Customer perceived value of electricity in the province of New Brunswick in Canada: A sustainable development approach

by

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Abstract

Since 1881, when the first electric utilities were formed, their business model has been barely altered. However, recently liberalization of energy markets, technological innovations, adaptation of renewable energy resources and an increasing environmental awareness have dramatically transformed electricity markets. As a result, the role of customers' preferences increased significantly. To address these problems, this study attempts to revise the existing business model for electric utilities by introducing the concept of customer perceived value (CPV). CPV is then used to quantify the value of products and services in electricity markets from perspective of a supplier to better incorporate customers' needs in the development of new electricity products and services. Two major research tasks were undertaken in the study in this regard: (i) development of interdisciplinary conceptual framework for CPV, and (ii) identification and evaluation of fundamental determinants of CPV for electricity products and services. Addressing the first task, discussions around CPV across various academic disciplines were reviewed. The review served as basis to construct a clear, structured and systematic definition of CPV for both general market products and services as well as industry-specific products and services for electric utilities. The second task was addressed on basis of the sustainable development philosophy and hedonic price approach. Eventually the latter was used to evaluate the impacts of key determinants on CPV of electricity products in the province of New Brunswick in Canada. Rigorous statistical work was performed regarding the following two assessment groups: (i) urban versus rural customers, and (ii) residential versus industrial customers. Our findings show the need for a more comprehensive, multidimensional and customer-centric approach and specifically that economic determinants, particularly average electricity price and household income, were the most crucial determinants of CPV for electricity followed by social, environmental and technological factors. However, the ranking of determinants varies between customer segments. Based on these results, it was suggested that electric utilities in the province should incorporate some specific factors into their design of new electricity products and services for different consumer groups to provide higher CPV and consequently enhance business performance.

1. Introduction

This study introduces and discusses the concept of customer perceived value (CPV) and its application in the electricity industry. The concept of consumers' perceived value (CPV), a concept emerging in marketing and business literature in the 1990s, revitalized the understanding of the interface between customers and suppliers from the conventional one-way thinking of a natural monopoly to the two-way value-oriented interaction between suppliers and customers within competitive markets. Even though, the concept of CPV has been actively employed in investigating markets like retailing and servicing industries, only a limited attention was placed on the possible benefits of its use on traditional markets. Electricity utilities, one of the most typical traditional markets that is currently undergoing a global market liberalisation trend enables increasing competitiveness and therefore qualifies as a unique research opportunity to investigate the customer value creation processes.

The concept of CPV was firstly introduced in the late 1990s in marketing literature and is therefore a relatively new concept that is still under-explored and displays a lack of general agreement on its definition, theoretical grounding and practical application among researchers. Hence, in order to improve the current understanding of the concept of CPV, an interdisciplinary conceptual framework is suggested to help define CPV more comprehensively and bridge discussions across academic disciplines. An energy-specific model of the conceptual framework enables the opportunity to better understand and interpret the interface between electric utilities as suppliers and its customers in order to develop energy products and services with higher perceived value within an increasingly competitive market.

Focusing on electric utilities, this study conducted two major research tasks: (i) development of interdisciplinary conceptual framework for CPV, and (ii) identification and evaluation of CPV determinants for electricity products and services, to incorporate the concept of CPV in the existing business model of electric utilities and investigate how it can be used in improving its business performance. The first task was based on extensive review of existing CPV-related studies. Two conceptual frameworks - one for general market and one for specifically designed electric utilities - were developed. They will serve as a common language for scholars, government, business managers and other relevant stakeholders in the field. The second task was addressed on the basis of sustainable development framework coupled with the hedonic price approach. Using New Brunswick in Atlantic Canada as the case study, the key determinants of CPV for electricity in the four categories, (i) economic, (ii) technical, (iii) social, and (iv) environmental were identified and examined. Statistical analyses were performed based on panel data analysis for two assessment groups: (i) urban versus rural customers, and (ii) residential versus industrial customers.

2. The conceptual framework for CPV

2.1. Theoretical background

Customer perceived value (CPV) is one of the latest marketing concepts developed on the basis of previous discussions of concepts like 'theory of value' and 'customer satisfaction'. It is based on the assumption that a customers' opinion or view towards a market product or service, namely customer perceived value, is formulated not only based on the product or service itself, but also influenced by a branch of other elements, such as customer's cultural and personal values, his/her opinions and experiences related to

the product/service provided. This concept of CPV has been even argued to be on the verge of overtaking price and product quality as the key factor determining performances of products, services, and organizations (Anastasia, 2017). Shifting marketing approaches from product- and service-oriented approaches to customer-oriented ones; and measures in improving customer experience and perception have also been considered as essential mean to achieving company's success and gaining success in a competitive market (Vargo & Lusch, 2004; Zeithaml, Berry, & Parasuraman, 1996; Woodruff, 1997).

