Multi-Unit Willingness to Pay Elicitation in the Field

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Abstract

We present and field-test a novel mechanism to elicit the willingness to pay for multiple instead of a single unit of a good. At each price of the canonical multiple price list (MPL) approach, we elicit varying multi-unit demand instead of limiting the choice to two options. We showcase our mechanism by applying it in the Lake Victoria fisheries of Tanzania to elicit valuations for fishing net panels, a production input generally purchased in bulk. Our application demonstrates the mechanism in a challenging field environment and gives best practice advice on minimizing common weaknesses of the MPL approach.

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Keywords: willingness to pay; multiple units; multiple price list; field application

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1 Introduction

Due to missing or asymmetric market access, various types of production inputs and household commodities are utilized inefficiently. Especially in developing countries, the observed demand and adoption of seemingly beneficial technologies is surprisingly low. Examples include low take-up of malaria prevention (Cohen and Dupas, 2010), rainfall insurance (Cole et al., 2013), air purification (Ito and Zhang, 2020), efficient cookstoves (Mobarak et al., 2012), and fertilizer (Duflo, Kremer and Robinson, 2011). In such settings, the targeting and pricing of policies crucially relies on willingness to pay (WTP) measurements that are provided through carefully designed elicitation methods. The Becker, DeGroot and Marschak (1964) (BDM) mechanism, a multiple price list (MPL) approach, or combinations and variations thereof are increasingly adapted and applied in low literacy field environments that necessitate a trade-off between accurate valuations and procedural simplicity (see *e.g.*, Berry, Fischer and Guiteras, 2020; Cole et al., 2020; Burchardi et al., 2021; Jack, McDermott and Sautmann, 2022).

What is woefully absent from the related literature is a mechanism that elicits the WTP for multiple units of a good or service. The lack of methodology for the elicitation of multi-unit demand is surprising. Many production inputs and household commodities are either used as a composite of multiple units, such as photovoltaic systems and fishing nets, or are continuously depleted and therefore bought in bulk such as packs of fertilizer or hybrid seeds. Declining marginal utility of additional units implies that a simple extrapolation of the maximum WTP for one unit to an aggregate demand curve for multiple units is incorrect. Moreover, many of the established WTP elicitation methods, such as an iterative BDM procedure, are not feasibly scaled to multiple units without soaring costs of implementation. It is therefore necessary to develop a mechanism that not only measures whether but also how much of a good is bought at a certain price.

In this paper, we present and field-test a novel mechanism to elicit multi-unit WTP. We extend a discrete list of prices in the canonical MPL approach to measure valuations for multiple units of a good (muMPL). We do so by allowing for varying multi-unit demand at each price instead of presenting participants with a choice between two options, which in a standard MPL measurement of WTP is usually a choice between buying the good at a certain price or not.[1] Thereby, our muMPL mechanism not only elicits the sample specific demand function for a single unit of a good but also the individual-level demand function for multiple units of that good.

Measurements of WTP in the field are generally taken through one of three approaches: the BDM mechanism, a MPL, or some form of a take-it-or-leave-it (TIOLI) offer. TIOLI is simple and therefore easy to comprehend but elicits only a bound for the valuation in question. In contrast, the BDM mechanism generates a precise WTP measurement and incentivizes true valuations. However, it is difficult to comprehend and "...can seem particularly unusual" (Berry, Fischer and Guiteras, 2020, p. 1469) to participants. The MPL represents a middle ground between these methods. Compared to BDM, the method loses precision since the discrete price list only allows the WTP to be identified on an interval of prices. However, the MPL approach has important benefits: it is easy to understand and is closer to a normal market interaction. The ease of explanation and implementation, incentive compatibility, and the rich set of valuations it can generate, makes the MPL approach a popular choice for a plethora of field settings (Jack, McDermott and Sautmann, 2022).

Here, we argue that the MPL is uniquely suited for an extension that measures the WTP for multiple units. The key difference between a standard MPL approach and our novel muMPL mechanism lies in the choice set at each discrete price. In the muMPL, participants are not limited to two options (buying a single unit or not), but are presented with a cardinal variable representing the quantities that can be demanded. Thereby, the muMPL retains the strengths of an easy implementation and of closely mimicking a natural market interaction while not adding much complexity, as long as the list of prices and the set of quantities is reasonably small. It is able to measure the WTP for each quantity of a good over not buying any unit as well as the WTP for any amount of additional units, *e.g.*, the price interval at which two units are preferred over one, or ten units are preferred over five.

Note that neither BDM nor TIOLI are particularly well-suited to elicit the

[1] The binary MPL is also used for a series of other purposes such as measuring preferences for risk (pioneered by Holt and Laury, 2002) or moral behavior (Bénabou et al., 2020).

WTP for multiple units. Both methods would need to be repeated for each quantity of the good, likely exacerbating their weaknesses, which we review in more detail in section 2, while substantially lengthening the procedure. This is especially true for an iterative BDM procedure in which the WTP is narrowed down through repeated price adjustments in a one-on-one interview (see Berry, Fischer and Guiteras, 2020; Berkouwer and Dean, 2022, for applications in the field). Due to its complexity, researchers tend to shy away from the BDM or adapt it to a simpler variation in order to improve comprehension and reduce participant fatigue already when eliciting valuations only for a single unit (de Meza, Reyniers et al., 2013; Cole et al., 2020). Added repetitions to elicit multi-unit demand would likely push the method beyond the limits of feasibility.

