Economic Valuation of Oceanographic Forecasting Services: A Cost-Benefit Exercise

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Summary

This paper provides an assessment of the economic value of the oceanographic services provided by the Mediterranean operational forecasting system, MFSTEP. The main purpose of this exploratory study is to carry out a cost-benefit analysis for different development scenarios, by comparing the costs associated with the project implementation with the private benefits that arise from delivering its products on the market. As far as the costs are concerned, a total cost assessment has been performed by identifying, classifying and estimating the wide range of inputs that have been allocated both to the project development and maintenance. Against this context, a cost questionnaire has been designed and administered to all MFSTEP partners. In addition, the study focuses on an end-users analysis in order to examine end-users' attitudes and interests for the forecasting products, their needs and satisfaction. As before, we make the use of a survey. Finally, this questionnaire is characterized by exploring the use of the contingent valuation approach so as to address and estimate the private benefits derived from the provision of the MFSTEP products. Estimation results show that the mean willingness to pay for accessing the forecasting products amounts to 65 euro per download. Cost-benefit analysis reveals that, from a market perspective relying on the profit maximisation, a total of 163 downloads per day are required for total maintenance costs recovery, whereas 90 downloads per day are required to recover personnel maintenance costs. Finally, 33 downloads per day are required so as to recover durable equipment maintenance costs.

Keywords: Cost-Benefit Analysis, Contingent Valuation, Survey Design, Willingness to Pay, Cost Assessment, Observing and Modelling Oceanographic System

JEL Classification: D60, D61, D12

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1. Introduction and background

Operational oceanography plays a crucial role in nowadays' society because of its significant contribution to manage the many environmental problems affecting the earth, including desertification and extreme weather events, coastal erosion, oil and chemical spills, variability of fish stocks and other climate change related ecosystem changes. This is feasible by setting up an efficient forecasting system of the sea, which in turn requires real time monitoring and predictions of the sea temperature, salinity, wind stress, surface height, heat fluctuation and sea currents. In other words, by providing an operational system for the protection of the sea marine environment and the sustainable exploitation of its resources.

Against this background, the present paper addresses an economic analysis and valuation of the services aiming at the development of an operational forecasting system for the Mediterranean Sea, MFSTEP. This project consists of the technological progress on two macro-areas, the observing system and the modelling and forecasting system of the Mediterranean Sea. More specifically, MFSTEP project has advanced the monitoring technology of the observing system of the Mediterranean Sea, has developed regional scale forecasting in several Mediterranean areas, biochemical modelling and data assimilation toward environmental predictions and finally the end-users interfaces for the exploitation of the project products. Possible exploitation of the forecasting products provided by the system are intended for oil spill modelling, contaminants predictions, floating objects search operations, fast emergency intervention at sea, fish stock assessment and management in the open sea..

The oceanographic system will stimulate the promotion of new private business exploiting the marine forecasting products. Economic valuation of the system and the end-users analysis of the products provided are therefore key elements in developing applications of the system. The first purpose of this exploratory study is to carry out a cost-benefit analysis for different development scenarios by comparing the costs associated with the project implementation with the private benefits which could arise from delivering its products on the market. As regards the costs, a total cost assessment has been performed by identifying, classifying and estimating the wide range of inputs that have been allocated into the project development and maintenance. A cost questionnaire has been designed and administered to all MFSTEP project partners contributing to construct the system. On the other side, the private benefits have been estimated using the contingent valuation approach. Secondly, the study focuses on the end-users analysis in order to examine the consumers attitudes and interests for the forecasting products, their needs and satisfaction.

The remainder of this paper is organized as follows. Section 2 reports the cost assessment methodological approach, which has been addressed so as to estimate results for total costs and its components. Section 3 focuses on the monetary valuation of the MFSTEP products, putting

forward the concept of the economic valuation perspective and its theoretical foundations. Section 4 integrates both valuation results by exploring a cost-benefit approach and its application for different development scenarios. Section 5 presents the caveats and section 6 concludes.

2. Total cost assessment

2.1 Methodological approach

In order to assess the total costs supported for implementing and maintaining the MFSTEP oceanographic forecasting system, we developed a cost questionnaire. This questionnaire was designed for an efficient collection of data on the costs related with the MFSTEP system, and its specifications, by following the guidelines as presented in the survey literature (Groves, 1989; Groves *et al.*, 2004). In order to guarantee the quality of the survey as a measurement instrument, and the validity of the respective monetary measures – crucial input for any cost-benefit analysis – the design of the questionnaire included an extensive pre-test phase next to all MFSTEP research partners. This phase was, therefore, characterized by a strong and enthusiastic interdisciplinary work. Therefore, a number of drafts of the questionnaire have been designed for this purpose and discussed during project meetings and workshops. After this pre-testing phase, the most appropriate and efficient classification of the costs have been identified, as well as the level of detail required. Therefore, the final version of the questionnaire refers to the four main cost categories: (1) personnel; (2) durable equipment; (3) meeting and travel, (4) consumables, and other costs.