While in academia, compared to the number of studies in customer-related concepts like 'customer satisfaction', 'quality', 'customer value' and 'personal values', the concept of customer perceived value (CPV) is still under-explored and has just started to receive more attention recently with a drastically increase of more than 140 peer-reviewed publications in academic journals each year in the last decade. However, since CPV is still a relatively new concept, there is now a lack of general agreement on its definition, theoretical grounding and practical application. Ongoing studies have been found of theoretical background, definitions, determinants, measurement, and practical application of the concept of CPV; but most are limited to theoretical discussions with little practical applicability or represent a narrow view within one academic discipline. Some scholars like Zeithaml (1988) and Dodds, Monroe and Grewal (1991) focused on its theoretical foundations and classification; while a few (e.g. (Chang & Dibb, 2014; Gale, 1994)) attempted to investigate the variations in CPV from various stakeholder perspectives. Another group of them have followed the classifications and investigated the interdependencies between CPV and the influential elements, namely dimensions (e.g. (Kotler, 2000; Sheth, Newman, & Gross, 1991)). Finally, following the idea of dimension, some attempt to identify and test the contribution of determinants in various dimensions (e.g. (Parasuraman & Grewal, 2000; Lin, Sher, & Shih, 2005)); and others aim at introducing a precise and valid measurement scale or approach for CPV (Zhou, Li, & Li, 2008). And as summarized by Woodall (2003), 19 different terms like "values" and "perceptions" have been utilized to refer to the concept of CPV by scholars with various backgrounds. In addition, it has been criticized that existing studies, the theoretical discussions, and linkages to relevant concepts still remained vague and unclear, (Sánchez-Fernández & Iniesta-Bonillo, 2007; Lapierre, Filiatrault, & Chebat, 1999), which become one of the major obstacles for researchers in communicating in a common language and raising a sound conclusions. Through the following presented table (see

Table 1), it can be summarized and concluded that the key publications defining CPV in term of disciplines, research streams and classification categories, clearly reflect the wide range of variety in the current discussions. It can be also identified that there is an absence of a general agreement in definition of CPV. Misunderstanding might, hence, easily caused and results in difficulties in communicating among scholars. Inconsistent perspectives (e.g. consumer, supplier, shareholder, etc.) that are included in some of the work might also lead to a multitude of disconnected and ambiguous definitions.

Table 1: Summary of definitions of CPV by classification categories, disciplines and research streams

Category	Discipline	Research Stream	Definitions of CPV,	Author (Year)
Uni-dimensional	Marketing	Price-based studies	As cognitive trade-off between perceptions of quality and price	Dodds & Monroe (1985)

		Means-end theory	As the consumer's overall assessment of the utility of a product is based on perceptions of what is received and what is given	Zeithaml (1988)
Multi-dimensional	Marketing	Consumption-values theory	As an interactive relative value constructed by functional, social, emotional, epistemic, and conditional value.	Sheth et al. (1991)
			As notions of value (net value; marketing value; derived value; sale value; rational value) and four temporal categorizations (ex-ante; transaction; ex-post; disposal).	Woodall (2003)
			As values entailing by six dimensions: monetary, convenience, social, emotional, conditional, and epistemic.	Pura (2005)
		Consumer value theory	As typology of value with interactive, comparative, personal, and situational preference experience.	Holbrook (1994, 1996, 1999)
			As customer value hierarchy with three hierarchical levels of value (attributes, consequences, and desired end states)	Woodruff & Gardial (1996)
			As perceived preference for an evaluation of those product attributes, attribute performances, and consequences arising from use that facilitate (or block) achieving the customer's goals and purposes in use situations	Woodruff (1997)
			As assessment of four interrelated dimensions for functional, social, emotional and economic value	Sweeney & Soutar (2001)
	Economics	Utility theory	As value scale of shopping experience along the dimensions of utilitarian value (instrumental, task-related, rational, functional, cognitive, and a means to an end;) and hedonic value (reflecting entertainment and emotional worth of shopping; non-instrumental, experiential, and affective)	Babin et al. (1994)

Thus, this study argues that instead of adding additional perspectives to increase complexity in the discussion, a more inter-disciplinary, comprehensive and clear discussion is needed as guidance to achieve a common understanding and promote better communication among scholars. Hence, in the next sections, in order to address this gap and problem of unclear theoretical backgrounds and lack of agreement on CPV, this research will establish a comprehensive conceptual framework to better define CPV. The conceptual framework will provide an interdisciplinary perspective with reference to grounding theories, antecedents, general and industry-specific applications as well as linkages to quantifications approaches.

2.2. Proposed conceptual framework for general products & services

As discussed in the previous section, the interdisciplinary conceptual framework is called to address the problem of mutual understanding and lack of common language in the CPV-related studies. Corresponding to this objective an extensive literature review was conducted and served as the ground for developing the following framework. The aim is to devise a comprehensive framework exploring and investigating the factors affecting CPV at various levels and perspectives on the basis of empirical

discussions in a wide range of academic fields. Through reviewing, evaluating, integrating, and organizing empirical studies and discussions in different academic fields, the novel conceptual framework of CPV bridging discipline-specific viewpoints will be presented and discussed.

The interdisciplinary conceptual framework is illustrating how CPV of a general market product or services is constructed, characterized as i) multidisciplinary; ii) general, but applicable for practical use; and iii) broad in coverage, i.e. covering all essential dimension and grounding elements.

