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Embedding Effects in Contingent Valuation

The term embedding has been popularized by Kahneman and Knetsch to describe a troublesome valuation phenomenon: willingness to pay for a good *z* may vary "over a wide range depending on whether the good is assessed on its own or embedded as part of a more inclusive package" [1991, p. 58]. Embedding means that the value of an item is smaller when it is offered late in a long sequence of items than when it is offered first or alone. Embedding also implies that the value of a package of items tends to be less than the sum of the values of each item when each item is valued alone.

Randall, Hoehn, and Tolley (1981) were first to report systematic embedding effects. Contingent values for air quality improvements at the Grand Canyon were smaller when evaluated as the third increment to a larger package of air quality improvements than when offered alone. They proposed a theoretical framework and empirical hypotheses than linked the so-called embedding effects to standard economic interactions involving substitution and budget constraints. This early economic analysis of substitution effects among non-market goods has been extended by Hoehn and Randall (1989), Hoehn (1991) and Madden (1991).

Kahneman and Knetsch (KK), in contrast, argue that embedding is inconsistent with a standard economic valuation model and is purely a phenomenon of contingent valuation. They reject the notion that either substitution effects or budget constraints are sufficiently strong to produce embedding. While they do not claim that embedding is a universal phenomenon in contingent valuation, they conclude from their empirical analysis that it is common enough to invalidate the approach as an acceptable method of economic valuation.

The KK argument is a loosely crafted compilation of conjectures rather than a tightly knit deductive analysis. As a result, numerous counter arguments may be raised. For instance, the empirical methods used by KK have come under heavy and telling criticism (e.g., Smith

1991). But empirical methods are not relevant to our present concerns. We are prepared to concede that at least some of the phenomena grouped under the rubric of embedding effects are empirically robust. Better empirical methods may well modify (perhaps substantially) some of KK's empirical results, but they will not make embedding effects disappear.

Our objective is to consider KK's core claims: (a) that embedding effects are uniquely a contingent valuation phenomenon and (b) that a valuation method that exhibits embedding effects if *ipso facto* invalid. To clarify this argument, we expose it as a syllogism:

Premise 1: A valid measurement device (procedure, etc.) produces value observations that are invariant to irrelevant side-conditions.

Premise 2: Estimates of economic value generated via CVM vary with the structure of embedding.

Conclusion: CVM is not a valid measurement device.

Premise 1 simply defines a valid measurement device. Premise 2 apparently summarizes KK's empirical results. However, it is immediately clear that these two premises are insufficient to generate KK's conclusion. An additional premise is required. The most direct form for such a premise would be:

Premise 3a: The structure of embedding is an irrelevant side-condition in determining economic values.

Alternatively, we could drop Premise 3a and substitute premise 3b:

Premise 3b: The observed responsiveness of CVM generated economic values to the structure of embedding is an artifact of the CVM itself (and not a property of the economic values that are being measured).

In this paper, we begin by examining Premises 3a and 3b. First, we examine 3a and consider whether economic values really are invariant to the structure of embedding. Both economic theory and empirical evidence from estimated demand systems for marketed goods reject Premise 3a. We conclude that the magnitude of economic values is not invariant to the structure of embedding.

Second, we examine the validity of Premise 3b. Part of our work is already done: since embedding phenomena apply to economic values in general, they cannot be entirely an artifact of CVM. We proceed, however, to inquire whether the CVM procedure is likely to affect or exacerbate the magnitude of CVM observed embedding effects. To do this, we first extend our model of CVM respondent behavior (Hoehn and Randall 1987), to address the structure of embedding. Then, we infer an alternative KK model of CVM respondent behavior under embedding.[2] We derive predictions of the direction of any bias that CVM may induce from both models. Both models predict that single-item values will fall as the level of embedding increases, at least as rapidly for CVM generated values as for the underlying values. But, for single item unembedded, the Hoehn-Randall model predicts CVM values equal to or less than the underlying values, while the rationally-reconstructed KK model predicts CVM values greater than the underlying values. Since the models are contradictory on this point, we examine the empirical record for clues as to which model is supported by the data.

[2]KK do not develop a coherent model of CVM respondent behavior. They appear intent upon building a case that CVM values are arbitrary, and such a model would not advance their purposes. Our task was one of rational reconstruction: to construct a model from clearly stated behavioral premises that is consistent with their interpretation of the empirical evidence.

Third, we address the KK claim that the choice of embedding structure for welfare estimation is arbitrary. To the contrary, we argue, there are sound bases for determining the embedding structure appropriate for certain kinds of policy purposes, including natural resource damage assessment. We end by discussing the implications for our analysis for natural resource damage assessment.

Economic Values of Embedding

It is a fundamental economic principle that economic prices and values are not fixed points. Rather, they are conditional. Economists argue that this conditionality is the great virtue of price: it adjusts rapidly in response to changes in conditions, providing incentives that tend to reallocate resources and ration consumption so as to restore efficiency.

So, stability in the face of changing conditions is not a property that one would expect of prices and economic values. Any theory of measurement of economic values must come to terms with the fundamental conditionality of price and economic value.