Furthermore, we argue that only a methodology to elicit multi-unit demand such as the muMPL can provide accurate policy recommendations when production inputs or household items are bought in bulk or when uptake of a product beyond the first unit is desirable. A single-unit WTP elicitation is ill-equipped to do so. Take the example in Michelson et al. (2021) who find that the WTP for a one kg sample of fertilizer among Tanzanian farmers greatly exceeds the price per kg of fertilizer on the market. Considering that farmers in their sample appear to use an average of over 75 kg of fertilizer and that purchases follow a standard downwards sloping demand curve, the finding is unsurprising. While the authors are primarily interested in the difference of the WTP for varying product attributes, a natural next step would be for policy makers to inquire about the pricing of potential market interventions. However, without a mechanism to elicit individual-level demand curves, one cannot inform such policies.

We showcase an application of the muMPL in the Lake Victoria fisheries of Tanzania to elicit valuations for legal wide meshed fishing net panels. Because fishermen tie several panels together to form a larger net, panels are often purchased in bulk. From a policy perspective, the use of legal net panels is desirable because they put less pressure on the resource stock than their more productive but illegal, close meshed counterparts. However, since fishing regulations are insufficiently enforced, illegal net panels dominate the market, essentially generating a market access problem for legal nets. To understand the potential of a price-based policy such as a subsidy to increase demand for legal net panels, a WTP measure for multiple units is necessary.

In our application of the muMPL, we offer up to four net panels at seven ascending price points, giving participants five different response options (between zero and four units) at each price. We follow best practices for WTP elicitation under low literacy to adapt the mechanism to a challenging field setting. That is, we use a low-stakes practice environment to improve comprehension before any valuations of interest are elicited and insist on an immediate transaction of goods for money. As a result, we limit common weaknesses of the MPL approach. We observe no inconsistencies akin to "multiple switching behavior" (Filippin and Crosetto, 2016; Yu, Zhang and Zuo, 2021), *e.g.*, participants increasing the quantity demanded when the price increases, negligible rates of potentially problematic "never switching behavior" (Jack, McDermott and Sautmann, 2022), *i.e.*, participants choosing the same option throughout the price list, and no recorded case of participants defaulting on their purchase (Cole et al., 2020; Grimm et al., 2020).

2 Willingness to Pay Elicitation in the Field

Mechanisms for WTP elicitation in the field need to consider a trade-off between accurate valuations and procedural simplicity, especially in low literacy environments. Ideally, the mechanism is easy to explain and implement while generating a rich dataset of accurate and truthful valuations. Here, we do not consider multi-unit auctions such as the Vickrey–Clarke–Groves mechanism. They are primarily designed to allocate a finite number of units of a homogeneous good to the highest bidders to maximize total welfare (Ausubel et al., 2014; Milgrom, 2019). Examples include telecommunication spectrum, electricity, or emission permits. Rather, we are interested in methodologies to elicit the WTP for production inputs and household commodities in order to inform the targeting and pricing of policies without constraining supply.

2.1 WTP Elicitation: Strengths and Weaknesses

The two popular elicitation methods are the BDM and the MPL approach.[2] In the classical BDM, participants state their maximum WTP for an item from a continuous set of prices. The method elicits true valuations because whether the participant purchases the item is determined through a randomly drawn offer price. If the offer price is equal to or lower than the stated WTP, the participant purchases the item but only pays the offer price that was drawn.

The related literature highlights several weaknesses of the BDM mechanism (de Meza, Reyniers et al., 2013; Cason and Plott, 2014; Cole et al., 2020). BDM elicits true valuation only when participants maximize their expected utility. However, the lottery character of the random price draw (often based on an unknown distribution of prices) can bias the WTP upwards as participant try to avoid the disappointment of "losing" the item due to a high offer price draw that is perceived to be unlucky or downwards as participants bid a low price and gamble on a favorable price draw (Horowitz, 2006). Moreover, the mechanism is often misunderstood. Cason and Plott (2014) show this by using the BDM mechanism to elicit the WTP for a known preference, a voucher that is redeemable for \$2. They find that several repetitions of the WTP elicitation are necessary for participants to bid \$2 for the voucher, implying that the game form is not correctly interpreted when participants state their initial bid.

A popular adjustment of the BDM is the use of an iterative procedure. A recent example is the study by Berry, Fischer and Guiteras (2020) who elicit the maximum WTP for a water filter with a sample from Ghana. After participants state their initial WTP, they are tested on their comprehension of the outcome and are asked whether they want to adjust their WTP for the filter upwards by a small amount. If the WTP is indeed adjusted, the comprehension test and the question of upward adjustment is repeated until the participant declines to adjust the WTP. While this iterative procedure improves precision of the WTP

[2] A TIOLI offer is unpopular as a stand-alone elicitation method due to the limited data it generates. Still, it is often used as a comparative benchmark for the performance of other elicitation methods, see *e.g.*, Berry, Fischer and Guiteras (2020) and Berkouwer and Dean (2022) for recent comparisons between BDM and TIOLI with populations from Ghana and Kenya, respectively.

estimate, it is lengthy and likely perceived as unusually convoluted. Furthermore, the outcome of the repeated adjustment will be biased if the initial WTP is a mistake. These challenges have prompted the common adaptation to use a discrete instead of a continuous set of prices, trading off a precise identification of the WTP with an increase in comprehension (Berkouwer and Dean, 2022; Dizon-Ross and Jayachandran, 2023).

An iterative BDM with a discrete set of prices closely resembles a MPL procedure.[3] In fact, the MPL method often borrows the random offer price draw from the BDM to be incentive compatible, making it susceptible to the same limitation as described above, *i.e.*, it elicits true valuations only when participants maximize their expected utility.

