Factors influencing buyers' willingness to offer price premiums for carbon credits sourced from urban forests

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Abstract: Marketing carbon offset credits generated by urban forest projects could help cities and local governments achieve their financial self-sufficiency and environmental sustainability goals. Understanding the value of carbon credits sourced from urban forests, and the factors that determine buyers' willingness to pay a premium for such credits could benefit cities in strategically marketing carbon credits to generate revenue. This study surveyed business organisations participating in carbon trading in order to explore the factors influencing buyers' willingness to pay for urban forest carbon credits in alternative marketing scenarios (i.e., with and without explicit recognition of purchase). Results suggest that buyers are willing to pay a premium for carbon credits sourced from urban forests and the amount of this premium was influenced by the purchasing business's ownership type, size, geographical scope of operations, and the level of importance placed on the co-benefits provided by urban trees.

Keywords: price premium; urban forests; ecosystem service; carbon credits; Tobit model.

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1 Introduction

Markets for forest-based ecosystem services including carbon offsets have emerged in the European Union, and are slowly emerging in the USA and other countries (Sridhar, 2010). In the absence of mandatory regulations for carbon emitters, carbon offsets are still voluntary in many countries. Commercial platforms like Chicago Climate Exchange (CCX) have facilitated voluntary trading of carbon credits in the North American market. While many types of carbon offsets, including landfill methane, agriculture methane, agriculture soil carbon, coal mine methane, and renewable energy have been traded at the CCX, forest carbon remains the second largest source of offset credits behind agriculture soil carbon. In 2009, forest carbon credits (equivalent to 1 metric ton of CO_2 emission) registered by the CCX (2009) amounted to about 6 million metric tons of CO_2 equivalents. This indicates the relative importance of forest-carbon credits. Although the US Government has yet to develop a policy regulating emissions of greenhouse gasses (GHGs), and voluntary efforts have slowed during the economic downturn since 2008, interest remains among emitters in buying carbon credits.

Forest-based carbon credits in the USA and elsewhere represent mainly carbon sequestered through private and industrial forest projects. If the US Government were to introduce mandatory carbon emission controls while allowing forest carbon credits to meet relevant requirements, a substantially higher quantity demanded for carbon credits could ensue. In that scenario, urban forests remain a substantial, and yet unfulfilled, source of carbon credits (McPherson, 1994; Nowak, 1993; Jo and McPherson, 2001). Literature on carbon offset credits argues that carbon offset projects in rural areas, especially in developing countries, can create barriers to industrialisation (Ciscell, 2010), and therefore emphasises the need for certified offsets assuring ethical and socially responsible offset credits be traded. Urban forests, primarily managed by city councils or municipal governments can achieve and maintain such ethical standards and provide

adequate assurances to credit buyers regarding credit quality, legitimacy, and characteristics.

The USA has vast urban forest resources and opportunities to develop carbon offset projects. Nowak et al. (2001) reported that millions of trees along roadsides and riparian borders, and in parks and other public areas cover 27% of urban areas throughout the nation. A study by Nowak and Crane (2002) estimated that urban forests in the conterminous USA can absorb 22.8 million tons of atmospheric carbon annually. Carbon storage capacity of urban trees has also been explored and quantified for other countries (Jo, 2002; Shin et al., 2007; Zhao et al., 2010).

Developing carbon storage projects and credit trading are topics of interest to US local governments. The US Conference of Mayors Climate Protection Center was established in 2007 to help municipal governments mitigate and reduce the impacts of global warming. The CCX approved the first proposal from one of its members to generate and register carbon credits from an urban forest project in Michigan (CCX, 2009). Recent studies have suggested that local governments, partly driven by the interest of their voting constituents and the need for revenue, are interested in storing carbon in urban trees and selling offset credits (Poudyal et al., 2010). The same study also found that potential US sellers of urban forest carbon credits have both the technical and managerial capabilities necessary to implement carbon projects (Poudyal et al., 2010). About a dozen local government units including cities, counties, and municipalities have already participated in CCX carbon trading.

