Economic Evaluation of Investment for Oceanographic Research by using Cost Benefit Analysis (A Case study of Iranian National Institute for Oceanography)

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Abstract: This article presents an evaluation of Cost Benefit Analysis (CBA) from oceanographic research in Iranian National Institute for Oceanography (INIO) as a case study over a 10-year period from 2002 to 2012. From three forms of CBA, we have calculated Benefit-Cost Ratio (B/C ratio) for three categories of benefits depending on how the level of confidence is. Annual adjusted benefit is based on value added by cost saving or avoided cost method. Adjusted costs are the public funds which have been indicated to INIO each year. For those benefits that have direct economic effect, the level of confidence is high and for indirect benefits that need more assumption to apply or more investment, confidence level is medium and low. The results show that B/C ratio for oceanography research in Iran ranging from a low of 0.14 to a high of 4.77 depends on different scenario for benefits. So if a tangible monetary benefit is our case, the B/C ratio shows that there is no economic efficiency and more investment is needed to make oceanographic studies applicable and economical.

Keywords: Economic benefits, Benefits-costs ratio (B/C ratio), Cost benefit analysis (CBA), Oceanographic research, Iran

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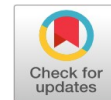
INTRODUCTION

Public expenditures for basic researches have increased rapidly in most developing countries. In recent years after successful experience of developed countries in technological development, legislative groups and the general public in most developing countries support such researches (Dahlman, Ross-Larson, & Westphal, 1987; Krishnan, 2003). Many technological developments are the result of these investments in the past. So policy makers must be sensitive to this public need. The most important reason is need for correcting market failure by governments and long-term economic return for basic research investment that private sectors do not have much tendencies to invest on it. However, governments face a lot of competing demands for public funding (Martin & Tang, 2007), these applications are more challenging in developing countries. Material science, computer science and chemistry are those fields which had received more public funds until 1990 in USA (Pavitt, 1991). Public agriculture research also continued to get support because of high rate of return from the investment (Huffman & Evenson, 1993, 2001; Gray, Malla & Ferguson, 2001; Jones, 1982; Halim, Adnan & Khusaini, 2017). Despite the key role of oceans in human welfare for most developing countries, less attention is given to marine sectors. The potential economic benefits from investment in different marine sectors in developed countries have been studied so far. Ocean observing systems in USA and Australia with focus on potential economic benefits from coastal ocean observing information show that annual benefits are likely more than 100s of millions of dollars that will affect wide range of industrial and recreational activities (Kite-Powell et al., 2005; Kite-Powell, 2009, 2011). Maritime activities also are important to diminish poverty and hunger especially in coastal areas for developing countries. Like other fields, basic researches are vital for conservation, efficient usage and good management of oceans and marine ecosystems. So the benefits of studies on marine sectors could convince governments to allocate and spend more money on oceanographic researches.

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In doing so, the assessment of the economic value and economic benefits of public spending is vital for policy makers.

In the literature, three principal methodological approaches to assess the benefits of researches are adopted including: econometric studies, surveys and case studies (Salter & Martin, 2001). Case studies are the best tool to estimate direct economic benefits of particular technology or subjects (Freeman, 1984) and do not have limitations of surveys and econometric approaches (Salter & Martin, 2001). Research and development about environmental issues and oceans could have affected people thorough three ways: 1- Improve the knowledge about the world and its universal ecosystems functions. 2- Providing specialists who can solve environmental problems which human faces. 3- Creating accumulation of knowledge in which new ideas and innovations have appeared and by changing technology that could affect welfare and standard of living (Jones, 1982). So in this study we will consider a case study of economic benefits of oceanic researches in Iran. Considering a large coastal area of Iran, practically 2700 km, covered by the shorelines (Pak & Farajzadeh, 2007), Iranian National Institute for Oceanography (INIO) was established in 1992 according to the agreement between Ministry of Science, Research and Technology of Iran and UNESCO. Although there are other organizations that are responsible for researching about marine sector, but INIO is chosen as a governmental institute to see how much economic benefits have been received by its researches to the national economy. So the aim is to estimate the economic return from oceanographic researches that have been done by INIO during 2002-2012.

The emphasis will be on the researches that have potential to create economic benefits from services or market products. The purpose is to provide an assessment of the economic value of those researches which should be useful in indicating more public funds for future research to have tangible effects on marine activities.

