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**Understanding Behavioral Explanations of the WTP-WTA Divergence
through a Neoclassical Lens:
Implications for Environmental Policy**

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Abstract

The often observed empirical divergence between WTA and WTP measures of welfare change continues to be a topic of interest to both theoretical and applied economists. The divergence has particularly important implications for environmental policy. In this paper, we review behavioral and other explanations of the disparity with a focus on their connections to neoclassical welfare theory, and evaluate the empirical evidence of these explanations through the same lens. Some explanations of the disparity are consistent with neoclassical models and some are not. Likewise, some imply that the divergences are attributed to underlying preferences (neoclassical or not) while others suggest the divergences are due to elicitation methods, cognitive limitations, or other non-preference related reasons. We argue that the source of the divergence can inform the choice of which measure, WTP or WTA, to use in a given empirical application.

Keywords: WTP-WTA disparity, Hicksian welfare theory, nonmarket valuation, welfare economics

1. Introduction

The empirically observed disparity between estimates of willingness to accept (WTA) and willingness to pay (WTP) has become an iconic puzzle in microeconomic theory and empirical findings. A voluminous literature has studied the magnitude of these disparities, offered explanations for the differences, and discussed implications of the findings for neo-classical economics (Brown and Gregory 1999; Horowitz et al 2013; Ericson and Fuster 2014). That some of the earliest work exposing this disparity occurred in environmental economics is unsurprising: implementing policy recommendations in the sphere of environmental economics requires empirical estimates of the WTP and/or WTA for changes in environmental goods. Examples of policy actions where empirical estimates are needed include the application of benefit-cost analysis, the computation of damages for compensation claims (such as in a Natural Resource Damage Assessment), and the computation of Pigouvian taxes. The consequences of the disparity also have important ramifications for environmental policy. If there are large differences, the choice of a WTP over WTA (or vice versa) could significantly affect that magnitude of a compensatory claim or level of Pigouvian tax and therefore resulting pollution levels.

In this paper, we revisit behavioral and other explanations of the empirical divergence between WTA and WTP with a focus on their connections to neoclassical welfare theory. We describe and evaluate the empirical evidence on these explanations through the same lens. To foreshadow our findings, our interpretation of the literature is that there are a number of plausible theoretical explanations for the divergence that are supported by at least some empirical evidence. Some of these explanations are consistent with neoclassical theory and some are not. Given the multitude of explanations proposed and for which evidence is available, it appears likely that there are multiple factors at play in any given empirical finding of a divergence. This, in turn, raises a separate question for applied welfare analysts --- what measure of value should be elicited and used in a specific application such as a cost-benefit analysis of a proposed wildlife refuge, a damage assessment for lost passive use values from an oil spill or an *ex post* evaluation of national air quality regulations? Should the choice be based solely on property rights as much of the traditional literature argued, or does the source of the disparity itself inform the choice?

In this paper, we suggest an approach for choosing amongst the alternatives based directly on the analyst's belief about the cause(s) of the disparity as well as the property right structure governing the environmental good. To set the stage, we begin with a brief review of the theory of welfare measurement within the neoclassical framework and the underlying assumptions, and briefly describe the historical evolution of thinking concerning the choice of measure.

2. Hicksian Theory of CV and EV

Hicksian welfare theory is built on two central concepts, namely compensating variation (CV) and equivalent variation (EV), for price or quantity/environmental changes.¹ These measures can also be interpreted as willingness-to-pay (WTP) and willingness-to-accept (WTA), and are often empirically measured from stated preference methods based on WTP or WTA questions. Which of CV and EV is the appropriate welfare measure and which of WTP and WTA corresponds to CV (or EV) depend on whether the good being studied is environmental improvement or degradation and on whether the individual's property rights rest with or without the change, as illustrated in Table 1.² To understand the Table, let the individual's indirect utility function be $v(p, q, m)$ where p is the price vector of a bundle of consumption goods, q is the quality of the environment, and m is her income. Let q_0 be the current environmental quality and q_1 be the new quality level, with $q_1 > q_0$ representing an environmental improvement and $q_1 < q_0$ representing degradation. Suppose $q_1 > q_0$ so that the welfare being measured is for environmental improvement.³ If the individual has property rights over the improved environment, then she is entitled to utility $v(p, q_1, m)$ and the welfare measure for the improvement is equivalent variation EV , which is implicitly given by

$$v(p, q_0, m + EV(m)) = v(p, q_1, m). \quad (1)$$

Here $EV(m)$ measures how much money is needed to bring her to the utility level that she is entitled to (i.e., $v(p, q_1, m)$) if she does not obtain the improvement. Thus, EV measures the increase in her income that is equivalent in utility to the environmental improvement, and equals her willingness to accept for not obtaining the "good." If, on the other hand, the individual has property rights to only the degraded level of environmental quality, then she is entitled to utility $v(p, q_0, m)$, and the welfare measure is compensating variation CV , which is given by

$$v(p, q_0, m) = v(p, q_1, m - CV(m)). \quad (2)$$

In this equation, CV measures the reduction in income that "compensates" the individual for the environmental change, i.e, how much money she is willing to pay to obtain the improved environment

¹ For quantity/quality changes, CV is often called compensating surplus and EV called equivalent surplus (Freeman et. al, 2014). To reduce clutter, we use CV and EV to represent welfare changes associated with both price and quantity changes.

² Table 1 is similar to the first table in Knetsch (2005).

³ The case of environmental degradation can be similarly analyzed.

that she is not initially entitled to.