Bearing in mind the specific needs of the present cost assessment, the valuation methodology is able to assess and disentangle the monetary costs associated to two main investment stages of the MFSTEP project. We refer to the *start-up* and *maintenance* phases. The start-up phase refers to the launch of the project and by definition the respective costs are only incurred in the first year of the project. These costs can be interpreted therefore as fixed costs (Pinardi *et all.*, 2003). The maintenance phase refers to the investment effort put forward on annual basis. The maintenance costs can be therefore interpreted as variable costs whose magnitude may vary from year to year. In addition, the cost valuation methodology is able to assess and disentangle the monetary costs associated to the two MFSTEP's operational systems: *observing* and *modelling* systems. Bearing in mind such framework, respondents – i.e. all MFSTEP research partners – are to report for each cost category, the amount of financial resources allocated in both start-up and maintenance phases. In addition, personnel and durable equipments costs have been further classified between *modelling* and *observing* systems. The final survey has been administered by email, to all MFSTEP partners. The period of administration was November-December 2005.[1] The results of the cost estimation are reported in the next two paragraphs.

[1] A copy of the final cost questionnaire is available upon request.

2.2 Total cost estimates: results

We estimated the total costs associated with the running of MFSTEP according to two specific phases, the start up and the maintenance phase. According to the survey responses, cost estimate range up to 3,865,326 Euro, for the annual maintenance costs component, and 1,924,718 Euro, for the starting-up phase.[2] Bearing in mind these estimates, the total costs attributable to the first year of the project (kick-off year) are estimated to be 5,790,045 Euro. Therefore, the maintenance represents the largest share of total costs, accounting for 67% of total costs supported in the first year and being two times higher than start-up costs. Table 1 shows the breakdown of the maintenance and start-up cost category in reference to a typical year. According to the costs estimates, the distribution among cost categories shows that the two most important cost categories are personnel and durable equipments costs, for both maintenance and start-up, representing respectively 55.6% and 19.9% of maintenance costs, and respectively 48.5% and 30.8% of starting-up – see Figure 1.

Table 1: Distribution of the maintenance and start up costs (in Euro, 2005)

Phases	Personnel	Durable Equipment	Meeting & Travel	Consumables	Rental & Power	Other Costs
Maintenance costs[A] (per year: 3,865,326)	2,148,753	771,797	206,438	460,336	8,700	269,303
Cost incidence (in %)	55.59%	19.97%	5.34%	11.91%	0.23%	6.97%
Mean estimate	89,531	32,158	8,602	19,181	363	11,221
Maximum estimate	471,000	375,000	50,000	180,000	5000	170000
Minimum estimate	2,300	600	500	200	1700	4,037
Count not relevant (%)	0 (0%)	7 (29.2%)	0 (0%)	7 (29.2%)	21 (87.5%)	16 (66.7%)
Count relevant (%)	24 (100%)	17 (70.8%)	24 (100%)	17 (70.8%)	3 (12.5%)	8 (33.3%)
Start-up costs (only kick-off year: 1,924,718)	933,706	593,500	96,313	283,357	2,000	15,843
Cost incidence on total cost (%)	48.51%	30.84%	5.00%	14.72%	0.10%	0.82%
Mean estimate	38,904	24,729	4,013	11,807	83	660
Max estimate	221,000	275,000	50,000	150,000	2,000	14,028
Min estimate	2,360	2,000	880	1,500	2,000	1,815
Count not relevant (%)	12 (50%)	15 (62.5%)	14 (58.3%)	17 (70.8%)	23 (95.8%)	22 (91.7%)
Count relevant (%)	12 (50%)	9 (37.5%)	10 (41.7%)	7(29.2%)	1 (4.2%)	2 (8.3%)

[A] The reported results for maintenance costs refer to a typical year of MFSTEP project implementation.

The other cost categories represent a lower percentage on total costs. If we compare maintenance and start-up for each cost category, we notice that maintenance is higher for each cost category with

[2] These estimates were computed in reference to the 24 completed questionnaires, which constitute the most representative and relevant MFSTEP project partners.

respect to start-up. In particular, personnel requires 2.3 times higher investment for annual maintenance than for start-up. For durable equipment the rate is 1.3, for meeting and travel 2.1 and for consumables 1.6.

Table 1 also reports other descriptive statistics: mean, maximum and minimum[3] estimates, number and percentage of respondents supporting the cost or not ("relevant" and "not relevant" classes). This latter information is particularly important for interpreting the results, because a cost category could result in a high proportion on total costs, but at the same time it could be relevant only for few respondents. In order to interpret correctly the data it is important therefore to consider jointly the incidence of each costs and the percentage of respondents for whom the cost is relevant. In general, the percentage of respondents supporting maintenance costs is higher for all cost categories. As regards personnel, maintenance costs are relevant for all the respondents, while start-up costs are relevant only for 50% of the respondents.