Virtually all credit buyers are businesses operating in a wide variety of locations across the world, dealing with consumers, media, and governments. These businesses represent public and private entities and operate for profit as well as not for profit purposes. Organisations operating at various geographical scales vary in terms of accessing and utilising knowledge in business management (Berkes, 2009). Previous studies on environmental attitudes of business managers have indicated that a business's environmental response is significantly influenced by the perceptions, attitudes, and values of managers and executives (Brust and Liston-Heyes, 2010). Therefore, it is reasonable to expect that business organisations in the market for carbon credits may have different preferences for credits sourced from various types of carbon projects. Urban forest carbon credits could potentially represent a credit type that is particularly desired by businesses for corporate image purposes. For example, purchases of carbon credits generated by storing carbon in urban trees could help local governments in managing their trees and green heritage and benefit residents with aesthetic beauty, recreation, and other ecosystem services (Chaudhry and Gupta, 2010). Furthermore, urban forests are typically of a small project nature, and could prove useful in maintaining biodiversity and foster local development through revenue generation from carbon credit sales.

Despite a vast literature on factors determining willingness to pay (WTP) for a variety of forestry products and services [e.g., eco-labelled furniture: Veisten (2007); certified wood products: Cai and Aguilar (2013)], literature on buyers' WTP for forest-based carbon credit is relatively scarce. A few studies have investigated the buyers' side of carbon credit markets (Ashford et al., 2008; Hamilton et al., 2008, 2009; Neeff et al., 2009; Brouwer et al., 2008; Peters-Stanley and Hamilton, 2012). Some have used revealed preference approach that relies on credit sales data to examine buyers' preferences. For example, Ashford et al. (2008) assessed the factors that buyers consider

important in selecting offset credits. Neeff et al. (2009) used a stated preference approach to directly ask buyers about their preferences for carbon credits and desirable characteristics of the underlying projects. They found that buyers care about the characteristics of offset projects, and place significantly different values on credits generated from different projects. However, these studies examined buyers' preferences for more general types of projects such as forestry, agriculture, or methane capture and did not focus on more specific settings such as urban forests.

Three related studies surveyed the general public to elicit WTP for offsetting carbon footprints during air travel or family vacations (Brouwer et al., 2008; Gossling et al., 2009; Lu and Shon, 2012). These studies found positive responses from tourists in mitigating pollution, and more importantly a significant WTP to fund such programs. However, the respondents in these studies were not typical buyers of carbon credits such as businesses facing voluntary or mandatory emission reduction targets. Rather, they were individuals facing a question of offsetting their carbon footprint from a hypothetical vacation trip or air flight.

In order to fill this gap in literature, a survey of current and prospective buyers of carbon credits participating in carbon markets through the CCX was conducted in this study. The specific objective of the current paper is to develop an econometric model and test hypotheses about factors that affect buyers' WTP a premium for credits sourced from urban forests. Understanding what determines the variation in WTP, and evaluating the role of value added programs (through promotion and publicity) could be beneficial to urban forestry project managers in marketing offset credits, increasing revenue, and, more importantly, in achieving financially self-sufficient urban forestry programs.

2 Data collection

2.1 Respondents

The major objective of this study was to assess the opinion of carbon credit buyers and assess their willingness to pay a price premium. Thus, entities involved in carbon trading at the CCX were targeted. CCX members were selected for two primary reasons. First, the CCX comprised the largest market platform for carbon trading in the USA. Second, it was relatively easier to contact CCX members than reaching buyers from the over-the-counter market.

Members and associate members of the CCX were selected as respondents. Members are businesses and organisations with a commitment to reduce their direct emissions whereas associate members have a commitment to reduce their indirect emissions. Other member categories, such as aggregators and liquidity providers, were not surveyed because they were not the primary users of carbon credits and may have little influence on ultimate credit demand. The targeted group was diverse in terms of geography and business sectors representing manufacturing, real estate, information technology, financial services, electric power generation, consulting, electronics, and forest products.

2.2 Survey process and instrument

Initially, a telephone call was made to contact as many participants as possible. Given the complex organisational structures of participant business organisations, telephone contact

was made for two reasons. First, it helped to find the appropriate official capable of completing the survey. Second, it provided an early confirmation of participation and an opportunity for respondents to choose the desired mode of survey delivery (mail or e-mail). If the initial phone call was unsuccessful, the survey was addressed to the entity's chief executive officer.

