violating the IIA assumption (Dhar and Simonson, 2003). The application of conditional logit model has been commonly used in health economics when calculating welfare estimates from a DCE (Lancsar and Savage 2004 (a); Lancsar and Savage 2004 (b); Ryan, 2004; Santos Silva, 2004).

3.2 Nested Logit approach

A partial solution to the IIA problem is to use a generalised extreme value distribution, which allows alternatives to be grouped in a manner that allows alternatives to be correlated within, but not between, groups. These models are generally referred as Nested Logit Models (NLM) (Manski and McFadden, 1981). In health economics a limited used of the nested logit has been reported when applying DCE (Ryan and Skatun 2004; Puig-Junoy, Saez and Martinez-Garcia 1998). When using the NLM the researcher must make a decision about the nesting structure between alternatives. Since economic theory has nothing to say about this nesting structure the researcher must make the decision.

For example, within the context of the current study, subjects decide which pharmaceutical service they wish to receive, with the options 'Medicines review by a collaboration between community pharmacist and GP', 'GP only review' and 'Current service' (either GP only or CP&GP collaboration, depending on the group considered[2]) being considered simultaneously. Four possible substitution patterns are investigated in this paper: all options are equal substitutes (as implied by the standard CLM); the new proposals are closer substitutes than the current one (to test for status quo bias, see Salkeld et al, 2000); 'GP and pharmacist review' and 'current' (it represents an alternative 'CP&GP review' for people *still receiving the service*) are closer substitutes than 'GP only'; 'GP only review' and 'current' (it represents an alternative 'GP only' option for people not receiving the treatment) are closer substitutes than 'CP&GP review' (assuming the respondent does not want to see an increased role for the pharmacist to one of collaborating with the GP in reviewing the medicines). These substitution patterns are represented, respectively, by the tree structures A, B_1, B_2 and B_3 reported in Figure 2. Each pattern implies an alternative econometric method of analysis:

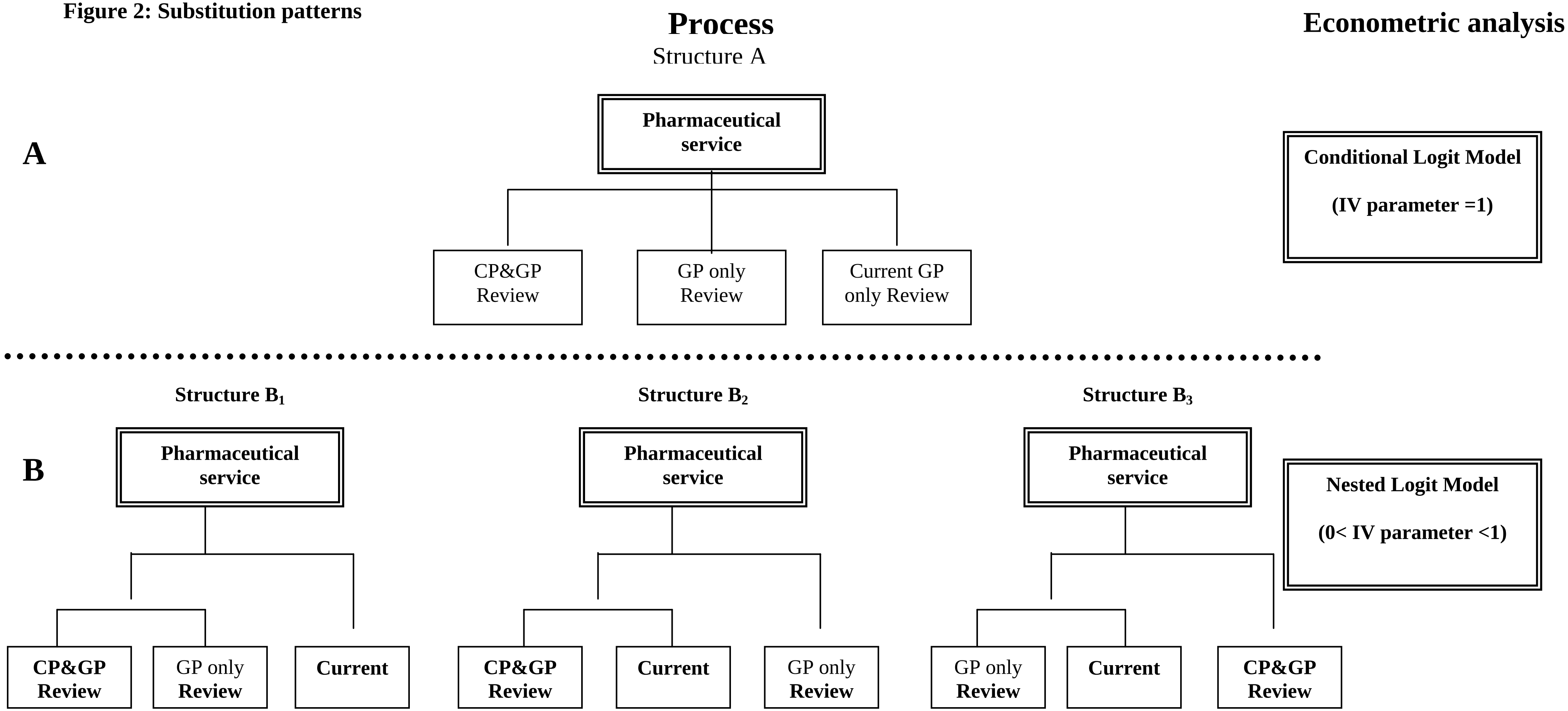
- **Situation A**: An increase in the probability of choosing "Medicines review by a collaboration between CP&GP" results in an equal proportional decrease in the probability of choosing "New GP only review" and "Current situation" (Structure A). This is based on the irrelevant alternatives (IIA) assumption and the Conditional Logic Model (CLM) is the appropriate modelling technique ($\theta_N = 1$, see below).
- **Situation B**: "Medicines review by a collaboration between CP&GP" and "GP only review" are closer substitutes with each other than with the current situation, but the "Current" is still seen as a substitute for them (Structure B_1). This may be the case if subjects prefer the current situation, representing status quo bias. The Nested Logit Model (NLM) is an appropriate technique to test this hypothesis ($0<\theta_N< 1$, see below).