TABLE 1 HERE

Although which welfare measure to use depends on the property rights, Hicksian theory argues that CV and EV should be close to each other for moderate environmental changes under rather general conditions. To see this, we can rewrite (2) at a different income level, $m + EV(m)$:

$$v(p, q_0, m + EV(m)) = v(p, q_1, m + EV(m) - CV(m + EV(m)))$$

This equation, together with (1) and the monotonicity of $v(p, q, \bullet)$, implies that

$$EV(m) = CV(m + EV(m)) \quad (3)$$

Equation (3) underlies the argument that CV and EV are approximately equal when the income effects are small, which can be shown by a Taylor expansion of $CV(\cdot)$ around m (Horowitz and McConnell 2003), by the bounds developed in Randall and Stoll (1980), or by an exact relationship shown in Weber (2003). For instance, if the environmental improvement is moderate (so that $EV(m)$ is small), if $CV(\cdot)$ is differentiable, and if $CV'(m) \neq 0$, a Taylor expansion of the right hand side of (3) around m implies that

$$EV(m) \approx CV(m) + CV'(m)EV(m). \quad (4)$$

Thus for moderate improvements, and when the income effect is *nonzero* but small (i.e., when $CV'(m)$ does not equal zero⁴ but is small in absolute value), $EV(m)$ and $CV(m)$ should not significantly differ from each other.

These results can be extended to welfare measurement under uncertainty. Let θ be a random parameter that affects the value of the environment, then (1) and (2) can be rewritten as

$$E_{\theta}v(p, q_0, m + OP_{EV}; \theta) = E_{\theta}v(p, q_1, m; \theta); \quad E_{\theta}v(p, q_0, m; \theta) = E_{\theta}v(p, q_1, m - OP_{CV}; \theta). \quad (5)$$

When OP_{CV} and OP_{EV} are independent of θ , they are called option prices and correspond to the *ex ante* WTP and WTA (Graham 1981; Bishop 1982).⁵ From (5) and following a procedure similar

⁴ Note that $CV'(m) \neq 0$ is required in order for higher order terms to be safely ignored in the Taylor expansion.

⁵ If OP_{CV} and OP_{EV} are contingent on the realized value of θ , they are state-contingent welfare measures and

to the case of certainty, we get

$$E_{\theta}v(p, q_1, m; \theta) = E_{\theta}v(p, q_1, m + EV(m) - CV(m + EV(m)); \theta)$$

Again, given that $v(\cdot)$ is monotone increasing in m , this equation leads to the same condition (3) obtained under certainty.

3. Reasons for the WTP-WTA Divergence

Equation (4) implies that, under rather general conditions, CV and EV should be of similar magnitude for moderate environmental improvements. Since, in the absence of measurement error, CV and EV should uniquely correspond to WTP and WTA (or WTA and WTP respectively), the significant divergence observed between WTP and WTA values calls into question the validity of the Hicksian theory as either a reasonable representation of consumer behavior or as a foundation for welfare measurement.

The importance of this issue has led a number of economists to propose and empirically test explanations for this divergence. We turn to those explanations in this section and to aid in understanding, we categorize the proposed explanations for the divergence in Table 2 in the context of Hicksian welfare theory. The first column of Table 2 lists categories of implicit and explicit assumptions needed in order for $WTP \approx WTA$, and the second column summarizes deviations from these assumptions that have been discussed in the literature. As summarized in the third column, some deviations are well within the Hicksian framework, calling for enrichment of the basic Hicksian theory to capture the specific contexts of valuation. Others build upon alternative theories, challenging fundamental neoclassical economics. Some explanations are theoretical conjectures only, while others have been tested in lab, field, or valuation surveys.

TABLE 2 HERE

3.1. Explanations that are consistent with the Hicksian framework

We first discuss several categories of explanations of the WTP/WTA divergence that operate within the Hicksian framework. They are fundamentally based on neoclassical preferences but enrich the basic model by exploring the unique features of environmental changes, by paying attention to the details of decision processes involved in forming WTP/WTA values, and/or by recognizing that individuals have limited capacities in optimizing when forming these values.

the corresponding WTP and WTA values are given by Graham's locus (Graham 1981; Zhao and Kling 2009).

3.1.1. Discrete quantity changes and substitution effects

Two implicit assumptions are made when applying a Taylor expansion to the right hand side of (3) to obtain (4): $EV(m)$ is small in absolute value, and $CV'(m) \neq 0$. Randall and Stoll (1980) show that the first condition is satisfied for infinitesimal environmental improvements. However, environmental improvements are mostly discrete, and discrete improvements, when coupled with other conditions, can cause (4) not to hold. An obvious condition is when the improvements are large, in which case the associated EV is not small relative to income. An alternative condition is low substitutability between the environmental good and each of the private goods in the individual's utility function (Hanemann, 1991). When it is difficult to substitute for the environmental good, a much larger amount of private goods are needed in lieu of the environmental improvement for the individual to be indifferent. That is, even for moderate environmental improvements, the associated EV can be quite large, causing (4) to fail. In the extreme case of Leontief utility functions with no substitutes for the environmental good, not only can EV be large, but a first order Taylor expansion cannot be applied at all since CV is a constant, implying $CV'(m) = 0$.

