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Contrasting self-reported willingness to pay and demonstrated purchase behavior for energy-saving technologies in a small island developing state

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ABSTRACT

Sustainable development in small island developing countries often hinges upon the successful adoption and diffusion of energy technologies developed abroad. To guide investments and policies seeking to promote new energy efficiency technologies academic and marketing studies often rely upon consumer self-reports of willingness to pay (WTP) for the environmental and economic benefits such technologies may provide. But marketing research has long reported disparities between consumer self-reports of willingness to pay and the actual amounts consumers will pay when making a purchase decision. This study uses the results of a survey and associated coupon distribution in Saint Lucia to contrast self-reported willingness to pay for energy-efficient compact fluorescent light bulbs (CFLs) with actual consumer behavior in a developing country context. Survey responses suggested that more than 94% of urban consumers in Saint Lucia were willing to pay some price premium for a high quality CFL bulb. However, when given a coupon allowing them to purchase a CFL bulb at a price equal to or below their self-reported willingness to pay, only one-third of the consumers actually purchased the product. High income respondents, low income respondents, and younger respondents were among those most likely to not purchase a CFL bulb when offered the chance to do so at or below their self-reported willingness to pay. The presence of systematic discrepancies between self-reported willingness to pay and observed consumer behavior in CFL markets has important implications for energy efficiency market research, coupon-based incentive programs and energy policy in Saint Lucia and other developing nations.

Introduction

Recent estimates suggest that the adoption of already-available energy-efficient technologies in Latin America and the Caribbean could cut electricity consumption by as much as 10% over the next decade, potentially saving the region up to USD $36 billion in investments that would otherwise be needed to expand power generation capacity (IDB, 2013). Energy efficiency improvements also offer significant opportunities for reducing costs for individual businesses and household consumers: retail electricity rates in the Caribbean average $0.35/kWh (CARILEC, 2010), putting them among the most expensive rates in the world. Recognition of these potential savings has prompted a variety of ambitious international energy efficiency investments alongside major domestic energy policy reforms promoting energy efficiency (Nogueira et al., 2015; Meza et al., 2014; Shirley and Kammen, 2013; Belizza and Claudia, 2010). Many such investments and policies target commercial energy users (IDB, 2013; Altomonte et al., 2003). However across the Caribbean major efficiency gains remain to be realized at the household level, where relatively low-efficiency appliances and lighting are still widely used.

Consumer surveys eliciting self-reported willingness to pay (WTP) for new and improved technologies are often used in both marketing research and in public policymaking, including in the process of developing and expanding markets for energy efficient products (Hogarth, 2012; Adkins et al., 2010; Banfi et al., 2008; Poortinga et al., 2003; de Jannuzzi and dos Santos, 1996; Dutt and Mills, 1994; Pye and Nadel, 1994). However marketing research has revealed a significant disparity between self-reports of willingness to pay for a given product and the actual amounts consumers will agree to pay when making a purchase decision (Sun and Morwitz, 2010; Verhoef and Franses, 2002; Carson et al., 2001). Particularly in the case of survey research, where self-reports of willingness to pay typically entail no obligation that respondents actually purchase the product at the stated price, consumers often report a willingness to pay that is too high (Zarnikau, 2003). In other words, though an individual may claim that he or she will purchase a new product if it is offered at price *P*, when the opportunity to obtain that product at price *P* arises, many (and in some cases, most) consumers will decline to make a purchase. This finding has led some to question when and whether self-reports of willingness to pay may be of practical use in conducting market research, in predicting

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consumer behavior, and in devising policies to promote new efficiency technologies and other pro-environmental consumer goods (Barber et al., 2014).

This study uses the results of a consumer survey and associated coupon distribution to explore the degree to which self-reports of willingness to pay for improved energy technologies are representative of the amount that consumers will actually pay in the market for compact fluorescent light bulbs (CFLs) in the Caribbean island nation of Saint Lucia. CFLs were selected as a focus for the study because they represent a relatively well-studied energy efficiency technology (more than 4 times as efficient at producing a given quantity of light as traditional incandescent bulbs (DoE, 2012)) and because expanded use of CFLs has been explicitly identified by the Government of Saint Lucia as a tool for promoting national energy security and reducing dependency on fossil fuel imports for electricity generation (CARILEC, 2010). CFLs have also been available in small quantities in Saint Lucia for several years, increasing the chances that consumers will have had the opportunity to develop informed assessments of their willingness to pay for the product (Reynolds et al., 2012). Finally, CFLs represent an energy-efficient product that is potentially attainable by almost all consumers: they require no new lighting fixtures, are easy to use, and are substantially less costly than other energy-efficient technologies such as household appliances. CFLs thus represent a technology where self-reports of willingness to pay might reasonably be assumed to reflect actual consumer behaviors in response to price changes (e.g., energy efficiency promotional programs that lower the purchase price) in the marketplace. Inversely, if self-reported WTP does not accurately predict consumer behavior in the market for CFLs we may then ask: (i) What variables explain discrepancies between consumer self-reports and observed behavior? and (ii) How might WTP measures be more effectively utilized for informing policy in markets for efficient lighting and other improved consumer energy technologies?

The remainder of the paper is structured as follows. The Conceptual model of energy efficient technology adoption in small island developing states (SIDS) section describes the theoretical model linking consumer demographics, energy efficiency knowledge, and willingness to pay with purchase behavior in developing markets for energy efficiency products. The Survey method and data analysisS section then summarizes the study design and statistical approach, followed by the Description of the sample and Results sections. The Contrasting self-reported WTP and observed behavior in CFL markets section discusses the findings from Saint Lucian CFL markets. The concluding section summarizes the study's contributions and policy implications.

Conceptual model of energy efficient technology adoption in SIDS

Small island developing states (SIDS) offer a particularly valuable reference point for the study of public policy and consumer behavior vis à vis energy efficient technologies. First, islands offer small, isolated, and thus relatively straightforward case studies for developing, testing, and evaluating promotional programs for new energy products (Weisser, 2004). Second, because of their small size, the impacts of energy efficiency programs – and related government policies such as public education and product subsidies – can be observed over a relatively short period of time (Shirley and Kammen, 2013). Finally, and perhaps most importantly, consumer behavior research is particularly useful and informative in small island developing countries because so much of island nations' economies depend upon the successful adoption and diffusion of technologies developed abroad. With limited resources for research and development activities, small island developing states rely heavily on imported innovations to increase production (or efficiency) and promote economic development (CARILEC, 2010; Nexant, 2010; Loy, 2007; Domah, 2002). Those developing countries that are best able to undertake and accurately interpret consumer research at home thus position themselves to take maximum advantage of technological innovations produced elsewhere (Peter, 2006).