In this section, our objective is to determine whether the level of embedding -- the package of other goods and services offered along with, or prior to, the item of interest -- is one of the conditions to which economic values (or prices and quantities taken, in the case of marketed goods) are responsive. We develop a conceptual argument that embedding is a general economic phenomenon. We then provide empirical evidence of embedding in ordinary private goods demands.

Resource scarcity is a basic principle of economics. Hoehn and Randall (1989) examine the impact of scarcity on the benefit cost evaluation of multi-component policy packages. Their focus is the economic benefit associated with a policy proposal or prospect. They describe a general economic model in which there are a large number of policy proposals under consideration at the same time. Each proposing agency or office views its own proposals as unique and evaluates each as if it were the next item on the policy agenda. The analysis is confined to proposals each of which is beneficial *if* it is implemented as the next policy increment to the existing agenda. However, given the large number of proposals, any one proposal is highly unlikely to be selected as the next incremental prospect when the number of prospects evaluated becomes large.

The Hoehn and Randall analysis shows that the value of an incremental program declines as the number of prospects becomes large. Scarcity limits the number of proposals that can be beneficially implemented. As the size of an agenda increases, the net benefits of a prospect may actually switch from positive to negative. This constitutes a general proof of the economic structure of embedding. Benefits of policy proposals are conditioned on scarcity. As the agenda of proposals grows large (effectively increasing scarcity), net benefits of incremental prospects decline.

Similar scarcity-induced effects occur at the level of household purchases and willingness to pay (Hoehn 1991). Household wealth places an upper bound on total willingness to pay. Since total willingness to pay is equal to the sum of the incremental valuations, this sum must be bounded by the household's wealth. Hence, the value of an incremental program must eventually decline as the number of proposals increases. If the incremental valuations did not decline, their sum would eventually exceed household wealth as the number of programs grows large enough.

As a practical matter, the upper bound on willingness to pay is likely to be much less than household wealth. Households typically are locked into long-term to be much less than household wealth. Households typically are locked into long-term agreements regarding expenditures for housing, schooling, and other capital goods. They also face cash-flow and liquidity constraints that prevent them from converting long-term wealth into current expenditures. Both of these effects imply that short-term discretionary income is a small fraction of household wealth. The greater scarcity of discretionary income relative to wealth means that incremental valuations decline more abruptly then one would expect based on consideration of wealth. Substantial declines may be expected after the consideration of a few programs.

The analyses of Hoehn and Randall (1989) and Hoehn (1991) lead to three empirical implications that characterize embedding as an economic phenomenon. These implications may be used to test the economic theory of embedding.

The first implication is that, while the total valuation of any package of prospective programs is unique, incremental valuations of specific prospects increase or decrease as their position in a sequence changes. The sum of the incremental valuations should yield the same total, regardless of the particular sequence of valuation.[3] This constancy of the total valuation distinguishes the economic hypothesis from the psychological alternatives.

The second implication is that, while embedding tends to reduce single-item willingness to pay, it tends to increase willingness to accept. Embedding is induced by substitution relationships among goods and services (Hoehn 1991): improvement in on environmental good or service diminishes what one is willing to pay for subsequent *improvements* in other goods or services. Willingness to accept compensation (WTA) is the correct welfare measure of deteriorations in environmental quality. For substitute goods or resources, WTA for good A increases as the available quantity of good B declines. To see this intuitively, an example may help. Consider the case of two recreation sites that are perfect substitutes. The household is absolutely indifferent between use of site A or site B and may use either site without any loss of well-being due to not using the other site. First, consider the household's WTA to accept the loss of A given that B remains available and uncontested. WTA is zero since the household would simply use site B with *no* loss of utility. Now, consider the household's WTA to accept

[3]Pei-Ing Wu (1991) reports an empirical test that corroborates this conceptual result.

the loss of A given that B is no longer available. WTA is now positive since the household would have neither site available and would therefore incur a loss of well-being. For substitutes, WTA increases as substitute goods deteriorate in quality or quantity.

The third implication is the equivalence of embedding for market and non-market goods: both market and non market goods valuations manifest the effects of embedding. There is little that theoretically distinguishes the valuation of market goods from the valuation of non-market goods. For non-market goods, typically we evaluate the welfare effects of changes in quantity and quality; for market goods we usually evaluate the welfare effects of price changes. Both types of valuation, however, involve the same preference concepts, optimization rules, and utility functions. There is another peculiar about the economic structure of valuation that would confine embedding effects to non-market goods.

Embedding Effects with Marketed Goods. The effects of embedding on market goods valuations are readily examined using ordinary market goods demands. Such demand systems are routinely estimated by economists who study household expenditures.

The present research used one such household demand system (Yen and Roe, 1989) to estimate embedding effects in welfare evaluation of a series of price changes for market goods. The system was estimated for households in the Dominican Republic and focused particular effort on estimating demands for 10 specific food groups such as legumes, cereals, and animal products. This particular demand system was selected for use because it was estimated in a manner consistent with economic theory, it encompassed all household expenditures, and parameter estimates were reported in detail (Yen, 1987).