METHODOLOGY

Cost-Benefit Analysis (CBA) can be used to help decision makers to evaluate potential investments or projects. For quantifying and evaluating the relevant costs and benefits of a particular project or program, CBA is an economic technique which can be applied to appraise whether the investment or project is worth undertaking. After costs and benefits have been derived, the project's result can be presented in three forms: Net Present Value (NPV), Benefit-Costs Ratio (B/C ratio) and Economic Internal Rate of Return (EIRR).

Net Present Value (NPV) $= \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$

Benefit-Costs Ratio (B/C ratio) $= \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}}$

Economic Internal Rate of Return (EIRR) $= \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$

Where Bt is equal to benefit at time t, Ct is for Cost at time t, i is for Discount rate, r is equal to EIRR and n is number of years.

NPV is more useful for projects with exact life time and for this study it is not an appropriate criterion. NPV criteria are limited in that it cannot be used to rank a number of alternative projects and so B/C ratio is designed to avoid the limitation of NPV method. According to B/C ratio, the adjusted benefits and adjusted costs of a project will be compared and benefits per one monetary unit of cost is reported. The investment is advisable if B/C ratio is greater than 1. The economic internal rate of return is the highest interest rate that an investor should economically pay. This criterion must be greater than the social discount rate (Tangvitoontham and Chaiwat, 2012; Layyinaturrobaniyah, Masyita & Sekartadjie, 2016). For every year benefits and costs are deflated by using dollar value of them (based on exchange rate for the first year of study). Both of them are based on annual costs and benefits deflated by social discount rate for Iran which is estimated based on 31 years data (Abdoli, 2010). In this study because of the nature of research, we have used B/C ratio for three levels of benefits. Two other criteria are more useful for single investment with tangible product so we have omitted them in this study.

RESULTS

Before elaborating the results, it should be mentioned that by basic research we mean simple definition of research that covers both research and innovations. This study focuses on economic benefit broadly which considers direct benefits and less direct benefits such as ability to solve problems, develop a subject, instruments and giving advice based on studys results. The study concentrates on public fund for basic research. This includes specifically basic researches conducted in Iranian National Institute for Oceanography as an acceptable center for ocean studies in Iran.

Benefits of oceanography studies

Data were obtained from annual reports, internal documents and consolation with internal experts to identify the level of confidence for each of the benefits. Estimates are divided into three categories: for those services in which there is direct evidence and market value confidence level considered high, those that are applicable at present but significant assumption and extra fund are needed to provide them as tradable services or products, medium level of confidence is assumed and those that are more speculative or potential with required much public fund support to be acceptable by potential users are categorized as low level of confidence.

For those where no evidence or data were available, benefit transfer method with its implications has been applied. The internal data of public fund annually for costs as basis but adjusted cost and adjusted benefits are used. Sources of economic benefits from INIO studies and researches include:

- Marine observation, monitoring and ocean forecasting
- Provide ocean database and center
- Education, consulting and facilities for marine sectors

As long as INIO is a scientific institute, its products are basic studies and most of its benefits can be considered with medium and low confidence levels. Economic valuation methods are applied to show the economic benefits of different activities in dollar value so they could be summed up and compared with other studies. Most of these benefits are in the nature of avoided costs (increased producer surplus) and market prices. In other words the difference between with and without project situation is our net benefit. In those studies where market prices of output are available, market analysis is used and market price could be close substitute of real economic value. Replacement costs and benefits transfer are also used to evaluate as much as services that INIO provides to national economy.

For those goods and services in which a dollar value could be estimated through market analysis, the results are shown with high level of confidence (Table 1). These direct benefits include: education in terms of workshops and providing consulting to other organizations, selling information and data, providing lab services and held seven times training course of making ocean handicrafts for women who are living in coastal areas in which full time job was created for them. In table 1 we have summarized estimates of the annual economic benefits for a range of activities with high level of confidence. For these activities there are direct evidences of benefits.

Table 1: Economic benefits of INIO researches with high confidence level

Source of benefit	Discounted annual benefit at 7.2% ($ 2012)
Consulting and education (workshop)	150,000
Ocean software services	37,290
Data and information	9,250
Training course for employment	21,000
Lab and other services	4,460
Total high confidence benefits	222,000

For workshops and education, tuition fee is our benefit and for training course which could create job, according to Central Bank of the I.R. Iran, the benefit of each employee is equal to $ 30,000 annually. So based on seven times of holding handicraft training course, annual benefit to economy is about $21,000. Total high confidence benefits of INIO studies and services are about $ 222,000 annually which directly affect the national economy.