The θ_N parameter, also known as the "inclusive value (IV) parameter" or "the dissimilarity parameter", measures the degree of independence in unobserved utility among the alternatives within the nest, N, and lies between 0 and 1[3] (Manski and McFadden, 1981; Borsh-Supan, 1990; McFadden, 1978; Train, 2003; Greene, 2003). A higher value of θ_N means greater independence and less correlation. The statistic $1 - \theta_N$ is a measure of correlation, in the sense that as θ_N parameter rises, indicating less correlation, this statistic falls.

Testing for $\theta_N = 1$ is equivalent to testing whether the conditional logit model is a better model specification than the more general nested logit model. These tests are usually performed with the likelihood ratio statistic (Borsh-Supan, 1990; McFadden, 1978; Train, 2003; Greene, 2003). After specifying alternative models consistent with utility theory, we can select the most appropriate comparing their likelihood ratio index. The most suitable model presents the highest likelihood ratio index.

[2] In control group, current= GP only; in Intervention all, current= either service; in intervention receiving service, current=GP&PH collaboration in reviewing drugs
[3] According to McFadden 1978 a globally sufficient condition for nested logit model to be consistent with utility maximisation is that $0< \theta_N <1$. However, Borsch-Supan 1990 demonstrated that $\theta_N >1$ can be consistent with utility theory.

Figure 2: Substitution patterns



CP&GP review = Collaboration of community pharmacist&GP in medicines review
GP only review =New medicines review by GP only (alternative to the current)
Current = Medicines review by GP only (control group); either service (intervention all); Collaboration of CP&GP in medicines review (intervention receiving the service)

3.3. Mixed Logit or Random Parameters Logit approach

Mixed Logit (ML) or Random Parameters Logit (RPL) model is another generalisation of standard logit model with the introduction of hetereogeneity across individuals and allowing for multiple observations from each respondent (Hensher and Greene 2001; Train, 2003; Munizaga and Alvarez-Daziano, 2001; Hynes and Hanley, 2006). The parameters associated with each observed variable are allowed to vary randomly across respondents and the variance in the unobserved respondent-specific parameters induces correlation over alternatives in the stochastic part of the utility. As a result of this, mixed logit is relaxing the restrictive independence from irrelevant alternatives assumption of the more traditional conditional logit models. Mixed logit also allows for efficient estimation when there are repeated choices by the same respondent, as in DCEs. A flexible substitution pattern is then recognised. The log likelihood ratio index can help in selecting the most appropriate model between the conditional logit and the more general mixed logit (Greene 2003). Their limited application to health economics when analysing DCE is indicating the need of further research (Hall et al, 2006).