The conceptual model for the current study assumes that a combination of socio-economic factors, awareness and knowledge of energy efficiency and energy-saving technologies, and past purchase behavior leads to the development of a preference for compact fluorescent lighting technology, which in turn translates into a given willingness to pay for CFL bulbs and, ultimately, purchase (Howarth and Rosenow, 2014; Min et al., 2014; Mills and Schleich, 2012; Wall and Crosbie, 2009). This general framework is in keeping with the well-established "hierarchy of effects" model of consumer behavior as formalized by Lavidge and Steiner (1961), also referred to as the "cognitive–affective–conative sequence of psychological states" (O'Brien, 1971). The hierarchy of effects model in its simplest form suggests that consumer behavior is ultimately the product of three major processes: developing awareness and knowledge of the new product (cognition), developing a preference for the new product (affect), and deciding to purchase the new product (conation). In other words, in the case of compact fluorescent light bulbs, consumers are presumed to learn about energy-saving compact fluorescent bulbs, develop an affinity for them, and ultimately decide to purchase them.

A wealth of empirical research into markets for energy-efficient technologies supports the inclusion of knowledge- and affect-based variables along with demographic variables in models of consumer behavior, as recently reviewed by Howarth and Rosenow (2014). For example, early research by Reddy (1990) found ignorance, indifference, uncertainty, and cost-sensitivity as major barriers to consumer adoption of energy-efficiency improvements in the United States, and Dyner and Franco (2004) observed similar barriers in England. Kjaerulf (1997) found the most significant barriers to CFL adoption in Denmark to be high initial price, quality concerns, and doubts about actual savings accrued through CFL-use. Urge-Vorsatz and Hauff's(2001) research into Hungary's rapid adoption of CFLs in the late 1990s cited lack of information as the greatest single market barrier to energy efficient technologies, while also noting that availability of information was a necessary but not sufficient condition for market success. More recently, Mills and Schleich (2010) found that before the 2009 ban on the sale of incandescent light bulbs in Europe use of energy efficient bulbs was already widespread in Germany, but at low intensity. Households with higher incomes were found to be the main demographic that had already adopted CFLs, suggesting low income as a market barrier. Consumer habits and preferences favoring incandescent lights also appear to have significantly slowed CFL adoption in Europe (Howarth and Rosenow, 2014; Mills and Schleich, 2012; Wall and Crosbie, 2009). And in the United States Min et al. (2014) found that politically liberal respondents were most likely to adopt CFL technology, but also that labels displaying estimated annual energy costs for lighting alternatives (altering consumers' calculus of the potential benefits from a CFL purchase) greatly increased reported willingness to pay for CFL bulbs.

With specific regard to developing countries, early work by Meyers (1998) found the main general impediments to the adoption of energy-efficient products in low-income countries to be a lack of information and a lack of financing. Research in India meanwhile found that high product cost, lack of consumer interest, and doubts about the savings promised were the main barriers to CFL adoption for residential energy consumers (Reddy and Shrestha, 1998). A similar study in Thailand also reported that a lack of access to information, limited access to capital, preferences for a very rapid payback, and a lack of access to – and trust in – efficient technologies were key factors inhibiting the adoption of energy-efficient consumer products (ARRPE, 2000). Although more recent empirical studies in developing countries remain scarce (Evander et al., 2005), current information- and subsidy-based energy efficiency policies underway in Latin America and the Caribbean seek to overcome similar informational and economic barriers (Nogueira et al., 2015; Meza et al., 2014), while also building consumer confidence

that new efficient lighting technologies will actually deliver their promised light quality, cost savings, and environmental benefits.

The above discussion suggests the hierarchy of effects, which brings together consumer knowledge, demographic factors, and past purchase experience to predict willingness to pay and purchase behavior (Lye et al., 2005), thus offers an appropriate framework for the study of demand for compact fluorescent lighting in Saint Lucia. However, the model for the current study also incorporates specific assumptions regarding willingness to pay: namely, we hypothesize that there is a statistically significant and meaningful difference between self-reported willingness to pay (as determined through survey data) and actual willingness to pay (as determined by coupon redemption rates). As shown in Fig. 1, we posit that demographic factors – including preferences and attitudinal factors in addition to practical constraints such as disposable income – exert a significant and direct influence on consumers' cost sensitivity and purchase behavior that is not captured by self-reported willingness to pay alone.

Although empirical research focused specifically on developing countries remains scarce (Urama and Hodge, 2006; Foreit and Foreit, 2003), existing research in developed countries strongly supports the assertion of a difference between self-reported willingness to pay and actual purchase behavior (Verhoef and Franses, 2002), including some studies related to consumer willingness to pay for energy-efficient technologies (Lee et al., 2013; Poortinga et al., 2003; Sadler, 2003; Thomson, 2002). For example, Lee et al. (2013) found that women may be particularly likely to overstate their willingness to pay for energy efficient lighting in the United States, with women exhibiting stronger environmental attitudes and stating a higher willingness to pay for CFL bulbs than men, but exhibiting virtually no difference in purchase behavior. The principal conclusion to be drawn from this growing body of research is that consumer willingness to pay for a product has both an affective component and a conative component, and that while self-reports of hypothetical willingness to pay are more influenced by attitudes and preferences, the actual purchase decision is a more complex process incorporating income constraints and other demographic factors to a greater degree. The end result of these effects is the trend, well-documented in developed countries, of self-reported willingness to pay greatly exceeding the amounts consumers will actually spend in the marketplace.

To test the hypothesis that there are significant and systematic differences between self-reported willingness to pay and actual consumer behavior in the market for compact fluorescent light bulbs in Saint Lucia this study analyzes the results of a consumer survey and an associated coupon distribution in two major Saint Lucian cities.

Survey method and data analysis

Sample selection

Surveys were collected in January, 2007 through semi-structured interviews conducted by trained research assistants. Respondents were randomly selected from among individuals entering hardware stores in four Saint Lucian communities referred to in this study as Rural A, Rural B, Urban A, and Urban B. The different locations were chosen because each offered access to a hardware store that sold high-quality compact fluorescent light bulbs, and each represented either an urban or a rural characteristic. Selecting respondents in front of hardware stores allowed the study to focus on Saint Lucian consumers, rather than on Saint Lucians as a whole (Reynolds et al., 2012).

With a Saint Lucian sample size of 535, the entire sample is large enough to represent the country with 95% confidence. However, because the supply of CFL bulbs in Rural A ($n = 65$) was exhausted prior to completion of the study, and coupon redemption rates in Rural B ($n = 101$) were exceptionally low (less than 3%), the two rural locations are excluded from the analysis, resulting in a final sample size of 375 urban respondents.