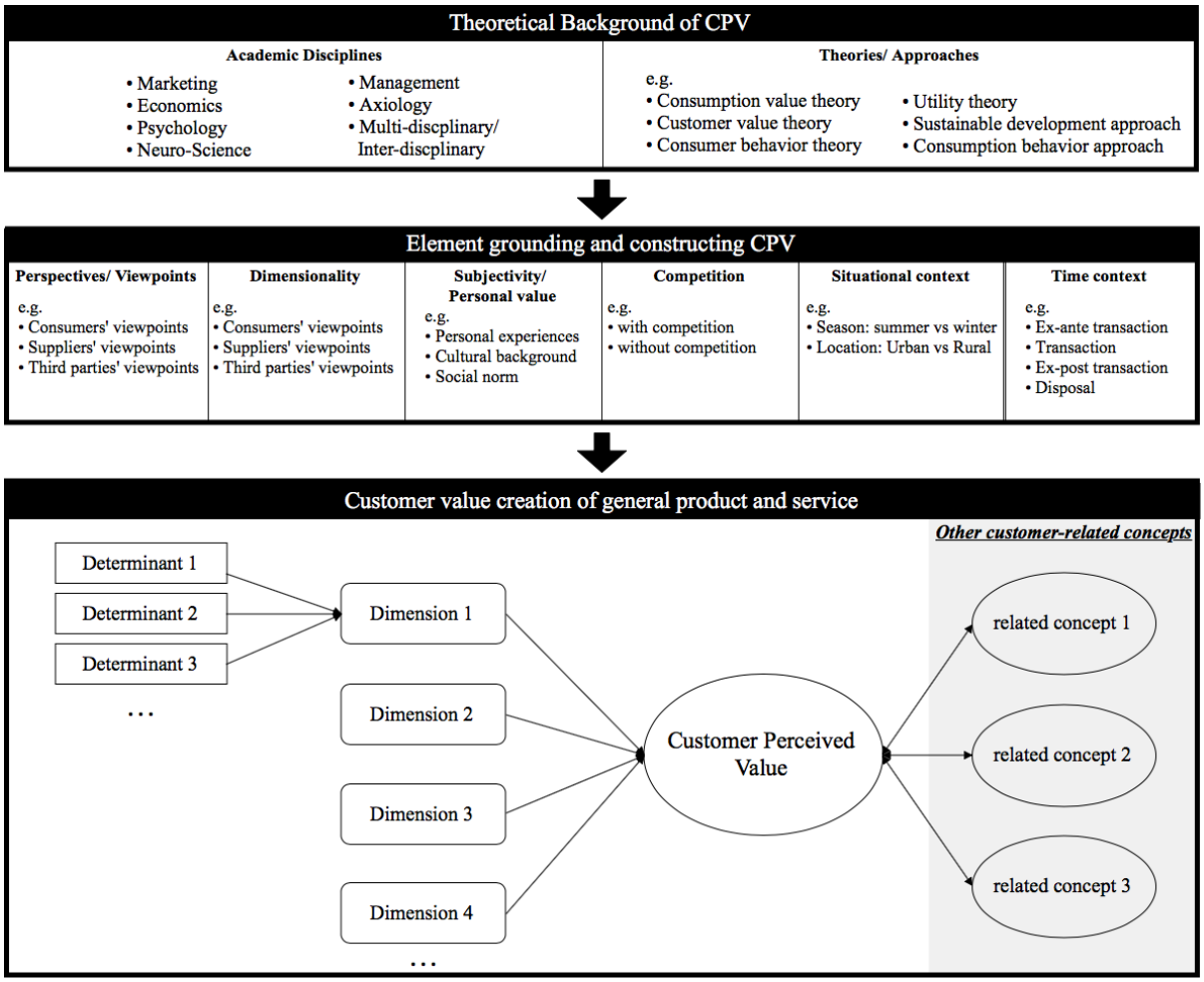

Figure 1: Proposed conceptual framework of CPV for general market products or services by the author

The proposed framework consists of three major sections, i) theoretical background, ii) element grounding and constructing CPV and iii) customer value creation of general product and service to serve as common ground to communicate different studies. First, the theoretical background of CPV refers to academic disciplines and theories within the discussion of CPV and helps to identify the background of a study. The second part, elements grounding and constructing CPV describes six major elements identified by previous CPV-related studies; and functions for distinguishing research stream within a discipline. Finally, and most importantly, the framework for a general market product or service that illustrates the interrelation among four major components: i) CPV, ii) dimensions, iii) determinants and iv) other related concepts are introduced. I.e. As an example, dimensions are a general category, like social, economic and technical, helping to facilitate a better comparison across industries, giving the opportunity to categorize

aggregation (here sustainable development approach is used due to its academic prominence); determinants are measurable indicators defining industry-specific sub categories and assisting the application to practical cases. Finally, related concepts (antecedents) are illustrated, which found to be significantly related, but own distinct concepts to CPV like customer satisfaction or loyalty.

2.3. Proposed sustainable framework of CPV for energy products and services

It became evident that within the recent decade, the energy industry has been transforming due to reasons in innovations in information and communication technologies, disruptive technologies, inventions of new energy products and services; and the shift of a conventional monopolistic market into a more competitive one (Gilliland & Teufel, 2015). Besides, the global trend to liberalization of energy markets, new competitors are entering the marketplace and creating increasingly competitive markets. Thus, these trends have pressured electricity utilities to focus on customer-oriented products and services leveraging latest concepts in academic research, such as the concept of CPV discussed in this paper.

In order to support competitiveness through a better understanding of the supplier and customer interface a first industry-specific framework of CPV for electricity is introduced. The following interdisciplinary framework how CPV of an energy product or services is constructed, is characterized as i) multidisciplinary; ii) industry-specific for electricity with practical use; and iii) broad in coverage, i.e. covering all essential dimension and grounding elements. Besides, this study enriches the concept by using a well established approach, the sustainable development approach (see detailed discussion in Section 2.3) and the indicator of willingness to pay (see detailed discussion in Section 2.4) for its quantification.