Second category is those activities that need more significant assumption to estimate benefits or more investment to make them tradable and tangible. Two items are in this category including avoided of being drowned in Caspian Sea because of ripe currents and improve amenity and safety in coastal areas by warning during major storm and flood events.

Only first item is quantified by using value of statistical life and the number of tourists that rescue from drowning by INIO's information about safe places for swimming. But the second one needs more assumption to estimate. So their benefits are less available than the first one (Table 2).

Table 2: Economic benefits of INIO researches with medium confidence level

Source of benefit	Discounted annual benefit at 7.2% ($2012)
Providing information about how to swim in Caspian Sea safe places	505,000-3,250,000
Improve safety and amenity of coastal areas	-
Total medium confidence benefits	505,000-3,250,000

The third and last category of benefits belongs to potential or speculative benefits which could be tangible with additional investment or a higher level of utilization from INIO data. These benefits include: forecasting and warning for marine hazard events in Iranian coastal area, tsunami warning system for Oman Sea, equip and apply research ship for monitoring, establishing permanent/temporal station in Antarctica for basic studies about climate change and related oceanographic issues.

Table 3: Economic benefits of INIO researches with medium confidence level

Source of benefit	Discounted annual benefit at 7.2% ($2012)
Forecasting and warning for marine hazards	7,145,000
Tsunami warning system	-
Equipped research ship	-
Establishing station in Antarctica	-
Total low confidence benefits	7,145,000

There is no simple answer to the question "what are the social and economic benefits of basic research?" As shown by estimations in table 3 during 10 years' oceanic researches in INIO, $ 222,000 annually is created with direct evidence for benefits. From $505,000 to $3,250,000 annually could be created with less direct evidence or with more attempts to make these services tradable. Third category of researches with lower confidence level could create $7,145,000 per annum with additional investment or higher level of utilization of research results. To sum up, INIO basic studies and other activities will add $7,872,000 each year depending on the value of statistical life for each person.

In the present study, three categories of economic benefits from oceanic studies and researches by Iranian National Institute for Oceanography were estimated. The output of research shouldn't be seen simply in terms of "knowledge", however the surveys and case studies reviewed seven channels though which benefits from basic researches flow into the economy (Martine and Tang, 2007). It was estimated that economic benefits from oceanic research and studies could be added between $7m and $10m annually to national economy. But only $222,000 is occurring with direct evidence and the rest of them are potential benefits that will be created by more investment or higher level of utilization.

Now to summarize the overall value of public funds on oceanic studies, we used B/C ratio which is an indicator in the formal discipline of CBA. For doing that we have applied discounted benefits and costs. Annual costs are amount of public funds that are allocated each year between governmental organizations (Table 4).

Table 4: CBA for INIO

Level of benefits	Discounted benefit (annually, $)	Discounted cost (annually, $)	B/C ratio
high confidence benefits	222,000	1,496,384	0.14
medium confidence benefits (Min)	505,000	1,496,384	0.33
medium confidence benefits (Max)	3,250,000	1,496,384	2.17
low confidence benefits	7,145,000	1,496,384	4.77

According to B/C ratio, in high confidence benefits for every unit of cost, less than one unit of benefits is accessible. This goes for medium confidence level in Min interval and only for Max of medium level of benefits to low confidence benefits, B/C ratio is economical and outweighs the costs. According to our findings, although some benefits would take a few years to become tradable in any market or be available for decision makers, but it is necessary to make them happen and in that case the result could show the cost effectiveness of spending money on marine studies.

CONCLUSION

It should be mentioned that attempts to quantify benefits for researches in oceanographic sciences is really difficult process. According to economic theories only when products can be utilized by another individual or group in society, there is economic value for them. Otherwise the results are uncertain and it's because of the nature of research and development subjects.

The present study assessed the actual and potential benefits of annual levels of expenditure by Iranian government in support of oceanic basic studies and researches. INIO is an oceanic research institute that has responsibility in different types of oceanic and marine studies. Its activities could be categorized to three levels according to direct or indirect evidence of creating economic benefits and then the B/C ratio has been calculated. The estimation of costs and benefits yields a high B/C ratio around 4.77 for each year only for low confidence benefits. According to short term products with market value, the oceanographic research is not economical but in long term with more investment in oceanographic studies and research equipment, could have a reasonable answer for the question of governments about how great are the economic benefits that flow from public funding of basic research in marine sectors.

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