Survey procedure and material

Surveys lasted 5–10 min, and included both closed-form and open-ended questions related to consumers' knowledge of energy efficiency, attitudes towards energy-saving products, and willingness to pay for

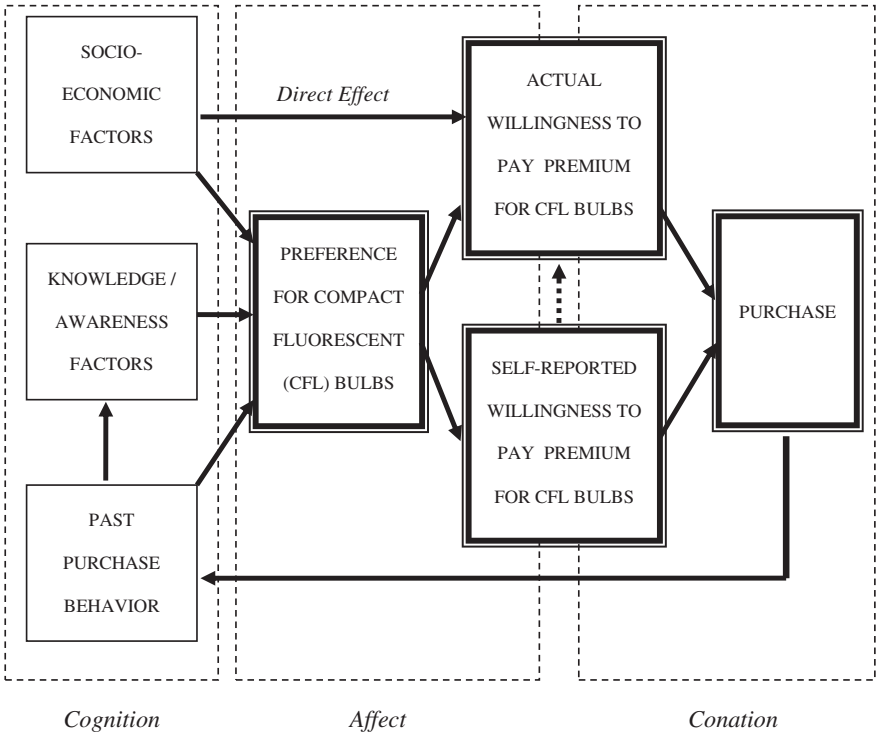

Fig. 1. Conceptual model.

CFL bulbs. A typical knowledge-based question was: "Have you ever heard the term 'energy efficiency'?" Respondents could then reply "Yes" or "No". This was followed by an open-ended question asking "What, in your own words, does energy efficiency mean?" Responses to this question were later recoded based on whether or not the consumer being interviewed provided a correct definition. Respondents were also asked if they currently used CFL bulbs in their household, and if they believed that CFLs could potentially reduce their expenditures on electricity. In the middle of the survey consumers were shown a brand-name compact fluorescent light bulb and were asked by the interviewer what amount, in Eastern Caribbean dollars ($EC2.64 = $USD1.00 at the time of the survey), was the maximum that they would be willing to pay for one high-quality CFL bulb. Responses were coded as continuous numerical data; in the rare event that a respondent was unable to name a willingness to pay price, a response of "Don't Know" was entered. Demographic information was collected at the end of the survey, including information on gender, age, income, and education.

Finally, as incentive to participate in the study, respondents were offered the opportunity to receive a free compact fluorescent bulb or a coupon for the purchase of a CFL bulb at a reduced price from a local hardware store. Coupons were issued to respondents randomly after completing the survey, in denominations including 90%, 75%, 50%, 25%, and 10% off the price of a high quality compact fluorescent light bulb (USD $8.70 at the time of the survey). The coupons were marked with the respondent number from the survey, and were valid for 30 days following completion of the interview. At the end of the promotional period all returned coupons were gathered and data obtained including the date of purchase, brand, and price paid for all CFL bulbs purchased with study-related coupons.

Data analysis

As a preliminary analysis we used t-tests, Chi-square analyses, and ANOVA tests to measure significant demographic, knowledge, and attitudinal factors influencing Saint Lucian consumers' self-reports of willingness to pay, with particular attention to differences among respondents who were offered the opportunity to purchase a CFL at or below their reported willingness to pay price. Comparisons sought to distinguish between those respondents who claimed a relatively higher versus lower WTP, and also those who chose to purchase a CFL bulb at a reduced price in the allotted time frame versus those who did not.

In the second stage of the analysis, we used binary logistic regression to explain coupon redemption behavior as a function of the self-reported willingness to pay (WTP) of the respondent and the discount that was offered to the consumer through the use of a coupon (DISC*i*). The different discount levels were represented by the dummy variables DISC90, DISC75, DISC50, DISC25, and DISC10, representing 90%, 75%, 50%, 25%, and 10% off the purchase price, respectively (Eq. (1)).

$$\begin{aligned}\mathrm{Log}[P_{REDEEM}/(1-P_{REDEEM})] = {} & ß_0 + ß_1\mathrm{WTP} + ß_2\mathrm{DISC90} + ß_3\mathrm{DISC75} \\ & + ß_4\mathrm{DISC50} + ß_5\mathrm{WTP}\times\mathrm{DISC}\end{aligned} \quad (1)$$

The variables for the discount categories DISC25 and DISC10 were excluded from the regression to avoid perfect colinearity among the discount variables, and because coupon redemption rates for DISC10 were very low (only 3 respondents). Additional continuous variables constructed by multiplying self-reported willingness to pay by the discount amount (WTP × DISC*i*) were included iteratively to account for any interaction effects associated with the independent variables. The estimated coefficients are represented by $ß_0$–$ß_5$; and represent the increase in the log-odds of a consumer purchasing a CFL bulb with a given discount level, or for an increase in WTP or WTP × DISC*i*.