There are a number of papers devoted to examining the empirical relevance of this *substitution effect*. For example, Adamowicz et al. (1993) find that the WTP-WTA disparity for hockey tickets increases when the hockey game is not broadcasted on TV or radio compared to when it is broadcasted, which suggests that the lack of substitutes increases the WTP-WTA disparity. Shogren et al. (1994) show that the WTP-WTA disparity for avoiding a food-born pathogen is larger than the disparity for ordinary goods such as candy bars. They attribute this finding to the fact that health does not have close substitutes while candy bars do.⁶ Further, they find that the WTP-WTA disparity for avoiding food-born pathogens remains even after repeated auctions while the disparity for candy bars disappears. The imperfect substitutability explanation is further supported in three meta-analyses by Horowitz and McConnell (2002), Sayman and Onculer (2005) and Tuncel and Hammitt (2014). Table 3 reports signs of estimated coefficients for variables influencing the WTP-WTA disparity in these three meta analyses. In each case, the dependent variable is the (log) ratio of mean WTA to mean WTP. The signs reported are significant at least at a 10% significance level, otherwise they are marked as not significant. In the first row of the table, the estimated coefficient for ordinary private goods are negative, which suggests that larger substitutability of goods decreases the WTP-WTA disparity as the theory predicts.

⁶ There are other studies reporting WTP-WTA disparity in the context of health and value of life. Examples include hearing aid provision (Grutters et al 2008), new medicine (O'Brien et al 1998), health risk from drinking water (Viscusi and Huber, 2012) and transport safety (Guria et al 2005).

TABLE 3 HERE

3.1.2. CV/EV do not equal the elicited WTP/WTA

Compensating and equivalent variations are theoretical concepts and are often measured indirectly through observing WTP and WTA choices under specific trading institutions, e.g., whether an individual reports that she would vote in favor of paying a certain amount of money to obtain an environmental improvement in a referendum. In order for WTP/WTA to be equivalent to CV/EV as indicated in Table 1, the trading institutions need to perfectly replicate all the elements that influence her CV/EV formation. The literature has identified a number of reasons why elicitation mechanisms in WTP-WTA studies can fail to replicate these elements and thus lead WTP/WTA to differ from CV/EV. In this case, a divergence between WTP and WTA does not imply a divergence between CV and EV nor does it suggest a contradiction to the Hicksian theory.

Perhaps the most obvious theoretical reason for WTP/WTA to differ from CV/EV is in a case where the elicitation mechanism is not *incentive compatible* so that an individual has incentive to misreport her true valuation of the environmental good. Since the reported values (WTP/WTA) differ from the true values (CV/EV), WTP can differ from WTA even when CV and EV are equal. Kolstad and Guzman (1999) provide an example where strategic behavior akin to those arising from private value first price auctions can lead to WTP-WTA divergence. They argue that in many experimental settings, eliciting WTP values is similar to bidding for a single object in first price auctions, and value shading implies that the reported WTP values are less than the true values. The difference increases as the individual becomes more uncertain about the true value of the good. Similarly observed WTA values are higher than the true value, resulting in a WTP-WTA divergence that increases in uncertainties about the true value of the good being traded. Although this theoretical conjecture has never been empirically tested, incentive compatibility is increasingly being studied as an essential condition in stated preference surveys (Carson and Groves, 2007; Kling, Phaneuf, and Zhao, 2012), and it has been observed that not all designs satisfy this condition (Harrison, 2007). The meta-analysis reported in Table 3 also provides evidence that incentive compatible mechanisms tend to reduce (but not eliminate) the WTP-WTA disparity.

Even when individuals are not strategic, their WTP/WTA values can differ from CV/EV since the former can be formed dynamically while the latter are inherently static concepts. In a series of papers, Zhao and Kling (2001, 2004, 2009) show that if an individual is uncertain about the good's value, has opportunities in the future to obtain more information about the value, and is forced to make a costly-to-reverse purchase/sell decision within an experiment or survey's time frame, then her optimal WTP (WTA) is lower (higher) than her CV (EV). The difference is captured by a *commitment cost* that

compensates for the lost opportunity of learning and making a more informed decision. The commitment cost and thus the wedge between WTP and WTA increase as the level of uncertainty rises, as reversing one's decision becomes more costly, and as future learning opportunities expand. Zhao and Kling (2001) discuss a series of experimental settings in the literature for which commitment costs might arise.

The *commitment cost theory* has been tested, directly and indirectly, in a range of lab and survey settings. Corrigan et al (2008) undertake a contingent valuation survey to value water quality improvements and adopt two treatments, with and without a delay option that offers the respondents another chance to vote on the referendum a year later if it fails this time. They find that the average WTP with the delay option equals only about 25% of that without the delay option, with the remaining 75% being accounted for by the commitment cost. Lusk (2003) conducts a lab experiment where subjects bid for coffee mugs and monetary lotteries, with treatments offering combined delay and learning opportunities, and/or costly return options. He finds support for the prediction that WTP decreases when subjects are given delay and learning opportunities, but finds that the effect of the return option on WTP is not statistically significant, possibly due to the cost of incurring the option. Kling et al. (2013) test the theory in a field experiment, where they measure the level of subjects' perceived difficulties to reverse their purchase or sell decisions. Consistent with the commitment cost theory, they find that lower perceived difficulties to reverse a decision raises WTP and reduces WTA, thereby decreasing the WTP-WTA disparity. Ratan (2013) finds similar results, showing that providing subjects with opportunities to reverse their decision removes the exchange asymmetry typically observed in exchange experiments between two goods (i.e. Knetsch, 1989). Neilson et al. (2013) find that opportunities to reverse purchase or selling decisions for lotteries remove the WTP-WTA disparity.

Elicitation mechanisms can inadvertently introduce other factors that might distort WTP/WTA away from CV/EV. For instance, Franciosi et al. (1996) find that using the terms "buying" or "selling" increases the WTP-WTA disparity because those terms could induce subjects to behave more strategically (i.e., buying low and selling high). Plott and Zeiler (2007) find a number of effects of experimental procedures on exchange asymmetry such as emphasizing ownership, physical proximity, and when choices are made by a public show of hands. Each of these increases exchange asymmetry.

