

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 article, 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), whereas others suggest that 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.

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 neoclassical economics (Brown & Gregory 1999, Horowitz et al. 2013, Ericson & 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 for and/or WTA changes in environmental goods. Examples of policy actions for which 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. This disparity also has 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 article, 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 a number of plausible theoretical explanations for the divergence 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, there are likely multiple factors at play in any given empirical finding of a divergence. This possibility, 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 argues, or does the source of the disparity inform the choice?

In this review, we suggest an approach for choosing among the alternatives on the bases of the analyst's belief about the cause(s) of the disparity and 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 we briefly describe the historical evolution of thinking concerning the WTP-WTA disparity and the choice of measure.

2. HICKSIAN THEORY OF COMPENSATING VARIATION AND EQUIVALENT VARIATION

Hicksian welfare theory is built on two central concepts, namely compensating variation (CV) and equivalent variation (EV), for price, quantity, or quality changes.¹ These measures can also be interpreted as WTP and 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 Table 1, let the individual's

¹For quantity or quality changes, CV is often termed compensating surplus and EV termed equivalent surplus (Freeman et al. 2014). For simplicity, we use CV and EV to represent welfare changes associated with both price and quantity changes.

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

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)

Abbreviations: CV, compensating variation; EV, equivalent variation; WTA, willingness to accept; WTP, willingness to pay.

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 that $q_1 > q_0$ 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 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 WTA for not obtaining the good. If, in contrast, 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 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 that she is not initially entitled to.

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 Equation 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 Equation 1 and the monotonicity of $v(\cdot)$ in terms of m , 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 & McConnell 2003), by the bounds developed in Randall & Stoll (1980), or by the exact relationship shown in Weber (2003). For instance, if the environmental improvement is moderate

³The case of environmental degradation can be similarly analyzed.

[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 Equation 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 Equations 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 termed option prices and correspond to the ex ante WTP and WTA (Graham 1981, Bishop 1982).⁵ From Equation 5 and following a procedure similar 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 (Equation 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. Because, 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 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. 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 for $WTP \approx WTA$, and the second column summarizes deviations from these assumptions that are 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. Other explanations build upon alternative theories, challenging fundamental neoclassical economics. Some explanations are theoretical conjectures only, whereas others have been tested in lab, field, or valuation surveys.

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

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

⁵If OP_{CV} and OP_{EV} are contingent on the realized value of θ , they are state-contingent welfare measures, and the corresponding WTP and WTA values are given by Graham's locus (Graham 1981, Zhao & Kling 2009).

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 or EV = WTP or WTA	(i) Elicitation mechanism not incentive compatible (ii) Commitment cost theory	(i) Not a challenge to Hicksian theory (ii) Enrich Hicksian theory with dynamics and information
Agents can fully optimize	Bounded rationality such as limited cognitive capacity and mental accounting	Enrich Hicksian theory to include constraints of cognitive capacity
Agents know their own preferences	(i) Value learning (ii) Institutional learning	(i) Modify Hicksian theory to allow for value learning (ii) Not a challenge to Hicksian theory
Preference is stable and context independent	(i) Attachment and motivated taste change (ii) Salience	Modify Hicksian theory 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 theory to allow for reference dependence and moral values

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 and WTA values, and/or by recognizing that individuals have limited capacities in optimizing when forming these values.

3.1.1. Discrete quantity changes and substitution effects. Two implicit assumptions are made when one applies a Taylor expansion to the right-hand side of Equation 3 to obtain Equation 4: $EV(m)$ is small in absolute value, and $CV'(m) \neq 0$. Randall & 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 Equation 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 substituting for the environmental good is difficult, a much larger quantity of private goods is 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 Equation 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, because CV is a constant, implying $CV'(m) = 0$.