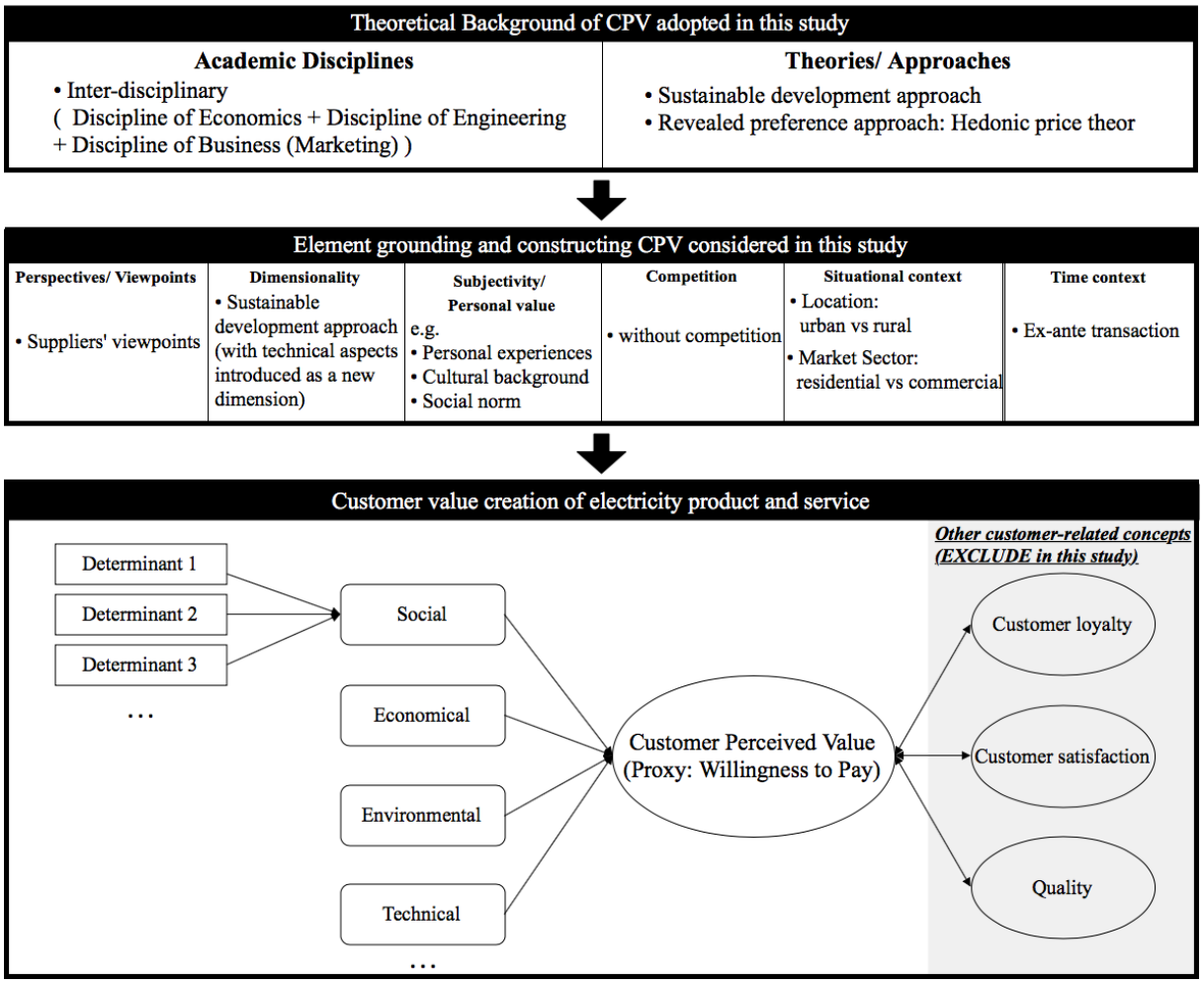

Figure 2: Proposed conceptual framework of CPV specific for energy products / services by the author

Similar to the previous conceptual framework of CPV for general market products or services and as illustrated in Figure 2, the interdisciplinary conceptual framework proposed for energy-specific products and services consists of three major sections, i.e. i) theoretical background, ii) element grounding and constructing CPV and iii) customer value creation of electricity product and service to serve as the common ground for different studies to communicate. Moving to the industry-specific implication in energy industry, the following empirical analysis will be found in three key academic disciplines in the field of energy, i.e. economics, business and engineering with a typical indicator of customer perception, willingness to pay and hedonic price approach as theoretical basis. While, for the second part, i.e. elements grounding and constructing CPV, the items will be selected and adjusted based on the nature of energy markets; for example, suppliers' viewpoint as property will be considered to better capture the supplier-oriented energy industry; without competition will be selected under the element of competition due to the natural monopoly of the observed energy supplier, urban/rural location and ex-ante transaction will be considered as the situational and time context for the discussion of CPV. Finally, for dimensionality, this study will adopt the sustainable development approach, which has been identified as an ideal approach to be general, well established in the academic discussions and broad in coverage as basis in constructing key dimensions in viewing CPV. Yet, it is important to note that the technical dimension is introduced to the existing three-dimensional sustainable development approach in

consideration of the characteristics of high dependence on technology within the energy industry. Even though, antecedents and other related concepts are recognized and might have correlation with CPV, they are not included as scope of this research (shaded in grey in Figure 2) to keep the focus on CPV and conduct an in-depth study in the energy sector.

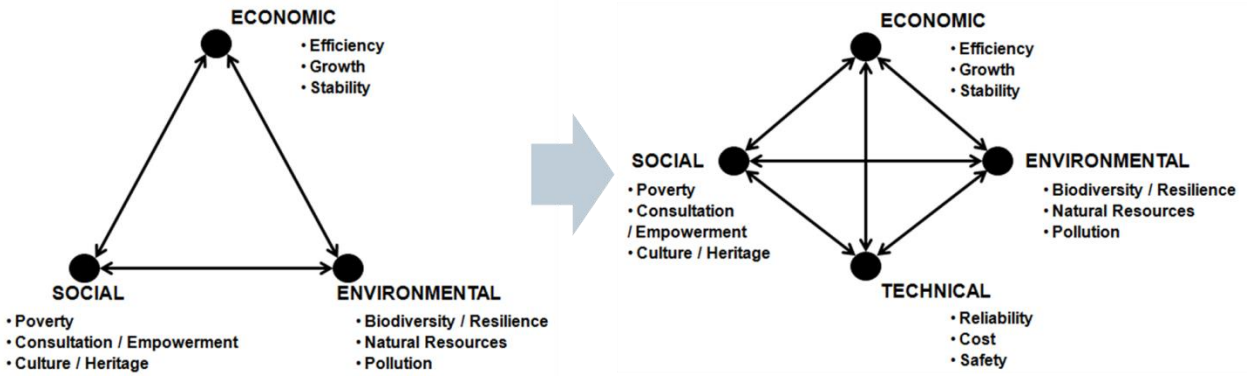

Figure 3: Illustration of proposed approach based on sustainable development approach with addition of a technical dimension (Data source: Club of Rome report, 1972; author's illustration)