The survey was implemented during the fall of 2009, and followed a modified tailored design method for mail questionnaires (Dillman, 2000). A copy of the survey along with a personalised cover letter or e-mail message was delivered to participants. After two weeks, a reminder message with a copy of the questionnaire was sent. Due to an initially low response rate, a third reminder, along with another questionnaire, was sent to the original contacts.

Figure 1 Payment card showing WTP in two valuation scenarios

Q– The following gives two different scenarios for paying a premium to purchase carbon credits from urban trees or forest. What is the most your company would be willing to pay IN ADDITION TO the current market price you are paying for a carbon credit? (Note: the market price for carbon on the Chicago Climate Exchange on July 27, 2009 was 50¢ per carbon credit = 1 metric ton of CO_2 emissions).

[Please check one box in each column that best represents your company's maximum willingness to pay above the stated 50¢ per credit]

If the city DOES NOT PROVIDE recognition of your company with a sign or logo highly visible at the project site	If the city PROVIDES recognition of your company with a sign or logo highly visible at the project site
☐ 0¢ not worth paying anymore	☐ 0¢ not worth paying anymore
☐ 1¢	☐ 1¢
☐ 5¢	☐ 5¢
☐ 10¢	☐ 10¢
☐ 15¢	☐ 15¢
☐ 25¢	☐ 25¢
☐ 50¢	☐ 50¢
☐ 75¢	☐ 75¢
☐ $1	☐ $1
☐ more than $1	☐ more than $1
☐ other amount (please specify) _____	☐ other amount (please specify) _____

The survey instrument (available from the authors) included 28 questions. Most of the questions were statements with five-point Likert scales allowing respondents to indicate their level of agreement/importance with/of the statement. Questions in the first section were about attitudes and perceptions of climate change, existing emission regulations, relationships with clients, and preferences for particular carbon offset project characteristics (e.g., location, project type). The second section included questions about motivation and interest in purchasing urban forest carbon credits.

Next, respondents were presented with economic valuation questions. Valuation questions used standard payment cards (Welsh and Poe, 1998; Bowker et al., 2003) to elicit respondents' WTP for urban forest carbon credits in two scenarios. In the first scenario, a city, county or municipality selling urban forestry carbon credits to business organisations would not provide any kind of buyer recognition or official logo. In the

second scenario, the seller of carbon credits would also provide an official recognition of the purchasing business organisation in a form of highly visible signage at the project site. A sample payment card with two valuation scenarios is presented in Figure 1.

The final section of the survey considered organisational characteristics such as employment, asset value, and revenue. Respondents were also asked to provide open-ended comments at the end of the survey. Experts in the area of forestry, urban forestry, and natural resource valuation assisted in development of the instrument, which was pretested on a subset of respondents. A detailed description of survey process is available in Poudyal et al. (2011a). Data analysis with a WTP model, which is the unique contribution of present study, was completed in 2013.

3 Analytical framework

3.1 Theoretical model

We modelled the utility of a business organisation similar to an individual facing a utility maximisation problem subject to a budget constraint (Johansson, 1993). Analogous to a household utility optimisation, a business operator (e.g., executives, board members) would maximise utility by choosing an optimal combination of goods and services subject to certain constraints imposed by its budget limit and necessary expenditures. Lancaster (1966) asserted that utility in such a case is not directly derived from the goods, but the attributes of investment options and is consistent with earlier application of utility theory in investment decisions acknowledging that decision-makers discriminate between different stimuli and choose the one with the highest level of utility. Recent applications of this theory to business organisations' preferences and investment decisions include Getzner and Grabner-Krauter (2004), and Aguilar (2009). Following this model, an individual business organisation's indirect utility function can be written as:

$$V = U(B, S, X, Q) \tag{1}$$

where V represents the utility of the business organisation, B is budget or income, S is the vector of the characteristics of the organisation, X is market goods essential for daily business operations, and Q is a proxy for corporate image through increased social reputation (e.g., a green image). There could be other indirect benefits associated as well. For example, investment in green projects could indirectly lead to increased productivity realised through the reduction in environmental impacts and clean-up costs (Nishitani et al., 2012). Other studies have linked proactive environmental practices with increased financial performance among small business firms (Argon-Correa et al., 2008). As the utility function is increasing in all of its arguments, any increase in the level of corporate image will leave the respondent organisation at a higher level of utility. Hence, if the benefits accrued from urban forest carbon projects increased corporate image or social reputation of a business organisation from Q_0 to Q_1, the change in utility is given as follows:

$$\Delta V = V\left(B, S, X, Q_1\right) - V\left(B, S, X, Q_0\right) \tag{2}$$

While the indirect utility functions cannot be directly observed, their difference can be estimated. In this case, the difference or compensating variation (CV) is the maximum

amount of money. In this case, the CV [equation (3)] is the maximum amount of money that can be taken from a business organisation while leaving it just as well off as prior to an increase in corporate image. This can also be explained as an organisation's WTP for an improvement in corporate image thorough supporting urban forest carbon projects. Since a given business organisation may increase corporate image by buying carbon credits from urban forest projects or by showing support for local green projects, the organisation will be willing to pay some amount of money to benefit from expected gain in utility and enjoy a better social image.

$$V\left(B-CV, S, X, Q_1\right)=V\left(B, S, X, Q_0\right) \tag{3}$$

It should be noted that since the respondents were presented with two independent scenarios of valuation (Figure 1), analysis of the expected gain in utility will require separate realisation of these functions. As the second scenario comes with extra benefit of publicity for credit buyers, respondents are expected to offer a higher premium.

It should be noted that selection of an analytical framework could have been approached from the profit maximisation perspective as well since businesses are typically considered profit maximisers rather than utility maximisers. However, we adopted utility approach for several reasons. First, not all buyers in our sample are private or for-profit companies, and a substantial portion of them are government entities or non-profit, non-governmental organisations (NGOs). Next, carbon offsetting investments, particularly involuntary markets common in the USA, represents real expenditures undertaken to improve the organisation's green image. These expenses are often conducted to demonstrate one's social responsibility through a voluntary action as opposed to the mandated compliance necessary for particular operations. Such an organisation will achieve higher utility through projecting a better image. Finally, the functional form of the econometric model estimated would be virtually the same based on either theoretical framework.

3.2 Empirical model

The WTP function can be modelled as:

$$WTP_i = \mathrm{X}_i'\beta + u_i. \tag{4}$$

where for the i^{th} respondent, WTP is the premium above a market price for urban forest credits, $\mathrm{X_i}$ is a vector of explanatory variables, and u_i is a random error term distributed $N(0, \sigma^2)$. Generally, equation (4) can be estimated to find the β parameters using ordinary least squares (OLS). However, if the WTP data are censored, meaning either potential negative premium values are recorded as zeros, or a corner solution resulting in a probability mass at zero, a Tobit model is preferred to OLS (Maddala, 1983; Greene, 2000). The Tobit model is written:

$$WTP_i = \begin{cases} X_i\beta + u_i & \text{if } X_i\beta + u_i > 0 \\ 0 & \text{if } X_i\beta + u_i \le 0 \end{cases} \tag{5}$$

The specification of the empirical model of willingness to offer a premium for carbon credits sourced from urban forests with hypothesised explanatory variables is as follows:

$$\text{WTP} = f(\text{ownership type, business size, geographical scope of operation, emission rate, preference for urban forest carbon, importance of community economic and environmental benefits}) \quad (6)$$

The model included variables describing the characteristics of the respondents, their preference for urban forest carbon projects, and the importance they place on co-benefits from offset projects. Explanatory variables are defined in Table 1. We expect that non-profit businesses are more likely than for-profit ones to offer a higher premium for urban forest carbon credits. Similarly, small business organisations, because of their local roots, and higher dependence on local markets, may be expected to pay a higher premium for urban forest credits compared to their larger counterparts. Nevertheless, it should be noted that an earlier study by Redmond et al. (2008) concluded that self-reported, pro-environmental views of small business managers did not translate well into action. We also expect that organisations operating exclusively within the USA, and those having higher annual emissions are less likely to offer higher premiums. Businesses with a positive attitude towards urban forests are expected to offer a higher premium for credits from such projects. Finally, organisations that place a higher level of importance on the community economic and environmental benefits as decision criteria in buying offset credits are also likely to offer a higher premium for credits sourced from urban forest projects.

