Valuing a Change in the Management of Australia's Biological Collections: A Conceptual Framework and Empirical Application

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Abstract

Biological collections maybe underutilised because of transaction costs incurred in their use. One way to reduce transaction costs and hence foster greater utilisation of biological collections that could benefit society is through the creation of a virtual central repository of biological collections. The objectives of this paper are twofold: (i) to develop a framework for the valuation of the impacts of a virtual central repository of biological collections; and, (ii) to estimate the benefits of that policy change using a discrete choice Contingent Valuation Method (CVM) survey of the primary users of biological collections. Marginal willingness to pay (WTP) for access to a new central database linking collections around the nation was investigated through an annual subscription user fee payment vehicle. The mean WTP of direct users of the proposed program (direct-use values) was between AUD 232 and AUD 326 per annum. Data on the expenditures incurred by the survey respondents in their current usage of biological collections support the CVM estimates obtained. These findings are useful for resource allocation decisions regarding biological collections.

Key words: *Value, biological collections, transaction costs, contingent valuation method.*

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1. INTRODUCTION

Biological collections include materials such as living (e.g. botanic gardens), nascent (e.g. seed banks, microbes), components (e.g. DNA banks, chemical extracts) and preserved collections (e.g. plant, and zoological specimens) in research institutes, museums and herbaria (Day *et al*., 2004). Biological collections generate benefits to society in areas as divergent as biosecurity, public health and safety, monitoring of environmental change, and traditional taxonomy and systematics (Suarez and Tsutsui, 2004). However, these resources may not be optimally utilised by the private sector because of transaction costs incurred in their use (Bennett and Gillespie, 2008). Furthermore, it is argued that the benefits provided by the collections are often undervalued by policymakers, resulting in insufficient resources being allocated for their management (Whiting and Associates, 1995; Gruere *et al*., 2006).

The existence of transaction costs represents a blockage to the formation of markets to supply biological collections. If government intervention can be instituted that reduces transaction costs to the level where net gains to society can be demonstrated, then the intervention would be justified. One of the potential ways for the government to lower transaction costs and hence foster greater utilisation of biological collections that could generate net benefits to society is through the establishment of a National Bioresource Centre (NBRC) (Bennett and Gillespie, 2008).[2] The development of a central repository (or virtual network) of biological collections within Australia would reduce transaction costs along the biotechnology value chain, thereby allowing the primary users of biological collections to utilise those resources more effectively. The objectives of this paper are thus twofold: (i) to develop a conceptual

[2] The concept of Biological Resource Centres (BRC) was formally launched by the Organisation for Economic Cooperation and Development (OECD) in 1999. According to the OECD definition (Clement *et al*., 2009), BRCs are part of the infrastructure in biotechnology which act as repositories of and providers of biological materials and their derivatives, e.g. nucleic acids and proteins, as well as data bases containing molecular, physiological and structural information relevant to these collections and related bioinformatics for research purpose. BRCs provide greater access to biological resources within the framework of national laws, regulation and policies, and international agreements.

framework for the valuation and analysis of the impacts of policy options associated with the management of Australia's biological collections as research and social infrastructure; (ii) to conduct an empirical study to estimate the value of a potential policy change related to the establishment of a virtual repository of biological collections.

This paper seeks to identify economic models which can be used to uncover the range of potential values of biological collections. Most existing economic models of bioprospecting have proved difficult to apply empirically due to data limitations (USDA, 2005), however some papers provide useful hints about the value of bioresource collections (Evenson and Gollin, 1997; Pardey *et al*., 2001, 2004).[3] In this study, a number of valuation methods could be applied to estimate the value types associated with biological collections. Figure 1 gives the range of potential valuation methods.

The Contingent Valuation Method (CVM) is a survey tool for valuing non-market goods, in which the user is asked how much they would be willing to pay (WTP) for an environmental good or service (Mitchell and Carson, 1989). The CVM has emerged as one of the primary tools for modelling and understanding WTP for scientific, cultural and heritage goods.[4] Most previous studies have attempted the estimation of scientific and cultural heritage values by asking respondents their WTP in the form of taxes or donations. Noonan (2003), Throsby (2003) and Provins *et al*. (2007) give a detailed methodological account of the use of the CVM to value cultural goods. In addition to the CVM, there is a growing pool of studies

[3] Evenson and Gollin (1997) estimated the likely benefits of additional accessions to the rice collection maintained by the International Network for the Genetic Evaluation of Rice. They estimated the present value of benefits (discounted at 10% over a 20 year period) to be US$325 million. Pardey *et al*. (2001, 2004) estimated the marginal costs of adding virtual accessions to the *ex situ* gene bank for wheat and maize collections at the International Maize and Wheat Improvement Centre (CIMMYT). Although the authors did not estimate the expected values of benefits for the additional collections, they showed that the cost of additional wheat collections was so low that the expected benefits would always outweigh this cost.

[4] There is a significant volume of CVM literature on scientific, cultural and heritage goods (e.g. Willis, 1994; Beltran and Rojas, 1996; Lockwood *et al*., 1996; Hansen, 1997; Chambers *et al*., 1998; Santagata and Signorello, 2000; Maddison and Mourato, 2001; Pollicino and Maddison, 2001; Tohmo, 2004; Salazar and Marques, 2005; Provins *et al*., 2008; Plaza, 2010).

applying the Choice Modelling (CM) approach to valuing components of archaeological and cultural heritage sites (e.g. Kinghorn and Willis, 2008; Choi *et al*., 2010).