We used this demand system as a starting point for simulating the impact of embedding in a well-specified, real-data, market demand system. Table 1 shows the impact of embedding on various welfare evaluations of a change in the price of rice.[4] The first five rows of the table describe WTA valuations for rice price increases ranging from 20 to 500 percent.

Embedding was examined by evaluating the rice price change as part of a sequence of changes in the price of each of the 10 food groups. For instance, the column labeled "First" gives the welfare effect of the rice price changes when they are evaluated first in a sequence of price changes. The column labeled "Second" gives the welfare effect of the rice price changes a similar change in the price of cereals. The third column gives welfare effects for rice when evaluated after price changes for cereals and sugar. The final column gives the welfare effects for rice when evaluated as tenth in a sequence of food price changes.

Table 1 demonstrates the key embedding effects. Incremental WTP valuations decline as they are positioned further along in a sequence of valuation. For instance, the valuation of a 80 percent reduction in the price of rice declines from $RD 23.3 when evaluated first to $RD 14.8 when evaluated a tenth in a sequence of valuation--a decrease of 36 percent. The impact of embedding also becomes more pronounced the greater the price reduction. With a price decrease of 95 percent, the rice price valuation decreases by 55 percent as it is moved from first to tenth place in a sequence of valuation.

Table 1 also illustrates the different effects of embedding for WTP and WTA. While incremental WTP valuations decline with embedding, WTA valuations increase. For instance, the incremental valuation of a rice price change of 100 percent increases from $RD 14.0 when evaluated first to $RD 16.2 when evaluated as tenth in a sequence.

Table 1 demonstrates that embedding occurs in standard economic valuation problems. It illustrates the determinants of embedding: the size of an embedding effect depends on the size of the imposed price or quantity change, and the number of items that are evaluated prior to or simultaneously with the item of interest. This table also illustrates the directional effect of

[4]The appendix discusses the mathematical structure that underlies Table 1.

embedding: deep embedding reduces single-item WTP but increases single-item WTA. Furthermore, embedding is a routine economic phenomenon that may be observed with both market and non-market valuation. Premise 3a is decisively rejected.

Embedding in a Contingent Choice Context

We have demonstrated that embedding is a general economic phenomenon. the possibility remains, nevertheless, that something about the circumstances pertaining specifically to CVM may exacerbate embedding results. If so, embedding effects would be more pronounced in CVM data than in the underlying values we are attempting to measure.

We proceed by developing two alternative models of the value formulation process of a stylized CVM respondent.[5] The first model builds on the Hoehn-Randall (1987) model, while the second is a rational reconstruction of a value formulation process consistent with KK's interpretation of their empirical results. The empirical consequences of each are developed.

The Hoehn-Randall Model

Willingness to pay is the maximum amount a household is willing to give up in order to get an economic or environmental change. An optimization problem is implicit in the concept of willingness to pay. A respondent must find the *maximum* payment that leaves the household no worse off if the proposed policy change is implemented.

The search for the maximum payment requires a rearrangement of the household budget. A standard economic model assumes that an individual carries out the search for

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[5]Hoehn and Randall (1987) identify a value formulation process, in which the respondent seeks to discover her true valuation, and a value reporting process, where strategic considerations might enter in. H-R provide models in which the optimal strategic response is truthful reporting of the formulated value, and Mitchell and Carson (1989) report that there is little empirical support for the conjecture that CVM data sets exhibit strategic response. Accordingly, we concentrate here upon the value formation process.

maximum willingness to pay instantaneously. The respondent instantly grasps the issue at hand, rearranges household budgets, and offers the maximum payment.

It is unlikely that the instantaneous decision model adequately describes the capabilities of a typical respondent. Household expenditure patterns are complex and untidy. It seems more likely that decisions are less than ideal, that the optimal rebudgeting process in incomplete.

Hoehn and Randall (1987) adapt the mathematics of the standard model to describe an incomplete optimization process. The model has two premises. First, the search for maximum payment is incomplete. Second, respondents offer a payment that does not make them worse off if the proposed change is implemented.

Hoehn and Randall (1987) show that these two premises lead to an important conclusion for valuation: elicited willingness to pay is less than (or, at best, equal to) true willingness to pay. In addition, the effect of incomplete search of asymmetric for willingness to pay and willingness to accept: elicited willingness to accept *exceeds* (or is, at best, equal to) true willingness to accept.

Multi-stage budgeting may be consistent with an incomplete search process. Multi-stage budgeting is the formal development of the idea that all expenditures are variable in the long-run but many kinds of expenditures are fixed in the short-run. In formulating willingness to pay, multi-stage budgeting suggests that a respondent works through successive stages of rebudgeting and valuation. For example,

Stage 1: rebudgeting to determine WTP for a proposed environmental policy takes place within a short-run discretionary account that includes only environmental goods.

Stage 2: rebudgeting is confined to short-run discretionary expenditures but may occur across budget categories, e.g., environment, recreation and vacations, food, clothing, etc.

Stage 3: rebudgeting occurs across all short-term and longer-term accounts.