Table 1 Definition and descriptive statistics of variables

Variable	*Description*	*Mean*	*Expected sign*
For-profit	Dummy variable, 1 if the company is for-profit, 0 otherwise	0.56 (0.49)	–
Small business	Dummy variable, 1 if the company has less than 1,000 employees, 0 otherwise	0.51 (0.50)	+
US only	Dummy variable, 1 if the company's scope of business is within the USA only, 0 otherwise	0.50 (0.50)	–
High emission	Dummy variable, 1 if the company's annual emission is more than 100,000 metric tons, 0 otherwise	0.43 (0.49)	–
Urban preference	Respondent's indicated level of preference for carbon captured through trees in urban areas (1 = low preference, 5 = high preference)	2.07 (1.92)	+
Co-benefits	Respondent's consideration of community economic and environmental benefit as a decision criteria in buying urban forest credits (1 = extremely unimportant, 5 = extremely important)	3.56 (1.02)	+

4 Results

4.1 Respondent characteristics

Altogether 186 members and associate members were listed as CCX members at the time of survey. Attempts were made to contact all, but 31 had undeliverable mail or e-mail

addresses, while 15 were unwilling to participate. Most of them expressed their unwillingness to participate at the time of the early contact, even before examining the content of the survey. Others, who refused after receiving the survey, cited company policy and changes in their portfolio as major reasons for declining to participate. Therefore, we assumed that their refusal was not to contest the ideas incorporated in the survey. A total of 58 responses were returned yielding an adjusted response rate of 41.42%.

The sample was highly diverse. In terms of ownership, roughly 55% were private or for-profit business organisations, 20% were government entities, and the remaining 25% were NGOs or non-profits of some sort (Table 1). Employee numbers varied from 2 to 21,000, with the median size of 1,150. In terms of geographical scope, nearly 48% of respondents indicated the USA as the only or primary business area, while 35% indicated worldwide operations.

Nearly all respondents (98%) provided a rough estimate of their annual GHG emissions with a median size of 47,150 metric tons per year. However, about 36% of respondents had no set target for reducing their GHG emissions in the next 5 years. About 10% targeted reducing emissions less than 5%, 23% targeted reducing emissions between 6% and 10%, 12% targeted reducing emissions between 11% to 20%, and 9% targeted reducing emissions by 21% to 50%. Less than 8% of respondents targeted reducing emissions by 51% to 100% over the next 5 years. About 40% of respondents had been participating in carbon trading for 1 to 3 years, 21% for 3 to 5 years, and 29% had participated for more than 5 years. Only 7% of respondents started trading during the year of our survey. On average, respondents bought approximately 33,000 CO_2 ton equivalent credits in 2008.

Respondents were fairly interested in offering a premium for urban forest credits. For the first valuation scenario, wherein the selling city would not provide the credit purchaser with a logo or official sign visible at the project site, 53% of respondents indicated a \$0 premium for urban carbon and about 26% revealed a positive value. Of those who answered positively, 45% offered a premium of more than half the market price of carbon credit (\$0.5/ton at the time), and the rest offered a premium of at least 1 cent per ton. For the second valuation scenario, wherein the selling municipality would provide explicit recognition of the buyer in the form of a highly visible logo or company sign at the project site, a greater portion of responders reported positive premiums (47%).

4.2 Factors affecting WTP premium

Results from Tobit models for both valuation scenarios are presented in Table 2. Because 73% of respondents in scenario 1 and 52% of responders in scenario 2 indicated a zero WTP, use of the Tobit model appeared justified. The McFadden R-square indicates how well the model fits the data. Likelihood ratio (LR) tests indicate that the explanatory variables are jointly significant ($\chi^2 = 42.52$, $p < 0.001$ in the first scenario estimation, $\chi^2 = 31.42$, $p < 0.001$ in the second scenario estimation). Moreover, all explanatory variables except the 'high emission' variable in scenario 1 and the 'for-profit' variable in scenario 2 were statistically significant at $p < 0.10$.