3.4. Utility function estimation: moving from Conditional Logit to Nested Logit Models

In DCE models each individual is assumed to make choices among discrete alternatives in a manner that provides the highest utility per chosen alternative. It is commonly assumed in the literature that this utility function is a linear function described in the following way:

$$U_i = V_i + \varepsilon_i \qquad [1]$$

Where U_i is the unobservable utility of offering service i; V_i is the deterministic component or observed utility**;** ε_i is the random component or unobserved utility (see Louviere, Hensher and Swait 2000). A variety of parameters can be estimated from choice data depending on the distributional and associated assumptions that are made to derive a particular model form. Possible examples of deterministic component when a conditional logit model is applied are [2] and [3]:

$$V_i = ASC_i + \beta' A_i \qquad [2] \text{ or}$$

$$V_i = ASC_i + ASC\_Z_i + \beta' A_i \qquad [3]$$

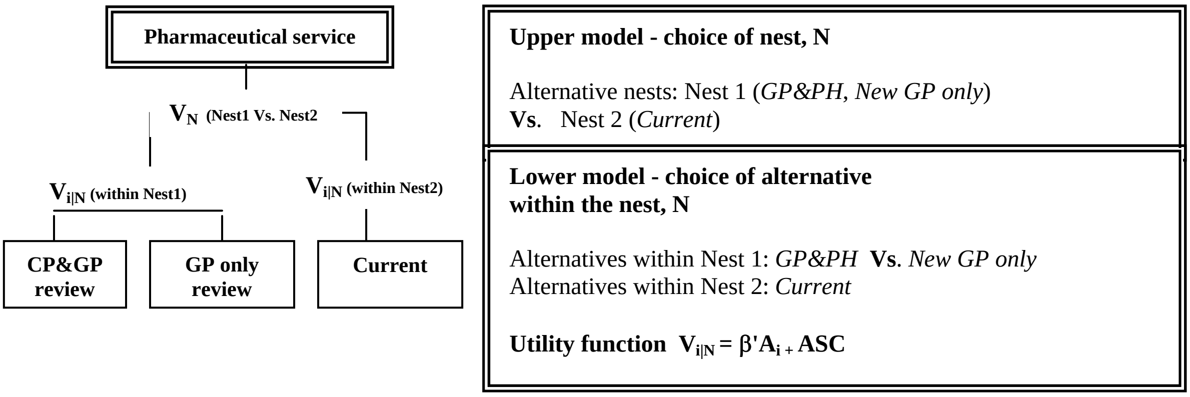
Where

ASC_i = a vector of alternative specific constants for i-1 of the i=3 choice options;
$\beta' A_i$ = A_i represents the vector of attributes of the pharmaceutical service provided, and β' the parameters of the model to be estimated;
ASC_Z_i = a matrix of possible interactions of individual characteristics with choice option intercepts
The individual characteristics included are: age, sex and income (see table 1).

When more than two alternatives are compared the decision making process can be broken into two possible decisions. An example of a possible two-phase hierarchical decision model with their corresponding deterministic components is reported in Figure 3:

- **Upper model**: The decision whether or not to stay with the change (i.e. "New GP and Pharmacist review" or "New GP only review") rather than the "current" option .
- **Lower model**: The decision regarding which alternative pharmaceutical service to adopt, ie "New GP and Pharmacist review" versus "New GP only review" (assuming that the individual decides not to choose their current situation).

Figure 3 Description of possible decision model (Structure B1)



CP&GP review = Collaboration of community pharmacist & GP in medicines review ; **GP only review** =Medicines review by GP only ; **Current** = Medicines review by GP only (control group); either service (intervention all); = Collaboration of community pharmacist & GP in medicines review (intervention receiving the service)

- **Upper model: Choice between different nests**

The deterministic component of the decision whether or not to choose an alternative pharmaceutical service to the current situation (V_N) can be modelled as a function of both individual characteristics (γ' X_N) and the expected utility of the pharmaceutical service adopted (IV_N) (Ryan and Skatun, 2004; Hensher and Greene, 2001; Louviere et al, 2000; Knapp et al, 2001, Hanemann 1999). The "inclusive value parameter" (θ_N) weights the contribution of the alternative attributes from the lower model ($V_{i|N}$) to the decision of whether or not move form the current situation to an alternative scenario [4]. The "logsum" or "inclusive value term" (IV_N) indicates the average utility the patient can expect from the alternatives within that particular nest N and is presented by [5].

$$V_N = ASC + \gamma' X_N + \theta_N IV_N \qquad [4]$$

$$IV_N = \ln \sum_{i=1}^{i_N} e^{ASCi + \beta' A_i} \qquad [5]$$

Where:

ASC is the ASC_i represents the vector of intercept terms for i-1 of the i=2 choice nests;

X_N represents the characteristics of the individual and γ' a vector of parameters to be estimated (see lower part of Table 1).

For the study here, $\gamma' X_N$ is defined as:

$$\gamma_0 + \gamma_1 AGE_N + \gamma_2 SEX_N + \gamma_3 INCOME \quad [6]$$

where AGE is a continuous variable representing age in years of respondents; SEX is a dummy variable where male=1 and female=0; INCOME is a categorical variable where 1=less than £20,000, 2= between £20,000 and £40,000, 3= more than £40,000. Assuming that individual characteristics are different across different nests and constant within each nest, their change affects the choice of nest (or marginal probability) and not the choice of alternatives within the nest (or conditional probability) (See Train 2003).