As a respondent moves though these rebudgeting stages, discretionary income and willingness to pay increase. At stage 1, a respondent works within the short-term budget constraint relevant to a category that includes environmental goods. At stage 2, a respondent may allocate budgets assigned to other categories to willingness to pay for environmental goods but there is at best incomplete reallocation of income across budget categories. At stage 3, rebudgeting optimizes budgets assigned to different categories and expenditures with each category.

Rebudgeting is unlikely to completely move through all three stages in a contingent valuation decision context. During a contingent valuation interview, a respondent has limited time and limited opportunity for making substitutions. It seems likely that the decision process is cut short somewhere near stage 1 and that willingness to pay is less than its ideal, maximum level.

The Yen and Roe demand system was used to simulate the effect of incomplete, multistage budgeting. The economic changes considered were across-the-board change sin the price of food. The rebudgeting problem was broken down into two stages. In the first stage, expenditures are rebudgeted only within the food category. Expenditures for clothing, housing, and other goods remain fixed. In the second stage, purchases are reallocated across all expenditure categories.

The results are given in Table 2 as the percentage difference between Stage 1 valuations (incomplete) and Stage 2 valuations (complete).[6] The first column of the table lists the price

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[6]The appendix details the mathematical structure of the simulation results.

changes considered. These include price reductions ranging from 20 to 95 percent and price increases ranging from 20 to 200 percent. Willingness to pay measures were calculated for price reductions and willingness to accept measures for price increases.

The second column of Table 2 lists percentage differences between Stage 1 and Stage 2 valuations when food expenditures account for 40 percent of a household's budget. For a 20 percent reduction in food prices, Stage 2 willingness to pay is about 5 percent higher than that of Stage 1. With a price reduction of 95 percent, the complete Stage 2 valuation is 39 percent larger.

The impact of multi-stage budgeting on willingness to accept is directionally opposite to its effect on willingness to pay. For a 20 percent increase in price, willingness to accept decreases by 4 percent as a respondent moves from Stage 1 through Stage 2. For a doubling of food prices, the stage 2 valuation is 15 percent less than the Stage 1 valuation.

The third and fourth columns report percentage differences between the Stage 1 and Stage 2 valuations for a case where the food budget is 10 and 1 percent, respectively, of overall household expenditures.

Table 2 illustrates two points. First, incomplete budgeting tends to reduce willingness to pay and increase willingness to accept from their fully optimal values. Second, the effect of incomplete budgeting is more pronounced the smaller the initial budget allocation to an expenditure category. For environmental goods, the respondent's initial direct expenditures are likely to be small and the impact of incomplete budgeting is likely to be large.

Incomplete optimization and multi-stage budgeting imply, first, that single-item or first-in-sequence WTP may be understated and, second, that the understatement of WTP may be exacerbated by deep embedding. As we have discussed above, embedding is a general economic phenomena. If, as we posit, CVM procedures are likely to induce incomplete optimization and multi-stage budgeting, elicited CVM values for WTP may start out too low and decrease too quickly as the level of embedding increases. For (the absolute value of) WTA, the CVM induced effects would be in the opposite direction.

A Rationally Reconstructed KK Model

KK claim that the embedding results demonstrate that CVM values are arbitrary. This claim seems to imply that they believe that some of the values obtained (presumably, the unembedded values) are "too high" while others (presumably, the deeply embedded values) are "too low."[7] Thus, without a principled method of determining the proper level of embedding, one is left without a clue about the proper value.

We begin the rational reconstruction of KK's argument by searching for a rational but suboptimal decision process that would generate overstatements of unembedded single-item WTP. Two processes suggest themselves: myopia (ignoring the budget constraint) and tunnel vision (incomplete search of the opportunity set).

Myopia. The respondent has a real budget constraint. If the CVM format has good incentive properties (Hoehn and Randall 1987), a rational respondent will treat her stated WTP as an expenditure that she would make if the offered policy is approved. On the other hand, a myopic respondent would either ignore her budget constraint, or assume WTP will never be paid even if the policy is approved, or both. A myopic respondent would overstate WTP for an unembedded single item.

Myopia may well be a pathology that occurs among a relatively few individuals. One suspects that not all of the caseload of credit counsellors, personal bankruptcy courts, etc., can be explained by unforeseeable misfortune. To be useful to KK, myopia must be more prevalent in the CVM setting than in ordinary markets. The growing body of empirical evidence

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[7]Alternative interpretations make no sense. If all of the values are "too high," deeply-embedded CVM-values would be not arbitrary but upper-bound estimates of true value. If all the values are "too low", unembedded CVM-values would be not arbitrary but lower-bound estimates of true value.

comparing CVM values with those generated by actual markets, experimental markets, actual referenda, and "revealed demand" methods such as the travel cost method and hedonic price analysis (hereafter called "comparison studies") provides no support for the conjecture that single-item CVM item values are systematically higher then the values estimated or observed by other methods. The evidence suggests that myopia is not particularly prevalent in the CVM setting.