In a MPL, the participant is usually able to see all prices and all available options at the same time. While such a menu of options is closer to a normal market interaction, the implementation of a MPL has to overcome several challenges. First, the MPL needs a discrete support of the price distribution that is chosen ahead of its implementation. Depending on the use case, this price list may or may not be reasonably easy to select. Second, participants may never switch but choose the same option throughout the price list. Such never switching behavior (NSB) can be problematic if it suggests that the WTP lies in an infinitely wide price interval. An often unproblematic form of NSB occurs when participants have no demand for a given product at all price points, be that because their demand is already fully met, due to a strict preference for other products, or due to liquidity constraints. In such cases, participants would never switch from selecting zero units. Third, participants tend to switch between options several times although prices are either monotonically decreasing or increasing. Such multiple switching behavior (MSB) may indicate indifference between options (Andersen et al., 2006) but it is more often interpreted as a sign of low data quality (Yu, Zhang and Zuo, 2021).

Efforts to limit NSB and MSB include directly asking participants for the switching point (Tanaka, Camerer and Nguyen, 2010) or stopping the MPL when participants switch for the first time (Burchardi et al., 2021). However, Jack,

[3]In fact, some already refer to the iterative BDM with a discrete set of prices as an "iterative MPL", see Jack, McDermott and Sautmann (2022).

McDermott and Sautmann (2022) caution against artificially curtailing the MPL and argue that the ability of identifying inconsistent preferences is a noteworthy strength of the MPL approach in comparison to BDM and TIOLI.[4]

2.2 The Challenge of Field Implementation

In a challenging field environment, the elicitation of WTP is particularly susceptible to measurement error caused by incomprehension. Therefore, the related literature has developed best practices beyond the adaptations discussed above. A popular strategy to improve comprehension is to practice the WTP elicitation with an inexpensive item such as a bar of soap or a napkin (Berry, Fischer and Guiteras, 2020; Cole et al., 2020). The practice procedure helps to familiarize participants with the key elements of the WTP elicitation, experiencing the offer price draw and actually purchasing the good. This limits payment defaults and assists the research team in uncovering fundamental comprehension issues ahead of the procedure of interest. Additional best practices include a clear formatting of the material, *e.g.*, visualizing items in a price list, and onsite randomization where one of the participants draws the random offer price (Burchardi et al., 2021). These features further improve comprehension and showcase to participants that the randomization process is transparent and fair.

A less frequently discussed element of field implementation are the practicalities of a WTP elicitation mechanism. Procedural complexity such as an iterative adjustment protocol will lengthen the WTP elicitation considerably, increasing participant fatigue and thereby inducing inattention and error (Beauchamp et al., 2020). Moreover, the mode of elicitation is an important determinant of the mechanism's overall cost. When the WTP is elicited in lengthy one-on-one interviews, a large sample size will imply a high cost for research assistance.

[4] In addition, both an iterative BDM with discrete prices and a MPL are susceptible to anchoring or framing effects (Andersen et al., 2006; Burchardi et al., 2021). The WTP may be systematically biased when participants are anchored to certain prices, *e.g.*, an attraction to the maximum price on the MPL (Cason and Plott, 2014) or values of the offer price draw distribution in case it is announced (Bohm, Lindén and Sonnegård, 1997).

2.3 Eliciting Multi-Unit Demand

We argue that the MPL is most suitable for an extension to measure multi-unit demand without compromising its implementation. The extension can be achieved by increasing the set of options at each price from a binary choice to a cardinal variable that represents the quantities the researcher is interested in. Importantly, such a multi-unit MPL still asks the participant to choose one option per price on the list, *i.e.*, the number of choices to make is equivalent to a single-unit MPL. Thereby, the multi-unit version retains the MPL advantages as an easy to explain and easy to implement methodology while adding a measurement of the individual-level demand function for multiple units. In the following, we describe the muMPL approach in a conceptual framework and present an application in the field.

Among the available mechanisms to elicit WTP, neither the BDM nor the TIOLI can feasibly be extended to measure multi-unit demand. In both cases, the elicitation procedure would need to be repeated for every quantity of the good for which the WTP is to be evaluated.[5] Especially for an iterative BDM procedure with practice rounds, repeated bid adjustments, and comprehension tests as implemented by Berry, Fischer and Guiteras (2020), the procedural length of eliciting multi-unit demand likely becomes a meaningful constraint on participant fatigue and research budget.

3 The muMPL Mechanism

3.1 Conceptual Framework

We describe the features of the multiple price list for multiple units (muMPL) with a simple framework that builds on and generalizes the model in Jack, McDermott and Sautmann (2022) to fit a multi-unit setup. In a MPL, individual i is presented with a $T \times J$ matrix of options and is asked to make a series of $t = 1, \ldots, T$ choices between $j = 1, \ldots, J$ different options. Under the assumption that utility is additive in monetary value, option j generates $U_{i,j} + v_{j,t}$ with $U_{i,j}$ denoting the

[5]Note that in a TIOLI mechanism, the sample size is already split for every price that is tested.

utility from option j and $\upsilon_{j,t}$ denoting the monetary value associated with option j in choice t.