- **Lower model: choice within a particular nest**

In the present example, for the decision regarding which alternative pharmaceutical service to adopt, the deterministic component of utility is defined as a function of the service attributes [7]:

$$V_{i|N} = ASC_i + \beta' A_i \quad [7]$$

where i represents the alternative service to the current chosen ("GP and pharmacist review" or "GP only review") given a decision has been made not to stay for the current. ASC_i represents the vector of intercept terms for i-1 of the i=3 choice options; A_i represents the vector of attributes of the pharmaceutical service provided, and β' the parameters of the model to be estimated (Table 1).

$$V_{i|N} = ASC_i + \beta' A_i = ASC_i + \beta_0\, ADVMED + \beta_1\, ADVHL + \beta_2\, ADVMH + \beta_3\, TIME + \beta_4\, PRIVD + \beta_5\, REPLD + \beta_6\, CH0 + \beta_7\, CH1 + \beta_8\, CH2 + \beta_9\, COST \quad [8]$$

3.5. Utility function estimation: moving from Conditional Logit to Mixed Logit Models

When a mixed logit model is applied and the respondent faces a choice among *i* services, the utility function of person *n* can then be represented as follow [9]:

$$U_{ni} = V_{ni} + \eta A_{ni} + \varepsilon_{ni} = ASC_{ni} + \beta' A_{ni} + \eta A_{ni} + \varepsilon_{ni} \quad [9]$$

where is defined by a deterministic component $V_{ni} = ASC_{ni} + \beta' A_{ni}$, a random component independent and identically distributed ε_{ni} and one or more additional random terms. These additional terms can be aggregated into the additive term η_{ni}. Two error components are then considered, one that can be function of the data and models the presence of correlation and heteroscedasticity, another independently, identically distributed over alternatives and individuals. ASC_{ni} is a vector of intercept terms for i-1 alternatives; A_{nj} are observed variables that relate to the alternatives; β'_n is a vector of coefficients of these variables for person *n* representing that person's preferences, and ε_{nj} is a random term that is iid extreme value. The coefficients vary over decision makers in the population with density $f(\beta')$. This density is a function of parameters θ, representing the mean and covariance of the β's in the population. This specification is the same as for standard logit except that β' varies over decision makers rather than being fixed.

The utility equation [2] can also be expressed as:

$$V_{ni} = ASC_{ni} + bA_{ni} \qquad [10]$$

$$\text{With } b = \beta' + \eta \qquad [11]$$

4. Results

Given space constraints we discuss the regression results but present only the MRS. More detailed results are available from the authors on request.

4.1 Conditional logit model

- **Basic conditional logit model.** The regression results indicated that when moving from the preferred current situation, respondents in the control and intervention all group are willing to choose an alternative GP only alternative to the CP&GP collaboration in medicines review. When still receiving the service, a movement from the preferred current Medman service is more likely to see a preferred alternative CP&GP collaboration to the GP only alternative.

In the *control* and *intervention all* groups only the chance of receiving appropriate treatment (moving from no chance, poor chance, or good chance, to very good chance), replies to their questions (only in the intervention all) and cost are important when choosing between the alternative services. *Intervention receiving the service* group valued also advice (on medicines or medicines and health/lifestyle) compared to the intervention all. Overall, the movement from a very poor chance to a very good chance of receiving an appropriate treatment was the attribute mostly valued. Privacy in the premises was not considered important in any group.

MRS when considering a movement from the preferred current to an alternative GP only scenario or CP&GP collaboration, receiving advice for medicines, replies to questions, a movement from a very poor chance to a very good chance of receiving an appropriate treatment are presented in Tables 2, 3 and 4 (*control*, *intervention all*, *intervention receiving the service*). When experiencing the new service responders are less worse off for the movement from the preferred current to an innovative ‘review by GP and pharmacist’ (-£81, -£70, -£48), while they are more reluctant to choose an alternative ‘GP only review’ (-£58,-£63,-£62). When moving from a ‘very poor’ to a ‘very high’ chance of receiving ‘best’ treatment respondents were willing to pay: £30, £32 and £38. When receiving advice on their medicines or replies is increasingly valued more across groups as follow: £8, £17 and £33; £7, £11 and £15.