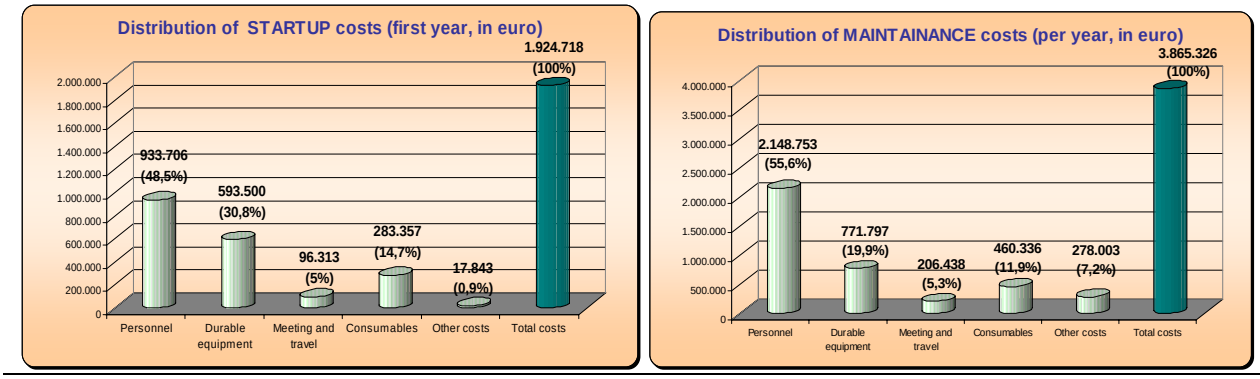

Figure 1: Distribution of total costs supported in the start-up and maintenance phase

2.3 Results: analysis of personnel costs

For the sake of illustration, we report a comprehensive analysis regarding the personnel cost component (see Chiabai and Nunes, 2006a) for the comprehensive analysis of the remaining components. The analysis is carried out according to the temporal investment stages, annual maintenance *versus* start-up, and to the operational systems of work, observing *versus* modelling systems. Results show that a total amount of 3,082,458 Euro has been devoted in the first year of the project for personnel, including both maintenance and start-up costs. The costs supported in the start-up phase are of 933,706 Euro, while 2,148,753 Euro have been spent for annual maintenance of the personnel. These figures show that annual maintenance of the system requires stronger investments than the start-up phase, the first being 2.3 times higher than the second. Research

[3] The minimum estimates are the lowest costs reported, for values different from zero.

activities involve the largest investment (56.6% of total costs), followed by technical activities, administration and training – see Figure 3.

If we compare observing versus modelling system total personnel costs, we see that similar amounts are invested for the two systems in the first year of the project, for overall maintenance and start-up phases (1,29 and 1,98 million Euro, respectively 43% and 45% of total personnel costs). Cost estimates and distribution are quite similar between observing and modelling when focusing on annual maintenance. But if we consider their allocation in the starting-up phase only, we see that modelling start-up phase requires higher financial resources than observing. This effect is attributable to the technical cost category. We can therefore conclude that the higher investments requested for personnel during the modelling start-up phase regard specifically the technician cost category – see Figure 4 and Figure 5.

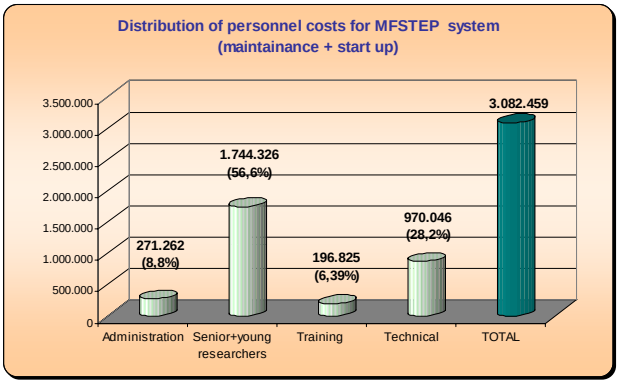

Figure 3: Distribution of total personnel costs supported for annual maintenance and start-up

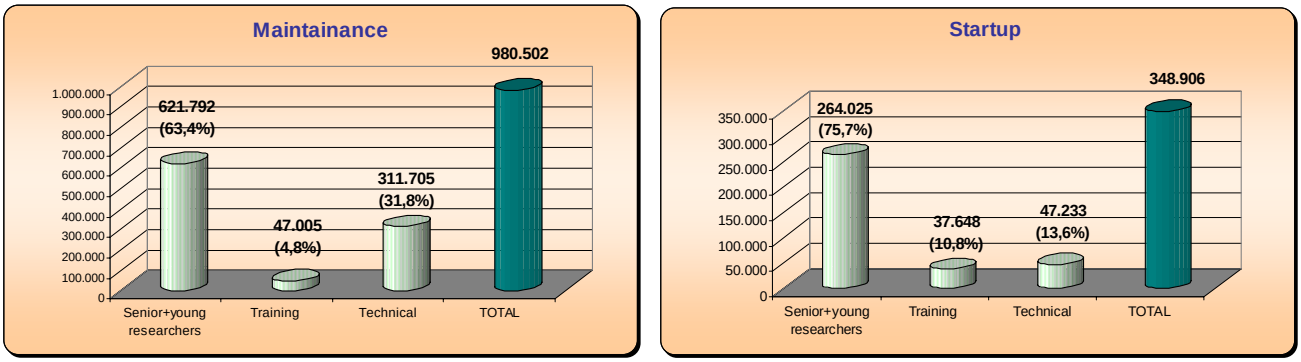

Figure 4: Distribution of personnel costs between maintenance and start-up (Observing)