2.4. Willingness-to-Pay (WTP) as proxy for CPV

As mentioned in the above section, the concept of CPV is a relatively new construct; and its measurement methods have not yet been well-developed and were highly relying on survey data. Particularly for goods like electricity products, its characteristics of being intangible and having a huge time gap between consumption and payment have caused extra difficulties in collecting appropriate survey data and having a correct estimation of CPV. Therefore, willingness to pay (WTP), the amount of money a customer is willing to pay for a unit of a product or service that found to be the characteristics of context-specific and customer-centered is considered to be the closest substitute for CPV. Amini, Falk, Hoth, and Schmitt (2016) even argued that WTP could be established based on CPV. Therefore, in the recognition of difference in time context between CPV and WTP, WTP for electricity is adopted as proxy of CPV in estimating the impacts of determinants to address the problem of lack of accurate quantification of CPV for electricity. Hence, the concept of willingness to pay helps to establish the conceptual framework, which bridges the interdisciplinary discussion with a discipline specific adaption, helping to introduce a first industry-specific framework including key determinants for the quantification of CPV for electricity.

Willingness to pay (WTP), as the maximum price or below that, is a commonly used method that can be generally classified in two approaches: 1) stated preference approach and ii) revealed preference approach, as summarized for example by Breidert, Hahsler and Reuterrer (2006). First, the stated preference approach contains methods which measure WTP based on subjective data. Methods like contingent valuation and survey-based approach are used to collect consumers' direct expression of their preferences to estimate their WTP. While, for the revealed preference approach, the measurement is mainly based on objective data like market data and experimental data collected from laboratory experiments, field experiments and auctions. Its basic rationale is that customers make decisions and act based on the process of intrinsic utility maximization; thus, those observed behaviors will be indicators of

the maximum amount customers are willing to pay for a certain product or services. In other word, based on demand theory, the revealed preferences approach is a means to reconcile the maximum utility through observed behaviors of individuals. These methods have been applied in a wide array of goods and services, which include those in both market and non-market sectors. And among those, the three most popular methods are market price method, hedonic price method and travel cost methods; which all specify the consumer problem (budget constraint) as a utility maximization problem to derive the so-called indirect utility. These approaches have been proved to be effective in producing an accurate measurement of WTP; thus, in this research, the revealed preferences approach will be adopted in measuring WTP of electricity products and services with objective statistical market data collected.

By adopting the revealed preferences approach, this study leverages the concept of WTP in combination with the hedonic price method, which was firstly introduced by Zhou, Li and Li (2008) for estimating the electricity price for large commercial and industrial consumers in China from the consumer perspective. Yet, it is important to note that instead of solely focusing on technical dimensions like previous studies before, this study will cover four essential dimensions, technical, social, economic and environmental dimensions, to have a more comprehensive estimation of WTP based on the devised sustainable development approach suggested above; and measure WTP of a product or services based on the following statistical equations. As discussed in the earlier work of the author of this study (Sahin & Yevdokimov, 2016), CPV for a product or service can be viewed as the customers' WTP for the same product or service in the perspective of suppliers. Since the supplier of the product or services cannot obtain full information of the construction of their customers' utility function, it is argued that random utility is preferable than indirect utility, as discussed by Haab and McConnel (2002). A similar conclusion was also presented by Twerefou (2014) with respect to the electricity market. Hence, it is suggested from a theoretical point of view, that WTP can be considered as the change in indirect utility in respond to a change in a product's price holding all other factors constant. In other words, it means that indirect utility, WTP and CPV depend on the same set of variables; and has a close correlation. Therefore, based on the logical discussion, the CPV for an electricity product of *i*-th consumer group is the sum of economic factors, electricity attributes and other unobservable customers' intrinsic factors as following,

$$CPV_{ij} = WTP_{ij} = F_{ij}(p_{ij}, P_Z, Y_i) + H_j(X_j) + \varepsilon_{ij} \quad (1)$$

, where

CPV_{ij} is the CPV for the *j*-th electricity product of *i*-th consumer group;

WPT_{ij} is the WPT for the *j*-th electricity product of *i*-th consumer group;

F_{ij} is the function that depends on economic factors, such as the price of the *j*-th electricity product (p_j), personal/ individual income (Y_i) and consumer price index (P_z);

H_j is the hedonic function that depends on electricity attributes (X_j);

ε_{ij} is observed by the *i*-th customer, but not by the researcher.

In addition, to follow the proposed conceptual framework and devised sustainable development approach, additional adjustments are performed on equation (1). First, the equation was adjusted to

incorporate determinants in the economic dimension, such as economic growth and unemployment rate that will affect consumer's choice, the objective is to consider macroeconomic attributes and specifics (*macro*) of a study area or region to enrich the model with local economic awareness. In addition to the macroeconomic attributes, the adopted model will assess the impacts of determinants in three additional dimensions (technical, social and environmental) on WTP for electricity products and services for various consumer groups, together with the time component *t*, expressed as:

$$CPV_{it} = \ln WTP_{it} = \beta_0 + \beta_1\, ln(G_t(macro)) + \beta_2\, ln\,(T_{it}) + \beta_3 ln(S_{it}) + \beta_4 ln(E_{it}) + \varepsilon_{it} \quad (2)$$

, where

CPV_{it} is the CPV for the electricity product of *i*-th consumer group;

WPT_{it} is the WPT for the electricity product of *i*-th consumer group;

G_t *(macro)* is the function of regional macroeconomic factors;

(T_{it}) determinants in technical dimension for *i*-th consumer group;

(S_{it}) determinants in social dimension for *i*-th consumer group;

(E_{it}) determinants in environmental dimension for *i*-th consumer group;

Subscript $_t$ is the time component *t*;

ε_i is observed by the *i*-th customer, but not by the researcher.