Table 2: Marginal WTP (control)

Marginal WTP (control)…	**Conditional logit £ (CI)***	**Nested logit £ (CI)***	**Mixed logit £ (CI)***
	Basic model	**Nested 1**	
…to move from the current to … *-the innovative "review by GP & pharmacist"* *-to the "new review by GP only"*	-81.56 (-81.80 to -81.30) -57.84 (-58.18 to-57.50)	-	-80.88 (-81.12 to-80.65) -57.38 (-57.53 to-57.23)
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	29.73 (29.42 to 30.04)	31.84 (31.55 to 32.13)	29.46 (29.19 to 29.74)
…to receive advice for medicines	7.83 (7.69 to 7.98)	8.90 (8.78 to 9.01)	7.75 (7.61 to 7.88)
…to receive replies to questions	7.13 (7.04 to 7.21)	7.80 (7.73 to 7.88)	7.17 (7.09 to 7.24)
	Socioeconomics interacting with ASCs	**Nested 2**	
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	27.61 (27.41 to 27.81)	26.90 (-27.58 to-26.22)	-
…to receive advice for medicines	7.42 (7.31 to 7.53)	2.23 (2.04 to 2.42)	-
…to receive replies to questions	6.61 (6.54 to 6.68)	22.71 (22.45 to 22.98)	-
		Nested 3	
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	-	12.80 (12.60 to 12.99)	-
…to receive advice for medicines	-	1.59 (1.51 to1.67)	-
…to receive replies to questions	-	-4.46 (-4.62 to 4.29)	-

*CI = confidence intervals, equal to $[(a_i/b_i – z^2 cova_ib_i/b_i^2)\underline{+} z/ b_i\sqrt{} (vara_i –2(a_i/b_i)*cova_ib_i + (a_i/ b_i)^2varb_i + (cov\ a_ib_i)^2 – var\ a_i *varb_i)]/(1-varb*z^2/ b_i^2)$, where a_i =coefficient for cost variable and b_i =coefficient for the ith variable

Table 3: Marginal WTP (intervention all)

Marginal WTP (intervention all)…	**Conditional logit £ (CI)***	**Nested logit £ (CI)***	**Mixed logit £ (CI)***
	Basic model	**Nested 1**	
…to move from the current to … *-the innovative "review by GP & pharmacist"* *-to the "new review by GP only"*	-69.77 (-69.99 to -69.55) -62.76 (-63.13 to -62.39)	-	-69.85 (-70.07 to -69.64) -62.75 (-63.11 to -62.38)
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	31.80 (31.47 to 32.14)	28.33 (28.03 to 28.63)	32.18 (31.84 to 32.51)
…to receive advice for medicines	17.51 (17.19 to 17.84)	20.03 (19.65 to 20.40)	17.51 (17.18 to 17.84)
…to receive replies to questions	10.64 (10.51 to 10.77)	10.89 (10.76 to 11.02)	10.66 (10.53 to 10.79)
	Socioeconomics interacting with ASCs	**Nested 2**	
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	28.13 (27.84 to 28.43)	21.77 (21.54 to 22.00)	-
…to receive advice for medicines	18.32 (17.97 to 18.66)	22.91 (23.34 to 22.48)	-
…to receive replies to questions	9.54 (9.42 to 9.66)	31.46 (31.07 to 31.85)	-
		Nested 3	
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	-	16.24 (16.07 to 16.41)	-
…to receive advice for medicines	-	-4.25 (-4.33 to -4.17)	-
…to receive replies to questions	-	-8.28 (-8.38 to -8.18)	-

*CI = confidence intervals, equal to $[(a_i/b_i – z^2 cova_ib_i/b_i^2)\underline{+} z/ b_i\sqrt{} (vara_i –2(a_i/b_i)*cova_ib_i + (a_i/ b_i)^2varb_i + (cov\ a_ib_i)^2 – var\ a_i *varb_i)]/(1-varb*z^2/ b_i^2)$, where a_i =coefficient for cost variable and b_i =coefficient for the ith variable

Table 4: Marginal WTP (intervention receiving the service)

Marginal WTP (intervention receiving the service)…	**Conditional logit £ (CI)***	**Nested logit £ (CI)***	**Mixed logit £ (CI)***
	Basic model	**Nested 1**	
…to move from the current to … *-the innovative "review by GP & pharmacist"* *-to the "new review by GP only"*	 -47.57 (-47.72 to -47.43) -62.28 (-62.64 to -61.91)	-	 -47.53 (-47.68 to -47.38) -62.32 (-62.69 to -61.96)
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	37.93 (37.54 to 38.33)	34.22 (33.86 to 34.58)	39.00 (38.59 to 39.41)
…to receive advice for medicines	33.51 (32.89 to 34.14)	35.40 (34.74 to 36.06)	33.41 (32.79 to 34.04)
…to receive replies to questions	14.71 (14.53 to 14.89)	11.90 (11.75 to 12.04)	14.78 (14.59 to 14.96)
	Socioeconomics interacting with ASCs	**Nested 2**	
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	34.51 (33.54 to 34.25)	39.12 (38.71 to 39.53)	-
…to receive advice for medicines	35.59 (34.93 to 36.26)	24.92 (24.46 to 25.39)	-
…to receive replies to questions	11.85 (11.70 to 11.99)	32.93 (32.53 to 33.34)	-
		Nested 3	
…to move from a very poor chance to a very good chance of receiving an appropriate treatment	-	18.36 (18.17 to 18.55)	-
…to receive advice for medicines	-	16.30 (15.99 to 16.60)	-
…to receive replies to questions	-	8.58 (8.47 to 8.68)	-