Myopia -- failure to recognize the constrained nature of total budget or that expenditures from that budget may be influenced by one's stated WTP -- while it provides a reason why single-item unembedded CVM values may be "too high", provides no explanation for the basic embedding result: single-item values fall as the level of embedding increases. A myopic respondent does not consider how payment would affect her budget. So, why would not CVM values for single items remain high regardless of the level of embedding?

Tunnel vision. The respondent is assumed to allocate her budget across her opportunity set, considering all of the possibilities therein. A respondent with tunnel vision, however, conducts only an incomplete search of her opportunity set. If confronted with a "new" buying opportunity -- e.g., by advertising, by displays in shops, or by a CVM survey -- this incomplete search of alternatives would increase the probability that she would purchase "too much" of the highlighted market good or formulate WTP "too high" for the non-market good.

It may well be that tunnel vision plays some part in the real-life budget allocation processes of some consumers. Many of the activities undertaken in advertising and marketing seem designed to encourage tunnel vision while highlighting particular brand-name products. As with myopia, tunnel vision would serve KK's purpose only if they are prepared to conjecture that (for whatever reason) tunnel vision is more prevalent in the contingent valuation setting than in ordinary markets. Then the tunnel vision hypothesis would provide a reason why unembedded single-item CVM values may be "too high".

Now, introduce multi-stage budgeting with incomplete optimization. As it does in Hoehn-Randall model, this assumption leads to the prediction that single-item CVM values fall "too fast" as the level of embedding increases. Combining ***tunnel vision and multi-stage budgeting with incomplete optimization***, we would predict that single-item CVM values are "too high" when unembedded and fall "too fast" as the level of embedding increases.

Consider these assumptions we have invoked. Tunnel vision assumes an incomplete search of the opportunity set. Multi-stage budgeting with incomplete optimization assumes reallocation within but not beyond budget categories. These assumptions do not invoke irrationality; rather, they draw upon a well-established research program in incomplete rationality. Thus, we consider this model to be a rational reconstruction of the KK embedding argument. Furthermore, there is reason to believe that KK, themselves, may find our rational reconstruction congenial. They (especially Kahneman) have previously conjectured that CVM respondents may have "mental accounts" e.g., for environmental protection. While they have never provided a rigorous exposition of the "mental accounts" idea, it seems to suggest that CVM respondents spend "too much" of their mental account on the first item offered in a CVM survey and "too little" on subsequent items. Our notion of multi-stage budgeting with reallocation within categories but not among categories, combined with tunnel vision within budget categories, provides an account of the "mental accounts" idea that is consistent with incomplete rationality.

Comparing the Hoehn-Randall and KK Models

Embedding is a general economic phenomenon. Therefore, a single-item value falls as the level of embedding increases, as in the line labelled 1 (Figure 1). The H-R model of multi-stage budgeting with incomplete optimization in CVM predicts that single-item CVM values may understate true value in the absence of embedding, and may understate true value even more so with deep embedding (line 2, Figure 1). The rationally reconstructed KK model -- which adds tunnel vision to the H-R assumptions--predicts that single-item CVM values overstate true value in the absence of embedding, but understate true value in the case of deep embedding (line 3, Figure 1). We highlight some implications of comparing the H-R and KK models.:

1. Both models predict that CVM tends (if anything) to exacerbate the general economic phenomenon of embedding.

2. Both models base this prediction on incomplete rationality or, more precisely, a rational but incomplete decision process. It follows that improvements in design and execution of CVM would tend to reduce any tendency of CVM to exacerbate embedding, i.e., to reduce the slope of lines 2 and 3 toward the slope of line 1 (Figure 1).

Here, the criticisms of KK's empirical research procedures (Smith 1991) become relevant. KK found rather extreme embedding effects: single-item value fell by a factor of almost 10 in one case, when the item was deeply embedded. Weaknesses in KK's procedures may well account for some of this observed reduction in CVM value. Other researchers have reported much smaller effects from deep embedding.

The Schulze and MacClelland (1991) joint-production hypothesis is relevant here. They hypothesize that some observed embedding effects in CVM may be attributable to respondent perceptions that (purportedly independent) policy components are in fact jointly produced. For example, a *policy* to provide a single component (say, clean-up one lake) would be indistinguishable from a *policy* to provide a package of improvements (clean-up all the lakes in the region). In other words, respondents may reasonably believe that it is in the nature of water-quality-improvement policies that they are seldom targeted to individual lakes. Schulze and MacClelland have posited a special case of a more general problem: scenario rejection. This problem can be corrected by proper CVM design and execution. A research program to reduce any tendency of CVM to exacerbate embedding effects seems justified.

3. The Hoehn-Randall and KK models generate contradictory predictions in the case of unembedded single-item CVM values: HR predict CVM values ≤ true WTP; KK predict CVM values < true WTP. Comparison studies--comparing CVM values with evidence from actual markets, market experiments, actual referenda and non-market values generated via travel cost and hedonic methods--provide no systematic evidence to reject the HR conjecture that CVM values ≤ true WTP. We concede, however, that the empirical evidence on this point is less than conclusive. If conclusive evidence could be developed, it would provide a strong test of the HR and KK models.