In the study of Choynowski (2002), it was argued that in the electricity industry which is strictly monitored and regulated, its historical data of unit price and consumption levels is often carefully tracked; therefore, it served as the optimal data source for defining WTP for electricity products and services based on market price model. Using the information of price and consumption for electricity by i) urban residential customers for the period 1991-2013 obtained from the electric utility board New Brunswick and the provincial electric utility NB Power and ii) price elasticity of demand taken from Ryan and Razek (2012), Yevdokimov, Getalo, Shukla and Sahin (2018) have illustrated willingness to pay (WTP) within the territory of the electricity utility NB Power in New Brunswick, Canada. Following the interdisciplinary conceptual framework proposed, the four dimensions, technical, economic, social and environmental dimensions, are identified as key factors determining CPV/ WTP for electricity products and services. It is argued that even most of the existing work in the field of CPV or WTP is only concerned on technical attributes, the importance of the other three dimensions should not be neglected. Hence, in reference on the framework and other empirical studies, a set of factors are identified and grouped as determinants in each dimension. The process to identify appropriate determinants is based on an extensive literature review, including academic peer-reviewed journal papers, empirical studies and seminal papers, as well as their prioritization according to the proposed methodology and analyses (e.g. correlation analysis). The results of the determinants are illustrated in the following table:

Table 2: Description of variables analyzed in the case study of electricity industry in New Brunswick, Canada

Variable		Description of data items analyzed in assessment group	
		1. Urban vs Rural customer	2. Residential vs Industrial customer
Dependent variable:			
Total Willingness to Pay	(lntwtp)	The amount of money a customer willing to pay for one unit of electricity calculated based on ▪ Electricity consumption (From provincial electric utility NB Power) ▪ Price elasticity (From Ryan and Razek, 2012) ▪ Electricity prices (From provincial electric utility NB Power)	
Independent variables:			
		Technology dimension	
Safety	(lnsafety)	Number of all safety incidents, including first aids, medical aids, near miss, property/equipment damage and disabling within the electric utility (From provincial electric utility NB Power)	
Reliability	(lnsaidi)	Average system interruption duration index (From provincial electric utility NB Power)	
	(lnsaifi)	Average system interruption frequency index (From provincial electric utility NB Power)	
Unit cost of electricity	(lnucreal)	Average cost to generate one unit of electricity (From provincial electric utility NB Power)	
Load factor	(lf)	Variability of consumption / generation measured by average load divided by peak load in a specific given time period (per year). (From provincial electric utility NB Power)	
		Economic dimension	
Personal income	(lnincreal)	Personal household income (CAD$) (From the report "The rural-urban income gap within provinces: An update to 2000" for the period 1980-2000.)	For residential customer: Personal household income (CAD$) (From the report "The rural-urban income gap within provinces: An update to 2000" for the period 1980-2000.) For industrial customer: Revenue of corporations (CAD$) (From annual plans of corporations)
Price of electricity	(lnepreal)	Average price of electricity per unit of electricity, measuring in real price in the level of 2000 (From provincial electric utility NB Power)	
Regional GDP	(lnrgdppc)	GDP for province of New Brunswick (From Statistics Canada)	
Unemployment	(ur)	Unemployment rate for province of New Brunswick (From Statistics Canada)	
Inflation	(cpi)	Inflation rate for the province of New Brunswick (From Statistics Canada)	

	Social dimension:	
Housing type	(lnhouse)	Housing types of customers (farm, house, apartment, commercial, industrial). (From provincial / electric utility NB Power)
Party affiliation	(lib)	People's preferences for the liberal political party, i.e. Progressive Conservative Party of New / Brunswick. (From provincial election results)
	(pc)	People's preferences for the democratic political party, i.e. Progressive Conservative Party of New / Brunswick (From provincial election results)
	(ndp)	People's preferences for the democratic political party, i.e. New Brunswick New Democratic Party / (From provincial election results)
Population	(lnpop)	Population in the province of New Brunswick (From Statistics Canada)
Number of customers	(lncustomers)	Number of residential and industrial customers of NB Power. (From annual report of electric utility NB Power)
Total number of customers	(Intc)	Number of total customers of NB Power. (From annual report of electric utility NB Power)
	Environmental dimension	
Emissions of SO_2	(lneso2)	Emissions of sulfur dioxide (chemical compound) created by generation fleet of NB Power (From provincial electric utility NB Power)
Emissions of NO_2	(lneno2)	Emissions of sulfur dioxide (chemical compound) created by generation fleet of NB Power (From provincial electric utility NB Power)
Emissions of CO_2	(lneco2)	Emissions of carbon dioxide (chemical compound) created by generation fleet of NB Power. (From provincial electric utility NB Power)
Temperature	(lnt)	Annual average air temperature in province of New Brunswick. (From Environment and Natural Resources of Canada)

3. Empirical Study on the Case of New Brunswick

3.1. Background information on New Brunswick

New Brunswick is the largest among the three Maritime provinces in Canada. It is located in the southeastern part of Canada and covers overs 73,440 square kilometers. It is the only official bilingual province in Canada with 33% French- and 66% English-speaking population. New Brunswick's struggling resource-based economy dependent largely on forestry, mining, and fishing was tied for the ninth place in the country's expected economic growth rate, and one of the highest unemployment rates among the ten provinces in Canada. In regard to electricity supply, the utility is the largest vertically-integrated electric utility in Atlantic Canada, primary supplier of the province New Brunswick since 1920s; and a crown corporation fully owned by the Government of New Brunswick (New Brunswick Power Corporation, 2019). According to the annual report 2017/2018 (New Brunswick Power Corporation, 2018), the utility has generated 17,013 million kWh services to more than 400,000 indirect and direct customers in the residential, industrial and commercial sectors. Besides future developments, the utility plans to modernize the power grid into a smart grid system and wants to provide customer-oriented energy services (Canadian Electricity Association, 2018). Thus, shifting toward a more customer centric view by incorporating CPV, New Brunswick serves as an ideal case for this study in the utilization of CPV within a traditional electricity market.