Table 2 Results from Tobit analysis of factors affecting WTP

Variable	*Scenario 1 (no recognition)*		*Scenario 2 (with recognition)*	
	Coefficient	*Marginal effects*	*Coefficient*	*Marginal effects*
Intercept	–3.862*** (0.937)		–2.077*** (0.310)	
For-profit	–0.375** (0.187)	–0.013	–0.095 (0.174)	–0.025
Small business	0.615** (0.235)	0.021	0.597** (0.280)	0.152
US only	–0.466* (0.258)	–0.016	–0.408* (0.223)	–0.108
High emission	0.379 (0.294)	0.013	0.533* (0.296)	0.148
Urban preference	0.664*** (0.174)	0.022	0.227*** (0.066)	0.059
Co-benefits	0.313** (0.133)	0.010	0.320*** (0.114)	0.083
σ	0.270*** (0.059)		0.404*** (0.065)	
N	42		42	
Log likelihood	–4.663		–18.068	
Pseudo R square	0.82		0.46	

Notes: Dependent variable: premium offered for carbon credit sourced from urban forestry projects.
***, ** and * indicate $p \leq 0.01$, $p \leq 0.05$ and $p \leq 0.10$ respectively.

The expected value for the uncensored urban carbon premium, $E[WTP]$, under either scenario is calculated as:

$$E\left[WTP_i\right] = X_i\beta\left[\Phi\left(X_i\beta/\sigma\right)\right] + \sigma\left[\varphi\left(X_i\beta/\sigma\right)\right] \tag{7}$$

where Φ is the cumulative normal distribution and φ is the normal density, with X and β representing the relevant explanatory variable and parameter vectors (McDonald and Moffitt, 1980). For the first valuation scenario, $E[WTP1] = 10¢$, which was nearly 20% of concurrent market price (Table 3). A significantly higher premium was estimated for the second scenario, $E[WTP2] = 17¢$, where respondents were assured that their organisation would be recognised via a highly visible logo. This premium amount is nearly 34% of the concurrent market price. A basic summary of average WTP has been reported elsewhere (see Poudyal et al., 2011a). The following paragraphs illustrate the results of factors related to the variation in WTP among the buyers, which is the focus of the current paper.

For scenario 1, the dummy variable 'for-profit' had a negative and significant coefficient (Table 2), suggesting that for-profit businesses are less likely to offer a premium for carbon credits sourced from urban forest projects. The marginal effect suggested that inclusion of a respondent into for-profit category resulted in a 1.3¢, or about a 13% decrease in premium offered. This result appears consistent with profit maximisation behaviour. Conversely, for scenario 2, which included explicit recognition

of the organisation, this variable was statistically insignificant, suggesting that differences in value based on profit motive dissipate when organisational recognition is included.

Table 3 Average premium offered by valuation scenario

Valuation scenario	*Average premium ($)*	*Premium offered (%)*
Scenario 1: City does not provides any recognition logo or sign acknowledging the purchase	10¢	20%
Scenario 2: City provides an official sign or recognition logo highly visible at the project site	17¢	34%

Note: CCX market price for a credit (1 metric ton CO_2e) was 50¢ at the time of survey.

The coefficient on the dummy variable 'small business' in each scenario was significant and positive. The marginal (discrete) effect in the first scenario indicates that small business organisations would be willing to pay 2.1¢ more than their larger counterparts. This observation is consistent with our a priori assumptions that unlike large domestic and international ones, small businesses are likely to have local roots and may have a higher level of concern and support for the local environment and public goods. It is possible that larger businesses have higher emissions, resulting in higher total premium costs. The relatively higher marginal effect in the second scenario (15.2¢) indicates that such businesses may respond very well to the official recognition offer.

The 'US only' variable had a negative coefficient that was significant at $p = 0.07$, suggesting that business organisations operating solely within the USA may be less likely than those operating worldwide to offer a premium for urban forest carbon credits. For scenario 1, a 'US only' business is likely to pay 1.6¢ less in premium than its international counterpart. This observation probably derives from the fact that international businesses deal with a wide variety of consumers, media outlets, and government regulations and likely face higher level of scrutiny in their business activities. Also, non-US-only firms are more aware of and sensitive to carbon rules in other countries. Such exposure probably encourages, or in some cases even forces, businesses organisations to become more pro-environmental than those with operations confined into nations were carbon laws and carbon markets are not as stringent. For scenario 2, the marginal indicates that US only businesses are likely to offer nearly 11¢ less than their international counterparts.