4. These conceptual results severely damage Premise 3b. First, since embedding effects apply to economic values in general, they are surely not entirely an artifact of CVM. Second, we have specified conceptual models in which the CVM setting may exacerbate embedding effects. However, three points should be noted: these models merely permit but do not require CVM induced magnification of embedding; the consequences of these models are empirically testable hypotheses, so that one or both may be rejected upon testing; and the structure of these models suggest there is scope for reducing any tendency of CVM to exacerbate embedding effects.

5. With respect to the KK claim that CVM values for WTP to gain an environmental improvement are upper-bounded by true WTP for all levels of embedding; deep embedding at worst increases any tendency of CVM values to understate true WTP.

Implications for Natural Resource Damage Assessment

The KK assertion--empirical evidence of embedding effects demonstrates that CVM values are empirically arbitrary--is untenable.

The claim that CVM values are arbitrary for policy purposes requires first that item valuations depend on the level of embedding (which is true in general), and second that the appropriate level of embedding for policy analysis is itself arbitrary. To the contrary, the appropriate level of embedding for natural resource damage assessment is actually quite clear.

First, the question of the appropriate valuation conditions for policy analysis is *not* a special or unusually question that arises only in the particular cases of embedding and/or embedding in the context of CVM values. The fundamental conditionality of price and economic value means that policy analysts must always decide the appropriate conditions for valuation before proceeding with quantitative welfare evaluation.

Second, the embedding effect is relevant only to purchase and/or valuation decisions about *prospects*. An unembedded prospect is offered alone or first; a deeply embedded prospect is offered simultaneously with, or sequentially after, a host of other prospects. Natural resource damage assessment is not about prospects. It is about valuing damage that has already occurred. The appropriate embedding structure for damage assessment is *unembedded*.

Third, natural resource damage assessment logically requires estimates of WTA, not WTP. As we have demonstrated, the kinds of scarcity and substitution relationships that produce the standard embedding result (embedded WTP < unembedded WTP) imply that embedded WTA > unembedded WTA. Pragmatic researchers, upon encountering problems in estimating WTA in a damage assessment context, may choose to estimate WTP as an approximation for WTA. Some error is involved in this procedure, and a considerable literature is addressed to this error (Randall and Stoll 1980, Hanemann 1991). In general, WTP understates WTA. It would be thoroughly inappropriate to compound the understatement inherent in substituting WTP for WTA by substituting embedded WTP for WTA.

We have shown that embedding is a general economic phenomenon, and that any tendency of CVM to exacerbate embedding can be analyzed with explicit economic models that generate predictions amenable to empirical testing. Further, it follows from our analysis that CVM induced exacerbations of embedding effects can be reduced with sound research practice.

Finally, the appropriate level of embedding for natural resource demand assessment is not arbitrary but can indeed be deduced by reasoning. The appropriate level of embedding for damage assessment is *unembedded*.

Table 1. Effect of Embedding on the Welfare Evaluation of Rice Price Changes[a]

Value Measure	Price Index Change (%)	Welfare Effect of Price Change by Position in Sequence of Price Changes ($RD)			
		First	Second	Third	Tenth
WTP					
	-20	3.8	3.8	3.8	3.6
	-50	11.1	10.9	10.8	9.0
	-80	23.3	22.3	22.0	14.8
	-90	31.7	29.5	28.8	16.4
	-95	39.5	35.8	34.6	17.6
WTA					
	+20	-3.3	-3.3	-3.3	-3.5
	+50	-7.7	-7.8	-7.8	-8.4
	+100	-14.0	-14.2	-14.2	-16.2
	+200	-24.6	-24.9	-24.9	-30.5
	+500	-50.3	-50.6	-50.5	-68.9

[a]Demand system paramter estimates are from the market goods demands reported in Yen anbd Roe (1989). Initial household expenditure is $RD 224.

Table 2. The Effect of Incomplete Multi-Stage Budgeting on Willingness to Pay and Willingness to Accept[a]

		Percent Difference Between Stage 1 and Stage 2 Compensating Variations		
Value Measure	Price Index Change (%)	Budget A, 40% Food	Budget B, 10% Food	Budget C, 1% Food
WTP				
	-20	5	7	27
	-50	13	20	79
	-80	27	41	161
	-90	34	52	202
	-95	39	59	229
WTA				
	+20	-4	-6	-22
	+50	-9	-13	-50
	+100	-15	-22	-86
	+200	-23	-35	-136

[a]Demand system parameter estimates for budget A are from Yen and Roe (1989). To obtain budget B(C) parameters, the Yen and Roe estimates were adjusted so that 10(1) percent of initial income is spent on food. Initial expenditure in both cases is 224.