3.1.3. Bounded rationality

Equations (1) and (2) rely on indirect utility functions, which are derived from the individual's constrained utility maximization. An implicit assumption of the Hicksian theory is that in forming her CV/EV, the individual is able to formulate and solve the utility maximization problem subject to her

overall income constraint. But in reality she might have limited capacity in understanding the trading institution, in formulating her optimization problem, and in finding her optimal decision. The literature on bounded rationality argues that, even if individuals have neoclassical preferences, they may not optimize when making their decisions, including WTP/WTA decisions, and many contradictions to neoclassical theory found in lab and field studies can be attributed to this failure of optimizing (Harstad and Selten, 2013). Smith and Moore (2010) go a step further and argue that introducing additional “cascading constraints” of cognitive capacity, energy and physical dexterity to an individual’s optimization problem can explain many of the behavioral anomalies and should be adopted in benefit cost analysis.

Hoehn and Randall (1987) provide an explicit example of how bounded rationality can lead to the WTP-WTA divergence. They first invert (1) and (2) to obtain $CV = m - e(p, q_1, u_0)$ and $EV = e(p, q_0, u_1) - m$, where $e(\cdot)$, the inverse of $v(\cdot)$, is the expenditure function. They then argue that it takes time for an individual to search for the minimum expenditure. When time is constrained, such as in stated preference surveys (and similarly in experiments), the individual might be forced to stop before finding the minimum expenditure, resulting in a higher $e(\cdot)$, thereby reducing CV but raising EV.

The individual’s search for her optimal WTP/WTA can be further impeded by additional (and often non-monetary) constraints. The literature on *mental accounting* argues that individuals might treat money differently by putting them in different mental accounts depending on their uses (Thaler 1985). In other words, money may not be fungible. For example, when deciding her WTP for the environmental good, an individual might mentally put the payment in one account that is tailored for environmental goods where the marginal value of the budget constraint is higher. In contrast, when deciding her WTA, the money flowing in is put in a general account where the marginal value of money is lower. The higher shadow value of money when paying for the environment and the lower marginal value of money associated with WTA can lead to the WTP/WTA divergence.⁷ This observation is supported by the meta-analyses of Sayman and Onculer (2005) and Tuncel and Hammitt (2014). Table 3 shows that out-of-pocket payments have a positive effect on the divergence, suggesting that these payments are treated differently from indirect payments such as tax and utility bills.

⁷ Mishan and Quah (2007) argue that the WTP-WTA disparity can arise when the WTP decision is constrained by the budget, noting that the WTA decision never faces a budget constraint. While the payments for environmental improvements in most applications are modest, the budget constraint for WTP might be binding when mental accounting imposes a tight budget for the account tailored for environmental goods.

Another form of bounded rationality arises when the individual is not familiar with the trading institution or mechanism and, instead of optimally forming their WTP/WTA values, resorts to her basic instinct of “buy low and sell high.” We discuss this literature together with the preference discovery literature in Section 3.2.1.

3.2. Explanations that challenge the Hicksian framework

In reaching (1) - (5), Hicksian theory makes a number of implicit assumptions about an individual’s preference: she knows her preference structure, her preference is defined over her own final consumption bundle, and her preference is stable, unaffected by exogenous shocks such as policy changes. Several strands of literature on the WTP/WTA disparity deviate from these implicit assumptions and introduce the possibilities that individuals do not know their preferences and might have to discover them, that their preferences are not stable and might be context dependent, and that their preferences are affected by a set of elements richer than final consumption bundles. Each of these departures is capable of generating the WTP/WTA divergence.

3.2.1. Preference discovery

Individuals may not know their complete preferences or the full effects of their decisions when making WTP and WTA choices. Instead, they gradually “discover” their preferences and learn about the trading institution. The *discovered preference hypothesis (DPH)* of Plott (1996) proposes three stages of choices with rational choices being formed gradually as individuals gain experience and learn about their true preferences and the outcomes of their decisions. Following Braga and Starmer (2005), we distinguish *value learning*, which describes learning about one’s preferences, from *institutional learning*, which represents learning about the outcomes of one’s decisions.⁸ Unlike commitment cost theory in which individuals anticipate and respond to future learning opportunities, individuals passively learn and respond to new information under the discovered preference hypothesis.

DPH does not provide a complete theoretical foundation on its own to explain the consistent direction of the WTP-WTA disparity. When one is not sure about her own preference or the trading institution, she operates beyond the Hicksian framework and thus her WTP and WTA might differ. But by no means does WTP have to be far lower than WTA. However, under uncertainty about one’s preferences or the trading institutions, an individual might adopt the basic market instinct of “buy low

⁸ Value learning focuses on underlying preferences such as risk and time preferences and tradeoffs between consumption goods and money while institutional learning focuses on auction rules and bidding behaviors of other participants in an auction.

and sell high,” which would indeed lead to the observed WTP/WTA disparity. For instance, List and Shogren (1999) find that in repeated auctions, buyers typically start their bids low and sellers start their offers high. This is similar to the argument that individuals draw from the lower end of the value distributions when buying but draw from the upper end when selling. Dubourg et al. (1994) show experimentally that when people are uncertain about their valuations of a good, and if the supports of their WTP and WTA distributions overlap, they tend to draw values from the lower end of the WTP distribution and from the upper end of the WTA distribution. Note that for this line of argument to work, one has to make the additional assumption that individuals are *more likely* to rely on basic market instincts instead of optimization under preference or institutional uncertainties. To our knowledge, this assumption has not been empirically tested in the literature.