*CI = confidence intervals, equal to $[(a_i/b_i – z^2 cova_ib_i/b_i^2) \pm z/ b_i\sqrt{} (vara_i –2(a_i/b_i)*cova_ib_i + (a_i/ b_i)^2varb_i + (cov\ a_ib_i)^2 – var\ a_i *varb_i)]/(1-varb*z^2/ b_i^2)$, where a_i =coefficient for cost variable and b_i =coefficient for the ith variable

- **Conditional logit with socioeconomics interacting with ASC.** When including the patient's characteristics as interaction with the ASCs, the following conclusions can be drawn. In the intervention all group the innovative CP&GP review service is likely to be preferred to alternative GP only review. In the other groups the situation is invariant compared with the conditional logit model without socioeconomics.

Female and older are more likely to move to alternative services to their current. In the *control* group respondents with lower income are more likely to prefer their current situation to any other scenario. In the intervention groups (*intervention all* and *intervention receiving the service*) subjects with lower income are more likely to move to an alternative CP&GP review to their current rather than a GP only review. When still receiving the service this movement is not supported by statistical significance.

MRS estimates are lower than when applying the basic conditional model previously presented (see Tables 2, 3 and 4). For example, when moving from a 'very poor' to a 'very high' chance of receiving 'best' treatment respondents were willing to pay: £28, £28 and £34 (conditional logit including socioeconomics); £30, £32 and £38 (Basic conditional logit model).

4.2 Nested logit results

The Hausman test, with a highly significant chi-square values $\chi 2$ = 102.7469, 176.9203 and 94.1652 (control, intervention all and intervention receiving the service, respectively), indicates that the IIA assumption is violated and a nested logit model could be more appropriate.

In Tables 2, 3 and 4 the three different nesting structures are applied to the three groups, reporting information on the inclusive values, log likelihood ratio indexes. Different substitution patterns (B_1 vs B_3) apply according to the different groups (*control* and *intervention all* vs *intervention receiving the service*). Their associated IV parameters (1.5 for *control* and *intervention all* vs 1.9 for *intervention receiving the service*) are statistically significantly different from zero at the 1% level and are included between 0-2[4], indicating rejection of the IIA hypothesis (see Smith and Desvouges and Fisher 1986). The other nested logit models (patterns B_2 and B_3 for *control* and *intervention all*, or patterns B_1 and B_2 *intervention receiving the service*) are not consistent with utility maximisation theory (negative IV values) and, therefore, excluded. For the nesting structures the influence of individual characteristics on choice over alternative pharmaceutical services is considered. However, the signs of the coefficients differ, depending on the nesting structures, and the magnitudes of the coefficients are slightly different. The coefficients in the branch (lower model) and alternative specific constants differ, reflecting the alternative substitution patterns implied by the different nesting structures. Consequently, these differences are translated into marginal WTP for moving from their current to alternative scenarios (CP&GP review or GP only review) (see Tables 2, 3 and 4). The preferred nesting structures (see shadowed boxes Table 5) are explained as follow.

- **Control group (Nested B_1).** The substitution pattern presented in B_1 is that the two proposed alternatives 'GP and pharmacist review' and 'GP only review' are closer substitutes than the current service. The positive IV value implies that it is likely to be compatible with random utility maximisation theory (Bosh-Supan, 1990). Most individual specific and service coefficients are significant at the 5% level, suggesting that both these are important when deciding what system to choose.

Upper model – choice between different nests. ASC show that **r**espondents prefer their current state to any change and the IV parameter shows that services' attributes influence the choice (IV parameter > 0).

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[4] According to McFadden 1978 a globally sufficient condition for nested logit model to be consistent with utility maximisation is that $0< \theta_N <1$. However, Borsch-Supan 1990 demonstrated that $\theta_N >1$ can be consistent with utility theory.