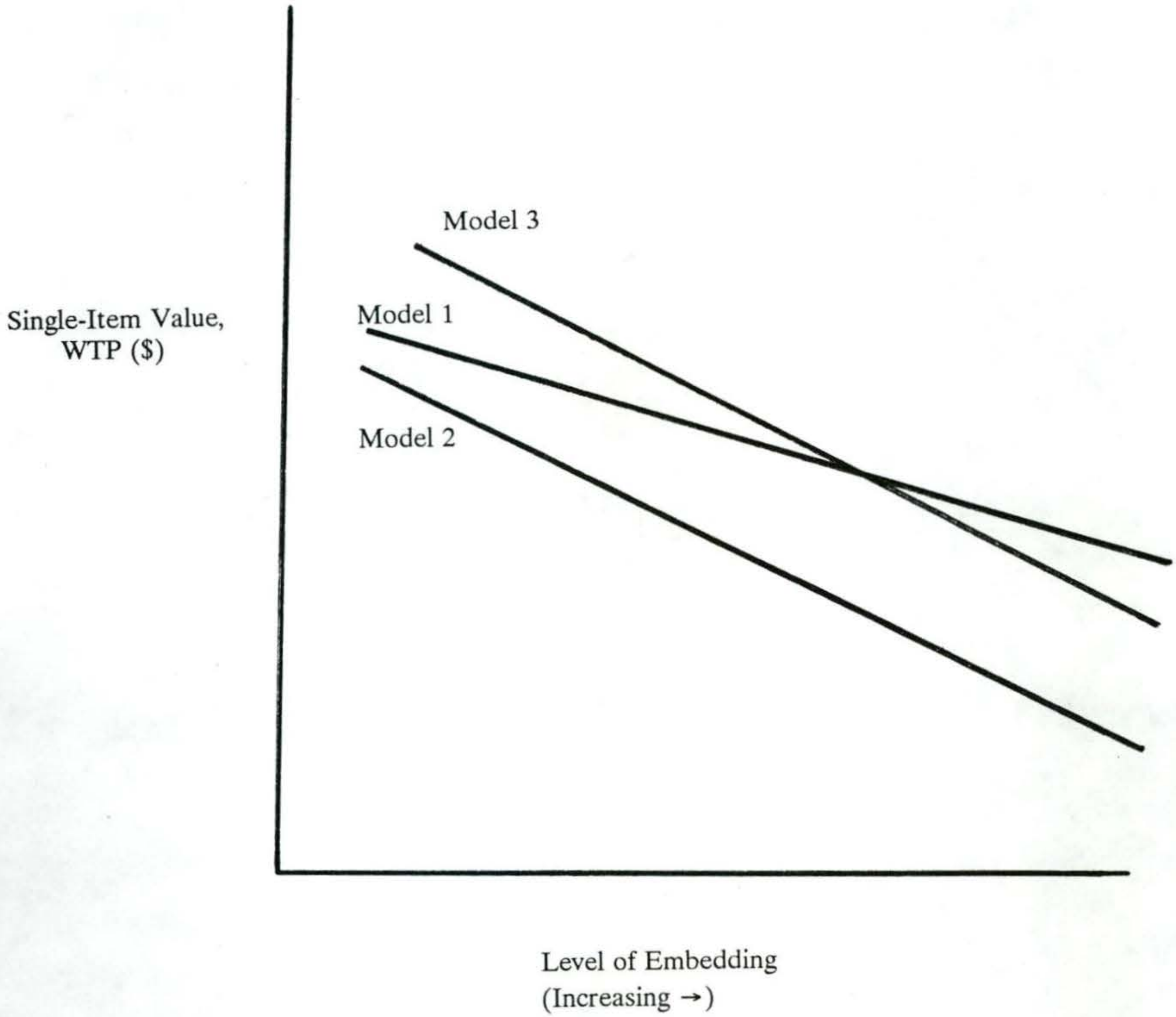

Figure 1. **Alternative Models of the Effect of Embedding On Single-Item Values**

1. **"Real" value**
2. **CVM value, Hoehn-Randall**
3. **CVM value, Kahneman-Knetsch**

Appendix

The welfare values in Tables 1 and 2 were calculated using the two-stage utility function proposed and estimated by Yen and Roe (YR). The utility function derived by YR follows the Gorman polar form and is so constructed that utility is additive across commodity groups. Below, we first derive the relevant expenditure functions for the YR utility structure and then describe the welfare measures that lead to the results of Tables 1 and 2.

YR describe the utility gained from the rth commodity group, u_r, as

$$\text{(A1)} \quad u_r = a_r[\, y_r/P_r - b_r]^c + \omega_r$$

where a_r is a constant, y_r is expenditure on the rth commodity group, $P_r = P_r(\mathbf{p}_r)$ is a price index measuring the impact of the price vector, $\mathbf{p}_r = (p_{r1},...,p_{rK})$, for the rth commodity group, b_r is a term that accounts for how household demographic characteristics affect consumption of the rth commodity group, and ω_r is a term that depends upon price and quantity indexes for the rth commodity group.[8]

Across R commodity groups, household utility, u, is the sum of the utilities obtained from the commodity groups,

$$\text{(A2)} \quad u = \sum_{r=1}^{R} u_r$$

[8]The variables that enter into the utility function are discussed in more detail in Yen and Roe (1989).

$$= \sum_{r=1}^{R} \{a_r[y_r/P_r - b_r]^c + \omega_r\}$$

Maximizing household utility as described by equation (2) subject to total household expenditure, y, yields an equation for expenditure on commodity categories,

$$\text{(A3)} \quad y_r = P_r b_r + P_r \theta_r [y - \sum_{s=1}^{R} P_s b_s]$$

where θ_r is a function of the price indexes. Substituting equation (3) into equation (2) and rearranging results in the expenditure function,

$$\text{(A4)} \quad e(P_1,...,P_R,u) = [(u - \sum_{r=1}^{R} \omega_r)/\sum_{r=1}^{R} a_r\theta_r]^c + \sum_{r=1}^{R} P_r b_r.$$

The expenditure function states the minimum expenditure required to maintained household utility at u--when the optimal level of expenditure is allowed to adjust across all commodities and commodity groups.