The experimental literature has offered additional empirical support for DPH’s predictions. One strand of the literature suggests that as initial uncertainty about the value of a good increases, the WTP-WTA disparity rises. For instance, Okada (2010) and Neilson et al. (2013) use mean-preserving lotteries and find that subjects have larger WTP-WTA disparities for lotteries with larger outcome variances. Georgantzis and Navarro-Martinez (2010) find that a higher familiarity for a good decreases the WTP-WTA disparity. As we discuss below, other studies show that the disparity decreases as individuals learn about the values and/or the institutions.

There are a few studies related to *value learning*. Kingsley and Brown (2013) find that a choice exercise where subjects answer pairwise choice questions between goods removes the WTP-WTA disparity. The goods they use include consumption goods such as a mug and a shirt, as well as public goods such as parking lots and open space. They find that the choice exercise eliminates the WTP-WTA disparity for a mug, and argue that this shows value learning helps subjects discover their underlying preferences. Bateman et al. (2009) show that providing more information on environmental goods through virtual reality visualization reduces the WTP-WTA disparity. In their experiment, subjects are asked to value land use change in coastal areas. They find that the WTP-WTA disparity decreases when relevant information is provided in virtual reality visualization rather than in a numeric format, which suggests that more salient information on goods improves respondents’ value learning.

In the case of *institutional learning*, several empirical studies find that repeated participation in an auction dissipates the WTP-WTA disparity (Coursey et al. 1987; Shogren et al. 1994, 2001; Loomes et

al. 2003, 2010).^{9,10} In those studies, subjects learn auction rules and others' bidding behavior by observing auction results through repeated trials and feedback on their decisions. In a similar vein, Plott and Zeiler (2005) provide subjects extensive training to reduce their misconception on how an auction mechanism works. In their study, subjects learn about the auction mechanism through detailed instructions and paid practice rounds. They find that their training removes subjects' WTP-WTA disparity. Engelmann and Hollard (2010) find that exchange asymmetry is removed by a simple but novel trading exercise in which subjects are forced to trade their goods with other participants. Institutional learning has also been found in the field. List (2004) compares valuations for sports cards between experienced traders and inexperienced trades and finds that more market experience reduces the WTP-WTA disparity. These results are also confirmed in List (2006). In the meta-analyses of Table 3, the estimated coefficients for repeated trials within the same elicitation method and market experience are negative, suggesting that institutional learning decreases the WTP-WTA disparity.

3.2.2. Context-dependent and endogenous preferences

Hicksian theory assumes stable preferences that are independent of the trading institutions, experiences or exogenous shocks. However, empirical evidence suggests that in many choice settings, individual preferences are subject to influence by a wide variety of psychological factors, such as an individual's attachment to different choice options arising from the trading institution (Carmon et al. 2003), induced negative emotion (Lerner et al. 2004), salience of certain decision factors such as costs or benefits (Bordalo et al. 2012), and other framing effects. These factors are typically not modeled in deriving the indirect utility functions in (1) and (2), but including them can potentially lead to divergence between CV and EV. In a broader sense, the endogenous preference literature (e.g., Bowles, 1998; Loewenstein, O'Donoghue and Rabin, 2003), by arguing that preferences are affected by such institutions as markets and government policies, has led to the debate on government paternalism (Thaler and Sunstein, 2003). It also poses another challenge to welfare theory: if a policy that improves the environment helps lead consumers value the environment more, should *ex ante* or *ex post* preferences be used to measure the policy's welfare impacts (Tan and Zhao, 2015)?

⁹ There is a potential concern that subjects follow market price feedback ("shaping effect") rather than learning their preferences ("learning effect") in repeated auction participation. Empirical evidence is mixed. Shogren and List (1999) and Loomes et al. (2010) find support for the learning effect while Knetsch et al. (2001) support the shaping effect. Loomes et al. (2003) find evidence consistent with both effects.

¹⁰ The WTP-WTA disparity disappears with the repetition of Vickrey auctions, median price auctions and random *k*th-price auctions. On the contrary, the disparity remains with the repetition of a Becker, DeGroot and Marschak's (1964; BDM) mechanism with a multiple-price-list format (Kahneman et al. 1990; Shogren et al. 2001), probably because the BDM mechanism has a weak penalty for deviation from optimal bids compared to other auctions. (Noussair et al. (2004) show that the BDM mechanism has a lower penalty than a Vickery auction.) Note that market price is random and exogenous in the BDM mechanism whereas the market price is endogenous and reflects other participants' decisions in a Vickery auction.

Positive and negative *emotion* has been shown to be related to the WTP-WTA disparity. Georgantzis and Navarro-Martinez (2010) find that positive feelings from owning a good leads to the WTP-WTA disparity because owners want to maintain positive feelings from owning a good. They find that owning a good increases positive feelings of subjects, and that the positive feelings raise WTA. On the other hand, Lerner et al. (2004) find that induced negative feelings such as sadness and disgust reduce the WTP-WTA disparity because subjects want to escape from their negative emotion by changing their current environment through selling their endowed goods and buying goods that they do not own. Lin et al. (2006) find similar results using induced negative feelings.

Individuals are also found to treat goods they own as part of themselves, and as a result they rate the goods more highly than non-owners. Morewedge et al. (2009) provide evidence supporting this *motivated taste change*. They find that buyers who have already owned a good have a higher WTP for the same type of good than other buyers who do not own it. However, *attachment* from physical proximity other than ownership can also increase valuations because proximity gives subjects a sense of ownership. Reb and Connolly (2007) test how physical possession affects WTP and WTA and find that physical possession has a similar effect as ownership.

