Article

Consumer Perceived Economic Value of Electronic Charts

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Abstract

This paper applies the Contingent Valuation Method (CVM) to derive the mean willingness to pay (WTP) for the chart information in electronic format by end users. A case study of the members of the Passenger Vessel Association (PVA) was conducted. The results show that on average a PVA Vessel member is willing to pay approximately US$ 700 per vessel just for the chart information in electronic format. The proposed valuation methodology can be modified to assess WTP for electronic charts of other key users such as recreational boaters and larger cargo shipping companies so the overall benefits of electronic charts can be derived.

Résumé

Cet article applique la méthode d'évaluation CVM (Contingent Valuation Method) afin de calculer la volonté de payer de l'utilisateur (WTP) moyenne pour les informations cartographiques dans un format électronique. Une étude de cas été menée à bien parmi les membres de l'Association des navires à passagers (PVA). Les résultats ont montré qu'en moyenne, un membre de la PVA est prêt à consacrer approximativement 700 $ par navire, uniquement pour disposer des informations cartographiques dans un format électronique. La méthodologie d'evaluation proposée peut être modifiée pour évaluer la WTP pour les cartes électroniques d'autres utilisateurs clés comme les plaisanciers, et les compagnies maritimes plus importantes afin de pouvoir calculer les bénéfices globaux des cartes électroniques.

Resumen

Este artículo aplica el Método Contingente de Valoración (CVM) para derivar la voluntad de pagar (WTP) promedio del usuario de la información de cartas en formato electrónico. Se efectuó el estudio de un caso de la Asociación de Buques de Pasajeros (PVA) para demostrar la metodología. Se pidió a los miembros del buque de la PVA. Los resultados muestran que, en promedio un buque miembro de la PVA está dispuesto a pagar aproximadamente $700 por buque sólo por la información de la carta en formato electrónico. La metodología de valoración propuesta puede modificarse para evaluar el WTP por las cartas electrónicas de otros utilizadores clave como los navegantes de embarcaciones de recreo y las compañías navieras mayores, de manera que los beneficios generales de las cartas electrónicas pueden derivarse.

1. Introduction

1.1 Background

A complete and accurate hydrographic survey is fundamental to the production of good nautical charts. Inexpensive computers and the availability of low-cost electronic positioning devices have prompted the development of electronic charts as an alternative to paper charts. Since the 1980's, the US National Oceanic and Atmospheric Administration (NOAA) has been involved in developing standards and technologies to store and display electronic chart information. Integrated electronic navigation systems that incorporate information from various navigational tools have also been developed. It is expected that the integrated systems can improve safety and efficiency of navigation.

Traditionally the need for hydrographic surveys is underpinned by the military rationale and by economic incentives. Currently there are very few studies on economic valuation of hydrographic charting. Kite-Powell and Jin (Kite-Powell and Jin, 1996) estimate the safety benefits of using electronic charts and integrated navigation system to be approximately 2.1 billion dollars (1995 dollars) in 15 years from 1996 to 2010. Their benefit is based on the estimated reduced casualties in commercial shipping. Subtracting the estimated costs of installing the electronic chart system on all vessels, the net benefit is about 1.34 billion dollars. In a simulation study, Jin et al. (Jin et al., 1995) show that electronic charts can be a more cost-effective means than double hulls for preventing oil pollution from marine transportation. Leenhouts et al. (Leenhouts et al., 1998) emphasise the productivity gains from using the Electronic Chart Display and Information System (ECDIS) in the Canadian Coast Guard and estimate the benefit-cost ratio to be 18 to 1. An Australian study (Coochey, 1992) focuses on the economic evaluation of hydrographic charting. Coochey provides guidelines for valuing hydrographic charting and points out relevant economic research (such as value of human life). However, no direct economic valuation of various uses of hydrographic surveys is conducted.

These studies show that providing chart information in electronic format can be profoundly beneficial. However, with the exception of the Canadian Coast Guard study, the few existing studies focus on the aggregate cost savings and avoided losses of using electronic charts to indirectly recover benefit measures. The perceived benefits of using electronic charts by consumers have not been examined. The difficulty arises from the public good nature of hydrographic charting. In general, products or technologies developed by the US government, including the hydrographic survey data, are not copyrighted and can be freely reproduced by the public. Commercial re-production of hydrographic survey information, such as nautical charts, is priced and sold without taking into account the costs of the source information and does not reflect the full value of the information. Unlike a private good where its market price reflects a consumer's WTP for the good, the perceived benefit (WTP) of a public good such as hydrographic surveys is not revealed in the market place.