High emitters were expected to offer a lower premium based on having to pay a substantial amount for their high volume of emissions. However, the 'high emission' variable was insignificant in scenario 1. The coefficient on this variable in scenario 2 was positive and marginally significant ($p = 0.08$) suggesting that businesses with higher emissions levels are likely to pay higher premiums to buy credits that would come with the official recognition of a purchase. High emitters could be in greater need of social image, and hence any official endorsement of their green initiative from local municipalities might be advantageous to them. This result does not contradict the conclusions in previous literature that a consumer's decision to buy voluntary offsets is primarily driven by a sense of responsibility, and the importance of contributing to mitigating harmful environment effects (Blasch and Farsi, 2012).

Respondents' preference (1 = lowest, 5 = highest) for carbon captured through urban trees had a statistically significant ($p = 0.00$) positive effect on the premium offered in

both scenarios 1 and 2. Estimated marginal effects reveal that a one-unit increase in respondents' urban preference increases the premium by 2.2¢ in scenario 1 and by 5.9¢ in scenario 2. The variable, 'co-benefits', captured the importance that respondents placed on economic and environmental benefits as decision criteria in buying credits from urban forestry. It had a positive and significant ($p = 0.05$) effect on premium offered in both valuation scenarios. The estimated marginal effect indicates that a one-unit increase in the reported importance of community economic and environmental benefits from urban forestry (1= lowest, 5 = highest) yields a 1¢ increase in premium offered. When official recognition was included, the marginal effect rose to 8.3¢.

From a theoretical standpoint, the potential issue of endogeneity was suspected for the last two variables, i.e., importance of co-benefit as decision criteria, and level of preference placed on urban forest projects. An endogenous Tobit regression model was employed on the dataset by utilising the IV-TOBIT option in STATA, which allows testing for endogeneity of a regressor, and estimates a Tobit model with endogenous regressors. Two separate approaches (i.e., ML estimation method, and minimum chi-squared estimator approach (a.k.a. two-step method)) were employed to test for exogeneity. Results from a Wald test of exogeneity in both the ML method ($\chi^2 = 1.51$, $p = 0.21$) and the Two-step method ($\chi^2 = 1.87$, $p = 0.17$) accepted the null hypothesis of exogeneity for the co-benefit variable. An equivalent null hypothesis for the preference variable was also not rejected by a Wald test conducted in ML and two-step methods ($\chi^2 = 0.14$, $p = 0.70$, and $\chi^2 = 0.15$, $p = 0.69$), respectively.

5 Conclusions and discussion

Existing literature on marketing of forest-based ecosystem services has not explored the value determinants of a specific service like urban forest carbon credits. However, a systematic marketing of urban forest carbon credits could provide economic opportunities for thousands of cities and municipalities nationwide. A number of observations from the analysis presented in this study provide some useful insights for urban forest management, particularly in understanding the desirability of urban forest carbon credits and developing market protocols for their trade.

First and foremost, buyers show an identifiable interest in buying urban forest credits, which they find more desirable than many other credits currently traded in the market. Buyers are willing to pay more for a credit sourced from urban forest projects, which could represent business opportunities for cities and municipalities managing urban forests. However, the amount of a premium offered is influenced by factors such as the buyer's organisation type, size, and the geographical scope of operations. Our analysis indicates that certain types of business organisations, and in particular non-profits, small businesses, and international businesses are more likely to offer higher premiums for urban forest carbon credits. This in turn indicates that there exists a market segment that has higher appreciation for, and therefore places higher value on credits generated from urban forests. This information would be useful to cities that are currently selling or planning to sell their carbon credits to identify these particular market segments to increase their carbon sales revenues. In addition, there is substantial potential for collecting additional premiums by publicising the transaction in order help buyers develop their green image. A simple proposal offering a basic acknowledgment at the project site led to a decrease of zero bidders from 73% to 52%. Social sustainability

scholars argue that encouraging various business sectors to engage in voluntary measures, rather than imposing regulations, might be a better way to achieve sustainability (Bennington, 2010). A marketing scheme such as the one discussed in this study (i.e., publicity of purchase) could be a feature actively sought by businesses considering involvement in green projects.