In the final stage of the analysis, we used another binary logit model to estimate the degree to which knowledge, attitude, and demographic factors influence Saint Lucian consumers' decision to actually purchase a CFL. This second model was first run with all coupon recipients, and then re-run focusing specifically on the factors influencing consumers' decision to purchase or not to purchase CFLs when a coupon allowed them to buy a bulb at or below their self-reported willingness to pay price. In other words, we first selected for only those respondents who received a coupon that allowed for the purchase of a CFL at a coupon price (OFFER) that was equal to or below their self-reported willingness to pay (WTP):

$$\mathrm{WTPMORE} = 1 \text{ if } \{\mathrm{WTP}-\mathrm{OFFER}\} \geq 0 \text{ else } 0 \quad (2)$$

The expanded binary logit models for coupon redemption (REDEEM) included a number of knowledge, attitude, and demographic variables drawn from theoretical and empirical literature on consumer willingness to pay for new energy efficiency products (Howarth and Rosenow, 2014; Lee et al., 2013; Reynolds et al., 2012; Evander et al., 2005; Reddy and Shrestha, 1998; Golove and Eto, 1996). The variable DEFINE was set to one if the respondent was able to accurately define the term "energy efficiency". BELIEVE was set to one if consumers were confident that the use of compact fluorescent bulbs currently did or potentially could reduce their electric bills. PASTPURC was set to one if the last light bulb purchased by the consumer was a compact fluorescent bulb. For the demographic variables, FEMALE was set to one if the respondent was a female, and the income variables were set to one if the respondent reported monthly household earnings within a given range (INC5 = more than USD $2273; INC4 = $1515–2272; INC3 = $1136–1514; INC2 = $758–1135, INC1 = $379–757, INCLOW = less than $379).[1] Similarly, the dummy variables ED3 (some college or more), ED2 (high school graduate) and ED1 (middle school or less) represent the respondent's highest educational attainment. AGE represents the respondent's age in years, and the dummy variable URBANA was used to represent the location where the survey took place, reflecting a variety of factors that cannot be easily distinguished from one another, including the level of access and exposure respondents had to energy efficient technologies and other regional factors have informed consumers and influenced preferences (Zarnikau, 2003). Finally, the continuous variable WTP again reflects self-reported willingness to pay for a CFL bulb, and the dummy variables DISC90, DISC75, DISC50, DISC25, and DISC10 account for the direct effect of the size of the offered discount (90%, 75%, 50%, 25%, or 10%) on coupon redemption rates.

The final logit equation takes the form:

$$\begin{aligned}\mathrm{Log}[P_{REDEEM}/(1-P_{REDEEM})] = {} & \Gamma_0 + \Gamma_1\mathrm{DEFINE} + \Gamma_2\mathrm{BELIEVE} \\ & + \Gamma_3\mathrm{PASTPURC} + \Gamma_4\mathrm{FEMALE} + \Gamma_5\mathrm{INC1} + \Gamma_6\mathrm{INC2} + \Gamma_7\mathrm{INC3} \\ & + \Gamma_8\mathrm{INC4} + \Gamma_9\mathrm{INC5} + \Gamma_{10}\mathrm{ED2} + \Gamma_{11}\mathrm{ED3} + \Gamma_{12}\mathrm{AGE} + \Gamma_{13}\mathrm{URBANA} \\ & + \Gamma_{14}\mathrm{WTP} + \Gamma_{15}\mathrm{DISC90} + \Gamma_{16}\mathrm{DISC75} + \Gamma_{17}\mathrm{DISC50}.\end{aligned} \quad (3)$$

The variable for the income category INCLOW was excluded from the regression to avoid perfect colinearity among the income variables; similarly the education category ED1 and the lowest discount categories (DISC25 and DISC 10) were also excluded. The coefficients to be estimated are represented by Γ_0–Γ_{17}. For the dummy variables (DEFINEEE, BELIEVE, PASTPURC, FEMALE, the income and education variables, URBAN A, and the discount variables) the estimated coefficients indicate the increase in the log likelihood that the consumer with the applicable characteristic is likely to purchase a CFL bulb with a coupon reducing the price below his or her reported willingness to pay. The coefficient on the AGE variable expresses the increase in the log likelihood that the consumer with the applicable characteristic is likely to purchase a CFL for each additional year of the respondent's age.

[1] Income categories on the survey were asked in Eastern Caribbean dollars ($EC), but are reported in US dollars ($USD) in the text and tables for consistency.

Description of the sample

To assess how representative the data are of the urban population of the island, we compare the Saint Lucian sample to national census figures. The mean age of respondents was 42, and the mean family size was 4.35, which is consistent with Saint Lucian census data for urban communities (Saint Lucia, 2010). The survey respondents were also fairly representative of the urban Saint Lucian population in terms of income and education: the median survey respondent had a monthly household income of $758 to $1135 per month, as compared to the 2001 reported Saint Lucian national average of $351 per month. This difference from national figures is likely due to the fact that more men (62.1%) than women responded to the survey, and that survey respondents were mostly urban residents. Finally, the overwhelming majority of respondents (87.5%) affirmed that they were the primary purchasers of light bulbs in their households, suggesting that collecting surveys in front of hardware stores was an effective way to focus the study on consumers, rather than on the population of Saint Lucia as a whole.

Summary sample descriptive statistics are provided in Table 1.

Survey results are thought to reflect the knowledge, preferences, and attitudes of urban Saint Lucian consumers. Overall, 56.8% of respondents were familiar with the term "energy efficiency", and almost all respondents (93.9%) reported a preference for energy-efficient CFL bulbs over regular incandescent bulbs. Roughly three-quarters of respondents believed that the use of CFL bulbs would reduce their electricity bills, and just under half reported that the last bulb they purchased was a compact fluorescent.

Results

Patterns in self-reported willingness to pay for efficient lighting

Fig. 2 presents a summary of the survey responses regarding self-reported willingness to pay for a single high quality compact fluorescent light bulb. The mean reported willingness to pay for a high quality CFL bulb was $4.28, and the median was $3.79. This can be compared to the price of a brand-name CFL in Saint Lucia at the time of the survey ($8.71) and to the average price of a standard incandescent light bulb as estimated from survey responses ($1.04). More than 94% of urban consumers in Saint Lucia reported that they were willing to pay some price premium (i.e., more than $1.04) for an energy efficient CFL bulb. However less than 9% reported a willingness to pay equal to or higher than the market price of a high-quality CFL.

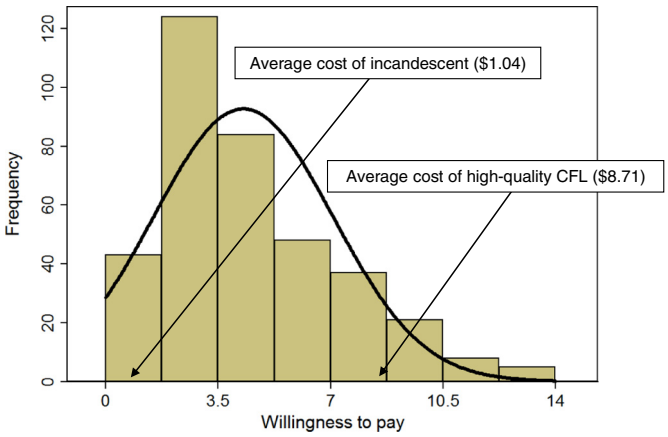

Fig. 2. Reported willingness to pay for a high-quality CFL bulb (n = 373 urban respondents).