1.2 Research Objectives

In this study, elicitation techniques are applied to the valuation of electronic charts by asking potential users to design and value their own 'smart chart' system that best fits their navigational needs. The economic values of electronic charts derived from this proposed method are based on chart related products that are customised according to individual needs and take into account the complementary effects of the electronic charts and other existing navigational tools. The proposed valuation method differs from the standard cost saving approach for projecting economic impact of a new publicly developed technology. It elicits benefit measures directly from the potential users. The specific aims of this study are to (1) develop a survey questionnaire to collect information regarding chart uses by chart users and their perceived economic benefits of using navigational chart information in electronic format and (2) conduct a case study of users of the navigational charts, and based on the collected information derive estimated benefits of using electronic chart information.

The rest of the article is organised as follows. Section 2 reviews the common methods for valuing public goods, in particular the CVM. Specific issues to apply CVM to the economic valuation of electronic chart information are discussed. Section 3 describes the case study and documents the development, design and pre-test of the survey instrument. Section 4 presents the implementation of the survey; summarises the characteristics of the survey respondents; and presents the data analysis and results. Section 5 summarises the findings of this study and provides some recommendations for further research. Section 6 gives the references. Two appendices providing the key valuation questions in the survey questionnaire and regression analysis of the collected data, respectively, are given at last.

2. Valuation of Hydrographic Charting

2.1 Non-market Valuation

Non-market valuation is used to value non-market goods that are not traded in private markets. Publicly provided goods such as national security, defense, and state parks are examples of non-market goods. Unlike private goods, the price of a non-market (public) good is not determined by buyers and sellers in the market. Various non-market valuation methods have been developed to derive economic values of non-market goods. The method that is commonly used for deriving the WTP for a non-market good and pertinent for recovering values of hydrographic charting is the CVM. The CVM is a survey method where survey respondents are asked directly about their WTPs for increments or to avoid decrements of a public good. Due to its increasing popularity, NOAA established a panel of social scientists, chaired by two Nobel laureates, to evaluate the validity of CVM. The report was published in 1993.[1] The panel provided guidelines for CV surveys. Since then, substantial research effort has been devoted to improving CVM (Carson et al., 2001). There is a good variety of CVM such as the standard yes-no response to the question of whether to pay a proposed dollar amount for some quality improvement and the conjoint analysis that an individual is asked to evaluate alternative goods with multiple features and costs. In general CVM still serves as the only method to recover both direct use and indirect or future use values of non-market goods. Even though CVM has become widely used for non-market valuation, the debate over its ability to deliver reliable benefit measures continues. The reliability of the benefit estimates from a CV survey can be affected by the nature of the good being valued, market definition (of the individuals who will be influenced by the proposed good), and survey design and implementation. Nevertheless, carefully designed CV surveys can be very useful in cost-benefit analyses for policy forums.

2.2 Issues in Valuing Hydrographic Survey Information

Given the established basic methodologies for non-market valuation, three issues of valuation of hydrographic survey data remain to be addressed. First, the hydrographic survey data can be used in support of various activities that include nautical charting, dredging for port and harbour maintenance, coastal zone management, and offshore resource development such as fish population management and oil exploration/extraction. The overall economic benefits of hydrographic surveys are difficult to arrive at without examining the contributions of hydrographic survey data to each of these applications and there is no simple way to account for the economic values of all these applications. This study will focus on the primary use of hydrographic survey data, i.e. nautical charts for navigation. There are various nautical chart users ranging from recreation boaters to large cargo shipping companies. As a starting point, a survey of the Vessel members of Passenger Vessel Association (PVA) was conducted. The PVA members were chosen for the case study because of the availability of the contact information. More importantly, they represent the middle ground in the wide range of nautical chart users in terms of the size of operation.

Second, in addition to nautical charts, mariners use a wide spectrum of tools to aid navigation such as radar, compass, marine VHF radio, Global Positioning System (GPS), and echosounder. Navigational safety relies on the *combination* of navigational tools so that the economic benefits of improving nautical charts (on accuracy and ease to use) can be enhanced (or exaggerated depending on the situations) by the presence of other navigational aids. Furthermore, according to their needs/preferences, mariners use different combinations of navigational tools so the benefits of improving nautical charts can differ among individual users. It is important to identify the heteroge-

[1] See a review of NOAA Panel: Carson, R.T., W.M. Hanemann, R.J. Kopp, J.A. Krosnick, R.C. Mitchell, S. Presser, P.A. Ruud, and V.K. Smith, 1996, 'Was the NOAA Panel Correct about contingent Valuation?' Resources for the Future, Discussion Paper 96-20

neous uses of navigational devices so values of nautical charts can be derived in the presence of different navigational devices.