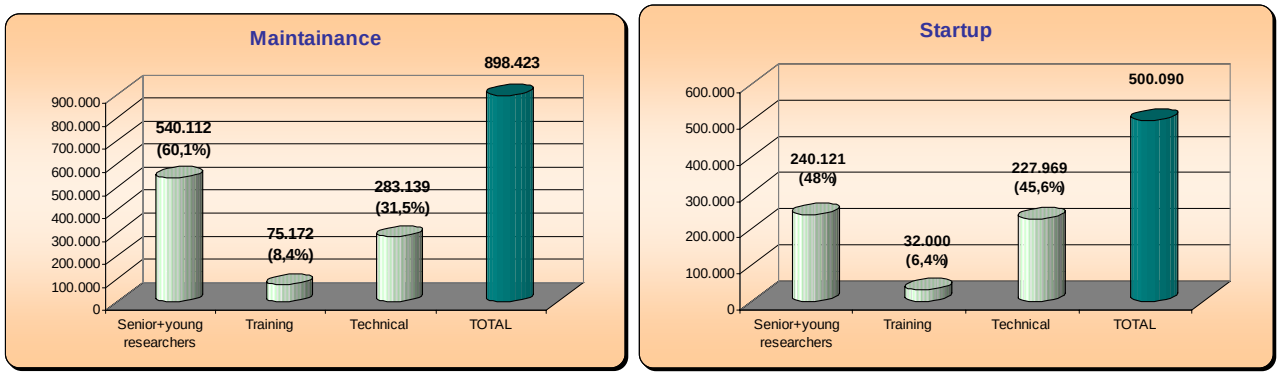

Figure 5: Distribution of personnel costs between maintenance and start-up (Modelling)

3. Valuation of MFSTEP products: an economic perspective

3.1 Introduction

Economic analysis and valuation of oceanographic forecasting services is based on an instrumental perspective. This means that the value of oceanographic forecasting services is regarded as the result of an interaction between humans and the object of valuation, which is changes in the current provision of forecasting services, either in quantitative or qualitative terms. 'Economic value' does not denote an absolute value of levels, but of system changes, preferably marginal or small ones. The reason for this is that the theoretical basis of economic valuation is monetary (income) variation as the response to a certain policy or management practice change. Therefore, economic valuation provides a monetary indicator of oceanographic forecasting services values. Explicitly description of the oceanographic products changes, in term of data quantity, data quality and term of provision should be clearly described to the end-users. The economic valuation exercise is also characterized by reflecting a variety of use-related motivations of different stakeholders. The theoretical backgrounds of the economic valuation are explained in the next section.

3.2 The concept of economic value

A basic micro-economic premise is that individuals make welfare-optimizing consumption decisions. These decisions are captured in the consumer demand functions with respect to available goods and services. Marine ecosystem quality considerations enter into these demands. To illustrate this setting, we consider an individual whose utility function has the following form:

$$V = V(x, q, z) \quad (1)$$

Here x is the individual consumption of all private goods, q the quantity of the oceanographic stakeholders' related operational activities, and z the oceanographic forecasting indicator. For example, q could represent the number of fishing activities per day in one area (the number of yachts excursions or the number of fast emergency interventions), and z an oceanographic forecasting indicator, such as the Adriatic Forecasting Bulletin. We assume that x is a composite private good whose price is normalized to one. p is the price associated with q. This framework allows the study of a welfare change in the oceanographic forecasting indicator, z. This change may be interpreted as the introduction on the market of the MFSTEP forecasting services, which today are provisionally available free of charge on the web. In the original situation, i.e., before the market supply of MFSTEP forecasting services, the individual faces a temporarily specific level of the oceanographic forecasting service. Let us denote such a level by z^0, characterised by free access and provisional availability (e.g. trial product). For an oceanographic forecasting indicator level z^0, given the price p of the oceanographic related activities q, and given the consumer monetary income M, the consumer maximizes its utility $V(x,q,z)$. This yields an optimal consumption bundle (x^0, q^0), with $q^0(p, M, z^0)$ and $x^0(p, M, z^0)$, and a utility level $V^0(x^0, q^0, z^0)$. Inserting the demand functions into the utility function gives the indirect utility function $V(x^0(p, M, z^0), q^0(p, M, z^0) = v(p, M, z^0)$. Suppose now that the oceanographic forecasting service is provided through the market mechanism at the level z^1, characterised by long-term availability (e.g. final product). The associated utility level is V^1, higher than V^0.Table 2 summarizes the notation.