If individuals correctly state their preferences, the $WTP_i(j, j^*)$ for option j over another option j^* is given by $U_{i,j} - U_{i,j^*}$. Individual i will prefer option j over j^* if,

$$U_{i,j} + \upsilon_{j,t} > U_{i,j^*} + \upsilon_{j^*,t} \quad \vee \quad WTP_i(j, j^*) > \upsilon_{j^*,t} - \upsilon_{j,t}, \tag{1}$$

and prefer option j^* over option j if,

$$WTP_i(j, j^*) < \upsilon_{j^*,t} - \upsilon_{j,t}. \tag{2}$$

Therefore, $WTP_i(j, j^*)$ lies in the closed interval between the largest value of $\upsilon_{j^*,t} - \upsilon_{j,t}$ for which individual i chooses option j and the smallest value of $\upsilon_{j^*,t} - \upsilon_{j,t}$ for which she chooses option j^*.[6]

The standard (single-unit) MPL poses a series of binary choices ($j = 1, 2$) with the objective of identifying the WTP for one option over the other. Hence, the participant is presented with a $T \times 2$ matrix of options. For an illustrative example, see the left part of Figure 1. The example is taken from Burchardi et al. (2024) who ask participants to indicate whether they want to sign up for an educational program by ticking "Yes" or "No" next to each of eleven different price points presented in ascending order, *i.e.*, a 11×2 matrix of options. Given that participants switch from "Yes" to "No" exactly once, the maximum WTP for the educational program is identified in the interval between the highest price for which the answer is "Yes" and the lowest price for which the answer is "No".

In the muMPL, individuals are presented with a larger set of options that directly depends on the set of quantities of the good or service that can be demanded. The right part of Figure 1 shows an example, taken from the practice procedure of our muMPL application, which we describe in section 4. Here, participants are presented with a 4×5 matrix of options for the purchase of soda bottles. At each of the four different prices, they are asked to make one choice, stating their demand for up to four bottles. Thereby, the muMPL measures the $WTP_i(j, j^*)$, $\forall j > j^*$.

[6] Under never switching behavior, the interval for $WTP_i(j, j^*)$ is open. Assuming that demand for zero units is the first option (j=1), one would have $WTP_i(j, j^*) \in (-\infty, min_t(\upsilon_{j^*,t} - \upsilon_{j,t})]$ for $j = 1$ and $WTP_i(j, j^*) \in [max_t(\upsilon_{j^*,t} - \upsilon_{j,t}), \infty)$, $\forall j > 1$.

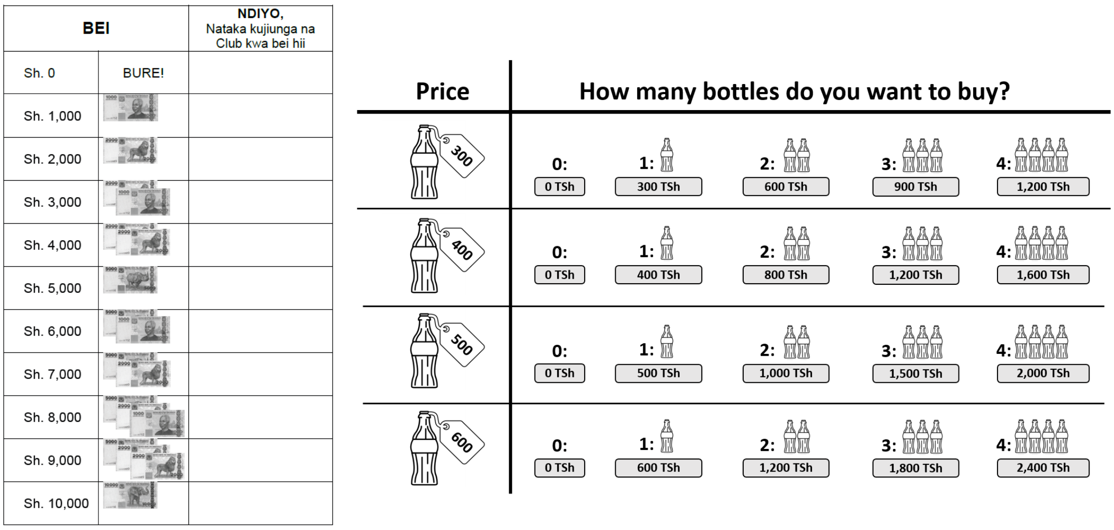

Figure 1: Example of the design for a standard MPL and a muMPL.

Notes: The figure shows an example of a standard MPL design (left) and an example of the muMPL design (right). In the standard MPL design, taken from Burchardi et al. (2024), participants are asked to indicate whether they want to join an educational program by ticking "Yes" or "No" next to each of eleven different prices. In the muMPL example, taken from our application in section 4, participants indicate their demand for up to four bottles of soda at each of four different price points. The respective total cost is displayed below each choice. In both methods, participants are asked to make one choice per row.

That is, the muMPL measures the WTP for each quantity of the good over not buying any unit, *i.e.*, the price interval at which a participant prefers to buy one, two, three, or four bottles of soda over not buying any soda. Moreover, the researcher can evaluate all other pairwise comparisons and measures the WTP for any amount of additional units, *e.g.*, the price interval at which participants prefer two bottles over one, three bottles over two, and so on.

3.2 Limitations

Ideally, the muMPL elicits well-defined WTP measurements for multiple units. However, the identification of $WTP_i(j, j^*)$ in the muMPL directly depends on whether individual i chooses option j in the first place. Hence, the support of the price distribution for the muMPL is even more important than in the single-unit case because it needs to offer a sufficiently large range of prices to be able to capture multi-unit demand. At the same time, the price intervals need to be sufficiently narrow to allow for an identification of the WTP between the different