Third, the common confusion of non-market valuation is the total versus marginal values. For example, we may derive individuals' WTP for unit reductions of total suspended particulates in micrograms per cubic meter. This is the marginal value of air quality, not the total. For policy purposes and benefit-cost analysis, it is the marginal value (from the current state to a new improved state) that is often of interest. Similarly, to value nautical charts, a clear definition of improvement is needed. From the users' point of view, the improvement of nautical charts is not only the update of the chart information but also its accuracy and ease to use in company with other navigational devices. Integrated electronic navigation systems have been developed that can combine information from various navigational tools on the same computer screen. The values of electronic delivery of the chart information and the capability of incorporating other tools for navigation should be examined.

A CV survey was designed and administered for the members of the PVA. A 'smart chart' system that could provide nautical chart information electronically and be capable of integrating information from other navigational tools was evaluated. The design of the survey is discussed in the next section.

3. Survey Design

3.1 Profile of Passenger Vessel Association

The target survey population for the case study is the Vessel members of PVA, a not-for-profit organisation serving the passenger vessel industry for more than 30 years. The Association provides the members representation before Congress, Coast Guard, and other federal regulatory agencies. It also runs safety and risk management programmes and provides legal counsel. The Association hosts annual meetings to assist networking and provide latest operation information and solutions to common problems. The official magazine, Fog Horn, is published monthly. It provides information on current legislative and public policy developments, new products and services, and discussion on issues in the marine, tourism, and related industries. As of 2002, the Association has 329 Vessel members and 164 associate members. The Vessel members typically operate small to mid-size passenger vessels for cruises, ferries, fishing, etc. The associate members are typically legal offices, equipment suppliers, and port authorities.

3.2 Development of Survey Questionnaire and Pretest

Individual values of improving nautical charts can differ according to need. In addition to the key valuation questions for nautical charts, it is important in the survey to learn individual business operations and their current use of nautical charts. Hence, the survey was designed to acquire information in three areas: current use and satisfaction of nautical charts, business operations, and individual characteristics.

A pre-test of the survey instrument was conducted at the PVA annual Original Colonies meeting on 19 October 2001 in Portland, Maine. Several PVA members were randomly selected at the meeting to fill out the survey questionnaire and give comments. The pre-test results were used to revise the survey questions and to eliminate ambiguous wording.

3.3 Outreach and Information Sharing – Article on Electronic Charts

The pre-test of the survey questionnaire at the annual regional PVA meeting revealed that it would be beneficial to the PVA members to provide them with basic information on electronic charting prior to the survey. To ensure that survey respondents had basic knowledge of electronic charts and for outreach purposes, an article titled *The Era of Electronic Navigation* was written and published in Fog Horn, the official magazine of PVA, in April 2002. The article covers a brief history of US hydrographic surveys, survey technologies, and electronic charts. The article was well received. Among those survey respondents who knew the difference between Raster Nautical Chart (RNC) and Electronic Navigational Chart (ENC), about forty-five percent of them indicated in the survey that they acquired the knowledge from the article.

4. Survey Implementation and Analysis

4.1 Survey Implementation and Responses

The PVA members were contacted through either electronic mail (email) or regular mail in late April

(% of Survey Respondents)			
	All	Web Survey	Mail Survey
Use Charts to Plan Routes	61%	68%	55%
Generally Satisfied with Charts	87%	90%	84%
Update Charts Periodically	72%	68%	76%
Prefer Paper Charts	68%	61%	74%
Use NOAA Print-On-Demand Paper Charts	3%	0%	6%
Subscribe to Electronic Chart Update Service	6%	6%	6%
Believe Charts Accurate	82%	74%	90%
Know the Difference between RNC and ENC	40%	48%	31%
Believe Safer Navigation if Surveys Conducted Periodically	57%	68%	47%
Expand if New Chart Information Available	25%	26%	24%
Interested in Training Courses in Using ENC	53%	52%	55%

Table 1: Current Use of Paper and Electronic Nautical Charts

2002, following the publication of the April issue of Fog Horn that contained the aforementioned article on electronic charts.[2] Of the 329 PVA Vessel members contacted, 68 of them responded to the survey (36 from the web survey and 32 from mail), with an overall response rate of 20.7%. Over half of the respondents are the owners of businesses and close to 80% of them are licensed vessel operators. On average, the respondents have close to 20 years of experience in passenger vessel operations and over 80% of them have personally used nautical charts in the past 5 years.