Table 2: Summary of notation

Variables and function of interest	Original situation	New situation
Oceanographic forecasting indicators level	z^0	z^1
Utility level	V^0	V^1 with $V^0 < V^1$
Indirect utility function	$v(p, M, z^0)$	$v(p, M, z^1)$

The literature suggests one particular measure that can be used to assess the magnitude of the welfare change as described by the introduction of the market supply of oceanographic forecasting indicators. This is the Hicksian compensating measure, which is a theoretical refinements of the ordinary consumer surplus (Hicks, 1939). Formally, the Hicksian compensating variation *(HC)* is the solution to

$$v\left(p, M - HE, z^1\right) = v\left(p, M, z^0\right) \qquad \text{with } v\left(p, M, z^0\right) < v\left(p, M, z^1\right) \qquad (2)$$

The *HC* measures the income change that reflects the consumer's maximum willingness to pay (WTP) to obtain the desirable change in *z*, characterised by the introduction of the oceanographic forecasting services on the market.

Different valuation methods are available to compute a monetary estimate with respect to the WTP. The contingent valuation method (CVM) is one of these. CVM is a survey based valuation technique that are widely used in the context of environmental valuation (Mitchell and Carson, 1989; Carson *et al.*, 1992; Nunes, 2002). CVM directly estimates the preferences for the potential market supply of oceanographic forecasting indicators. Against this background, CV can give an immediate monetary estimate of the WTP welfare measure associated to the provision of different oceanographic forecasting indicators. In short, CV makes use of a questionnaire that describes a survey market in which non-market goods can be traded. It is assumed that the values elicited with CV will correspond with those that would emerge on real markets. The contingent market defines the good itself, the institutional context in which it would be provided, and the way it would be financed. Respondents are then asked to express their maximum WTP for a survey described change in the level of the oceanographic forecasting services. Furthermore, these methods have the advantage that products may be valued even if they have not yet been adopted by the current market mechanisms (*ex ante* valuation) or lie outside the current institutional arrangements. Thus, it offers much scope and flexibility for specifying different forecasting indicators (Carson, 1991; Hausman, 1993).

3.3 The contingent valuation questionnaire

The final goal of the economic valuation is to estimate the monetary benefits associated with the delivery of MFSTEP oceanographic forecasting products[4]. A contingent valuation questionnaire has been designed and administered to all identified end-users, in order to estimate the willingness to pay for downloading the MFSTEP forecasting services and data[5]. A set of questions have been inserted in the questionnaire in order to analyse other issues, like the expected future downloads, the interest to each forecasting service and the rate of satisfaction for the downloaded data. The structure of the questionnaire is presented in the next section.

[4] The MFSTEP forecasting services are the Mediterranean Ocean Forecasting Bulletin, the Adriatic Forecast Bulletin, the Alermo Forecast System, the Cyprus Coastal Forecasting and Observing System, the Sicily Channel System, the Malta System, the Gulf of Lion System and the North-Western Mediterranean Bulletin.
[5] A copy of the final end-user questionnaire is available upon request.

The questionnaire is web-based and it has been administered during the period September-December 2005. It is organised in 11 sections. The first section (A) asks the respondent about the interest showed for each of the MFSTEP forecasting services provided. The next 8 sections focus on a qualitative analysis of the forecasting services. Respondents are asked which forecasting service they download, if they expect to continue to download this data in the next 12 months, the final use of the downloaded data and the level of satisfaction with the downloaded data in terms of quality/reliability, extent/quantity, timing of delivery.

Section J focuses on the monetary valuation. Respondents are asked to state how much they think a private vendor might charge for each download of data similar to the MFSTEP data. Further questions ask the respondents to report if they have purchased, or obtained free of charge, data similar to the MFSTEP and if they are aware of other government agencies, institutions or private vendors supplying data similar to the MFSTEP data. These questions have been included in order to identify existing substitutes of MFSTEP services.

Respondents have been asked an open-ended question about their WTP. This choice is due to the limited number of end-users (around 65), making it difficult to use other elicitation formats which require statistical models based on a high number of data. Another difficulty was that the end-users download the MFSTEP data free of charge, and asking them directly their willingness to pay would have raised protest answers. Therefore the problem was solved in asking them how much they think a private vendor might charge for each download of data similar to the MFSTEP data.

The last section (K) is about socio-demographic questions, and in particular to understand the professional position of the respondent in his organisation, his highest degree of education and the type of organisation he works for (university or research institution, government organisation, non-government organisation, private company or another type of organisation). These questions have been inserted because they help to understand the profile of the respondent.

Results are reported in the next section and they refer to 34 completed questionnaires (out of 65 end-users), with a response rate of 52.3%.