Despite their inherent conceptual limitations, a few other studies have used the ‘expenditure’ or ‘replacement cost’ approaches to estimate benefits derived from biological resources (OECD, 2002). Whiting and Associates (1995) estimated the social and economic value of scientific collections in Canada using the past expenditures approach. The analysis resulted in average annual capitalised values of about $14 million for the fish collection and $3 million for the bark beetle collection. Another similar study of biological collections in the US estimated economic values of museum collections for research and society using the method of ‘avoided costs’ (Suarez and Tsutsui, 2004). They estimated that the National Museum of Entomology Collections generated benefits in excess of US$1 million in 2002. The replacement cost method has also been used to estimate the value of ecosystem services (Costanza *et al*., 1997). However, since cost-based methods use ‘costs’ as a proxy to estimate ‘benefits’, they do not provide a correct measure of economic value, as costs need bear no direct relationship to WTP (McIntosh *et al*., 2009). Using costs as a measure of benefits will always give a benefit-cost ratio close to unity, and the method cannot give guidance on the efficiency of investing resources in the management of biological collections.

In this study, the policy option being evaluated is the creation of a central database of national biological collections, to be available online. Given this single policy dimension, the CVM is the most appropriate means of estimating the potential value of the policy change (Hanley *et al*., 2001). Accordingly, a CVM survey was conducted for the primary users of biological collections. Australia’s biological collections are used both domestically and internationally. We excluded international users from this study on the basis of the investment being made by Australian tax payers. A detailed list of current users of Australian biological collections was obtained from the Atlas of Living Australia and related databases (Tann *et al*., 2008).

This paper adds to the pool of studies that estimate the values of biological resources using the CVM by applying the method to a different type of good for which they have previously not been applied. Compared to previous CVM studies, the user of the good to be valued is a firm, institution, department or organisation, as opposed to an individual person. The results from this paper are designed to help provide direction for an improved contribution of biological collections to knowledge development and innovation. The rest of the paper is structured into the following sections. The next section constructs a conceptual framework for the valuation of the impacts of instituting a virtual repository of Australia's biological collections. Section 3 describes the value estimation methodology used and the survey instrument developed for the study. The results are reported and discussed in Section 4. Section 5 gives a synthesis of the results and concludes the paper.

2. Sources of Value in Biological Collections-A Conceptual Framework

Biological collections can be defined as species having a distinctive past, current or potential use value. It is argued that their use is currently limited relative to their economic potential (Gruere *et al*., 2006) largely because of high transaction costs and the lack of scientific knowledge of the species involved (Bennett and Gillespie, 2008). 'Underutilisation' translates into 'undervaluation' in economic terms as biological collections can have a lower observed (or expressed) value relative to their potential value. A question then arises as to why biological collections have an unrealised economic value? To examine this argument, first, one would need to identify the sources of economic value in biological collections, and then, based on this characterisation, identify the factors that cause thecollections to be underutilised. The framework used in this paper follows the definition of Total Economic Value (TEV) (Pearce and Turner, 1990); by which there are several types of value that could be associated with biological collections. Figure 1 divides the TEV of biological collections into use and non-use categories and subdivides them into separate motivation-based values (direct use value; indirect use value; option value; and non-use value). It has been argued that biological collections mainly provide indirect use values by supplying the foundation for scientific, educational, commercial, non-commercial, environmental and natural resource-related work (e.g. Gruere *et al*., 2006). The collections themselves are however somewhat removed both geographically and temporally from the benefits that arise from their existence (Whiting and Associates, 1995, p.3).

Economics is anthropocentric: all sources of ‘economic value’ originate from human kind as use values and non-use values (Fig. 1). There are two ways in which the value of a biological collection can be established. First, users of a biological collection value its provision of goods and services. The value of a biological collection is revealed by its sustained use. Secondly, some non-users of the species may also value it without any contact (Blamey and Bennett, 2001). For example, researchers may value its current or potential properties to produce useful goods (e.g. pharmaceutical drugs) or to provide services (e.g. basic research on genetic resources, selection for pest resistance, etc). Other non-users may simply value its existence and the fact that it is not extinct and continues to contribute to biodiversity.[5] In economic terms, the social benefit of maintaining (or not destroying) a biological collection is

[5] Biological collections may have economic value even if they are not currently being used. By preserving such resources, we retain the option to use them into the future, when they may become important for agricultural, pharmaceutical, ecological or industrial application, even if we do not currently know exactly what those applications are (Kaplan, 1998). Even if they are never used, biological collections maybe valued by some individuals simply for their existence or as a bequest left intact to future generations (Barbier *et al*., 1995).

equal to the private benefits of its users and the positive externalities associated with this use (Gruere *et al*., 2006).

In a perfectly competitive market, no biological collection would be considered to be underutilised because its use would be reflected in its market value.. However, biological collections may be underutilised as a consequence of inadequacies in the structure and operation of actual markets for those collections. Hence, some collections may be underutilised from the viewpoint of the social optimum, such that their value is not fully realised in market transactions. Perfect competition and full appropriation of value in a market requires that all economic agents have complete information and both private and public sources of value are reflected in the market price. Under these conditions, the use of the biological resource would reflect its social value. However, this state of the world does not exist due to various constraints which cannot be exhausted in this paper. We briefly outline some of these factors.