Bivariate analyses of the sample data suggest that knowledge variables influence self-reported willingness to pay for compact fluorescent lighting in Saint Lucia, while regional variables also exert a significant influence on consumer self-reported WTP. Respondents familiar with energy efficiency (DEFINE) reported on average that they were willing to pay $4.53 for a high quality CFL bulb, or $0.74 more than respondents unfamiliar with energy efficiency ($t = 2.43$; P-value $= 0.008$). Belief that the use of CFL bulbs reduced electricity expenditures (BELIEVE) was also associated with increased self-reported WTP in location Urban B ($t = 1.72$, $P < 0.044$) but not in location Urban A ($t = 0.62$; P-value $= 0.551$). Other knowledge-related variables such as the use of CFL bulbs (USECFL) or the recent purchase of a CFL bulb (PASTPURC) were not associated with changes in self-reported WTP, possibly suggesting modest or negative past consumer purchase experiences among survey respondents (Reynolds et al., 2012). Among demographic characteristics, only location was associated with changes in reported willingness to pay, with respondents in Urban B willing, on average, to pay $4.87 for a high quality CFL as compared to respondents in Urban A who would only offer $4.03 ($t = 2.68$; P-value $= 0.003$). The majority of demographic characteristics, including gender, age, and socioeconomic characteristics such as education and income, were not associated with significant changes in willingness to pay among survey respondents.

Patterns in observed purchase behavior for efficient lighting

Table 2 summarizes the results of the CFL coupon distribution. Data presented include the total number of coupons distributed, how many coupons of each discount level were offered, how frequently the discounted price was less than the self-reported willingness to pay of the respondent who received the coupon, and the final coupon redemption rates for each of the two urban locations. Note that because 33 randomly selected respondents received a free CFL bulb in lieu of a coupon (28 consumers in Urban A, and 5 in Urban B) the final sample size for the coupon distribution was 342.

The highest discount offered – 90% off the purchase price of a high-quality CFL bulb – reduced the cost of a brand-name CFL to $0.90, which is slightly lower than the price of a regular incandescent bulb (roughly $1.04). Over 95% of respondents in both locations reported they were willing to pay more than $0.90 for a high-quality CFL bulb;

Table 1
Summary sample characteristics.

Variable name	Description	Measure of central tendency (std. dev.)	N
WTP	Reported willingness to pay for CFL bulb ($USD)	4.28 (2.79)	373
Energy-related attitudes and behaviors			
DEFINE	Correctly define 'energy efficiency'	56.8%	375
BELIEVE	Believe CFL bulbs can reduce electricity bill	73.3%	375
PREFER	Would like to buy CFL bulbs	93.9%	375
PASTPURC	Last bulb purchased was a CFL	47.5%	347
Demographic variables			
WHOBUYS	Respondent is primary purchaser of lighting	87.5%	375
FEMALE	Respondent is female	38.1%	375
INC5	Income > $2273 per month	15.9%	358
INC4	Income $1515–$2272 per month	16.2%	358
INC3	Income $1136–$1514 per month	14.3%	358
INC2	Income $758–$1135 per month	16.2%	358
INC1	Income $379–$757 per month	18.2%	358
INCLOW	Income < $379 per month	19.3%	358
EDU3	Some college or higher	41.9%	373
EDU2	Completed high school but no college	41.8%	373
EDU1	Did not complete high school	16.3%	373
AGE	Respondent's age in years	42.3 (13.4)	370
URBANA	Respondent was surveyed in location Urban A	70.4%	375
URBANB	Respondent was surveyed in location Urban B	29.6%	375

Table 2
Summary coupon distribution results.

Location	Discount offered (% off CFL bulb cost)	Purchase price offered[a]	Number of coupons offered	Respondents willing to pay price offered	Predicted redemption rate[b]	Number of coupons redeemed	Observed redemption rate[c]
Urban A	90%	$0.90	48	46	95.8%	17	35.4%
(n = 236)	75%	$2.24	42	32	76.2%	12	28.6%
	50%	$4.48	54	22	40.7%	10	18.5%
	25%	$6.72	47	8	17.0%	4	8.5%
	10%	$8.07	45	3	6.7%	2	4.4%
Urban B	90%	$0.90	23	22	95.7%	8	34.8%
(n = 106)	75%	$2.24	25	20	80.0%	7	28.0%
	50%	$4.48	19	7	36.8%	3	15.8%
	25%	$6.72	24	7	29.2%	1	4.2%
	10%	$8.07	15	4	26.7%	0	0.0%
Total (n = 342)			342	171	50.0%	64	18.6%

[a] Purchase price offered = USD $8.71 − discount offered with coupon.
[b] Predicted redemption rate = (number of respondents willing to pay price offered / number of coupons offered) × 100.
[c] Observed redemption rate = (number of coupons redeemed / number of coupons offered) × 100.

consequently the predicted redemption rate ([Number of Respondents Willing to Pay Price Offered / Number of Coupons Offered] × 100) for this discount level is very high in both survey locations. Predictably, as the discount offered decreases, the predicted coupon redemption rate as given by self-reported willingness to pay also decreases.

Overall, 171 out of 342 respondents received a coupon that reduced the price of purchasing a CFL bulb to a point below their self-reported willingness to pay, resulting in a predicted coupon redemption rate of 50%. However observed coupon redemption rates were much lower — for example, while 95% of respondents claimed they were willing to pay more than $0.90 for a CFL bulb, when offered the opportunity to purchase a bulb at that price only 35% of respondents made the purchase (a result that was consistent across the two survey locations). Overall, only 18.6% of respondents redeemed coupons for CFL purchase — roughly one-third (37.2%) of the number predicted by self-reported WTP.

Fig. 3 summarizes the predicted coupon redemption rates (i.e., the redemption rates that would be seen if all respondents purchased a bulb when it was offered at or below their self-reported willingness to pay for it) and the observed redemption rates for both survey sites combined in the form of demand curves (y-axis = price of CFL bulb; x-axis = percentage of respondents making a purchase). The observed redemption rates follow the same decreasing pattern as the rates predicted based on self-reported willingness to pay, but the resulting demand curve is shifted downwards and displays a much steeper slope. In other words, observed redemption rates were lower than predicted for all discount levels, but were especially low for the higher discounts (corresponding to lower purchase prices).