3.4 Descriptive statistics for use, interest and satisfaction: results

We report descriptive statistics regarding the current and expected downloads of each forecasting services (see Chiabai and Nunes, 2006b) for the comprehensive analysis of the end-user survey. In particular, Table 3 displays the percentage of respondents downloading the data, for each forecasting service (column a); among those not downloading the data (column b), the percentage among the ones who do not download today and expect to download these data in the next 12 months (column c); the expected increase in the percentage of end-users for each service during the

next year (column d); and the total expected percentage of end-users during the next year (column e).

The most downloaded data are those from the Mediterranean system with 72.73% of the respondents downloading the corresponding data. The Adriatic system data are downloaded by 46.12% of the respondents, and the North-Western Mediterranean data by 38.89% of the respondents. As regards expected downloads in the next 12 months, responses show a potential increase in use for each service. In particular, the highest expected increase in next year downloads are for the Mediterranean system, Sicily Channel system, the Gulf of Lion System and the North-Western Mediterranean system, respectively with an estimate to increase the demand in 56%, 37%, 36% and 33%. For example, the Mediterranean system, which today show a demand of 72.73 is expected to have a potential demand of 88% (=72.73 + 15.27 with 15.27 = 22.27*56). In the same line of reasoning, the percentage of end-users of these services of Sicily Channel system, the Gulf of Lion System and the North-Western Mediterranean system will amount to 47.3%, 48% and 59.06% of total current end-users, respectively.

Table 3: Current and expected use of the forecasting services (in %)

Forecasting service	Downloading Today (a)	Not downloading Today (b)	Expected to download next year (c)	Expected increase in downloading next year (d)	Expected downloading next year (e)
Mediterranean	72.73	27.27	56	15.27	88.00
Adriatic	46.15	53.85	20	10.77	56.92
North Western Mediterranean	38.89	61.11	33	20.17	59.06
Cyprus	27.59	72.41	20	14.48	42.07
Gulf of Lion	18.75	81.25	37	29.25	48.00
Sicily Channel	17.65	82.35	36	29.65	47.30
Alermo	12.5	87.5	14	12.25	24.75
Malta	6.25	93.75	13	12.19	18.44

Respondents have been asked to state how much they are interested in each of the MFSTEP forecasting services. Responses have been ranked using a likert scale (very interested, interested, somewhat interested and not interested), and an index of interest has been estimated as it is shown in Figure 6. Results show that the respondents are at least somewhat interested in the forecasting systems of Alermo, Cyprus, Sicily Channel, Malta, Gulf of Lion and North-Western Mediterranean. The interest reported for the Mediterranean Ocean Forecasting Bulletin and the Adriatic Forecast Bulletin is the highest, displaying an index of 16.3 and 16.1, respectively. Nobody reported to be very interested in one of the mentioned forecasting system.

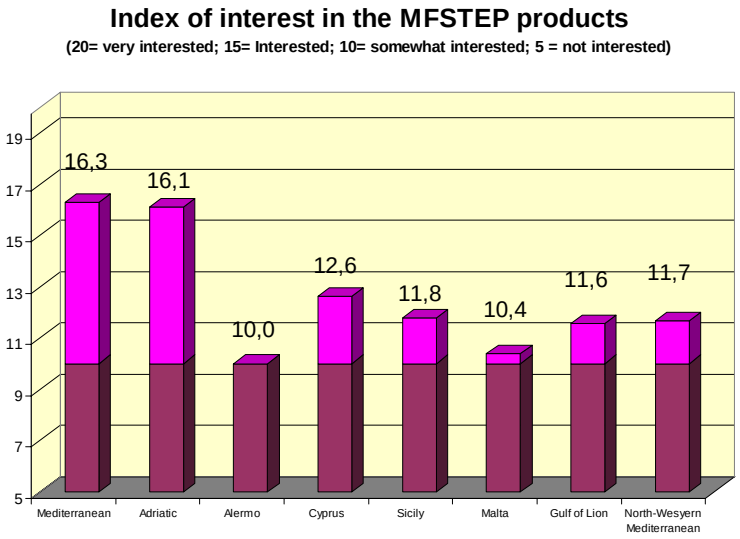

Figure 6: Index of interest in MFSTEP survey described products

Respondents have been asked about their satisfaction with the downloaded data, in terms of quality/reliability, extent/quantity, and timing of delivery. They have been asked to rank their satisfaction on a likert scale (very satisfied, satisfied, somewhat satisfied, not satisfied) and their responses have been used to estimate an index of satisfaction. Results in figure 7 are reported only for the Mediterranean Bulletin, the Adriatic Bulletin, the Cyprus System and the North-Western Mediterranean Bulletin, because of the insufficient number of responses registered in the other systems.