3.2. Regression analysis

In Table 3, all results of the regression analysis are summarized and presented with the direction and magnitude of impacts of determinants on TWTP for the two assessment groups, i) rural and urban customers and ii) residential and industrial customers, which would be further discussed in the upcoming two sections. Yet, it is important to note that in order to keep the preciseness and simplicity, this paper focuses on only reporting the key results, but not all the detailed intermediate and alternative model results. Besides, it is also noted that logarithmic transformations were performed on variables to eliminate the outlying factors. Thus, following the general interpretation approaches of log-transformed data, the impact size would be expressed in terms of percentage changes.

Table 3: Summary of all regression model results for WTP for urban and rural customers

Dimension	Determinant[2]	Result in Model[1]				
		1	2	3	4	5
Technical	safety	n	n	n	+	+
Economic	lnincreal	+	+	+	+	+
	lnepreal	+	+	+	+	+
	ur		-	-	-	-
Social	lib	+	+	+	+	n
	lnfemale			+	+	n
Environmental	lnt	-	-	-	-	-

	lneco2	-	-			
	lneso2			-	-	n
	_cons	-	-	n	-	-
Other	trend	+	+	+	+	
	lag1				+	+

Note 1: p<0.05 + = positive contribution to WTP; - = negative contribution to WTP; n = no statistically significant effects at 95% confidence level; N=46, i.e. 23 years data for each customer segment, i.e. urban and rural resident.

Note 2: variables are classified into four dimensions, which are

i) Technical dimension - number of incidents during a year (safety); system average interruption duration index (lnsaidi), unit cost (lnucreal), load factor (lf), system average interruption frequency index (lnsaifi);

ii) Economic dimension - GDP per capita (lnrgdppc); unemployment rate in New Brunswick, Canada (ur); income per capita (lnincreal); average elctricity prices (lnepreal);

iii) Social dimension - population in NB (lnpop), number of houses (lnhouse), party affiliation (lib; pc; ndp);

iv) Environment dimension - CO2 emissions (lneco2), SO2 emissions (lneso2); average annual temperature (lnt);

v) Other – constant (_cons); time trend (trend)

Based on the interdisciplinary conceptual framework proposed and the method of measuring CPV with WTP discussed previously, five separate regression analyses were performed to test and evaluate if there are changes in direction and magnitude of the impacts of determinants in control of various variables; and with results briefly summarized in Table 3. As it can be seen in the table, most of the variables have reported to have consistent direction and significant level of impacts on WTP throughout the models. As an economic determinant, the average electricity price (*lnepreal*) was found to have the highest contribution to WTP throughout the models, followed by income per capita (*lnincreal*). Yet, it was recognized that there were changes in absolute magnitude among various models, showing that a more comprehensive approach is required. In model 4, i.e. the best model for illustrating the casual relationship between urban and rural residents suggested in this study, the dependent variable, i.e. WTP of urban and rural customers, was regressed against eight determinants from technical, economic, social and environmental dimension and two other variables. The predication model resulted was expressed as

$$\begin{aligned}\ln WTP = {} & -0.803 + 0.096\ln(\text{lnincreal}) + 0.904\ln(\text{lnepreal}) + 0.000\ln(\text{lib}) + 0.009\ln(\text{safety}) \\ & - 0.0437\ln(\text{lnt}) + 0.019\ln(\text{trend}) - 0.004\ln(\text{lneso2}) + 0.38\ln(\text{lnfemale}) \\ & + 0.39\ln(\text{lag1})\end{aligned}$$

, with R2 of 99.9%. Consequently, a percentage increase in the average electricity price will increase the WTP of urban and rural customers by 0.904%. The determinant with the second highest impact was the economic variable income per capita (*lnincreal*) with the coefficient of 0.096. While other variables, i.e. gender variable (*lnfemale*) and liberal party affiliation (*lib*), were also found to have positive impacts on WTP of urban and rural customers. Besides, it is also noted that the technological variable was changed from a statistically insignificant variable in model 1 to a significant one at 95% in model 4, which was suggested to be a better fit, describing the real situation and relevance of the technical aspect. While for other variables, like unemployment rate (*ur*) and average annual temperature (*lnt*), their direction and magnitude of the impacts were found to be also relevant and important. Finally, based on the brief model results the important determinants in affecting WTP were found to be economic determinants, i.e.

average electricity price (*lnepreal & lnincreal*), followed by social and environmental determinants and lastly technological determinants.

Table 4: Summary of all regression model results for WTP for residential and industrial customer segments

Dimension	Determinant[2]	Result in Model[1]					
		1	**2**	**3**	**4**	**5**	**6**
Technical	safety	n	n				
	lnsaidi				-		
	lnsaifi					+	
	lf						+
	lnucreal			n			
Economic	lnincreal	n	+	+	+	+	n
	lnepreal	+	+	+	+	+	+
Social	ur	n	+	n	n	n	n
	lncustomer	-		-	-	-	-
Environmental	lnt	-	-	-	-	-	-
	lneco2	-	-	-	-	-	-
Other	trend	+	+	+	+	+	+
	lag1	-	-	-	-	-	-
	_cons	+	n	+	+	+	+

Note 1: p<0.05; + = positive contribution to WTP; - = negative contribution to WTP; n = no statistically significant effects at 95% confidence level.