People tend to pay attention to different aspects of an item depending on the nature of their decisions, and this different assignment of *salience* can lead to the WTP-WTA disparity. Bordalo et al. (2012) find that sellers tend to pay more attention to the consumption value of the traded good while buyers focus more on the related expenditures, resulting in the WTP-WTA disparity. These different assessment behaviors between sellers and buyers are also reported in Carmon and Ariely (2000). They find that in their experiments using basketball tickets, sellers care more about basketball games whereas buyers care more about ticket price and transportation costs.

Since salience can be altered by framing, certain *framing effects* can also help remove the WTP-WTA disparity. If owners can be induced to view the goods as exchange goods rather than consumption goods, then benefits of the goods would no longer be salient to owners. Svirsky (2014) uses a simple method to induce subjects to perceive chocolate as exchange goods in his experiment, by calling chocolate a “chocolate coin.” He finds that this simple name change removes the WTP-WTA disparity for chocolates, apparently since the chocolate coin framing helps focus subjects’ attention away from the consumption benefits of chocolate to its exchange value. Arlen et al. (2002) use a different method to induce subjects to perceive mugs as exchange goods rather than consumption goods. They frame their valuation experiment using a corporate-agency setting; subjects are employees in a firm, and mugs are a production factor. As a result, they find no WTP-WTA disparity for mugs. This result is consistent with Kahneman et al.’s (1990) conjecture that the WTP-WTA disparity would not happen when subjects purchase goods for resale.

3.2.3. Expanded domain of preferences

Perhaps the biggest challenge to Hicksian theory is about its implicit assumption that an individual's utility depends only on her own bundle of final consumption goods. Two central tenants of *prospect theory* are that preference might depend on a certain reference point with higher marginal utility for losses than for gains relative to the reference point (Kahneman and Tversky, 1979).¹¹ Reference dependence and loss aversion are considered by many as offering the most compelling explanation for the WTP-WTA disparity. In addition, individuals might derive pleasure from moral values and warm glow (Boyce et al. 1992; Biel 2011), and this type of other-regarding preferences can also lead to the disparity.

Reference points in three different dimensions are hypothesized to cause the WTP-WTA disparity: reference consumption, reference price and reference risk. Losses in consumption (increases in price and risk) relative to the relevant reference point is hypothesized to generate a larger loss of utility relative to an equal size gain,¹² leading to WTP-WTA disparity because when deciding WTA, the individual suffers loss of the good. The reference consumption can be defined in dimensions of goods and money. In the case of reference consumption, Bateman et al. (1997) find that subjects' valuations are not independent of endowment states and conclude that subjects' preferences follow reference-dependent preferences rather than Hicksian preferences. Gächter et al. (2010) find that individual loss aversion is positively associated with the WTP-WTA disparity. Knetsch and Wong (2009) find that the manipulation of reference states influences subjects' exchange behaviors in their exchange experiments. They also find that emphasizing reference states leads to the exchange asymmetry although subjects do not own the good.

Reference points do not have to be consumption levels. Prices can be reference points and individuals can demonstrate aversion to bad deals (Isoni, 2011). Weaver and Frederick (2012) find that price information on an outside option influences the WTP-WTA disparity. In their experiment, they provide different price information between groups to induce subjects to form different reference prices. They find that a higher price of an outside option increases the WTP-WTA disparity.¹³ Effects of reference prices are also found in the purchase of eggs. Putler (1992) finds that consumers are more sensitive to a price increase for eggs than to a price decrease because they experience losses

¹¹ See Barberis (2013) for an extensive review on applications of prospect theory.

¹² Reference points are affected by ownership, expectations (Koszegi and Rabin, 2006), history of past ownership (Strahilevitz and Loewenstein, 1998) and proximity (Reb and Connolly, 2007).

¹³ Results in Weaver and Frederick's WTP experiment are similar to those in Cherry et al. (2004), but the two studies offer different explanations for the results. Cherry et al.'s explanation is based on strategic behaviors of *bid shaving* where subjects do not bid beyond the price of an outside option whereas Weaver and Frederick explain the results using reference prices.

when the market price is higher than their reference price. Brown (2005) conducts an ex post survey after valuation experiments to find out how subjects have decided on their valuations. Around one-fifth of the subjects indicate “seeking a good deal”—i.e. selling high, buying low—as a reason for the WTP-WTA disparity, which is consistent with the reference price explanation.

Risk can also be reference points. Viscusi and Huber (2012) find that reference risk and loss aversion for additional risk lead to the WTP-WTA disparity in evaluating health risk from drinking water. In their study, tradeoffs between health risk and the cost to reduce the risk are examined to calculate the value of statistical life. They find that subjects are more sensitive to increases in their health risk than decreases.

The WTP-WTA disparity can also occur when choices involve moral values and ethical responsibility. The effects of moral values may be larger for WTA than for WTP because owners have stronger guilty feelings when they give up an item involving moral values than buyers who have no such guilt. Higher WTA is therefore required to offset the negative feelings from giving up the item (Biel et al. 2011). There are a few studies that provide support for moral values and ethical responsibility as the explanations for the WTP-WTA disparity. Anderson et al. (2000) find that subjects demonstrate a larger WTP-WTA disparity for ecologically-produced eggs than for conventional eggs. Boyce et al. (1992) find that killing trees left with an experimenter increases the WTP-WTA disparity more than if the trees were not to be killed.

4. Which welfare measure to use ---WTA or WTP?

Now that we have described alternative theoretical explanations for the WTP -WTA disparity, we turn to the question of which measure (WTA or WTP) an applied researcher should use, say in performing a benefit cost analysis, and how the choice of welfare measures can be informed by understanding the likely source(s) of the disparity.