Consider a situation where the users of a biological collection cannot access a market for their products, then the market is said to be ‘missing’. This may result from the presence of high transaction costs which arise because of imperfect information. This problem is not unique to biological collections; transaction costs can curtail trade in any type of good. Transaction costs are legitimate costs of exchange that do not necessarily mean there is some form of ‘market failure’. Rather, the issue for biological collection provision is whether or not the transaction costs can be influenced by public policies that provide overall gains in net social well-being. This is not just the case for ‘missing markets’. There may be an established market for a biological collection but provision of services through that market may be suboptimal due to transaction costs that could be lowered through public policy.. In this case, the market price does not reflect the full value of the good or consumers' WTP and the quantity produced does not represent the optimal level of use or productive capacity of the biological resource. Weak demand for and supply of the service comes from the transaction costs caused by incomplete or asymmetric information among market actors (Giuliani, 2006). High transaction costs for collections can also come about because of the public good nature of some of the services they provide. Here the prohibitive transaction costs arise because of the difficulties of excluding from use those who have not paid for provision (the 'free-rider' problem). It is a well-known result that in the presence of public goods- and their associated high transaction costs - , profit maximising agents will not voluntary contribute to support its use at the socially optimum level (Laffont, 1998).

The question then is if the government can install policies such that the market barriers presented by transaction costs can be reduced at a cost less than the efficiency benefits generated by the trade that would result? One such policy initiative is the creation of a central repository of biological collections, available online. A theoretical example is provided to demonstrate this hypothesis. Figure 2 describes a simplified economic model for a biological collection. The supply curve *S1* is the marginal social cost curve with transaction costs embedded. It represents the marginal costs of getting the products supplied by biological collections to the market. That includes production and transaction costs. *D* represents the demand for products derived from biological collections, and also includes the transaction costs faced by the buyer. Consumer Surplus (*CS*) is the area P_1CA, and Producer Surplus (*PS*) is the area P_1CB.[6] In this scenario, *Q1* (where *S1* is equal to *D1* and is the equilibrium in the market without government intervention) underutilises because it is less than the equilibrium level (i.e.*the point of equality between D2and S2 where policy has been implemented to lower*

[6] Consumer surplus is the difference between what a consumer would be willing to pay and what he does pay to consume a given quantity of the product while producer surplus is the diference between the revenue received for supplying a given quanitity and total payments needed to supply it (Boardman *et al*., 2006).

the transaction costs of both buyers and sellers). If transaction costs of producers are lowered through establishing a virtual database of collections, then marginal costs are lowered and the supply curve shifts to the right to *S2*. The vertical difference between the new and old supply curves is the extent of the change in transaction costs (Fig. 2). Consequently, price will fall and quantity will increase as indicated in Fig. 2. CS is now the area P_2ED, and PS is the area P_2EF. Consumers are made better off as CS increases ($P_2ED > P_1CA$). PS has also increased (P_2EF *is larger than* P_1CB).[7] The question for policy makers is whether or not the cost of securing the transaction cost reductions (i.e the cost of setting up the virtual database of biological collection) is smaller than the gains to producers and consumers. Only if the change in CS (i.e. P_2ED-P_1CA) as estimated by the CVM application is greater than the costs to taxpayers of the virtual collection will it be socially worthwhile.

3. METHODS

3.1 Contingent Valuation Method

A discrete choice (DC) CVM format is used to assess WTP of the primary users for a new central database of biological collections, to be available online. The DC CVM requires respondents to accept or reject a proposal. In a typical DC CVM question, a respondent is asked whether he or she would vote in favour of a government policy or a new product or service (e.g. central database of biological collections) given a specified cost to be borne by themselves. In choosing wether to answer ‘yes’ or ‘no’ to the DC question, it is assumed, based on utility maximisation, that respondents will choose options that are likely to offer more utility. Consider a situation where the respondent is offered an increase in the good (from Q0 to Q1) at an additional cost (c), the respondent will reply with a ‘yes’ only if his/ her utility level in the presence of the proposed change and cost exceeds the utility level in its

[7] The change in PS depends on the extent of the cost saving relative to the price fall. If demand is elastic, price will not fall by much so it is likely that PS will rise too.

absence (Haab and McConnell, 2002). The generalised model specified in Eq. (1) guides the identification of variables for empirical analysis. More details can be found in Haab and McConnell (2002).

$$yes \rightarrow U(x,1,m-t) \geq U(x,0,m) \qquad (1)$$

The proposed payment vehicle for the contingent valuation question in this survey is an 'annual subscription user fee', rather than as a one-time lump sum payment. Our analysis only considers annual payments because it was assumed that a continuous service will be needed (which cannot be purchased and paid for in a single lump sum payment).[8]

A standard DC CVM questionnaire with 17 questions was developed. Face-to-face interviews offer the most scope for detailed questions but are costly. They were also ruled out in this study because the primary users of biological collections are geographically widely dispersed so that it would not be possible to reach a large number of users within the timeframe of the project. In light of these conditions, an internet-based survey format was used to implement the CVM. A number of pre-tests were conducted with institutions currently using biological collections in order to check for clarity of the questions and to establish the range of the bid amounts used for the DC question. The questionnaire was revised accordingly before it was administered in the actual survey. Email invitations were sent out to 300 potential respondents drawn from existing databases of biological collection users (e.g. Atlas of Living Australia, Australian Wildlife Collections, and National Entomology Collections).