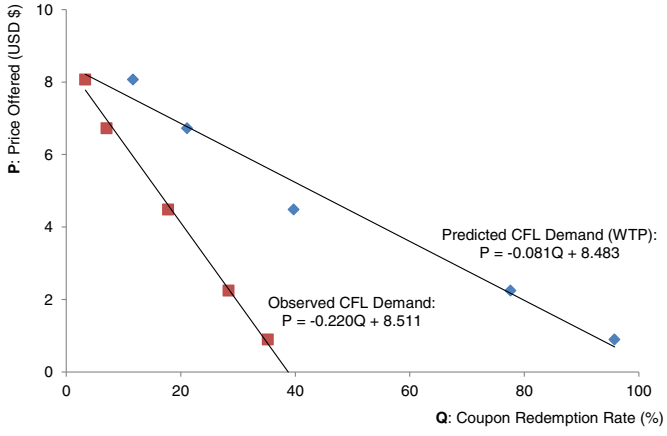

Fig. 3. Demand for high-quality CFL bulbs based on self-reported WTP and observed purchase behavior.

Explaining coupon redemption behavior based on self-reported WTP and discount offered

As a first step in exploring how determinants of purchase behavior might differ from determinants of self-reported willingness to pay, we regressed coupon redemption (REDEEM) on self-reported willingness to pay (WTP) for all coupon recipients with no covariates. The resulting model showed no relationship between self-reported WTP and coupon redemption ($X^2 = 0.91$, $P = 0.340$; results not shown), although this null finding in part reflects the random assignment of different coupons (offering different prices) to survey respondents. Table 3 presents the results of the binary logistic regression used to predict coupon redemption behavior (REDEEM) based on both self-reported willingness to pay and the size of the discount offered.

The logit model was statistically significant ($X^2 = 33.85$, $P < 0.001$), however the independent variables explain only a small amount of the variation in the dependent variable (pseudo $R^2 = 0.104$). All of the discount variables were significant, with the larger discounts (90% and 75%, and to a lesser extent 50%) dramatically increasing the likelihood of coupon redemption over the smaller coupons (25% and 10%, omitted from the model). But notably, after controlling for the size of the coupon discount itself, self-reported willingness to pay had an insignificant effect on coupon redemption behavior. This implies that for a given discount level (e.g., 90% off the purchase price of a CFL bulb), a respondent with a high self-reported WTP was no more likely to make a purchase than a respondent with a lower self-reported WTP. The inclusion of interaction terms between the willingness to pay and discount variables (WTP × DISC*i*) yielded no substantive changes to model results, hence the interaction terms were omitted from the final model.

Table 3
WTP predictors of coupon redemption for CFL purchase (method: logit).

Variable	ß	S.E.	Exp (ß)	Significance
WTP	−0.035	0.0	0.966	0.516
DISC90	2.248	0.462	9.472	<0.001***
DISC75	1.865	0.477	6.459	<0.001***
DISC50	1.315	0.495	3.726	0.008***
WTP × DISC*i*	–	–	–	–
Constant	−2.695	0.453	0.068	<0.001***

*** $P < 0.01$.

Table 4
Attitudinal and demographic predictors of CFL coupon redemption I (full sample n = 342, method: logit).

Variable	Γ	S.E.	Exp (Γ)	Significance
DEFINE	−0.145	0.373	0.865	0.698
BELIEVE	−0.065	0.392	0.937	0.868
PASTPURC	0.183	0.340	1.200	0.591
FEMALE	0.537	0.377	1.712	0.154
INC1	0.125	0.560	1.133	0.823
INC2	0.895	0.533	2.448	0.093*
INC3	0.848	0.603	2.334	0.160
INC4	1.053	0.637	2.867	0.098*
INC5	−0.178	0.649	0.837	0.784
ED2	0.378	0.530	1.460	0.475
ED3	0.992	0.575	2.698	0.084*
AGE	0.020	0.013	1.020	0.129
URBANA	0.066	0.392	0.937	0.867
WTP	−0.047	0.061	0.954	0.446
DISC90	2.779	0.556	16.109	<0.001***
DISC75	2.621	0.586	13.749	<0.001***
DISC50	1.702	0.584	5.486	<0.005***
Constant	−5.091	1.069	0.006	<0.001***

* $P < 0.10$.
*** $P < 0.01$.

Table 5
Attitudinal and demographic predictors of coupon redemption II (WTPMORE sample n = 171, method: logit).

Variable	Γ	S.E.	Exp (Γ)	Significance
DEFINE	0.152	0.456	1.164	0.739
BELIEVE	0.282	0.512	1.326	0.582
PASTPURC	−0.052	0.432	0.949	0.904
FEMALE	0.401	0.467	1.493	0.390
INC1	0.616	0.675	1.851	0.361
INC2	1.190	0.701	3.288	0.089*
INC3	1.267	0.752	3.550	0.092*
INC4	1.392	0.793	4.021	0.079*
INC5	0.611	0.820	1.843	0.456
ED2	0.554	0.677	1.741	0.413
ED3	0.611	0.736	1.843	0.406
AGE	0.034	0.017	1.034	0.042**
URBANA	0.301	0.477	1.350	0.527
WTP	−0.052	0.032	0.950	0.108
DISC90	1.602	1.181	4.963	0.175
DISC75	1.646	1.160	5.184	0.156
DISC25	1.504	1.184	4.497	0.204
Constant	−4.843	1.756	0.008	0.006***

* $P < 0.10$.
** $P < 0.05$.
*** $P < 0.01$.

Explaining coupon redemption behavior based on knowledge and demographic factors

Results of the binary logit regression predicting coupon redemption behavior based on knowledge, attitudinal, and demographic characteristics are presented in Table 4 and Table 5. Table 4 includes the full sample of coupon recipients, regardless of whether or not they reported a willingness to pay in excess of the CFL price they were offered through their coupons.

The model was statistically significant ($X^2 = 52.84$, $P < 0.001$) and resulted in a better fit than the previous model (adjusted $R^2 = 0.177$). Significant predictors of CFL coupon redemption in the overall sample included membership in two of the middle income categories (with respondents in the INC2 and INC4 categories significantly more likely to redeem coupons than relatively poorer or wealthier respondents) and high educational attainment (with respondents in the highest education category nearly 2.7 times more likely to redeem a coupon than respondents in the lowest education category). The strongest predictor of redemption, however, remains the size of the coupon itself (DISC90, DISC70, or DISC50).

Finally, running the same logit model but including only those respondents who were offered the opportunity to purchase a CFL bulb at or below their self-reported willingness to pay (WTPMORE = 1) yielded the results reported in Table 5 ($X^2 = 25.69$, $P < 0.080$). These results reflect determinants of respondents' choice to purchase a CFL when a bulb is offered at a price that is equal to or below their self-reported WTP.[2] Using this subsample (n = 171), four significant variables emerge, including three income variables (INC2, INC3, and INC4), and the age of the respondent (AGE).