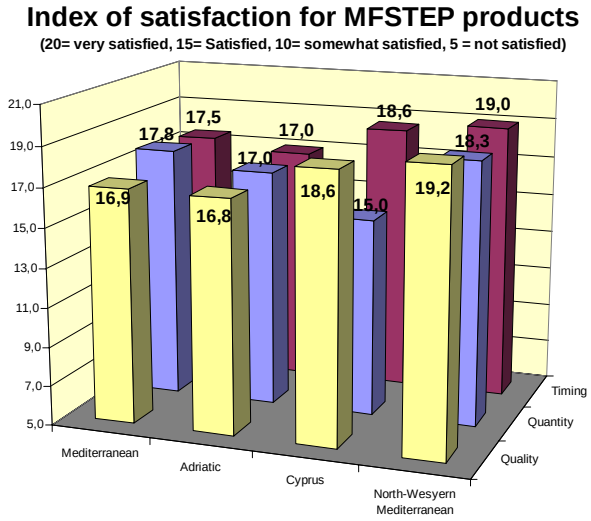

Figure 7: Index of satisfaction in MFSTEP survey described products

The results show that the end-users are well satisfied with the downloaded data, showing at least an index of 15. The highest satisfaction is reported for the North-Western Mediterranean Bulletin in terms quality, quantity and timing of delivery. The lowest reported satisfaction regards the data quality of the Cyprus system. Respondents report similar satisfaction for the Mediterranean and Adriatic Bulletins. If we compare quality, quantity and timing for each system, we notice that for the Mediterranean and Adriatic Bulletins, quantity and timing are more satisfactory than quality. For the North-Western Mediterranean Bulletin the highest satisfaction is for quality, followed by timing and quantity. As regards Cyprus, equal satisfaction is shown for quality and timing, while the quantity of the delivered data is less satisfactory.

3.5 Willingness to pay estimates

The willingness to pay question has been presented using the open-ended format: "How much do you think a private vendor might charge for each download of data similar to the MFSTEP data? ". As the payment question is open-ended, the mean WTP has been calculated by a non-parametric estimation procedure. The results show a mean WTP for the overall sample equal to 65 euro for each download of data. We have also estimated mean WTP for two sub-samples: the Mediterranean and Adriatic systems' users and the Mediterranean system's users only. In the first case, the mean WTP for each download is 83 euro, while if the respondent is a Mediterranean system's user only, his WTP is 30 euro – see Figure 8. Formal testing have been performed to control for statistical significance.

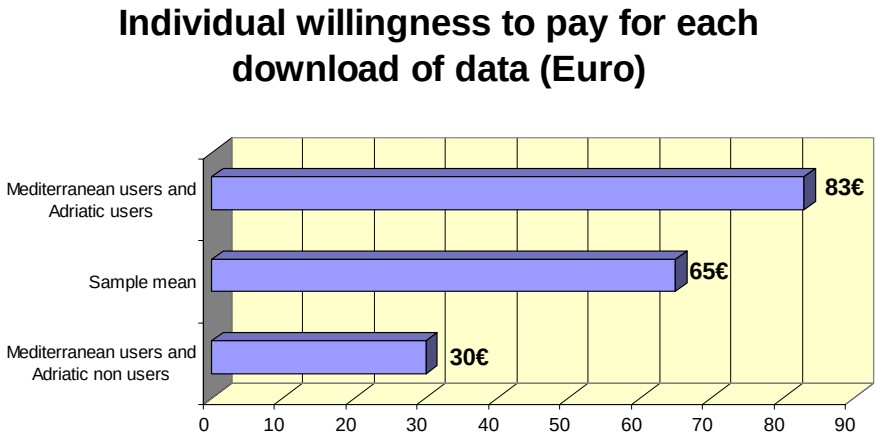

Figure 8: Individual willingness to pay for each download of data (Euro, 2005).

The results of the t-test statistic show that the difference between the mean WTP for the Mediterranean and Adriatic users and the mean WTP for the Mediterranean users and Adriatic non-users is positive and statistically significant at 10% confidence level. From the economic perspective, this means that the value from consumption of the Mediterranean forecasting services is higher among the Adriatic users sub-sample.

4. Cost-benefit analysis

4.1 Theoretical foundations

Cost-benefit analysis (CBA) is a welfare-theoretic method to trade-off the advantageous and disadvantageous effects of a proposed project by measuring them in monetary terms. CBA emerged as an attempt to systematically incorporate economic information that can be applied to project and policy evaluations. Since CBA has traditionally been defined in terms of gains and losses to society, project-oriented CBA has tended to be confined to public sector investment projects. The first evaluation studies were carried out in the US in the 1950s to deal with 'intangibles' in a consistent way, e.g., for river basin projects and infrastructure projects. These methods found much application, *inter alia* in World Bank practices. They were also heavily criticized for many inherent shortcomings, which has led to many new or adjusted methods, such as cost-effectiveness analysis, goals-achievement methods and multicriteria analysis (Nijkamp *et al.*, 1991).

The use of CBA to evaluate policy is more recent (see for an overview Boardman *et al.*, 2000). Like an investment project, policies have costs and benefits. For example, standards for marine pollutants concentrations and taxation of marine pollutants are two different policies, which, in turn, are associated with different gains and losses to society. The basic rule of CBA in decision-making is to approve any potentially worthwhile policy if the benefits of the policy exceed the costs. Moreover, to make the best choice, a decision-maker should opt for the policy option with the greatest positive net present value. Other criteria exist, such as ranking and evaluating projects according to their 'internal rate of value' or according to the 'benefit cost ratio' – see Hanley and Spash (1993) for a literature review on CBA and its application to environmental issues.