A series of questions in the survey queried the current use of paper and electronic nautical charts by each respondent's company. The usefulness of nautical charts to survey respondents is summarised in Table 1.

Notice that over a half of the survey respondents are interested in training courses in using the electronic navigational chart technologies. The survey respondents represent a wide range of passenger vessel operations. In general nautical charts are important for planning their routes. It is foreseeable that the willingness to pay for chart information can be affected by their business operations. Table 2 summarizes the respondents' businesses. The mean is the average of the observed values ($\bar{X}=\sum_i x_i$). The standard deviation is computed based on the formula $\sqrt{\sum_i (X_i-\bar{X})^2/(n-1)}$, and measures the spread of the values of variable X among survey respondents. Approximately the range created by mean±2*std covers 95% of the observed values of the variable. On average, the companies of survey respondents have been in operation for over 30 years. Over a half of the respondents' operations involve cruises and tours. On average each company has 4 vessels and serves 3 to 4 routes. The capacity of passenger vessels varies substantially among the PVA members. The median capacity is 150. The average fare per passenger per hour is somewhere between $11 and $14.

4.2 Values of Electronic Chart Information

In the survey, respondents were presented with brief descriptions of the electronic navigational chart technology that enables the integration of information from various navigational tools to develop a 'smart chart' system. The capability of the 'smart chart' can depend on the needs for different business operations. Information from a list of navigational tools/devices that could be potentially incorporated into the 'smart chart' system was presented in the survey. The exact format of questioning can be seen in Appendix A.

The survey respondents were asked to select from the list of potential features to design their own 'smart chart' system based on their needs. It was emphasised in the survey that the costs of the designed system would increase with features so they should only include features that were needed for their operations. The self-designed system by survey respondents is summarised in Table 3.

The majority of the respondents wanted to incorporate information from the chart, GPS/DGPS, and

[2] There were five non-US PVA members and only one of them was a Vessel member. The analysis in this study does not include non-US members

	All		Web Survey		Mail Survey	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Firm Age	30.41	32.23	30.07	27.99	30.79	36.76
#Vessels	4.00	4.19	4.03	4.03	3.96	4.43
#Routes Serviced	3.50	3.51	3.15	2.94	3.85	4.02
#Masters	11.35	12.46	12.38	12.82	10.29	12.21
#Mates	6.46	13.11	5.90	9.72	7.11	16.49
Hours Per Trip	12.19	35.30	9.50	30.71	14.98	39.89
#Passengers	399.28	622.59	426.10	675.54	371.50	573.70
Passenger Fee Per Hour ($)	12.76	11.08	14.25	11.11	11.28	11.06
Years Being PVA Member	9.36	7.00	9.45	5.64	9.26	8.37
Primary Operation - Cruise/Tours	55%		58%		52%	
Primary Operation - Ferry	27%		32%		21%	
Primary Operation -Fishing	2%		3%		0%	

Table 2: Business Operations of Survey Respondents - Summary

radar in their self-designed 'smart chart' system. An automatic update of chart information was also preferred. A valuation question followed to elicit the WTP for the self-designed 'smart chart' system. The WTP question was phrased as follows.[3]

"How much would you be willing to pay PER VESSEL for this 'smart chart' system that you design above for your vessels? (A one-time payment excluding the cost of a computer to run the system.)"

Ranges of dollars were presented and each survey respondent was asked to select one. On average, a survey respondent (a PVA Vessel member) is willing to pay approximately $1000 per vessel for the self-design system from the web survey and $1600 from the mail survey (excluding the costs of hardware such as computers). The range of WTP responses is relatively wide (large standard deviation). There is also a significant difference in WTP between the web and mail survey respondents that the mail survey respondents are willing to pay more for the integrated system.

The reported WTP estimates are the willingness to pay for the 'smart chart' system of *all* desired features. The economic value of electronic chart information itself is embedded in these WTP estimates. Individual WTPs for the system may differ according to the needed features. Further, it is seen that survey respondents from the two survey formats seem to disagree in various aspects. To disentangle the factors that contribute to the total reported WTP, linear regression analysis of WTP that explores the relationship between WTP and each potential impact factor, while holding other impact factors unchanged, is conducted. A linear approximation of the relationship is presented as follows.