Table 5: Nested structures

Nested B1	Nested B2	Nested B3
Control all	**Control all**	**Control all**
CP&GP Review; GP only Review; GP only Review (CURRENT) **No observation = 1969** **Inclusive value = 1.524010759 (P= 0.0157)** **Likelihood function = -1791.952** **Likelihood ratio index = 0.05820**	GP only Review; GP only Review (CURRENT; CP&GP Review **No observation = 1969** **Inclusive value = -2.132400329 (P=0 .0000)** **Likelihood function = -1788.063** **Likelihood ratio index= 0.28542**	CP&GP Review; GP only Review (CURRENT; GP only Review **No observation = 1969** **Inclusive value = -1.348404021 (P=0.0000)** **Likelihood function = -1836.512** **Likelihood ratio index = 0.24082**
Intervention all	**Intervention all**	**Intervention all**
CP&GP Review; GP only Review; Either service (CURRENT) **No observation = 3751** **Inclusive value =1.460637814 (P= 0.0001)** **Likelihood function = -3560.313** **Likelihood ratio index = 0.03812**	GP only Review; Either service (CURRENT); CP&GP Review **No observation = 3751** **Inclusive value =-1.416998430 (P=0.0000)** **Likelihood function = -3529.689** **Likelihood ratio index = 0.24007**	CP&GP Review; Either service (CURRENT); GP only Review **No observation = 3751** **Inclusive value = -1.317905557 (P=0.0000)** **Likelihood function = -3659.850** **Likelihood ratio index = 0.20409**
Nested B1	**Nested B2**	**Nested B3**
Intervention receiving service	**Intervention receiving service**	**Intervention receiving service**
CP&GP Review; GP only Review; CP&GP Review (CURRENT) **No observation = 1982** **Inclusive value = 1.258434740 (P=0.0041)** **Likelihood function = -1912.695** **Likelihood ratio index = 0.05174**	GP only Review; CP&GP Review (CURRENT); CP&GP Review **No observation = 1982** **Inclusive value =-1.469726060 (P=0.0000)** **Likelihood function = -1929.206** **Likelihood ratio index = 0.07957**	CP&GP Review; CP&GP Review (CURRENT); GP only Review **No observation = 1982** **Inclusive value = 1.883367749 (P=0 .0000)** **Likelihood function = -1947.661** **Likelihood ratio index = 0.20558**

Within patients' characteristics, income and sex have a greater absolute impact on choice than age. Younger are preferring "their pharmacist to provide a medicines review in collaboration with the GP" or "a GP only review of medicines" rather than the current service (being in the control group they were not experiencing the service). Female and people with lower income are willing to change to an alternative service to their current, while male and subjects with higher income prefer their current situation (status quo bias).

Lower model – choice within a particular nest. Having chosen to move from the current pharmacist service, people prefer the new 'CP&GP review' to a possible 'GP only review' of medications. The choice of a particular service is influenced by the characteristics of that service. Only the chance and cost attribute are statistically significant at 5% level. People prefer a service with lower cost, and a higher chance of appropriate treatment. The trade-off between attributes shows that respondents are willing to pay: £32 to move from a very poor chance to a very good chance of receiving an appropriate treatment; £9 to receive advice on the medicines; £8 to receive replies to their questions. MRS estimates are comparable to the one already presented with the other models (see Table 2).

- **Intervention all (Nested B_1).** The substitution pattern is the same as for control group. Both individual specific and service attributes are important when deciding what system to choose.

Upper model – choice between different nests. The model explanation is same as in control group. Now the preferred current situation could be either service proposed (CP&GP or GP only review).

Lower model – choice within a particular nest. The positive ASC indicate that having chosen to move from the current pharmacist service, people are more likely to prefer the new 'CP&GP review' to a possible 'GP only review' of medications. The trade-off between attributes shows, for example, that respondents are willing to pay £29 to move from a very poor chance to a very good chance of receiving an appropriate treatment. MRS estimates are comparable to the one presented with the other conditional and mixed models (see Table 3).

- **Intervention receiving the service (Nested B_3).** The substitution pattern presented in B_3 is that the alternatives current 'GP and pharmacist review' and the alternative to the current 'GP and pharmacist review' are closer substitutes than the 'GP only review' service. The positive IV value implies (1.8) that it is likely to be compatible with random utility maximisation theory. Both individual specific and service attributes are important when deciding what system to choose.

Upper model – choice between different nests. Respondents prefer a CP&GP review (their current or an alternative one) and the IV parameter shows that services' attributes influence the choice (IV parameter > 0). Within patients' characteristics, income and sex have a greater absolute impact on choice than age. Younger prefers "their pharmacist to provide a medicines review in collaboration with the GP" rather than "a GP only review of medicines" and people with lowest income value a CP&GP review, while subjects with higher income prefer "a GP only review of medicines".

Lower model – choice within a particular nest. Having chosen a 'CP&GP review', people prefer an alternative 'CP&GP review' to their current. The choice of a particular service is influenced by the characteristics of that service. The trade-off between attributes shows that respondents are willing to pay: £18 to move from a very poor chance to a very good chance of receiving an appropriate treatment; £16 to receive advice on the medicines; £8 to receive replies to their questions. MRS estimates are generally lower when comparing with the other conditional and mixed models (see Table 4) or with NLM1 for *control* and *intervention all* (see Table 2, 3, 4).