The questionnaire consisted of two CVM questions one in the DC format with a follow-up open-ended style question to establish maximum WTP. These followed a number of questions about the respondent's use of collections. The study used seven different dollar cost

[8] CVM studies use different payment vehicles depending on the nature of good or service being evaluated. Monthly payments, yearly payments, per use/visit payments, and lump sum are among the typical payment vehicles. It has been shown that lump sum payments and annual payments yield the same WTP values (e.g.Kahneman and Knetsch, 1992).

amounts (AUD50, 100, 150, 200, 250, 300, 400 per annum), of which one was randomly assigned to each respondent. The DC format was preferred because it is incentive compatible; it is an easy question for the respondent to answer, it is similar to how a real market works and it is also an easy question to use in an internet survey, with no apparent loss in reliability (Loomis, 1990; Hanley and Barbier, 2009). The text of the CVM question read as follows:

Suppose that the government were to invest funds to develop infrastructure (e.g. server, internet portals etc) to bring together all national biological collections into a central database, available online. This would result in lower search costs for collection users. However, it might require the introduction of a 'user fee' to maintain the new database in the long-term. Suppose that collection users were asked to contribute funds for this new central database of collections through user fees.

Q8. Would your department, organisation or institution be willing to pay an <u>annual</u> <u>subscription fee</u> of .. $\boxed{\$X}$ .... to purchase access to the new central database?

☐ **Yes→Q9.** ☐ **No.→Q9/Q10.**

Q9. What is the most that you would be prepared to pay every year, through a subscription fee, to purchase access to this new database? $_______________

The CVM scenario was followed by questions used to check respondents' understanding of the constructed scenario and to identify the motives for giving their answers (Venkatachalam *et al*., 2004). Additional questions were included in the survey to determine the users' experiences and perceptions of Australian biological collections, as well as expenditures associated with their use of Australian biological collections. The internet-based survey was conducted over a 4-month period from September 2010 through to December 2010. During this period, 300 primary users of Australian biological collections were invited to fill out the online survey. With a response rate of approximately 50% a total of 142 primary users of biological collections were surveyed.[9]

3.2 Descriptive Statistics

Figure 3 shows the identity of the responding primary users of biological collections in the survey. Respondents were queried about their reasons for using a collection. The main stated reasons for using a collection was for taxonomic identification, preparation of a book/journal article, research and teaching (Figure 4). The next question asked the respondents to identify the main problems encountered in using biological collections. A summary of the responses highlight the need for a central database of biological collections, to be available online (Figure 5). The respondents were also asked to rank the importance of biological collections to their current work. The results indicate that most of the respondents found that the collection was an important part in their research (Figure 6). In general, we can conclude that the contribution of biological collections was considered to be beneficial.

4. RESULTS AND DISCUSSIONS

4.1 Results from the Payment Principle Question

Following Bateman *et al*. (2002), a follow up valuation question was included to improve the statistical efficiency of the WTP estimates. If the response to this was a zero WTP, then the respondent was asked to indicate the main motivation for this choice. Overall, 85 respondents (60%), out of 142 indicated that they would be willing to contribute funds to the new central database of biological collections while 57 respondents (40%) answered negatively to the DC payment question (Table 1). The most important reason (44%) for not being willing to pay anything is that the use of the collections is uncertain or intermittent. The second important

[9] Inclusive of the pilot surveys, the total number of responses was 150 users.

motivation is that the government should cover the costs of setting up the database. Some respondents stated that they were not able to afford to pay for the new database or that they don't have to pay for access to other existing databases. The first two arguments reflect true zero WTP. However, the remaining arguments do not reflect a zero valuation of the proposed program but rather suggest a disapproval of the proposed payment vehicle. Dealing with such 'protest' zero bidders is a critical issue for CVM analyses. We used the strategy of counting them as real zero bids, which results in conservative estimates of the user's WTP (Santagata and Signorello, 2000).

4.2 WTP Estimation from the Single-Bounded DC Valuation Question

Table 1 summarises the basic dataset derived from the single-bounded DC valuation question for the survey sample. It shows the number of respondents who accepted and rejected each bid. The pattern of the responses indicates diminishing levels of support as the cost of the policy increases. When the pattern of responses for the DC model is well behaved as indicated in our dataset, the estimated mean WTP is not expected to be highly sensitive to the choice of the distribution for the unobserved random component of preferences or to the functional form of the preference function (Haab and McConnell, 2002). Table 1 shows the empirical distribution of 'no' responses to the WTP question to be monotonically increasing as the bid cost increases (i.e. a larger percentage of the respondents per bid price answered 'no' to higher bids). Based on the number of respondents who accepted the bids, the observed bid curve for the new central database of biological collections can be constructed (Figure 7).

The DC dataset presented in Table 1 was then analysed using a standard logit regression model to estimate the maximum WTP (Long and Freeze, 2006). The logit model assumes that in the population the latent true WTP variable follows a logistic distribution (Haab and McConnell, 2002). The logit model in this paper is specified as follows:

$$\ln\left(\frac{\Pr(yes)}{1-\Pr(yes)}\right) = \beta_0 - \beta_1 * c + \sum_{j=1} \beta_{2j} X_{2j} \tag{2}$$

where: c is the annual subscription user cost ($) the respondent was asked to pay; X is a vector of institutional related variables. The bid amount is expected to be negative while the coefficient on the size of the user is expected to be positive as larger firms are able to pay more. Table 2 gives the results of the best fitting logit equation. The model fit is adequate (with the rho-square value above 0.1) and the estimated coefficients have the expected signs and are statistically significant ($P \leq 0$) determinants of choice. The coefficient of the bid cost is negative and statistically significant ($P \leq 0.05$). The coefficient on the number of employees (used as a proxy for the size of the user) is positive and statistically significant ($P \leq 0.05$). Other variables were not significant and were dropped from the final model. Overall, the results indicate that the user's WTP for a new virtual repository of biological collections are highly sensitive to the cost of provision to the user. The relative probability of accepting the bid increases with the size of the firm or institution, as measured by the number of employees.