(Item Picked by % of Survey Respondents) Smart Chart Features	All	Web Survey	Mail Survey
Chart Information	81%	90%	72%
GPS/DGPS Information	75%	74%	76%
Radar Information	63%	55%	72%
Echosounder Information	48%	58%	38%
Near-by Vessel Identification	43%	29%	59%
Real-time Tide/Water Depth	50%	52%	48%
Automatic Alert of Navigation Situations	44%	48%	39%
Display of Docks/Piers	35%	23%	48%
Automatic Update of Chart Info.	68%	77%	59%
Other	8%	10%	7%

Table 3: Self-Designed 'Smart Chart' Features - Summary

[3] The full survey questionnaire is available upon request from the author

$$WTP_i = \alpha_i + \beta' X_i + \gamma' W_i + \delta' O_i + \varepsilon_i, \quad (1)$$

where X_i is a vector of features to be incorporated in the 'smart chart' system by individual i; W_i is a vector of characteristics of the individual i's business operations and navigational practice; O_i is a vector of characteristics of individual i; α, β, γ, and δ are unknown parameters to be estimated using the survey data; ε_i is the part of variation in WTP for individual i that cannot be explained by X, W, and O and it is assumed random. In this model, WTP is called the dependent variable where its value depends on the values of X, W, and O. The vectors of X, W, and O are called the explanatory or independent variables. From the above summaries of survey responses in Tables 1, 2, and 3, it is reasonable to suspect that the WTP measure can be affected by these variables. Each of the parameters, β, γ, and δ represents the effect of one unit change in respective X, W, and O on the value of WTP. For example, let X_i be the incorporation of chart information into the 'smart chart' system and β_i be the parameter associated with X_i in Equation (1). Then β_i is the (marginal) WTP for X_i (chart information in electronic format), holding other 'smart chart' features and individual characteristics fixed.

The parameters in Equation (1) can be estimated based on the reported WTPs in the two surveys. Linear regression analysis is a common tool to estimate the relationship between the variable of interest and the factors that affect the variable. In graphical sense, linear regression analysis is, based on the data, to find a line (if there is only one explanatory variable) or a hyperplane (if there are multiple explanatory variables) that best represents the points of a scatter plot; that is to find a set of parameter estimates so all the points are not too far from the estimated line (or hyperplane).

Equation (1) suggests the candidates of explanatory variables but it does not dictate the actual specification of the model. There are different variables that can be included in the vectors X, W, and O. In addition to the key variables proposed by the survey design, the usual rule of statistical significance for including or excluding a variable in an empirical regression model is applied to determine the final specification(s) of the equation.
Since model specification can affect the estimation results, it is customary to present multiple estimated models to ensure the robustness of results. Five empirical models based on Equation (1) are presented. *The definition of variables used in the regression analysis and the complete estimation results of the five models are reported respectively in Tables B1 and B2 in Appendix B.* The purpose of this exercise is to derive the benefit measure of chart information while taking into account the presence of other navigational tools and individual characteristics. The specification of the five estimated models and the corresponding WTP estimates for chart information in electronic format are summarised in Table 4.

The first two estimated models include the complete set of feature dummy variables to indicate the choice of each of the features for the 'smart chart' system.[4] Variables of company and individual characteristics such as number of vessels (#Vessels), ownership of the company, and preferences for more frequent update of hydrographic surveys are also included in the regression models. The underlined variables in each of the estimated models in Table 6 indicate statistical significance at the 0.1 level or higher; i.e., significant impact of these variables on WTP is detected in the regression analysis.[5] As seen, a few of the smart chart features significantly contribute to the WTP measure: chart information, echosounder information, and automatic chart update feature. Most of the selected company/individual characteristic variables show (statistically) significant impact on WTP. It is found that a survey respondent is willing to pay less for the self-designed 'smart chart' system if he/she is the owner of the company, so is a respondent with preferences for paper charts. Interestingly, the number of vessels operated by the company has no significant impact on the per-vessel WTP measure.