From the policy agenda point of view, CBA has been used in the US for evaluating policies since the late 1970s. However, only after Reagan's Executive Order 12291, in 1981, has CBA been extensively used for evaluating new regulations. In contrast, in Europe there are no legal requirements for CBA for new regulations. An exception is the UK, whose 1995 Environment Act envisions the use of CBA in policymaking. Clearly, the use of and the critical judgments of CBA in public policy is still a matter of ongoing scientific debate among economists.

4.2 The CBA results

The cost-benefit analysis has been performed taking into account the individual willingness to pay for downloading the MFSTEP data. The cost-benefit analysis has been carried out on an annual basis, for three main scenarios: full maintenance cost recovery, research personnel cost recovery and durable equipment cost recovery. The monetary benefits (estimated from the willingness to pay figures) have been compared, in the first scenario, with total maintenance costs, in the second scenario with the costs supported for research activities only, and in the third scenario with the costs supported for durable equipment only (see Chiabai and Nunes, 2006c) for more details. More specifically, we have estimated the number of downloads required every day (and annually) in the three different scenarios in order to recover the costs. The results are reported in Table 4. This is a market perspective, in which the services are provided only if the demand is sufficient strong. In economic terms, this means that the marginal benefits should be at least equal to the marginal costs.

In the first scenario, total costs for annual maintenance (equal to 3.865.326 euro) are recovered with 163 downloads per day, using the mean WTP of the sample (65 euro). In the second scenario, the personnel maintenance costs (equal to 2.148.753 euro) are recovered with 90 downloads per day. While in the third scenario, 33 downloads per day will recover the durable equipment maintenance costs (equal to 771.797 euro). The lower and upper bound estimates have been calculated taking into account the mean WTP for the sub-sample of the Mediterranean users' (WTP=83 euro), and for the sub-sample of the Mediterranean and Adriatic users' (WTP=30 euro) respectively. If we consider the sub-sample of respondents using only the Mediterranean system, the appropriate figure to be considered in the CBA should be the WTP of 30 euro for each download.

Table 4: CBA results (maintenance specific costs)

Scenario	Point estimate	Lower bound	Upper bound
Full maintenance cost recovery scenario			
Annual	59,467	46,570	128,844
Daily	163	127	353
Research personnel cost recovery scenario			
Annual	33,058	25,889	71,625
Daily	90	71	196
Durable equipment cost recovery scenario			
Annual	11,874	9,299	25,727
Daily	33	25	70

5. Caveats

From a public policy perspective, the implementation of MFSTEP oceanographic system will also entail a wide range of social benefits, besides the above mentioned private benefits provided to the end-users. Social benefits are non-market benefits related to environmental assets and marine environmental quality (Perman *et all*, 1996). These are non-use economic values (Freeman, 1993; Loomis *et all*., 2000). In case of an oil spill for example the system is capable of predicting the direction of the spill, which allows a fast emergency intervention in order to reduce damages. This will result in a reduction of the expected damages to commercial and sport fishing and to the natural resources (including beaches, coastal and marine flora and fauna) caused by oil spills that might occur in the Mediterranean (Carson *et all*, 1992). Other social benefits could be related to the fish stock assessment and management in the open sea. Further research should explore the use of oil spill modelling and economic valuation of the environmental related assets in order to estimate the total benefits arising from the application of MFSTEP oceanographic system (see also Nunes and Chiabai, 2006). All in all, the valuation results from the present valuation study should be considered at best as a lower bound to the total economic value of the survey described operational oceanographic products, and always contingent upon the available scientific information as well as the global socio-economic context.

6. Conclusions

In this paper we present the results of a cost-benefit study focusing on the Mediterranean forecasting system MFSTEP. The costs associated with implementation and maintenance of MFSTEP system have been calculated, as well as the benefits estimated from the willingness to pay of the end-users for downloading MFSTEP forecasting products. The cost estimation has been carried out using the responses of the MFSTEP partners to a cost questionnaire constructed for this purpose. On the other side, for estimating willingness to pay, a contingent valuation questionnaire has been designed and administered to the end-users of the oceanographic forecasting products. The mean willingness to pay for the overall sample was estimated equal to 65 euro for each download of data. For the end-users of both the Mediterranean and Adriatic systems, the mean WTP for each download is 83 euro, while for the end-users of the Mediterranean system's only, the mean WTP is 30 euro. Finally, a cost-benefit analysis has been performed for three main scenarios, the full maintenance cost recovery, the research cost recovery and the durable equipment cost recovery. Cost-benefit analysis shows that, from a market perspective relying on the profit maximisation, a total of 163 downloads per day are required for total maintenance costs recovery,

whereas 90 downloads per day are required to recover personnel maintenance costs. Finally, 33 downloads per day are required so as to recover durable equipment maintenance costs.

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