As noted earlier, in principle, property rights determine whether CV or EV is appropriate to use in valuing environmental changes because property rights determine the appropriate reference welfare level for evaluating the environmental change (Carson et al. 2001; Freeman et al. 2014).¹⁴ If CV and

¹⁴ Knetsch (1990, 2005, 2010) has argued that reference environmental levels that people actually use to evaluate changes would be more appropriate than ones determined by property rights. In other words, “what changes people regard as being in the domain of losses and those they feel to be in the domain of gains” (2010, p.186) should be considered in deciding welfare measures. However, this poses practical problems as an agreement on reference environmental levels may be hard to be reached, especially when people know that their choice of reference points can influence policy decisions (Hoffman and Spitzer, 1993). Knetsch suggests that “most people’s intuitions seem likely to allow for wide agreement” (2010, p.186) on reference environmental levels, but this is an empirical question. There may be cases where property rights may not be clearly specified (Brown and Gregory, 1999). In those cases, Knetsch’s approach may be useful.

EV are close to each other and can be measured accurately by WTP or WTA, then the choice of measure is largely a theoretical nicety. However, if there is a large divergence between WTP and WTA, the implications can be substantial. In the case of a significant divergence, how does the source of the disparity inform the empirical choice? One answer to this question that has become embedded in official guidance is that WTP is to be preferred and used, even in cases where the property rights would suggest a WTA value. This recommendation (Arrow et al. 1993; OMB, 2003) is logically consistent with the view that the divergence arises due to a problem in the elicitation method and implies that elicited WTP is a better proxy even for EV than is elicited WTA. However, as discussed earlier, the disparity between WTP and WTA might be driven by a divergence between CV and EV (e.g., due to substitution effects or reference dependent preferences), and WTP might be significantly different from CV (e.g., due to commitment costs). In both cases, using WTP instead of the theoretically correct measure could lead to erroneous conclusions (Knetsch, 2010).

To simplify our discussion, we consider an environmental improvement where property rights are to the improved level, so that EV is the relevant welfare measure and its observational equivalent is WTA. Whether elicited WTA values or some other values should be used to measure the welfare depends on the underlying reasons for the WTP-WTA disparity, specifically on answers to the following three questions:

- 1) Is CV approximately equal to EV?
- 2) Does the elicited value of WTA equal EV?
- 3) Does the elicited value of WTP equal CV?

Table 4 lists the appropriate welfare measures for the variety of reasons discussed in Section 3 and Table 2. These cases can be divided into two broad categories: those with a “No” answer to Question 1) and “Yes” answers to Questions 2) and 3), and those with opposite answers (“Yes” to 1) but “No” to 2) and 3)). In the first category, true CV/EV values can be elicited by WTP/WTA, but CV and EV are different for a variety of reasons, e.g., due to lack of substitutes, bounded rationality, reference and context dependence, value learning and moral values. Fundamentally what drives the WTP-WTA divergence is the individual’s own preference structure, and the divergence reflects results of her optimization rather than failure of the value elicitation procedure. Thus, the correct welfare measure is EV and thus WTA, so that elicited WTA values should be used for welfare analysis. The logic here is similar to that of Knetsch (2010), but the key distinction is that one does not have to give up on Hicksian theory to make the case for the use of WTA. Note that even in these cases, there might be delicate issues to consider. If an individual’s preference is endogenous and affected by the environmental policy, one needs to be careful in choosing whether *ex ante* or *ex post* WTA values

should be used. For instance, Tan and Zhao (2015) find that experiencing improved air quality during the 2008 Beijing Olympics Games increased Beijing residents' perceived value of air quality improvement. This result suggests that policies that improve the environment can change preferences for environmental goods and calls into question whether *ex ante* or *ex post* perceived value should be used for welfare measurement.

TABLE 4 HERE

In the second category where the answer to Question 1) is “Yes,” but answers to Questions 2) and 3) are “No,” CV is equal to EV, but the correct welfare values of CV/EV might not be elicited by WTP/WTA. Table 4 shows that there are several situations corresponding to this category: commitment costs, lack of incentive compatibility, institutional learning and bad deal aversion. For instance, in the case of commitment costs, if the lack of decision delay and learning opportunities in a survey reflects real world contexts, as would be the case if the government is making the environment decision within the survey's time frame, then the associated commitment cost should be part of the welfare measure and WTA should be used. But if the delay and learning opportunities are precluded by the fact that an individual has to answer a survey within a fixed time frame while such opportunities do exist in the real world, WTA is biased upward and commitment cost should be removed in order to obtain the true welfare measure.¹⁵ In this case WTP may be a better approximation of EV if its associated commitment cost is lower. Similarly, in the case of bad deal aversion, if price reference points are introduced by the elicitation mechanism and affect the elicited WTA values, WTA will be biased and need to be adjusted for the bias.

When EV is equal to CV, if WTP and WTA differ from them, it is possible that one is “more biased” than the other. For example, individuals might be more familiar with making purchase decisions than with making selling decisions. If their being unfamiliar with the trading institutions drives the WTP/WTA disparity, it is conceivable that WTP is closer to EV than is WTA. In this case, WTP might offer a closer approximation to EV than WTA.

In all likelihood, many real world welfare elicitation might involve multiple reasons underlying the WTP/WTA disparity so that answers to Questions 1) – 3) are all negative. The key message of Table 4 is that careful examination of the underlying preference structure and the elicitation mechanism is needed to determine the correct welfare concept of CV or EV, the direction of the biases of WTP and WTA, and which measure offers a better approximation for the correct welfare measure.

¹⁵ See Zhao and Kling (2009) for detailed discussion of the two situations.