The last three estimated models drop most of the

[4] A dummy variable takes on two values, 0 and 1. It is used to describe a qualitative character. For example, define 'Charti' equals 1 for the survey respondent i if he/she wants to have this feature incorporated into the 'smart chart' system, and 'Charti' equals 0 otherwise. Similarly, 'GPS' equals 1 if the respondent wants to have the GPS information displayed on the 'smart chart' and 0 otherwise. The parameter estimate associated with a dummy variable is the estimated dollar amount that on average a survey respondent is willing to pay for this feature, holding other things constant

[5] A dummy variable takes on two values, 0 and 1. It is used to describe a qualitative character. For example, define 'Charti' equals 1 More detailed discussion of statistical significance of parameter estimates is given in Appendix B

Model	Model Specification	Estimated WTP Per Vessel
1	WTP=f(Chart, GPS, Radar, Echosounder, Vessel ID, Alert, Tide Depth, Docking Aid, Auto Chart Update, #Vessels, Owner, More Update, Like Paper Chart, Web Survey, Use Radar, Use Radio)	$702
2	WTP=f(Chart, GPS, Radar, Echosounder, Vessel ID, Alert, Tide Depth, Docking Aid, Auto Chart Update, #Vessels, Owner, More Update, Like Paper Chart, Web Survey, Use Radar, Use Radio, Depth Info Useful)	$786
3	WTP=f(Chart, Echosounder, Alert, Auto Chart Update, #Vessels, Owner, More Update, Like Paper Chart, Web Survey)	$589
4	WTP=f(Chart, Echosounder, Alert, Auto Chart Update, #Vessels, Owner, More Update, Like Paper Chart, Web Survey, Use Radar, Use Radio)	$668
5	WTP=f(Chart, Echosounder, Alert, Auto Chart Update, #Vessels, Owner, More Update, Like Paper Chart, Web Survey, Use Radar, Use Radio, Depth Info Useful)	$751

Table 4: Estimated WTP for Chart Information

system features that do not seem to impact the WTP to derive more parsimonious models. Holding other things constant and excluding the costs of hardware (computers), the estimated WTP for just chart information (in electronic format) per vessel ranges from $589 to $786 among the five models (with an average of $700).[6] Given that on average a PVA Vessel member operates with 4 vessels. The average WTP for chart information per PVA Vessel member is the estimated WTP multiplied by 4, which is around $2800.[7]

5. Summary of Findings and Discussion

In this paper, a technique to derive a consumer's perceived economic value of an electronic chart system is proposed. A variation of the contingent valuation survey is designed to elicit the perceived benefit of using nautical chart information in electronic format. The design of the valuation questions in the survey enables the customization of the electronic chart system according to the needs of particular business operations. A case study of the Vessel members of the Passenger Vessel Association is conducted. Through direct elicitation, individual willingness to pay for a self-designed integrated electronic chart system (the 'smart chart' system) is derived.

It is found in the survey that there is general interest in learning about and using electronic navigational charts, and the integrated system to incorporate information from other navigational tools. The most desirable features for the integrated electronic navigation system include chart display, incorporation of GPS/DGPS and radar information, and automatic chart updates. Most of the respondents are willing to pay a positive dollar amount for the 'smart chart' of their design. On average, the respondents are willing to pay between $1000 and $1600 per vessel for the whole 'smart chart' system (excluding the costs of computers), but the WTP appears to vary in a wide range due to the variation in the self-designed 'smart chart' and individual characteristics. The results of linear regression analysis show that holding other things constant, the estimated willingness to pay for electronic chart information alone is approximately $700 per vessel. Given that on average a PVA Vessel member operates 4 vessels, a PVA member's WTP for chart information is around $2800.

The summary of self-selected features for the 'smart chart' system and the regression analysis of WTP reveal that the features are not equally desirable. The current cost of acquiring an electronic chart system also varies largely with the desired capability. For marketing purposes, it will be interesting to compare the perceived benefits of various system features with their cost. The cost of electronic chart systems can vary dramatically from hundreds of dollars to tens of thousand dollars depending on the capabilities. From the estimated mean

[6] Many other model specifications were tried with similar results
[7] The simple multiplication is supported by the regression analysis of the WTP. Please see Appendix B for the discussion

WTP of the PVA Vessel members, their demand for the electronic chart systems will be on the lower end of the ENC products, which is not surprising since these chart users typically operate along coasts with a few routes. The cost-benefit comparison is reassuring of the findings in this study.

This CV study differs from other CV studies by (1) allowing the content of the good being valued (in this case the 'smart chart' system) to vary across survey respondents and (2) allowing the customisation of the non-market good to meet the needs of individuals. Methodologically, it will be interesting to design a follow up survey to compare whether the WTP for the electronic chart system and chart information will be affected by not giving these flexibilities.

This is the first micro level study of economic values for electronic charting in the US. It serves as a starting point for the valuation of hydrographic survey information. To derive the total benefits of hydrographic survey data, it is necessary to identify the key (if not all) user groups and sum up their values for the chart information. The survey questionnaire developed in this study can be modified to assess willingness to pay for electronic charts by other users such as recreational boaters and larger cargo shipping companies. The next steps are to compile a database of users of the hydrographic survey data that details their operations and contact information, and examine the applicability of the proposed valuation methodology to other users of hydrographic survey data for purposes other than navigation.