The odds of a respondent purchasing a compact fluorescent bulb at their self-reported willingness to pay level were increased by a factor of 3.288, 3.550 or 4.021 if that respondent was in one of the three middle income categories. Respondents in the lowest income category (INCLOW) were thus among the least likely to purchase a CFL bulb when offered the opportunity to do so at their self-reported willingness to pay price using a coupon. However it is noteworthy that individuals in the highest income category (INC5) were no more likely than the lowest-income respondents (INCLOW or INC1) to make a purchase at their self-reported WTP level. None of the education variables appear to increase the odds of purchasing a CFL bulb with a coupon after controlling for self-reported WTP and other covariates. The continuous variable AGE was significant (P-value < 0.05), exerting a modest positive influence on coupon redemption behavior.

Finally, the continuous variable representing self-reported willingness to pay (WTP) was not a significant predictor of coupon redemption, and indeed had a negative sign in the final model. In other words, controlling for coupon size and demographic and attitudinal variables the odds of redeeming a coupon to purchase a CFL bulb were (insignificantly) lower for a consumer who reported a higher willingness to pay versus a consumer who reported a lower willingness to pay (P-value = 0.108).

Contrasting self-reported WTP and observed behavior in CFL markets

The results of the survey and coupon distribution reveal a clear difference between reported willingness to pay and actual purchase behavior among urban Saint Lucian consumers in markets for energy-efficient lighting. With regard to self-reported WTP, findings suggest that knowledge factors influence WTP responses, consistent with previous research into consumer attitudes towards energy-efficient technologies in Saint Lucia (Reynolds et al., 2012; Hamilton and Ashby, 1994). However the finding that income and other socioeconomic factors such as education did not influence self-reported willingness to pay is somewhat surprising. One possibility is that a certain degree of social desirability bias may be influencing consumer survey responses – in other words, out of a desire to not appear ignorant of new technologies, and possibly a desire to please the interviewer, consumers with lower incomes and less education may have reported a willingness to pay for CFL bulbs that was unrealistically high in an effort to "keep up with the Joneses" – a trend that has been observed in previous consumer research (Sun and Morwitz, 2010). Such a trend might also in part explain why, in well over half of cases in our sample, respondents who were offered the opportunity to purchase a high-quality compact fluorescent bulb at or below their self-reported willingness to pay price did not choose to purchase the product.

With regard to determinants of actual purchase behavior, whereas knowledge and regional factors were found to significantly impact self-reports of willingness to pay, as hypothesized in Fig. 1 it appears

[2] The application of a sample-selection model, using the heckprob procedure in Stata SE 12.0, showed no systematic bias in the restricted sample, hence no statistical corrections are performed for the WTPMORE = 1 subsample.

that socioeconomic characteristics including education, income and age exert a more significant influence on consumers' decision to make a purchase of an energy-efficient product. The fact that education exerted a positive influence on coupon redemption in the logit model results in Table 4 (including all respondents, regardless of self-reported WTP or coupon received) suggests that increases in education may increase the likelihood of consumers purchasing an energy efficient technology at any price. It is also possible that more educated respondents were better able to understand and use the coupons distributed in this study, as compared to less educated, often lower-income respondents who may have had difficulty interpreting phrasing such as "90% off the purchase price." As for the effects of income, the finding that being in the lower income categories is associated with a low likelihood of purchase and incorrect self-reports of willingness to pay is consistent with expectations and with the results of previous studies (Sun and Morwitz, 2010; Flores and Carson, 1997). This further suggests that social pressures that encourage consumers to respond a certain way to a WTP question on an interview or survey may not be strong enough to drive private purchasing behavior in the market.

It is also noteworthy and perhaps surprising that the logit regression results presented in Table 5 further suggest being in the highest income category fails to improve the odds of redeeming a coupon for the purchase of a CFL bulb at a theoretically acceptable price. There are two plausible explanations for this finding of seemingly inaccurate self-reports of willingness to pay at the high end of the income distribution. First, it may be that the social desirability bias referenced above exerts an especially strong influence on high-income consumers. Not wanting to appear "cheap", high-income respondents may be driven to offer overly high willingness to pay responses to survey questions. Alternately, it is also possible this result may also be explained by a different form of social pressure — namely a stigma associated with the use of coupons among wealthy Saint Lucian consumers. If this is the case, the low coupon redemption rates observed among high-income respondents may result not from erroneous willingness to pay responses, but rather from a class-related reluctance to use coupons under any circumstances.

Finally, the finding that the variable WTP is not a significant predictor of coupon redemption behavior in any bivariate or multivariate models (and at the extreme may actually be negatively associated with coupon redemption behavior) has at least two possible interpretations. Firstly, it may be that some types of consumers (namely low income respondents, high income respondents, and less educated respondents) consistently overstate their willingness to pay for CFL bulbs in a survey setting, and as a result those consumers whose self-reported willingness to pay is highest may not be those most likely to make a purchase when a lower CFL purchase price is offered. This finding may be of particular importance to policymakers in Saint Lucia seeking to emulate CFL promotion programs such as those on the islands of Guadeloupe and Martinique, where French state-sponsored subsidization of energy-efficient appliances and CFL bulbs resulted in a dramatic decrease in per capita electricity consumption (Electricité de France, 1993). Reducing CFL prices in Saint Lucia to $4.00, the median reported willingness to pay of Saint Lucian consumers, may not result in the dramatic increase in the use of CFL bulbs predicted by surveys. But a second – and perhaps more troubling – possible explanation for the discrepancy between self-reported WTP and actual purchase behavior is that consumers are truly willing to pay for the energy-saving and environmental benefits of a high-quality CFL bulb, but they doubt whether the bulb they purchase from the Saint Lucian market will actually provide those benefits. As reported in Reynolds et al. (2012) the emergence and proliferation of low-price and low-quality "discount CFLs" from China over the past decade in the Caribbean may have negatively impacted both self-reported WTP and consumer purchase behavior in our study. The low advertised price of discount bulbs may decrease consumer willingness to pay for quality CFLs (the mean reported WTP of $4.28 is half the cost of a high-quality CFL, but is very close to the cost of a discount CFL[3]), while negative purchase experiences with low-quality CFLs in the past may make consumers hesitant to invest further in CFL technologies, even at low prices.