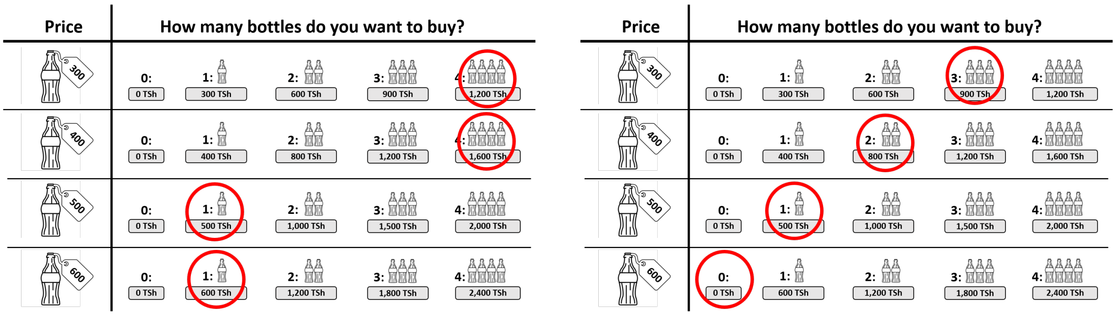

Figure 2: Examples of ill-defined and well-defined WTP measurement in the muMPL mechanism.

Notes: The figure shows two examples of how the muMPL may be answered. On the left side, the WTP for up to three units is ill-defined and the size of the $T \times J$ matrix is not sufficiently large. The researcher is only able to identify the WTP for four units over one unit in the interval between 400 TSh and 500 TSh. On the right side, the WTP for the offered quantities is well-defined and the $T \times J$ matrix is sufficiently large. Note that in both cases, valuations are consistent, *i.e.*, demand does not increase at higher prices.

quantities. Then, participants are less likely to skip an option entirely. Both arguments incentivize the researcher to choose a large set of prices T and options J. Yet, the $T \times J$ matrix should be reasonably small as not to overcomplicate the procedure. Similar to the standard MPL, the muMPL is susceptible to NSB, *i.e.*, demanding the same number of units at all prices, and a type of MSB, *i.e.*, increasing demand at increasing prices. Also, it is inevitably constrained by the maximum number of units it offers, leaving the $WTP_i(j, j^*), \forall j > j^{max} > j^*$ unidentified.

As an example for an ill-defined WTP measurement, see the left part of Figure 2. The example illustrates three potential drawbacks of the muMPL. First, there is demand for one unit at the highest price, implying that the WTP for one unit is in the open interval between 600 Tanzanian Shilling (TSh) and infinity. The muMPL would need to include higher prices to ensure that the WTP for the first unit is identified in a closed interval. Second, there is demand for the maximum number of units, raising the question whether there is demand for a larger number of units at the same price. Third, several responses are skipped. In the example, the identification of the WTP for the third and fourth option (two and three units) would necessitate narrower price intervals between 400 TSh and 500 TSh. In fact, the only WTP that the researcher is able to identify in the example is the WTP for four units over one unit.

In contrast, the right part of Figure 2 shows an example of a well-defined WTP measurement where (i) no option is skipped, (ii) there is demand for zero units, and (iii) the maximum number of units is never demanded. Ultimately, the ability of the muMPL to provide a well-defined WTP measurement is dependent on the choice of the $T \times J$ matrix which may be optimized through pre-testing and prior market research.

4 Application

We use a field experiment in the Lake Victoria fisheries of Tanzania to demonstrate our novel muMPL approach in a challenging field environment. In the field experiment, we measure the WTP for multiple units of legal wide meshed fishing net panels with the purpose of informing a potential subsidy program. Since several net panels are tied together to form a larger net, panels are generally bought in bulk.[7] This necessitates the measurement of multi-unit WTP to inform policy recommendations.

4.1 Data Collection

The muMPL mechanism was implemented with 462 fishermen in a workshop setting at 20 different landing sites along the Tanzanian lakeshore. The workshops were led by researchers from the Tanzanian Fisheries Research Institute and at each landing site, attendance was between between 18 and 24 participants.

The muMPL procedure was conducted in three steps. First, all participants in a workshop privately stated their demand for net panels at seven discrete prices presented in ascending order and a maximum number of four units offered at each price, *i.e.*, a 7×5 matrix of options. The WTP was elicited with an order sheet (see Supplemental Appendix Figure A-1) and participants were instructed about the rationale of giving consistent answers meaning that their demand should not increase at higher prices. Completed order sheets were then sealed in envelopes and collected. It was highlighted that all valuations would be made under a binding

[7] For more details on characteristics of the market for net panels at Lake Victoria, see Supplementary Appendix A-2.

purchase agreement, *i.e.*, that if selected, the participant would have to purchase the number of units indicated at the respective offer price. Second, one of the workshop participants randomly and publicly drew one of the seven prices as the offer price for the entire workshop. Lastly, one envelope at a time was randomly chosen and the number of units demanded at the offer price was publicly sold to the respective participant. Then, another envelope was drawn and the procedure was iterated until all envelopes were drawn or all available items were sold. Note that the supply of net panels was limited to one panel for every two participants, keeping the item to participant ratio constant across workshops. Logistical considerations that limit the supply of items are common in applied settings, making the random draw of the offer price and envelopes a crucial feature that ensures the elicitation of true WTP, independent of when the stopping rule during the envelope draw takes effect.

The muMPL procedure for the net panels was preceded by a practice procedure for soda bottles that utilized the offer sheet shown in the right part of Figure 1. The only difference between the practice and the net panel procedure was the size of the matrix of options, all other procedural steps were identical. The practice environment showcased the binding purchase agreement, the public procedure to allocate items, and helped to resolve comprehension questions before the valuations of interest were elicited. In particular, inconsistent preference patterns such as an increase in demand at higher prices were pointed out by the research team and reviewed with participants to ensure that the mechanism was well understood. Note that the muMPL design enabled the research team to give instructions to all participants in the workshop at the same time, thereby avoiding time-consuming (and costly) one-on-one explanations. Individual assistance was only provided when necessary.