Moreover, the importance buyers attach to community economic and environmental benefits of urban forest projects significantly increased the price premium they offered. This observation implies that extension and outreach programs aimed at educating potential buyers on the co-benefits of urban trees may encourage them to prefer and pay a premium for urban forest credits. Future research might also explore price discrimination to gauge how sellers could charge more for those interested in offering a premium and still remain competitive with other types of credits in the market. As local governments nationwide continue to struggle financially, concerted marketing efforts promoting carbon credits sourced from urban forests could provide revenues for urban tree care and management, and secure essential services associated with urban greenery to their citizens.

One may wonder about the value of results based on what is now a defunct carbon exchange. The CCX operated from 2003 to 2010 as a voluntary, legally binding, and comprehensive carbon cap and trade program. It has closed its doors because at one time it appeared that credits registered and traded in the CCX would not be grandfathered in any future federal climate change regulations in the USA which, in turn, resulted in the lack of trading activity and credit price collapse. Nevertheless, the CCX pioneered several approaches that continue to be used and developed by numerous other programs today. These include aggregation of forest landowners and projects, as well as novel carbon accounting approaches to facilitate expeditious project development and reduce transaction costs. Former CCX members represent early adapters and the research findings presented here can be of use for urban forest carbon project developers as carbon trading evolves.

While the future of US carbon markets in general, and forest carbon in particular, is somewhat uncertain, carbon trading still remains one of the most flexible approaches to reduce emissions. Forest carbon markets around the world continue to grow despite the recent economic downturn (2008 to 2011), reaching a record $178 million in transaction volume in 2010 (Diaz et al., 2011). The surge in volume can be largely attributed to Reduced Emission from Deforestation and Forest Degradation (REDD) projects. Credit prices continue to vary substantially by market and project type. It is apparent that co-benefits of forest carbon sequestration projects are increasingly important as is a third party verification of carbon credits to ascertain credit quality as well as corresponding co-benefits (Diaz et al., 2011). The key question here is regulatory drivers in the USA and elsewhere, which would increase demand for credits. In fact, reports published recently show some positive signs in this regard. For example, Peters-Stanley and Hamilton (2012) reported that the individual purchases of voluntary offset credits worldwide more than doubled between 2011 and 2012, and further claimed that the cumulative demand for offset credit in 2016 could be four times the amount projected previously.

However, even without regulatory drivers, there are several factors that indicate a strong promise for urban forest carbon. Urban forest projects can supply high quality carbon credits with numerous co-benefits (Poudyal et al., 2011b). At the same time, it

appears that tree cover in urban areas in the USA has been declining (Nowak and Greenfield, 2012). This trend may also take place in other regions of the world, particularly in the developing world where mega-cities continue to grow. As urban areas worldwide continue to grow and face numerous developmental challenges related to environmental quality and climate change impacts, urban tree planting programs are viewed as an important approach to store carbon and generate a range of very important environmental benefits for urban dwellers (United Nations Human Settlements Programme, 2011). As a result, urban trees and carbon, along with the other environmental benefits (e.g., urban cooling, flood control) they generate become increasingly scarce and more valuable. At the same time, at least in parts of southern USA, several cities have considerable areas available for tree planting purposes and the development of urban forest carbon projects (Merry et al., 2013). Further, Lambooy and Levashova (2012) argued that private entrepreneurs' attitudes towards investment in green projects are changing in recent years, and they are becoming more supportive of such projects. Recent studies conducted outside the USA have shown that the emphasis on forest management has been shifting with more community collaboration and private sector responsibility for sustainable and efficient management of forest resources (Ballet et al., 2010). Revenue generation from ecosystem services such as carbon sequestration may offer a financial motivation to promote such management strategies. This, combined with the increased recognition of the importance of urban tree resources by decision-makers, may eventually lead to the development of carbon financing mechanisms that will help achieve the potential of urban trees in providing ecosystem services and improving the quality of the environment.

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