Ultimately, the current study suggests that the results of research in developing countries incorporating self-reports of willingness to pay for energy efficient technologies should be interpreted with caution. At best, consumer self-reports of willingness to pay in Saint Lucia seem to offer an "upper bound" for the prices Saint Lucian consumers will actually accept in the market. However it should also be clarified that, since coupons were distributed randomly, many consumers were able to purchase a CFL bulb for far less than their self-reported willingness to pay amount. Among those respondents who purchased CFLs through the study, the average reported willingness to pay was $5.50. In contrast, the average price paid with a coupon was only $4.55 ($t = 3.09$; P-value < 0.01). It thus seems likely that, were all consumers offered the opportunity to purchase a CFL only at their maximum self-reported price, purchase behavior would be even further reduced.

Limitations of the current study include small sample size and the use of a nonrandom sampling method. It should also be emphasized that the focus of the current study was a single product – CFL bulbs – over a relatively short time period. A study on a different product, or on a different category of products (e.g., large consumer durables) might yield different results, as might a longitudinal study of consumer self-reports and purchasing behavior over time. Indeed, it is possible that some consumers didn't redeem their coupon simply because they didn't need a light bulb in the one-month timeframe of the study. Past research has also demonstrated that self-reports of willingness to pay are especially unreliable in the face of changes in the underlying context: if the cost of electricity in Saint Lucia were to rapidly increase (changing economic incentives for CFL use), if low-quality CFL bulbs disappeared from the market (increasing consumer certainty over bulb performance and longevity) or if the use of energy-efficient CFLs became popularly associated with "high-class" and "modern" behavior (changing social incentives), past self-reports of willingness to pay for CFLs might become even less reliable. As Urama and Hodge (2006) observe, human preferences are not static but are rather a process emerging from individual interactions in an economic and social context.

Policy implications

Findings from this study contribute to a growing body of research showing that while self-reports of willingness to pay may indicate general trends of consumer preferences, there remain significant differences between revealed and stated preference that are not accounted for (Sun and Morwitz, 2010; Uruma and Hodge, 2006). The results from self-reports of WTP consistently overestimate consumers' willingness to pay, and this bias has made stated preference methods controversial in economic and marketing literatures due to the extent to which predictions fail to correspond to actual market behavior. Nevertheless, self-reported WTP surveys are useful because they remain an easy way to reach a large, random sample of consumers — and in areas where revealed preference information is limited, including in emerging markets for energy efficient lighting technologies in developing nations such as St. Lucia, consumer surveys may be the only way for governments to learn how to effectively overcome market barriers and promote improved technologies (Levine et al., 1995). A better understanding of how to interpret self-reported WTP data is thus critical for effective public policy development.

In Saint Lucia, most consumers already exhibit favorable attitudes towards energy-efficient compact fluorescent lighting, accompanied

[3] As a part of the survey we also asked the price that respondents paid for their last light bulb purchased. For respondents whose last purchase was a CFL, the amount reported was on average a very low USD $4.18 (st. dev. 2.76), or roughly half the cost of a high-quality CFL at the time of the study ($8.71), suggesting that most past CFL purchases were "discount CFLs."

by relatively high self-reports of willingness to pay. But even these self-reports often still far short of the full price of a high-quality CFL bulb (Reynolds et al., 2012), and more than half of respondents in our study did not make a CFL purchase even when a coupon allowed them to buy a CFL bulb at a price below (and sometimes far below) their self-reported willingness to pay. The fact that younger and low income respondents are among those groups most likely to provide inaccurate estimates of the amount that they will pay for a compact fluorescent bulb is valuable information. In response, since increased education may increase the likelihood of CFL purchase, a combination of price incentives (e.g., large coupons) and educational efforts may be needed to reach this target group of poorer and/or younger consumers. Meanwhile, the finding that very high-income respondents also inaccurately report their willingness to pay may reflect either a bias towards over-reporting WTP, an upper-class bias against coupon-use, or simply consumer doubts that a CFL purchased in Saint Lucia would actually provide the promised benefits. Either way, government programs and marketing efforts seeking to expand the use of energy-efficient technologies among this relatively wealthy and energy-intensive subgroup may want to seek alternative promotional methods, such as producer subsidies (lowing market prices of high quality CFLs without the need for coupons), expanded advertising (encouraging the wealthy to use their existing means to purchase high quality CFLs), and public education efforts to raise the popular appeal of energy efficient technologies and to help consumers distinguish high quality from low quality products.

Even as CFLs themselves are phased out in favor of other technologies such as Light Emitting Diodes (LEDs) (Harish et al., 2013; Aman et al., 2013; Azevedo et al., 2009), the lessons learned from the study of CFL market development in low-income countries can provide valuable insights for future energy efficiency policy efforts. Indeed, new findings from Sub-Saharan Africa suggest that the rapid emergence of low-cost (and often low performance) LED flashlights has already dampened consumer interest, willingness to pay and purchase behavior for LED lighting (Mills et al., 2014), just as in the past low-cost CFLs appear to have undermined willingness to pay and purchasing of high-quality CFLs in Saint Lucia (Reynolds et al., 2012).

Advances in stated-preference survey methods may also offer further hope for improving the validity and policy-relevance of survey research in markets for energy efficient products. Blumenschein et al. (2008) conducted field experiments to compare methods of removing self-report bias, finding “cheap talk” approaches (in which consumers simply stated their WTP) to be far less accurate than “certainty” approaches (in which follow-up questions asked consumers how certain they were about their own WTP). Such findings suggest that WTP may be more accurately estimated by including only respondents that are “definitely sure” about their own WTP estimates. While even such refined self-reports must still be treated with caution, adding follow-up certainty questions may mitigate gross overestimation, and make predictions based on stated responses more closely aligned to the real-life actions of consumers. Moreover, since the process of being surveyed can itself greatly affect respondents' choices, attitudes, and stated preferences, complementing stated preference surveys with other market research tools such as in-depth socio-technical case studies can further illuminate ways in which consumers understand and value new technologies (Müggenburg et al., 2012; Hogarth, 2012), allowing for more nuanced and ultimately more effective technology promotion efforts.

Growth in both population and in energy use in the developing world is expected to well exceed growth in the developed world in the coming decades. An increased understanding of consumer behavior in low-income countries is critical for assisting governments, development practitioners, and even marketers to ensure that the benefits of new technologies developed in wealthier countries provide the maximum possible benefit to the worlds' emerging economies. This study represents an attempt to evaluate the accuracy of consumer self-reports of willingness to pay for energy-saving CFL lighting in Saint Lucia. However the findings of the study should be of interest not only to policymakers in Saint Lucia, but also to marketers and governments in other Caribbean island nations and developing countries seeking to make decisions based on self-reported measures in consumer surveys. Self-reports may offer some insight into consumers' decisions, but the degree to which self-reported WTP reflects actual consumer intentions in the marketplace can be more accurately assessed through mixtures of surveys, case studies, and simulated markets such as the coupon distribution used in this study.

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