Similar to the analyses of the WTP of urban and rural customers, the WTP for electricity products and services in residential and industrial customer segments have also been tested by regression analysis with the determinants in the known four dimensions. Slight adjustments were performed to better describe and distinguish the two customer segments, such as exclusion of the social variable party affiliation (*lib, pc & ndp*) and introduction of number of residential and industrial customer *(lncustomer*) as determinants for the social dimension. The time trend (*trend*) and long-effect (*lag1*) variables were also included in the analyses as learning from the previous analyses.

Six separate regression analyses were performed to test and evaluate if there would be changes in direction and magnitude of the impacts of determinants in control of various variables (Table 4). Yet, unlike the consistency of direction and level of significance among the models presented in the previous comparison of the customer segment urban and rural customers, the level of significance of determinants in economic and social dimensions were found to be varying with the change of technological variables entering the model, except the economical determinant average price of electricity (*lnepreal*) and the social variable number of customer *(lncustomer*). While, for the determinants in environmental dimension and others, a consistent direction and level of significance was observed. Model 1 was considered as the

best model after reviewing the results of the other five alternative models. As it can be seen in Table 4, nine variables from four dimensions and additional other factors were entered and a prediction model was generated expressed as,

$$\ln WTP = -3.001 + 1.001\ln(\text{lnepreal}) - 0.219\ln(\text{lncustomer}) - 0.059\ln(\text{lnt}) + 0.0207\ln(\text{trend}) - 0.043\ln(\text{lag1}) - 0.006\ln(\text{lneco2})$$

, with R^2 is 99.9%. Among the nine variables inputted, six of them were found to be statistically significant at 95% confidence level. The economic variable average price of the electricity (*lnepreal*) was found to be the determinant with the highest impact with a percentage increase in a Canadian dollar of electricity price resulting in 1.00% increase in WTP for electricity products and services, which was similar with the result in the segment for urban and rural customers. Another economic determinant income of the customer (*lnincreal*) was surprisingly found to be not significant, p=0.58. Instead of having highly dominant economic factors as in urban and rural customers, within this customer segments the social factor number of customer (*lncustomer*) plays a more important role in lowering the WTP as a 1% increase of customers will decrease the WTP by 0.219%. Another interesting finding was the negative impact of average temperature with a coefficient of -0.059, which possibly indicates that in New Brunswick, the major demand for electricity is during the long and cold winter time and mainly for heating purposes; thus, the lower temperature will result in a higher WTP for electricity products and services for both residential and industrial users. While other variables like time trend, long-time effect and CO_2 emissions also have a slight significant impact with the coefficients of 0.020, 0.043 and 0.006, respectively, but with no significant effect from unemployment rate (*ur*) and number of safety incidents during a year (*safety*).

3.3. Conclusion

One of the major learnings from this study is the significance of the variation among assessment groups in the impacts of determinants. For example, social determinants play a much more important role in determining CPV for electricity within the urban and rural customers assessment group than within the residential and industrial customers assessment group, although economic determinants were found to be the most crucial determinants for both. For urban and rural customers, economic determinants were the most important determinants of CPV for electricity followed by environmental, social and technological factors. For residential and industrial consumers, the order of importance was as follows: economic, social, environmental and technical.

While some of the results were expected, e.g. relevance of the economic dimension in a province with a not very strong economy, other results were quite surprising. For example, some of the results indicate that urban and rural customers have a high focus on the social dimension. Therefore, products and services that address social components, such as community participation, social responsibility or recognition, might increase the overall customer value perception for urban and rural customers. Another interesting finding is the relevance of the economical dimension, such as temperature. Through considering the average temperature (e.g. with previous years), customers can be informed and educated to increase the willingness to pay if lower temperatures occur, resulting in an increase of the value perception. However, the key consideration for each supplier (in this case electrical utility) should be a comprehensive attention on all relevant dimensions that affect the perceived value of customers. The additional transparency provided though this study will help to balance investments to strengthen product and service development, as well as marketing activities, within the limited available resources.

4. Implications for research, business, and policy development

This study explores the potential of using the concept of customer perceived value (CPV) of electricity in coping with new reality due to liberalization of electricity markets, technological innovations, adaptation of renewable energy resources and an increasing environmental awareness. In order to meet this objective, two major research tasks were performed. The first task established a common ground for the CPV of electricity by introducing a conceptual multi-disciplinary framework based on a comprehensive literature review. Within the second task, the impacts of relevant determinants organized in four groups - economic, social, environmental, and technical - were quantified on CPV for electricity in the province of New Brunswick in Atlantic Canada. The results of the empirical study indicate that there is the need for a more comprehensive model and that variations of impacts from these determinants for different customer groups must be understood in detail. Hence, based on our findings, we suggest that electric utilities should revise their existing business models and diversify their products and services using a multi-dimensional approach to achieve the highest CPV on the one hand and to increase their business performance on the other. Neglecting to use latest research outcomes can lead to the result that electric utilities are overtaken by new and dynamic competitors (especially through market liberalization, but also through technology providers for small-size distributed generation and storage), decreasing revenues in comparison with expenses required to operate the electrical infrastructure and market failure.

The proposed methodology helps to improve the academic discussion around CPV and its application to other industries as further study field. Furthermore, the results can further be compared with other jurisdictions, other quantification methods or approaches such as stated preference, and additional data sets / determinants to establish a more comprehensive view.

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