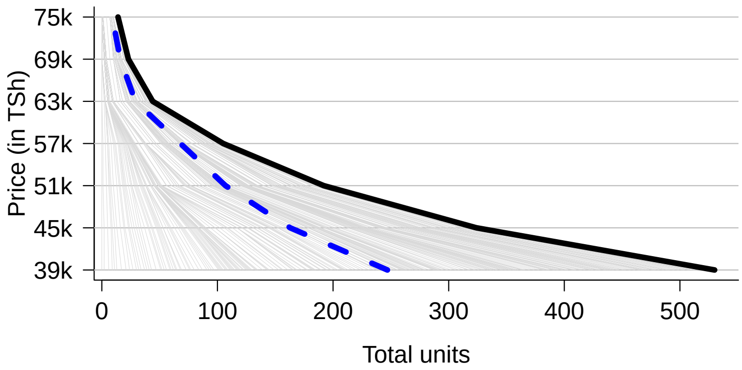

Figure 3: Aggregate demand curve.

Notes: Aggregate demand curve in our sample (in black) and the cumulative sum of individual demand curves (in grey, N=247) as well as the aggregate demand curve when curtailing our data to the single-unit WTP (dashed).

4.2 muMPL Measurements

In Figure 3, we plot the aggregate demand curve for our sample.[8] For orientation, the market price of a legal net panel is around 60k TSh (approx. US $25). We observe that the sample-specific demand curve is convex and is consistent with the empirical fact that net panels with a legal mesh size are an unpopular production input, dominated by the use of their illegal, close meshed counterparts (LVFO, 2020). That is, the mechanism elicits low demand at or above market price and only when panels are subsidized by 25% to 35% (*i.e.*, prices of 45k TSh and 39k TSh), average demand is above one and two panels per participant, respectively.

In our application, we limit the common weaknesses of a standard MPL. First, we observe no case of a participant increasing the quantity demanded when the price increases. We largely attribute this to the beneficial effects of the practice procedure, where inconsistent preference patterns were deliberately pointed out and reviewed. Second, we only record four cases of never switching behavior. This excludes the 215 participants (about 47% of the total sample) that have

[8]We only present demand and WTP measurements for the 247 participants that demand at least one unit at the lowest price. Also, we ran a norm-nudge treatment when we implemented the muMPL procedure, for more details, see Supplemental Appendix A-3. However, the treatment did not significantly affect the WTP such that we group the treatment and control group when presenting our application.

zero demand at all seven prices on the list. Importantly, we do not interpret such zero demand at all prices as an indication for problematically inconsistent preferences but rather as a truthful WTP. That is, the participants with zero demand at all prices differ from participants with positive demand. They report to face higher prices for production inputs (net panels), lower prices for production outputs (their catch) and report to run smaller fishing operations (number of total net panels owned), suggesting that they are more likely to be credit constrained while having less frequent demand for new net panels. [9] Third, there were no participants that defaulted on their purchase. Again, this was likely due to the practice procedure that showcased the immediate transaction but could also be a result of the workshop setting in which all transactions were made in public. That being said, the apparent salience of the fact that transactions had to be immediate may be one of the reasons for the large share of participants with zero demand. The possibility to take on credit or pay at a later time (see *e.g.*, Berry, Fischer and Guiteras, 2020) may have reduced zero demand but increased payment defaults.

4.3 Policy Advice on Market Interventions

For many goods and production inputs, a multi-unit WTP elicitation is necessary to formulate accurate policy advice on the pricing of market interventions. In Figure 3, we additionally plot the aggregate demand curve when curtailing our data to only consider the maximum WTP for one unit (dashed line), thereby mimicking a single-unit MPL procedure. The difference to our multi-unit demand curve (solid line) highlights that policies cannot be accurately formulated when the WTP is only elicited for a single unit. In fact, many studies that elicit single-unit WTP but focus on a product that is generally bought in bulk, limit their analysis to comparing the WTP between different product attributes or to testing the effect of an additional treatment (Michelson et al., 2021; Grimm, Luck and Steinhübel, 2023). To answer such questions, the WTP for a single unit may be sufficient but it precludes researchers from arguing whether and how these products can be

[9] Furthermore, we observe that these participants are more likely to strictly prefer a competing type of net panel, *i.e.,* more costly, imported nets with higher quality and legal mesh size, suggesting structural reasons for having no demand in our application. For more details on the subsample with zero demand throughout the price list, see Supplemental Appendix A-2.

subsidized at scale.

Similar arguments may be made with respect to products where the purchase of multiple units is at least not uncommon, *e.g.*, antimalarial bed nets (Dupas, 2014), solar lamps (Grimm et al., 2020), or water filters (Hoffmann, 2018; Berry, Fischer and Guiteras, 2020). In case policy makers look to subsidize the purchase of a second or third unit per household, policy advice is likely to be imprecise when WTP measurements are only available for a single unit.

In a naive first approach, one may be tempted to ignore the regularity of a downward sloping demand curve and approximate multi-unit demand by simply extrapolating the single unit WTP. In other words, the researcher would assume that the *unobserved* WTP for the second and third unit is equal to the *observed* WTP for the first unit. When tested in our application, we find that such a single-unit extrapolation significantly overestimates the WTP compared to our actual muMPL measurement for all quantities beyond the first unit. The WTP would be overestimated by 10.1% for two units ($p < 0.001$ in a two-sample t-test), by 18.0% for three units ($p < 0.001$), and by 25.7% for four units ($p < 0.001$).[10] These substantial differences highlight the need for our novel muMPL as an elicitation method when measures of multi-unit demand are required.