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Appendix A. Key Questions in the Survey

The new ENC (electronic navigational chart) technology enables us to develop a '**smart chart**' system that could incorporate input from a vessel's radar, DGPS receiver, echosounder, and an automated identification system (vessel transponder). Other inputs could include real-time tide and current information, and automated chart corrections. A vessel operator could view a screen display customised with only the desired information such as the tide-corrected depth of water and a safe-water contour. Quick displays of other information could be called up when prompted. The '**smart chart**' system could be configured to alert automatically when navigation situations develop, such as decreased underkeel clearance, danger ahead, or unanticipated course deviations. The '**smart chart**' system could also support highly accurate and detailed views of docks and piers to aid in docking or manoeuvring in reduced or restricted visibility conditions.

A_17. If you were to design a '**smart chart**' system to suit your company's operating area, what functions AT THE MINIMUM would you want your '**smart chart**' system to have for your vessels? Please check all the following functions that you want for your '**smart**

chart' system but please keep in mind that in general the more functions, the more the system will cost so please design a system that is practical for your business operation. (CIRCLE ALL THAT APPLY)

1. Incorporate all the information on the current paper charts.
2. Incorporate GPS and DGPS information.
3. Incorporate input from radar.
4. Incorporate information from echo-sounder.
5. Identify other vessels nearby.
6. Incorporate real-time tide, tide-corrected depth of water, and safe-water contour information.
7. Incorporate an automatic alert system to warn navigation situations such as decreased underkeel clearance and unanticipated course deviations.
8. Incorporate the ability to display detailed views of docks and piers to aid in docking or maneuvering.
9. Incorporate an automatic update system to correct chart information.
10. Other→ **Please Explain** ____________

____

A_18. How much would you be willing to pay PER VESSEL for this '**smart chart**' system that you design above for your vessels? (A one-time payment excluding the cost of a computer to run the system.) (CIRCLE THE ONE BEST DESCRIBES)

1. $ 0
2. $ 1 - $ 499
3. $ 500 - $ 999
4. $1,000 - $1,499
5. $1,500 - $1,999
6. $2,000 - $2,499
7. $2,500 - $2,999
8. $3,000 - $3,499
9. $3,500 and above.

Appendix B. Regression Analysis and Results

B.1 Variable Definition

The dependent variable in the regression analysis is WTP per vessel. The definition of variables used in the regression analysis is given in Table B1.

Variable Name	Definition (Data coding)
WTP	Willingness to pay for the self-designed 'Smart Chart' system ($ per vessel)
Chart	Incorporation of chart information into 'Smart Chart' system (=1 if selected, =0 if not.)
GPS	Incorporation of GPS information into 'Smart Chart' system (=1 if selected, =0 if not)
Radar	Incorporation of Radar information into 'Smart Chart' system (=1 if selected, =0 if not)
Echosounder	Incorporation of Echosounder information into 'Smart Chart' system (=1 if selected, =0 if not)
Vessel ID	Incorporation of vessel identification feature into 'Smart Chart' system (=1 if selected, =0 if not)
Alert	Incorporation of automatic alert system to warn navigation situations into 'Smart Chart' system (=1 if selected, =0 if not)
Tide Depth	Incorporation of real-time tide depth information into 'Smart Chart' system (=1 if selected, =0 if not)
Docking Aid	Incorporation of docks and piers information into 'Smart Chart' system (=1 if selected, =0 if not)
Auto Chart Update	Incorporation of auto chart update feature into 'Smart Chart' system (=1 if selected, =0 if not)
#Vessels	Number of vessels operated
Owner	(=1 if owner, =0 if not)
More Update	(=1 if believe safer navigation warranted by more frequent update of hydrographic survey data, =0 otherwise)
Like Paper Chart	(=1 if prefer paper chart, =0 otherwise)
Web Survey	(=1 if web survey, =0 if mail survey)
Use Radar	(=5 if use radar all the time for navigation, =4 if use it frequently, =3 if use it occasionally, =2 if don't use, =1 if don't have)
Use Radio	(=5 if use marine VHF radio all the time for navigation, =4 if use it frequently, =3 if use it occasionally, =2 if don't use, =1 if don't have)
Depth Info Useful	(=3 if find water depth information on chart very useful, =2 if useful, =1 if not very useful)

Table B1: Definition of Variables in Regression Analysis

B.2 Estimation Results of Five Empirical Models

Model specification can affect the estimation results. It is customary to present multiple estimated models to ensure the robustness of the results. In this article, five estimated models are presented. Many other specifications have been attempted. The qualitative results are similar. The numbers in Table B2 are the parameter (coefficient) estimates associated with the variables in the first column of the table. The number in brackets under each parameter estimate is the standard error that is used to determine whether the parameter estimate is statistically significantly different from 0. In general the absolute value of the ratio of parameter estimate to the standard error must be greater than 1.64 to warrant a statistically significant relationship between the dependent variable and the corresponding explanatory variable.