4.3 Mixed logit

Likelihood ratio index from conditional logit (0.153, control; 0.117, intervention all; 0.089 intervention receiving treatment) and the mixed logit models (0.156, control; 0.118, intervention all; 0.089 intervention receiving treatment) showed comparable goodness of fit in each group. Results follow what already presented with the conditional logit. When moving from the preferred current situation, respondents in the *control* and *intervention all* groups are willing to choose an alternative 'GP only' scenario to the 'CP&GP collaboration' review. When *still receiving the service*, a movement from the preferred current Medman service is more likely to see a preferred alternative CP&GP collaboration to the GP only alternative.

Marginal rates of substitutions when considering a movement from the preferred current to an alternative GP only scenario or CP&GP collaboration, receiving advice for medicines, replies to questions, a movement from a very poor chance to a very good chance of receiving an appropriate treatment are presented in Tables 2, 3 and 4. MRSs are comparable to conditional logit approach across groups (*control, intervention all, intervention receiving the service, respectively*). For example, when moving from a 'very poor' to a 'very high' chance of receiving 'best' treatment respondents were willing to pay: £29, £32 and £39 (mixed logit model); £30, £32 and £38 (Conditional logit basic model) .

5. Comments

Sensitivity analysis on alternative modelling structures confirms that respondent's welfare gains are sensitive to the model adopted (Tinelli M, Ryan M, Odejar M 2005 (2)). More specifically, adopting the conditional logit or mixed models indicated that respondents from all groups preferred their current situation to any alternative service, where their current could change across groups ('GP only review' for control; either 'GP only review' or 'CP&GP collaboration' for intervention all; 'CP&GP collaboration' for intervention receiving the service). These results suggest a common finding in health care, the status quo bias, with subjects preferring their current situation to any other alternative. The 'CP&GP collaboration' was then preferred to an alternative GP only system.

In *control* and *intervention all* the same preferences were likely to be presented by NLM_1 (their selected model), where at first respondents preferred the current to the nest including any change to their current (alternative 'GP only review' or 'CP&GP collaboration' service). If moving from their current, they then preferred the 'CP&GP collaboration' to an alternative 'GP only review'. In contrast, NLM B_3 (selected model for *intervention receiving service*) found the innovative collaboration service (current and alternative) preferred to the GP only option.

Econometric measures of goodness of fit guided in selecting the most appropriate model. The Hausman test and IV parameters led to the rejection of the conditional logit when compared with more general nested logit model. When comparing the nested models to define the most appropriate, different nesting structures applied to different groups. The *control* and *intervention all* were better described using $NLM_{1,}$ where the 'CP&GP

collaboration' was closer substitute to the 'GP only' alternative rather than the current scenario. The *intervention receiving the service* was better described using NLM_3, where the 'CP&GP collaboration' (current and alternative) were closer substitutes than the 'GP only' alternative.

The conditional logit and the more general mixed logit model presented comparable goodness of fit. This resulted invariant for each groups. They presented comparable MRSs across groups. The inclusion of socioeconomics in the conditional logit model resulted in a slight variation of the WTP estimates. Either models showed that when experiencing the new service responders are: less worse off for the movement from the preferred current to an innovative 'review by GP and pharmacist'; they are more reluctant to choose an alternative 'GP only review' to their preferred current; they value more moving from a 'very poor' to a 'very high' chance of receiving 'best' treatment, receiving advice on their medicines or replies. The preferred NLM1 (*control* and *intervention all*) presented comparable estimates to the conditional logit and mixed logit estimates, while the preferred NLM3 (*intervention receiving the service*) showed decreased WTP estimates. When comparing preferred nested models across groups (NLM1 *control* and *intervention all* vs NLM3 *intervention receiving the service*) MRSs are generally decreasing. NL approach is likely to present different direction in the results compared to the conditional and mixed logit models when comparing responders with no experience to the ones having experience of the service.

Future work needs to calculate welfare estimates for moving from the current to alternative scenarios ('GP and CP collaboration' or 'GP only review') across the different models. The calculation of MRSs and then welfare estimates in mixed logit models needs to be addressed when a ratio between random attributes is considered. It would be also interesting to compare results with other highly flexible approaches such latent class model, and add individual-specific conditional MRSs estimates to the sensitivity analysis (Hynes and Hanley, 2006). Another interesting area for future research is to include income effects into the modelling (Morey et al, 2003).

Acknowledgments

The authors acknowledge Maria Odejar for all her help in defining and testing the models on previous datasets.

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