A number of papers examine 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 with when it is broadcasted, which suggests that the lack of substitutes increases the WTP-WTA disparity. Shogren et al. (1994) show

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

	Horowitz & McConnell (2002): WTA/WTP	Sayman & Öncüler (2005): $\ln(\text{WTA}/\text{WTP})$	Tunçel & Hammitt (2014): $\ln(\text{WTA}/\text{WTP})$
Ordinary private goods	–	–	–
Real transaction	– (not significant)	–	– (not significant)
Incentive-compatible elicitation ^a	+		–
Out-of-pocket payment	NA	+	+
Repeated trials for the same good in the same elicitation method	NA	–	–
Market experience of both buying and selling the good	NA	NA	–
WTP framed as gain	NA	+	NA
WTA framed as gain	NA	–	NA

Signs for estimated coefficients significant at least at the 10% significance level are reported; otherwise they are marked as not significant. NA denotes not available. Sayman & Öncüler (2005) do not distinguish a real transaction from an incentive-compatible elicitation.

^aAn incentive-compatible elicitation includes open-ended questions with Vickrey auction, random n th-price auction and BDM (Becker-DeGroot-Marschak) (Becker et al. 1964) mechanism, and a single closed-ended question. Sayman & Öncüler do not provide detailed specification for an incentive-compatible elicitation.

that the WTP-WTA disparity for avoiding a food-borne 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, whereas candy bars do.⁶ Furthermore, they find that the WTP-WTA disparity for avoiding food-borne pathogens remains even after repeated auctions, whereas the disparity for candy bars disappears. The imperfect substitutability explanation is further supported in three meta-analyses by Horowitz & McConnell (2002), Sayman & Öncüler (2005), and Tunçel & 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 is negative, which suggests that larger substitutability of goods decreases the WTP-WTA disparity, as the theory predicts.

3.1.2. Compensating variation and equivalent variation do not equal the elicited WTP and 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. For WTP and WTA to be equivalent to CV and EV, as indicated in **Table 1**, the trading institutions need to perfectly replicate all the elements that influence her CV and EV formation. The literature identifies a number of reasons

⁶Other studies report 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 & Huber 2012), and transport safety (Guria et al. 2005).

why elicitation mechanisms in WTP-WTA studies can fail to replicate these elements and thus lead WTP and WTA to differ from CV and 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 and WTA to differ from CV and EV is in a case in which the elicitation mechanism is not incentive compatible so that an individual has the incentive to misreport her true valuation of the environmental good. Because the reported values (WTP and WTA) differ from the true values (CV and EV), WTP can differ from WTA, even when CV and EV are equal. Kolstad & Guzman (1999) provide an example in which 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 with 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 & Groves 2007, Kling et al. 2012), and 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 and WTA values can differ from CV and EV because the former can be formed dynamically, whereas the latter are inherently static concepts. In a series of papers, Zhao & 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 & 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 approximately 25% of the average WTP without the delay option, with the remaining 75% being accounted for by the commitment cost. Lusk (2003) conducts a lab experiment in which 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 in which 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 raise WTP and reduce 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 (e.g., 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 may distort WTP and WTA away from CV and 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 (e.g., to buy low and sell high). Plott & Zeiler (2007) find a number of effects of experimental procedures on exchange asymmetry, such as emphasizing ownership, being in physical proximity, and making choices 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 or EV, the individual is able to formulate and solve the utility maximization problem subject to her overall income constraint. But in reality she may 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 or WTA decisions, and many contradictions to neoclassical theory found in lab and field studies can be attributed to this failure of optimizing (Harstad & Selten 2013). Smith & 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 & Randall (1987) provide an explicit example of how bounded rationality can lead to the WTP-WTA divergence. They first invert Equations 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 may be forced to stop before finding the minimum expenditure, resulting in a higher $e(\cdot)$ and thereby reducing CV but raising EV.

The individual’s search for her optimal WTP or WTA can be further impeded by additional (and often nonmonetary) constraints. The literature on mental accounting argues that individuals may 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 an environmental good, an individual may mentally put the payment in one account that is tailored for environmental goods for which the marginal value of the budget constraint is higher. In contrast, when the individual is deciding her WTA, the money flowing in is put in a general account for which the marginal value of money is lower. The higher shadow value of money when the individual is paying for the environment and the lower marginal value of money associated with WTA can lead to the WTP-WTA divergence.⁷ The meta-analyses of Sayman & Öncüler (2005) and Tunçel & Hammitt (2014) support this conjecture. 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.