Welfare measures were then calculated from the resulting logit model by estimating the mean or median of the estimated WTP function. From the estimated logit equation, the mean WTP was calculated using the formula developed by Hanemann (1984) for a WTP distribution truncated at zero in the left hand side:

$$Mean\ WTP = \left(1/\beta_1 \right) \ln\left(1 + \exp(\beta_0)\right) \tag{3}$$

where: $\boldsymbol{\beta}_1$ is the slope of WTP function plotted against cost and $\boldsymbol{\beta}_0$ is the constant (Carson and Hanemann, 2006). The mean WTP and 95% confidence intervals are reported in Table 2. The users' mean WTP estimated by the CVM is approximately AUD 326 per year.

A lower-bound estimate of the mean was also calculated using the Turnbull estimator (Turnbull, 1976; Haab and McConnell, 2002). The lower-bound Turnbull WTP estimator imposes a monotonicity restriction and has become a popular WTP estimator for CVM practitioners using the DC format (Kristom, 1990; Santagata and Signorello, 2000). The Turnbull estimate can be calculated using Eq. (4):

$$E_{LB}(WTP) = \sum_{j=0}^{M*} c_j (F_{j+1}^*) \tag{4}$$

where: E_{LB} *(WTP)* is the lower-bound estimate, c_j is the annual subscription user fee, F_{j+1} is the percentage of respondents who stated they would not pay the price at *j+1*, and $M*$ is the maximum bid price. The value of the lower-bound estimate for the mean WTP can be determined as follows (Haab and McConnell, 2002):

$$V(E_{LB}(WTP)) = \sum_{j=0}^{M*} \frac{F_j^*(1-F_j^*)}{T_j}(c_j - c_{j-1})^2 \tag{5}$$

where: T_j is the total number of a given bid level offered to respondents. Using this approach, the lower-bound mean WTP for the new central database of biological collections is about AUD 232, which is lower than the mean WTP values from the logit model.

4.3 WTP Estimation from the Open-Ended Valuation Question

Table 3 presents summary statistics for the open-ended WTP question. The skewness and kurtosis measures reveal that WTP open-ended distribution is positively skewed and leptokurtic (kurtosis coeff. ≥3). The open-ended mean WTP (AUD 327) value is marginally smaller than the single-bounded DC mean value (AUD 363). The confidence intervals of the two estimates suggest there is no statistically significant difference between these two WTP estimates (Table 2, Table 3). However, there are a number of possible explanations for such disparity. One could simply be that the sample size was relatively small. Another reason maybe that answering an open-ended question is a more difficult task than the DC, as quantitative information is required (Hanley and Barbier, 2009). It is likely that the respondent will give lower values when cognitive difficulty and preference uncertainty are present. On the contrary, DC data may be affected by a certain degree of 'yea-saying' (Blamey *et al*., 1999). This phenomenon (i.e. 'yes' responses being given independent of the bid) can bias DC estimates of means upward. If we suppose that open-ended question can lead to individuals overstating their true WTP, then the argument of strategic bias is unlikely to apply here because the small open-ended WTP data rejects this hypothesis.

A particular anomaly can occur in CV surveys where the open-ended valuation question follows the DC question. This anomaly is the 'anchoring effect', whereby the open-ended WTP values are not independent of the bids that were randomly distributed among the respondents. Anchoring effect is a type of starting point bias. The presence of anchoring was tested empirically by regressing the open-ended WTP on the bid used in the previous stage of the questionnaire. This linear regression showed that the coefficient estimate of the bid price was not statistically different from zero (t-value=0.5). Inspection of the dataset further indicates that the percentage of cases in which the stated WTP was equal (censored) to the posed bid was 17% on average. Hence, our dataset does not appear to exhibit this anchoring problem.

4.4 Results from the Expenditure Approach

The survey asked respondents if they had incurred any expenditures associated with their use of biological collections. Results indicate that 40% of the respondents incurred various costs in using biological collections. These costs are reproduced in Table 4. The analysis indicates average annual expenditure values per user of approximately AUD 1,295 in 2010. Looking back over the 5-year period (2006-2010), there was an upward trend in expenditures on biological collections. A close examination of the figures further shows that the expenditure amounts incurred by the primary users of biological collections are of the same order of magnitude when compared to WTP values obtained using the CVM. Hence the expenditure figures appear to support the WTP values for a central database of biological collections. This result could simply be interpreted as respondents being WTP what they estimated to be their current expenditures, which is a form of anchoring whereby the respondents refer to the amount they would save if there was a virtual repository of biological collections.

However, it should be noted that the expenditures do not necessarily reflect the current and future benefits being derived from biological collections. This supposition can be illustrated using the simple model for biological collections (Fig. 2). After lowering transaction costs, area P_2ED represents consumer surplus, which is the benefits to the users of this biological collection. Area P_2EF is the producer surplus. Together the areas P_2ED+P_2EF represent the total economic benefit from introducing a virtual database of biological collections. By using the expenditure approach, we would simply multiply the new market price (P_2) times quantity (Q_2) to get the total expenditures for this biological collection. Total value would be represented by the area OP_2EQ_2. Now, if we compare the welfare triangles (P_2ED+P_2EF) with the rectangular area ($\mathrm{P}_2*\mathrm{Q}_2$), it becomes abundantly clear that there is no direct relationship between the two. The only way (P_2ED+P_2EF) would equal ($\mathrm{P}_2*\mathrm{Q}_2$) is by chance!