Of all the chart feature dummy variables, three of

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
Intercept	1141.13 (1308.29)	2402.22* (1401.66)	2196.62*** (484.95)	1186.63 (996.91)	2411.77** (1072.91)
Chart	702.06* (377.58)	785.70** (360.91)	589.33* (325.96)	668.31* (328.01)	750.62** (308.76)
GPS	-229.32 (334.42)	-277.51 (317.37)			
Radar	100.08 (332.17)	74.07 (315.52)			
Echosounder	545.99* (285.33)	775.00** (295.43)	515.49* (256.22)	563.49** (248.27)	763.96*** (247.88)
Vessel ID	-25.74 (335.06)	11.61 (318.56)			
Alert	53.42 (288.61)	174.63 (280.95)	-15.75 (267.46)	106.41 (252.31)	160.93 (237.09)
Tide Depth	-178.19 (294.51)	14.87 (296.70)			
Docking Aid	235.89 (339.45)	-61.23 (356.74)			
Auto Chart Update	-755.07* (381.94)	-766.28** (362.51)	-532.20* (295.83)	-721.02** (306.38)	-761.34** (287.00)
#Vessels	-24.09 (33.08)	17.07 (37.90)	-23.55 (29.95)	-23.80 (27.54)	10.44 (29.72)
Owner	-911.08*** (265.43)	-763.96*** (263.08)	-963.99*** (249.48)	-899.97*** (238.53)	-769.23*** (230.12)
More Update	920.29*** (308.19)	846.00*** (294.98)	799.18*** (274.86)	950.80*** (268.20)	837.95*** (255.50)
Like Paper Chart	-757.54** (363.71)	-587.47 (356.14)	-582.22** (278.37)	-600.04** (272.30)	-524.36* (256.69)
Web Survey	-1497.88*** (341.01)	-1459.55*** (324.22)	-1264.41*** (254.90)	-1619.49*** (261.06)	-1473.98*** (252.11)
Use Radar	-269.91* (137.00)	-262.04* (130.08)		-301.74** (115.36)	-265.29** (109.01)
Use Radio	539.87* (319.81)	552.80* (303.58)		510.96* (254.51)	523.13** (238.03)
Depth Info Useful		-702.83* (362.52)			-679.18** (294.56)
Number of Observations	42	42	44	42	42
R2	0.7232	0.7607	0.6096	0.7095	0.7545

****=significant at the .01 level, **=significant at the .05 level, *=significant at the 0.1 level*

Table B2: Coefficient Estimates of the WTP Models them show significant impact on WTP: Chart, Echosounder, and Auto Chart Update. On average the survey respondents are willing to pay for incorporating the information of charts and echosounder into the 'smart chart' system. The parameter estimate associated with the Auto Chart Update is negative, which indicates that holding other things constant, the overall WTP for the 'smart chart' system is less if the auto chart update feature is included. It is counter intuitive, although it is possible that the survey respondents consider this feature as a given and do not want to pay for it.

The parameter estimate associated with #Vessels is not statistically significant, which implies that the per-vessel WTP is not affected by the number of vessels operated and the per-business WTP can be computed by multiplying the estimated per-vessel WTP with the number of vessels. In general the WTP is lower if the survey respondent is also the owner of the company and/or prefers paper charts; the mail survey respondents are willing to pay more than the web survey respondents. The WTP is higher if a survey respondent would like more frequent hydrographic surveys in their operating areas. The current use of other navigational tools (such as radar and VHF radio) can affect WTP but the impact is not unanimously positive or negative.

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Biography

Dr Ju-Chin Huang is an environmental economist specialised in valuation of non-market goods. Her research focuses on the methodologies to derive monetary values of environmental goods such as improving air and water quality. Dr Huang received the Ph.D. degree in Economics and Statistics from North Carolina State University in 1994. She is currently an associate professor in the Department of Economics at University of New Hampshire.

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