⁷Mishan & 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. Although the payments for environmental improvements in most applications are modest, the budget constraint for WTP may 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 her WTP or 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

With regard to Equations 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 & 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 DPH.

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 may 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 may adopt the basic market instinct of “buy low and sell high,” which would indeed lead to the observed WTP-WTA disparity. For instance, List & Shogren (1999) find that in repeated auctions, buyers typically start their bids low, and sellers start their offers high. This observation is consistent with 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. 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.

⁸Value learning focuses on underlying preferences such as risk and time preferences and trade-offs between consumption goods and money, whereas institutional learning focuses on auction rules and bidding behaviors of other participants in an auction.

The experimental literature offers 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 & Navarro-Martínez (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 & Brown (2013) find that a choice exercise in which subjects answer pairwise choice questions between goods removes the WTP-WTA disparity. The goods that they use include consumption goods, such as a mug and a shirt, and 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 finding shows that 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. Bateman et al. 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 & Zeiler (2005) provide subjects with 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. Plott & Zeiler find that their training removes subjects' WTP-WTA disparity. Engelmann & 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 traders 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

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

¹⁰The WTP-WTA disparity disappears with the repetition of Vickrey auctions, median price auctions, and random k th-price auctions. In contrast, the disparity remains with the repetition of the BDM (Becker-DeGroot-Marschak) (Becker et al. 1964) 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 with other auctions. Noussair et al. (2004) show that the BDM mechanism has a lower penalty than a Vickrey auction does. Market price is random and exogenous in the BDM mechanism, whereas the market price is endogenous and reflects other participants' decisions in a Vickrey auction.

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 Equations 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 et al. 2003), by arguing that preferences are affected by institutions such as markets and government policies, has led to the debate on government paternalism (Thaler & Sunstein 2003). The endogenous preferences also pose another challenge to welfare theory: If a policy that improves the environment helps consumers to value the environment more, should *ex ante* or *ex post* preferences be used to measure the policy's welfare impacts (Tan & Zhao 2015)?

Positive emotion and negative emotion are related to the WTP-WTA disparity. Georgantzis & Navarro-Martínez (2010) find that positive feelings from owning a good lead to the WTP-WTA disparity because owners want to maintain positive feelings from owning a good. These authors find that owning a good increases positive feelings of subjects and that the positive feelings raise WTA. In contrast, 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 by using induced negative feelings.

Individuals also treat goods they own as part of themselves, and as a result they rate the goods more highly than nonowners. 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 do other buyers who do not own the good. However, attachment from physical proximity other than ownership can also increase valuations because proximity gives subjects a sense of ownership. Reb & 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) argue that sellers tend to pay more attention to the consumption value of the traded good whereas buyers focus more on the related expenditures, resulting in the WTP-WTA disparity. Carmon & Ariely (2000) report these different assessment behaviors between sellers and buyers. Carmon & Ariely find that in their experiments using basketball tickets, sellers care more about basketball games, whereas buyers care more about ticket price and transportation costs.

Because 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 as consumption goods, then benefits of the goods will no longer be salient to owners. Svirsky (2014) uses a simple method to induce subjects to perceive chocolate as exchange goods in his experiment: referring to chocolate as a "chocolate coin." He finds that this simple name change removes the WTP-WTA disparity for chocolates, apparently because 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 as consumption goods. They frame their valuation experiment by 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 to its implicit assumption that an individual's utility depends only on her own bundle of final

consumption goods. Two central tenets of prospect theory are that preference may depend on a certain reference point with higher marginal utility for losses than for gains relative to the reference point (Kahneman & 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 may derive pleasure from moral values and warm glow (Boyce et al. 1992, Biel et al. 2011), and this type of other-regarding preference can also lead to the disparity.