5. Final Remarks

In this paper, we have reviewed the explanations provided in the literature for the often observed divergence between WTA and WTP in laboratory and field experiments. A range of empirical evidence provides support to a number of alternative explanations, neither uniquely confirming, nor repudiating all others. Some of these explanations with supported evidence are consistent with neoclassical preferences, but some require adoption of an alternative paradigm. Given the prevalence of the divergence and its large empirical magnitude, the choice of using a WTP when the WTA measure is appropriate (or vice versa) can have important policy implications and potentially lead to inefficient public policy decisions.

To aid applied researchers facing this conundrum, we have argued that the appropriate measure will depend on the explanation for the cause of the disparity. If a researcher can identify the likely sources of the disparity arising in a given situation, she can make an informed decision about the appropriate measure to use. In this sense, the choice of which welfare measure to use is somewhat analogous to the choice of a good instrument in an econometric study or the most appropriate distributional assumption to represent uncertainty in a theoretical model: theory and evidence can provide input but the final decision will require judgment and careful thought on the part of the analyst.

As more evidence becomes available and/or additional explanations for the divergence are provided, it will be important to revisit the logic of choosing amongst the potential welfare measures presented here. Indeed, we view our efforts to categorize the appropriate welfare measure as shown in Table 4 as more of a road map for thinking about the issue than providing a definitive answer for any and all particular applications. Researchers need to carefully consider the elicitation procedure they are using and the context of the policy analysis before determining which of WTA and WTP (or neither) is the most appropriate measure to use.

Table 1. Correct welfare measures depending on property rights and the good to be valued

	Property rights lie with improved environment	Property rights lie with degraded environment
Environmental Improvement	EV / WTA (for not obtaining the improvement)	CV / WTP (for obtaining the improvement)
Environmental Degradation	CV / WTA (for obtaining the degradation)	EV / WTP (for avoiding / not obtaining the degradation)

Table 2. Causes of WTP-WTA Divergence

Implicit assumptions of Hicksian theory	Deviation and enrichment categories	Implications for welfare theory
Local price or quantity changes	Discrete quantity change and substitution effects	Enrich Hicksian theory with adequate modeling of substitution opportunities
CV/EV = WTP/WTA	(i) Elicitation mechanism not incentive compatible (ii) Commitment cost theory	(i) Not a challenge to Hicksian theory (ii) Enrich Hicksian with dynamics & information
Agents can fully optimize	Bounded rationality such as limited cognitive capacity and mental accounting	Enrich Hicksian to include constraints of cognitive capacity
Agents know their own preferences	(i) Value learning (ii) Institutional learning	(i) Modify Hicksian theory to allow for preference discovery (ii) Not a challenge to Hicksian theory
Preference is stable and context independent	(i) Attachment and motivated taste change (ii) Saliency	Modify Hicksian preferences to allow for effects of contexts
Preference is defined on own consumption bundle	(i) Reference dependence and loss aversion (ii) Moral values	Modify Hicksian to allow for reference dependence and moral values.

Table 3. Comparison of three meta-analyses on the WTP/WTA disparity

	Horowitz and McConnell (2002): WTA / WTP	Sayman and Onculer (2005): ln (WTA/WTP)	Tuncel and Hammitt (2014): ln (WTA/WTP)
Ordinary private goods	—	—	—
Real transaction	— (Not significant)		— (Not significant)
Incentive-compatible elicitation*	+	—	—
Out-of-pocket payment	n.a.	+	+
Sayman and Onculer: 4+ trials for a same good in a same elicitation method	n.a.	—	—
Tuncel and Hammitt: the last of repeated trials			
Market experience both buying or selling the good	n.a.	n.a.	—
WTP framed as gain	n.a.	+	n.a.
WTA framed as gain	n.a.	—	n.a.

Note that signs for estimated coefficients significant at least at 10% significance level are reported unless specified otherwise. Sayman and Onculer do not distinguish real transaction with incentive-compatible elicitation. *: Incentive-compatible question formats such as open-end questions with Vickrey auction, random n th-price auction and BDM mechanism, and single closed-end question, which is not specified in Sayman and Onculer.

Table 4. Appropriate welfare measure to use for policy analysis

Deviation and enrichment categories	Explanation for the WTP-WTA disparity	Value relationship questions			Welfare measure to use for policy analysis
		CV=EV?	WTA=EV?	WTP=CV?	
Welfare measure for quantity changes	• Lack of substitutes	No	Yes	Yes	Use WTA.
CV/EV different from WTP/WTA	• Commitment cost	Yes	No	No	Use WTA if the commitment cost occurs due to real world constraints. Otherwise WTA is biased upwards.
	• Lack of incentive compatibility	Yes	No	No	WTA is biased. Incentive compatible elicitation mechanism is needed.
Bounded rationality	• Mental accounting	No	Yes	Yes	Use WTA.
	• Limited cognitive capacity	No	Yes	Yes	Use WTA..
Preference discovery	• Value learning	No	Yes	Yes	Use WTA.
	• Institutional learning	Yes	No	No	WTA is biased. May need to allow for institutional learning.
Context dependent preferences	• Attachment • Motivated taste change • Salience	No	Yes	Yes	Use WTA. Should be cognizant of government paternalism.
Reference dependent preferences and moral values	• Reference dependence and loss aversion	No	Yes	Yes	Use WTA.
	• Moral values	No	Yes	Yes	Use WTA.
	• Bad-deal aversion	Yes	No	No	Use WTA if elicitation mechanism reflects real world constraints. If not, WTA is biased.

Note: The Table presents appropriate welfare measures for an environmental improvement when the property rights lie with the improved environment, so that the property right based welfare measure is EV.

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