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Quantifying the external cost of oil consumption within the context of sustainable development

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Abstract

The concept of sustainability implies that the flow of services derived from the use of natural capital must be constant over time and should be obtained at a constant price. For a depletable resource such as oil, the future generations are highly impacted due to the consumption behavior of the current generation. Since the ultimate oil stock within the Earth declines with cumulative consumption, excessive consumption of oil now reduces the availability of oil for future needs. Moreover, since oil reserves are normally extracted in the order of ascending cost and descending quality, excessive consumption of relatively high-quality, cheap oil reserves by the current generation raises the cost at which future generations can meet their needs of oil and hence imposes an external cost on the future generations. This study aims to quantify the external cost of consuming a barrel of oil within the context of sustainable development. An option-pricing model is developed to quantify this external cost assuming that the external cost of consuming a barrel of oil now equals the value of the option to get a barrel of oil in the future at the same current cost. Then, the total cost of consuming a barrel of oil now, that should be used in lifecycle costing to design more sustainable products, is the summation of the oil price and the external cost.

Keywords: Sustainable development; The external cost; Oil consumption; Lifecycle costing

1. Introduction

There is an increasing demand for integrating the concepts of sustainability into the earliest stages of production planning to design more economically sustainable products or product systems. In this respect, lifecycle costing is widely adapted as a means for connecting the environmental and social requirements with business strategies. According to the US Office of Management and Budget, lifecycle cost is the sum total of the direct, indirect, recurring, nonrecurring, and other related cost, incurred in the design, development, production, operation, maintenance, and support of a major system over its anticipated useful life span. The lifecycle cost assessment can be used to evaluate options for reducing total lifecycle costs and optimizing the use of resources (US EPA, 1995).

The cost of oil consumption in lifecycle cost assessment is usually accounted as the product of the amount of oil consumed and the market price of oil. Since oil is an exhaustible, nonrenewable, resource, excessive consumption by current generation reduces the resource available for future needs. Clearly, the new oil discoveries and the advances in technologies that make known resource stocks economically viable to extraction can increase the oil inventory available for consumption (Blignaut et al., 2000), but this does not alter the fact that the ultimate oil stock in the Earth declines with extraction. As illustrated by Adelman (1990), 'what actually exist are flows from unknown resources into a reserve inventory'. Although the ultimate resource is unknown, it is clearly nonrenewable. Since the sustainable economic development of societies relies on the sustainable supply of energy resources, the consumption behavior of the current generation affects the economic development and welfare of future generations.

With the increasing demand for oil and the declining resource base, the excessive consumption imposes a burden on the future generations and raises the cost at which they can meet their needs of oil. As explained by Vincent et al. (1997), oil extraction has an upward-sloping marginal cost curve (i.e., the marginal cost of extracting oil increases with the amount extracted).

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Also, Watkins and Streifel (1997) argue that the use of relatively cheap oil reserves now hastens the day when reliance must be placed on more costly oil reserves. As explained by Adelman (1990), at a given point of time, the market scans all known deposits to take the cheapest into production. Accordingly, the better quality, lower cost deposit will be exploited first until it is exhausted, and the lower quality, higher cost deposit will be exploited subsequently. Therefore, in addition to the private cost of consuming a barrel of oil now, whish is the current market price of the barrel, there is an external cost. This external cost is not a real cost incurred by consumers and accordingly they do not take it into account when making their consumption decisions. This type of cost is referred to as the external cost or externality because although the consumers are not financially responsible for it, it represents a real cost for other society members. Since oil is an exhaustible resource, the excessive consumption by current generation imposes a high external cost on the future generation. Therefore, this external cost should be quantified and taken into account when comparing two products or operations and in the earliest stages of planning to design more economically sustainable product or product system.

Sustainable development is a process of change in an economy, in which the word "sustainable" implies that certain indicators of welfare or development are nondeclining over the very long term (Stern, 1997). The main goal of development in general is to satisfy human needs and wishes (Tengbe, 2001). The most widely accepted definition of sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition implies that there are both basic needs and limits or constraints on economic activity that stem from both the human and physical dimension of the economy-environment system (Stern, 1997). De Janvry et al. (1995) argue that the concept of sustainability implies that the flow of services derived from the use of natural capital must be constant year after year over an infinite time horizon and this flow of services is obtained at a constant price.

For a nonrenewable resource such as oil, the sustainable development challenge is to provide sustainable supply of oil required for economic development and social welfare of generations. To meet the goals of sustainable development, the cost of obtaining oil should be constant over time. Since the oil reserves are normally exploited in the order of ascending cost and descending quality, and the ultimate stock of oil within the Earth decreases with cumulative consumption, which leads to increasing the long-term cost of obtaining oil, then current consumers should be charged for the externality they impose on the future generations. Therefore, within the context of sustainability, the total cost of oil consumed in producing a product or service should be the summation of the oil price and the external cost. This external cost can be regarded as an energy price tax that aims to reduce the oil consumption. As explained by Mulder et al. (2003), an energy price tax reduces energy consumption because it speeds up the diffusion of new energy-saving technologies. In this case, the reduction in energy inputs does not affect the economic growth since with induced technical change, the reduction in energy inputs is offset by faster improvement in energy-related technology (Smulders and De Nooij, 2003).

This study aims to develop a model for estimating the externality of oil consumption. The model is developed using option-pricing technique based on the concepts of sustainable development. The main idea is to find the value of the option to get a barrel of oil in the future at the same current cost, taking into account the time value of money. The value of this option represents the external cost, or externality, of consuming a barrel of oil now. Then the full cost of consuming a barrel of oil now is the summation of the barrel price (the private cost) and the value of the option to get a barrel of oil in the future at the same current cost (the external cost). This full cost is the appropriate one that should be used in the lifecycle cost analysis of a product or system.

2. Modeling the external cost

The concept of sustainable development implies that the future generations should obtain their needs of oil at the price whose present value equals the current market price of oil. This implies that the cost of consuming oil should be constant over time in real terms, taking into account the time value of money. In this context, the value of the external cost per barrel of oil consumed now can be regarded as the amount a consumer is willing to pay now in order to hold the option to get a barrel of oil in the future at the same present cost. This option is similar to the options traded on the financial exchanges. As explained by Amram and Kulatilaka (1999), one option contract traded on the financial exchanges gives the buyer the opportunity to buy a stock at a specified price on a specified date. Since the future stock price is uncertain, these options are valuable. Similarly, since the future oil price is uncertain, the option to buy oil in the future at a specified price is valuable. Within the context of sustainable development, this specified oil price should be the current market price of oil adjusted for the time value of money, and the value of the option to buy oil in the future at this specified price represents the external cost of consuming oil now. Therefore, the amount of the external cost per barrel of oil consumed now can be estimated using option-pricing technique.