In other words, expenditures do not provide a theoretically correct measure of economic benefits. In technical economic terms, benefits are WTP values less the cost of using the collections. The WTP values obtained using the CVM are amounts above the cost users expect to pay in their use of the collections. Nonetheless, such approaches are widely used. A study by Whitting and Associates (1995) claimed that the amounts incurred by users of scientific collections indicate the 'perceived minimum values' in the collections. They argued that the collections are at least considered to be 'worth the expenses' incurred in their use.

5. CONCLUSIONS

The aim of this paper was to develop economic models to uncover the potential values associated with the creation of a virtual repository of biological collections. In general, biological collections do not lend themselves readily to traditional economic valuation. Traditional, market-based economic valuation methodology is not capable of capturing the values unique to biological collections. The CVM is a direct and straightforward non-market technique to measure the user's WTP for establishing a central repository of biological collections. This paper contributes to the pool of studies using the CVM to value benefits from biological resources by applying the method to a different type of good for which they have previously not been applied, and the user of the commodity in question is likely to be a firm, institution, or organisation, rather than an individual user as in most CVM papers. The DC format of the CVM was used and the mean WTP of direct users of the proposed program (i.e. direct use values) was between AUD 232 and AUD 363 per year. The results indicate that the user's attitudes toward payment for the new central database are sensitive to the cost of provision. Additionally, we found that the current expenditure figures incurred in using biological collections appear to support the WTP values obtained using the CVM. The CVM and expenditure estimates are of the same order of magnitude. This strongly suggests that respondents are WTP what they perceive to be their current expenditures on biological collections (which is a form of anchoring). The information derived from this study has important policy implications for the future management of biological collections. The creation of a central repository of biological collections within Australia should help reduce transaction costs along the biotechnology value chain, thereby allowing the public and private sectors to utilise more effectively the resources for research and development.

ACKNOWLEDGEMENT

This study was funded by the Australian Department of Sustainability, Environment, Water, Population and Communities (SEWPC).

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Table 1: Distribution of responses to the DC WTP question

Bids ($)		**Accepting the bids**		**Rejecting the bids**	
	No. of respond.	**No. of ‘yes’**	**% yes**	**No. of ‘no’**	**% no**
50	23	17	0.74	6	0.26
100	21	14	0.67	7	0.33
150	17	10	0.59	7	0.41
200	23	13	0.57	10	0.43
300	37	21	0.57	16	0.43
400	21	10	0.48	11	0.52
Total	142	85		57	

Note: Two neighbouring price bands have been merged together.

Table 2: Estimated Logit Model

Variables	Coefficients	Standard error	*t*-statistics
Bid Cost	-0.0030	0.0021	-2.41**
No. of Employees	0.0002	0.0001	2.19**
Constant	1.5787	0.5408	2.92**
Log-likelihood	-53.7122		
Chi-2 value	7.63		
No. of Obs.	89		
Mean WTP (AUD)	363.60		
95% Confidence Intervals (AUD)	138.24-386.05		

Legends: Note: ** $P \leq 0.05$; *** $P \leq 0.01$.

Table 3: Statistics of open-ended WTP question (AUD)

Statistics	**WTP ($)**
Mean WTP	327.55
Maximum	10,000
Minimum	0.00
Standard error	86.97
Skewness	7.22
Kurtosis	61.40
95% Confidence Intervals	155.60-499.50

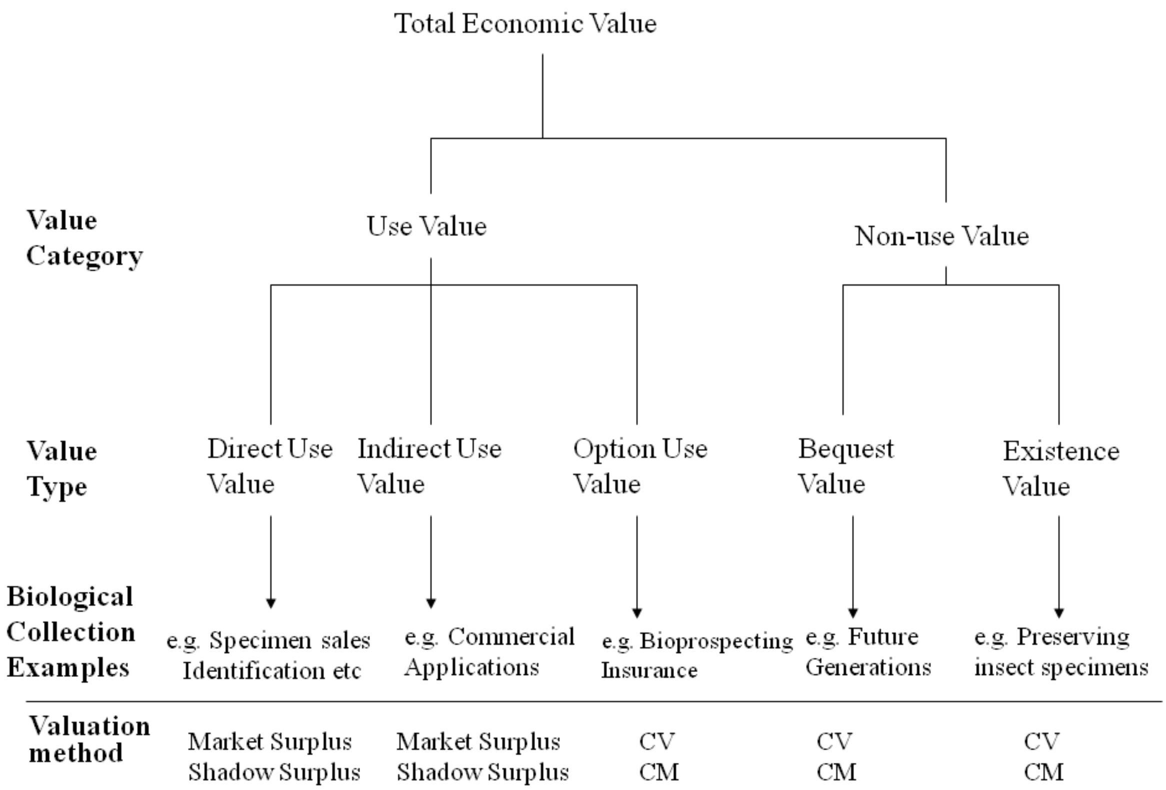
Note: statistics for the whole sample (N=141).