When a single price changes from p_{rk}^0 to p_{rk}^1, the price index changes from $P_r(p_{r1}^0,...,p_{rk}^0,...,p_{rK}^0)$ to $P_r(p_{r1}^0,...,p_{rk}^1,...,p_{rK}^0)$. The compensating variation for this first in sequence price change is

$$\text{(A5)} \quad CV_k^1 = y^0 - e[P_r(p_{r1}^0,...,p_{rk}^1,...,p_{rK}^0),...,P_R,u]$$

where the superscript 1 on CV_k^1 indicates that it is a first in sequence price change and the subscript k indicates that it pertains to the kth price.

When k prices change, the change in the kth price may be evaluated after the k-1 changes in the other k-1 prices (Hoehn and Randall, 1989; Hoehn, 1991). This kth in sequence valuation for the kth price change is

$$\text{(A6)} \quad CV_k^k = e[P_r(p_{r1}^1,...,p_{rk-1}^1,p_{rk}^0,...,p_{rK}^0),...,P_R,u]$$

$$- e[P_r(p_{r1}^0,...,p_{rk-1}^1,p_{rk}^1,...,p_{rK}^0),...,P_R,u],$$

where the superscript k on CV_k^k indicates that it is a kth in sequence price change and the subscript k indicates that it pertains to the kth price. The valid total valuation based on the k sequenced valuations is

$$\text{(A7)} \quad CV = \sum_{j=1}^{k} CV_j^j.$$

Equations (5) and (6) were used to computed the values underlying Table 1. Each equation was parameterized using the estimates in Yen. Equation (5) was then used to compute the valid first in sequence valuations. Equation (6) was used to compute the second, third, and tenth in sequence valuations.

In a time constrained setting such as contingent valuation, an individual may be unable to optimally reallocate expenditure across all commodities and all commodities groups. This is modeled by constraining expenditure allocated to within a specific commodity group s. This restricted, within group reallocation of expenditure leads to what we call a stage 1 valuation. The stage 1, group specific expenditure function is derived by rearranging equation (1)

$$\text{(A7)}\quad e_s(p_{s1},...,p_{sk},...,p_{sK},u_s^0) = e_s(p_{s1},...,p_{sk},...,p_{sK},u^0 | y_k = y_k^0, \text{ all } k \neq s)$$

$$= P_s\{(u_s^0 - \omega_s)/a_s\}^{1/c} + P_s b_s$$

where u_s^0 is the utility that a household derives from a commodity group at the initial level of prices for all commodity groups. The group level expenditure function, e_s, states the minimum expenditure on group s required in order to maintain group and total utility constant. It assumes that expenditures on other commodity groups are fixed at the initial level, $y_k = y_k^0$, all $k \neq s$. At the initial price level, the expenditure function is equal initial expenditure on the commodity group,

$$\text{(A8)}\quad e_s(p_{s1}^0,...,p_{sk}^0,...,p_{sK}^0,u_s^0) = y_s^0.$$

Restricting expenditure reallocation to group s, the compensating variation for a price change from p_{sk}^0 to p_{sk}^1 is,

$$\text{(A9)}\quad cv_{sk}^1 = y_s^0 - e_s(p_{s1}^0,...,p_{sk}^1,...,p_{sK}^0,u_s^0)$$

where the superscript 1 indicates that cv^1_{sk} is a first in sequence valuation, the subscript s indicates that it is obtained within the sth commodity group, and the subscript k means that it is for a change in the kth price.

The restricted reallocation welfare measure in equation (9) is derived from optimization on a choice set that is proper subset of the one that yields the unconstrained reallocation welfare measure in equation (5)--a household reallocates within a commodity group rather than across the entire commodity set. Since the choice set underlying equation (9) is a subset of the one underlying equation (5), it follows from the fundamental principles of constrained optimization that the welfare measure cv^1_{sk} is no larger than the welfare measure CV^1_k. In slightly less rigorous terms, the fixity of expenditures on groups other than group s leads to a welfare measure--a willingness to pay measure--that is smaller than the welfare measure that results from unrestricted budget reallocation.

The values underlying Tables 1 and 2 were computed using the equations (5) and (9) along with the utility parameter estimates obtain from Yen (1987). Equations (9) was used to compute the stage 1 valuation. Equation (5) permits optimal expenditure reallocation across all commodity groups and was therefore used to compute a stage 2 valuation.

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