5 Conclusion

We present and field-test a novel mechanism to elicit the WTP for multiple units via a modified multiple price list (muMPL). While offering a novel extension to measure multi-unit demand, the muMPL retains the strengths of the canonical MPL approach as an easy to explain and implement elicitation method. With the muMPL, we present a tool that not only elicits the sample-specific demand curve for one unit of a good but also the individual-level and aggregate demand curve for multiple units of that good. Thereby, we add to the toolbox of researchers in all empirical disciplines of economics, both in the laboratory and the field.

[10] The extrapolation is based on the individual's maximum WTP for the first unit but is limited to the individual's maximum demand as elicited during the muMPL application. For example, if a participant had a maximum demand of two panels at the lowest price in the muMPL, we will consider her WTP for the first unit only to inform the extrapolation for one and two but not for three and four units.

To showcase the strengths and limitations of the muMPL, we use our mechanism to elicit the WTP for fishing net panels in the Lake Victoria fisheries in Tanzania, a challenging low literacy field environment. In our application, we show that the mechanism avoids a number of common pitfalls of the MPL approach, including inconsistent preferences and purchase agreement defaults. We also believe it to be worth highlighting that the muMPL is easily adapted to different types of products or services and crucially, can be customized to many different sets of quantities that researchers want to evaluate. While in our application, we use the muMPL to elicit the WTP for up to four units, the approach can also be used for considerably larger quantities or different sizes of a product bundle. Future work may look to benchmark the muMPL against other methodologies designed to elicit multi-unit demand, for example by repeating a MPL, BDM, or TIOLI for all quantities the researcher is interested in.

We suggest the use of the muMPL mechanism whenever there is demand for multiple units. Possible applications are manifold, including production inputs and consumption goods on the firm, household, and individual level. For example, the analysis of the WTP for residential solar panels should not be limited to whether households are willing to install a rooftop solar system (Badole et al., 2024) but should include the WTP for the scale of the installation. Other applications are in agricultural production, especially in developing countries, where the muMPL may be used to inform farm input subsidy programs (Holden, 2019). In many such settings, the elicitation of the WTP for multiple units is indispensable to provide accurate policy advice.

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Supplemental Appendix

A-1 muMPL Application Order Sheet

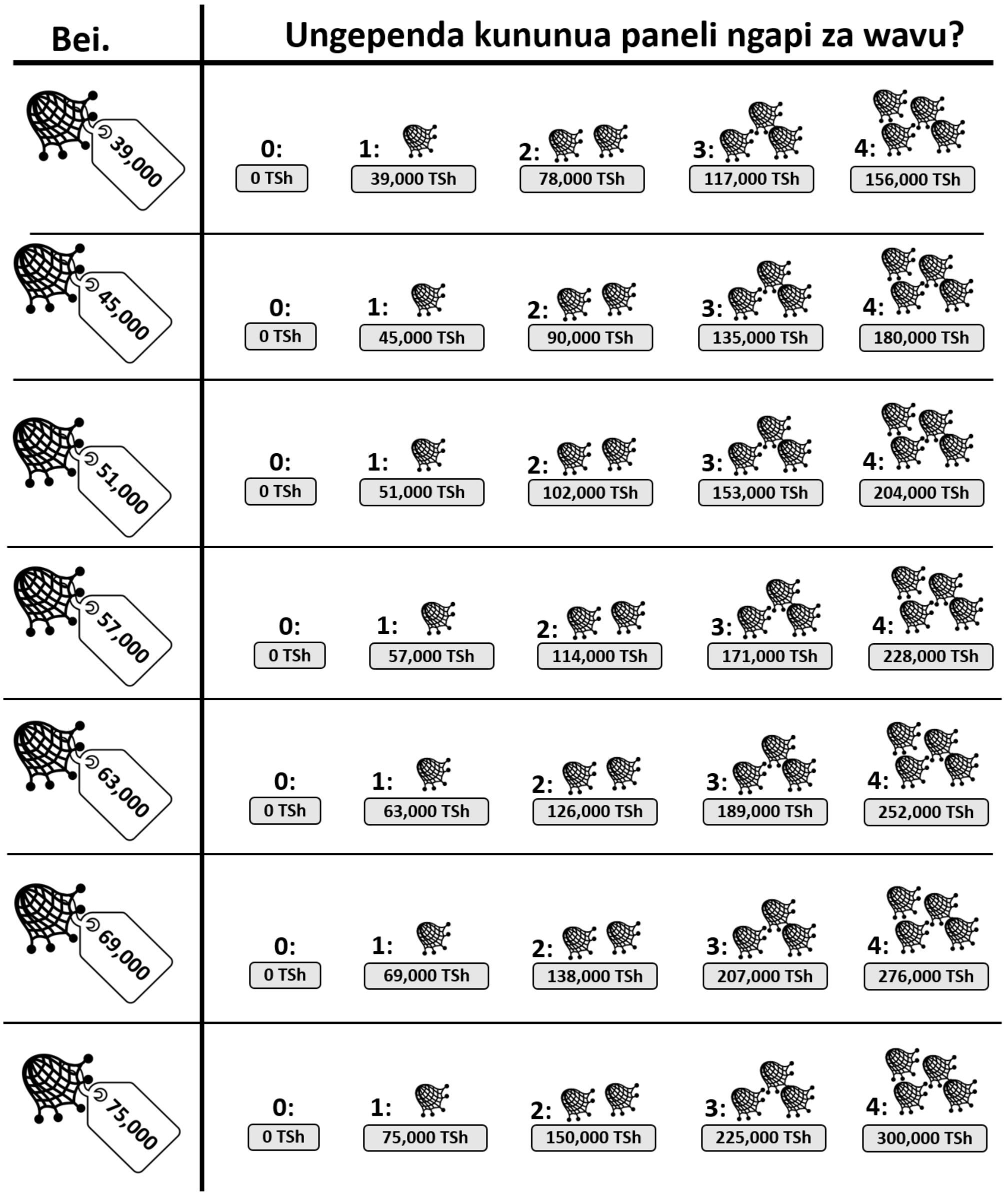

Figure A-1: Net panel order sheet with seven discrete price options in ascending order and four units offered at each price. The column titles translate to "Price" and "How many net panels would you like to buy?".