Table 4: Expenditures associated with the use of biological collections (AUD)

Items	2006	2007	2008	2009	2010
Charges for accessions	552	600	1,800	9,000	2,500
Transport costs	17,500	20,500	32,700	35,830	45,872
Other costs	1,800	3,925	5,280	6,280	22,825
Total expenditures	19,852	25,025	39,780	51,110	71,197
Average cost per user	361	455	723	929	1,295

Source: Survey of primary users

Figure 1: Total Economic Value (TEV) of a Biological Collection.



Source: Modified from Pearce and Turner (1990)

Figure 2: Demand and supply of biological collections

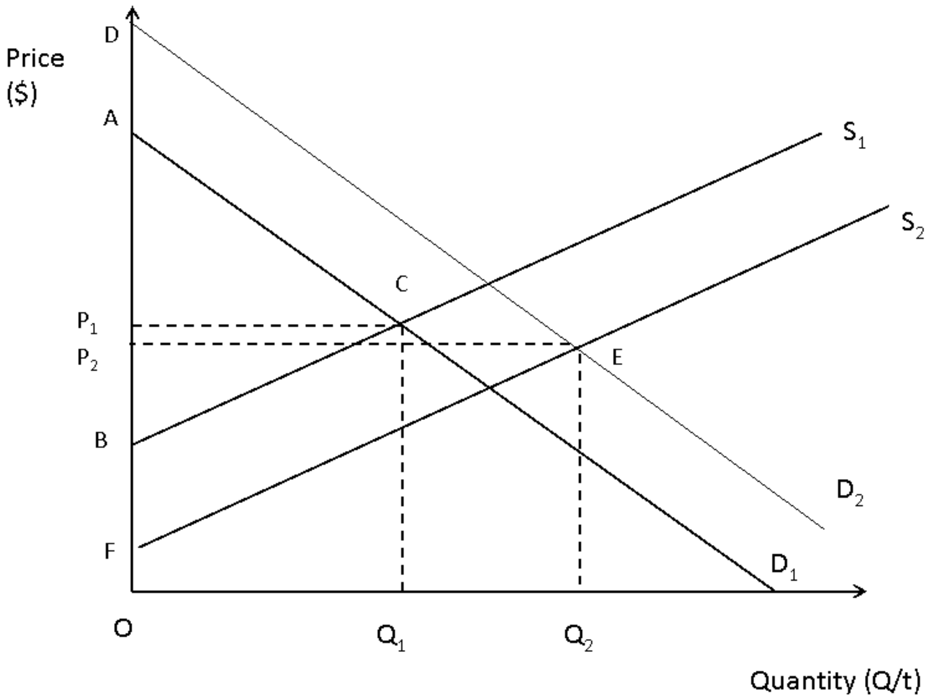


Figure 3: Responding primary users of biological collections

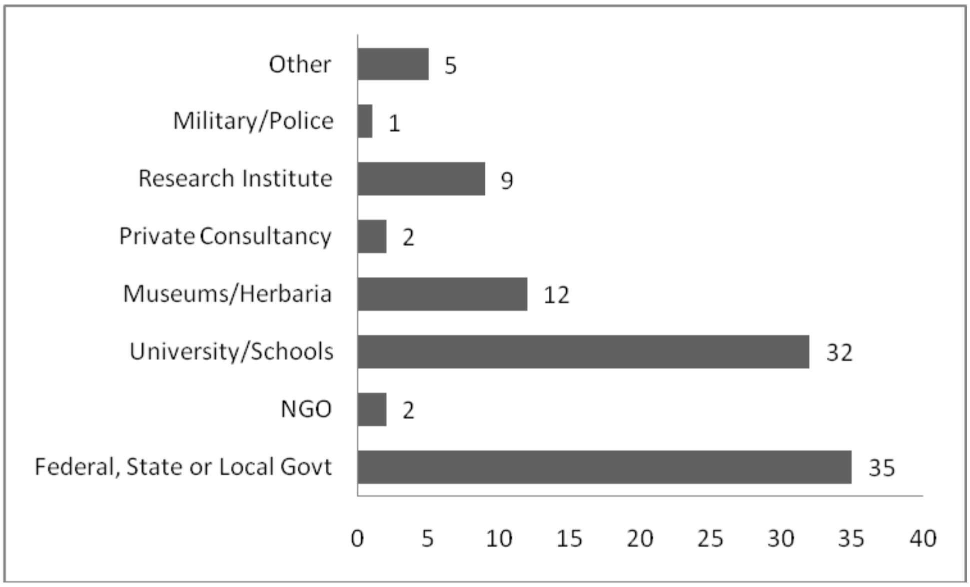


Figure 4: Main reasons for using a biological collection

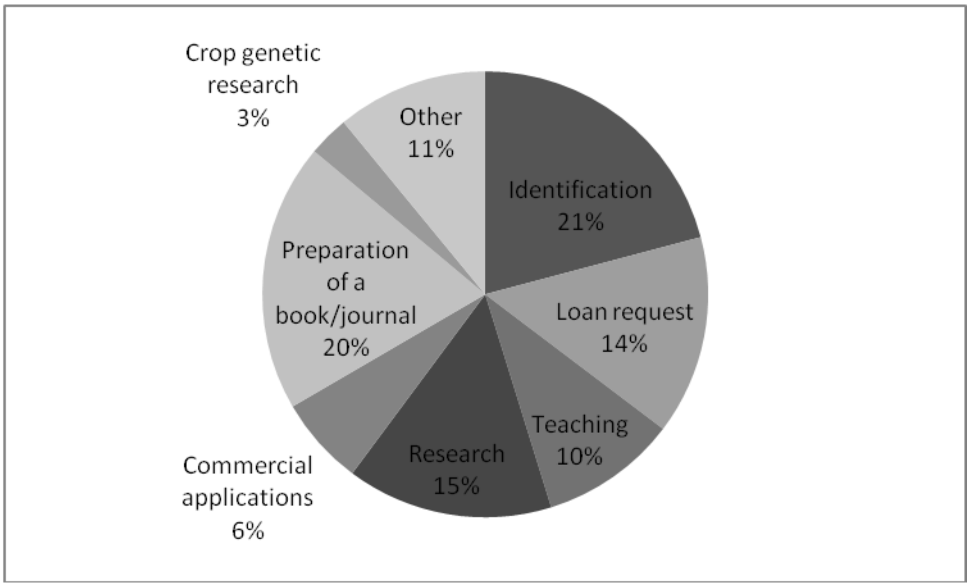


Figure 5: Problems of using Australian biological collections

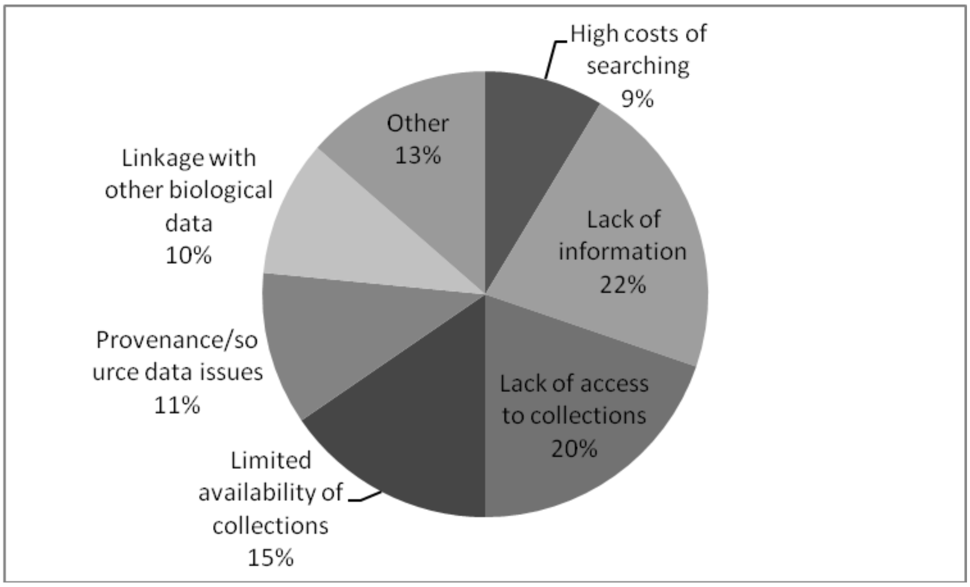


Figure 6: Importance of Biological Collections

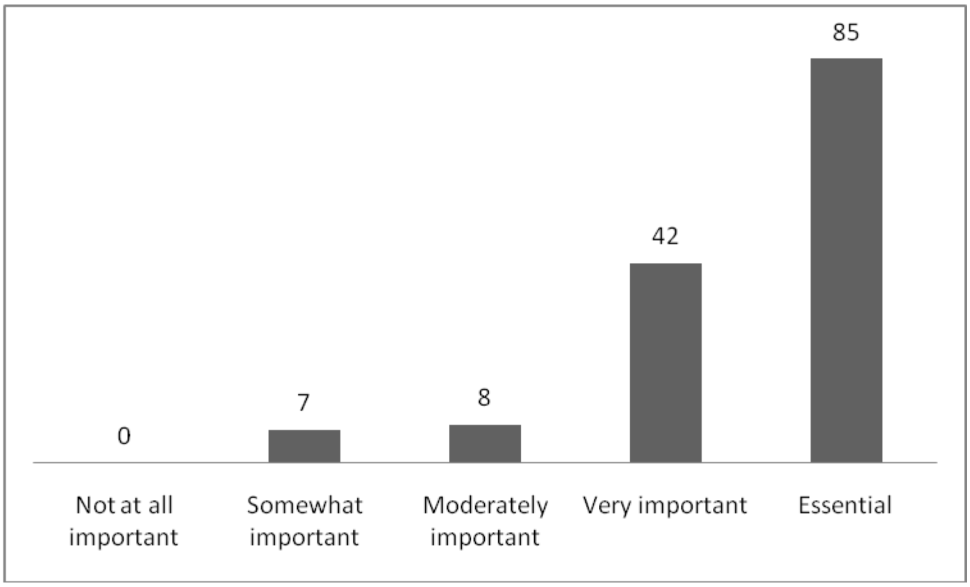


Figure 7: The observed bid curve for the new central database of biological collections