Reference points in three different dimensions—reference consumption, reference price, and reference risk—are hypothesized to cause the WTP-WTA disparity. Losses in consumption (increases in price and risk) relative to the relevant reference point are 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 they 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 & Wong (2009) find that the manipulation of reference states influences subjects' exchange behaviors in their exchange experiments. Knetsch & Wong also find that emphasizing reference states leads to 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 & 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, with regard to eggs, consumers are more sensitive to a price increase than to a price decrease because they experience losses 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. Approximately 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 & 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. Viscusi & Huber examine trade-offs between health risk and the cost to reduce the risk to calculate the value of a statistical life. They find that subjects are more sensitive to health risk increases than to health risk 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 do buyers who

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

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

¹³Results in Weaver & Frederick's (2012) 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, in which subjects do not bid beyond the price of an outside option, whereas Weaver & Frederick explain the results by using reference prices.

have no such guilt. Higher WTA is therefore required to offset the negative feelings from giving up the item (Biel et al. 2011). A few studies 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?

Having described alternative theoretical explanations for the WTP-WTA disparity, we turn to the questions 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 above, 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 EV are close to each other and can be measured accurately by WTP and 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 in which 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 it implies that elicited WTP is a better proxy even for EV than is elicited WTA. However, as discussed above, the disparity between WTP and WTA may be driven by a divergence between CV and EV (e.g., due to substitution effects or reference-dependent preferences), and WTP may 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 for which 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 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: (a) cases with a “No” answer to

¹⁴Knetsch (1990, 2005, 2010) argues 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 approach poses practical problems, as an agreement on reference environmental levels may be hard to reach, especially when people know that their choice of reference points can influence policy decisions (Hoffman & 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 in which property rights may not be clearly specified (Brown & Gregory 1999). In those cases, Knetsch’s approach may be useful.

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?	
Discrete quantity changes and substitution effects	Discrete quantity changes and 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 upward.
	Lack of incentive compatibility	Yes	No	No	WTA is biased. An 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. One may need to allow for institutional learning.
Context-dependent preferences	Attachment and motivated taste change	No	Yes	Yes	Use WTA. One should be cognizant of government paternalism.
	Salience	No	Yes	Yes	
Reference-dependent preferences and moral values	Reference consumption and risk and loss aversion	No	Yes	Yes	Use WTA.
	Reference price and bad-deal aversion	Yes	No	No	Use WTA if the elicitation mechanism reflects real world constraints. If not, WTA is biased.
	Moral values	No	Yes	Yes	Use WTA.

This 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. Abbreviations: CV, compensating variation; EV, equivalent variation; WTA, willingness to accept; WTP, willingness to pay.

Question 1 and “Yes” answers to Questions 2 and 3 and (b) cases with opposite answers (“Yes” to Question 1 but “No” to Questions 2 and 3). In the first category, true CV and EV values can be elicited by WTP and WTA, but CV and EV are different for a variety of reasons, e.g., lack of substitutes, bounded rationality, reference and context dependence, value learning, and moral values. What fundamentally 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 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. Even in these cases, there may 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 & Zhao (2015) find that experiencing improved air quality during the 2008 Beijing Olympic 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.

In the second category, in which 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 and EV may not be elicited by WTP and WTA. Table 4 shows that several situations correspond 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 is 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, although such opportunities do exist in the real world, WTA is biased upward, and commitment cost should be removed 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 will need to be adjusted for the bias.

When EV is equal to CV, if WTP and WTA differ from them, WTA may be more biased than WTP, or vice versa. For example, individuals may 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, WTP may be closer to EV than is WTA. In this case, WTP may offer a closer approximation to EV than does WTA.

In all likelihood, many real world welfare elicitation may involve multiple reasons underlying the WTP-WTA disparity so that answers to Questions 1–3 are 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 (WTP or WTA) offers a better approximation of the correct welfare measure (CV or EV).

5. FINAL REMARKS

In this article, we review 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 can potentially lead to inefficient public policy decisions.

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

To aid applied researchers facing this conundrum, we argue above 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 among the potential welfare measures presented here. Indeed, we view our efforts to categorize the appropriate welfare measure as shown in **Table 4** more as a road map for thinking about the issue than as 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 more appropriate measure to use.

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