A-2 Net Panel Market Characteristics and Zero Demand

The market for net panels at Lake Victoria can be categorized by mesh size and by the quality of the filament material. That is, net panels may either be legal (a mesh size $\geq$ 8mm) or illegal (a mesh size $<$ 8mm) and they may be made of high quality and durable filament (Asian import products locally referred to as "Japanese" nets) or low quality filament material that deteriorates faster (locally produced nets referred to as "Kenyan" nets). Importantly, only Kenyan nets are available at an illegal mesh size below 8mm. With the intent of informing a policy that incentivizes the use of legal instead of illegal nets, we therefore offer 8mm Kenyan nets in our application.

The demand for new net panels depends on two factors: (i) the durability of the net, which is dependent on the quality of the material and (ii) the size of the fishing operation. Therefore, while an owner will have regular demand, it will be more or less frequent. When administering a one-time subsidy (like in our muMPL application), one should expect to encounter owners that (a) have no demand for new legal Kenyan net panels at the time of the intervention because their demand is more infrequent, *i.e.*, they have *temporarily* zero demand[11], and (ii) have no demand for new legal Kenyan net panels in general because they either prefer high quality Japanese nets or only use illegal mesh sizes, *i.e.*, they have *structurally* zero demand.

Table A-1: Participant characteristics with mean comparison tests between samples with positive and zero demand.

	Positive demand			Zero demand			
	N	mean	sd	N	mean	sd	adj. p
Age	227	42.3	8.8	205	42.0	9.3	1.00
Female	227	0.1	0.3	205	0.0	0.2	0.12
Number of boats owned	225	2.6	2.4	205	2.5	2.2	1.00
Number of panels owned	227	9.6	4.6	203	7.2	5.0	0.00
Panel market price	247	59,661	5,372	215	62,106	5,763	0.00
Current price of dagaa (5L bucket)	227	9,769	4,036	205	8,801	3,439	0.04
Trips per week	227	4.4	2.3	204	4.0	1.5	0.10
Mean income (last 20 trips)	199	131,415	88,959	182	120,440	83,353	0.65
Last purchase (only Japanese)	247	0.27	0.44	215	0.51	0.50	0.00

Notes: Comparison of characteristics between participants with positive demand ($N = 247$) and participants with zero demand ($N = 215$), even at the highest discount offered. Prices and income are reported in TZS. All displayed test statistics are mean-comparison t-tests with adjusted p-values to accommodate for multiple testing.

In our data, there is evidence for both structurally and temporarily zero demand, see Table A-1 for a comparison of the subsample with positive (left) and zero demand (right). When being asked about their latest net panel purchase,

[11] The purchase of reserve net panels is generally limited because of (i) liquidity constraints, (ii) high storage costs, and (iii) the threat of theft.

workshop participants with zero demand at all seven prices are significantly more likely to only have purchased high quality "Japanese" nets, suggesting structural reasons for zero demand due to a preference for high quality import products over locally produced Kenyan nets (the ones that were offered during our muMPL application). Moreover, owners with zero demand report to own fewer fishing vessels and report to go on fewer fishing trips, a pattern consistent with temporarily zero demand due to running a smaller overall fishing operation. Lastly, we observe that owners with zero demand report to face higher prices for production inputs (net panels) and lower prices for the output (5L buckets of fish) which indicates that these owners run, on average, less profitable fishing operations and may rely on illegal production inputs to increase their productivity.

In summary, we interpret the share of participants with zero demand at all prices as a truthful WTP elicitation rather than as problematically inconsistent preferences.

A-3 The Norm-Nudge Treatment

The norm-nudge is similar to the one used in Diekert and Eymess (2024) and Diekert et al. (2022). It is a descriptive social information message that is verbally provided to all participants in the workshop immediately before their WTP is elicited, *i.e.*, before the order sheet is filled out. We use the following message:

"You are not the first landing site we visit for a workshop. We visit many communities around the Lake. At other landing sites, many fishermen support sustainable fishing by purchasing 8mm net panels."

The norm-nudge treatment was randomized across workshops. By leveraging a social comparison, the message is designed to affect participants' belief about what is common observable behavior. The message is carefully phrased as to avoid uncertainties about both the reference group and the normative implications of the described target behavior. Descriptive norm-nudges may fail if the reference group of the information message is not relevant or when it is unclear whether the target behavior is desirable also from a normative standpoint. Therefore, we use a message that explicitly refers to peer behavior (fishermen at other landing sites) and support the message with a normative statement (the desirability with respect to sustainable resource use). Moreover, the message does not name a specific price in order to avoid anchoring demand. Thereby, we make it more difficult for participants to rationalize that the applicability of the social information is subject to personal budget constraints, thus limiting self-serving belief formation.

The norm-nudge does not affect demand for net panels. A Kolmogorov-Smirnov test on the equality of the distributions of demand in the treatment and control group rejects a difference with with $p = 0.208$.