The Depletion of Non-renewable Resources for Non-sustainable Externalities as an Economic Development Policy***

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Abstract

The significance of non-renewable resources in economic development is an on-going debate between optimists and pessimists, but what insights does it provide for contemporary societies who need to choose between alternative growth paths? This paper aims to explain the depletion of non-renewable resources within the concept of externalities in order to determine the range of externalities for future generations by broadening the analysis of economic growth to sustainable development. The extensive depletion of non-renewable resources, particularly oil, along with a higher level of consumption will have a significant impact on the economic development of future generations. Sooner or later economies will have to rely more and more on the input of renewable resources, but the timing of this transition depends on a clear definition of non-renewable and depletable resources. The costs of transforming an economy from one that depletes non-renewable resources to one that is in accordance with sustainable development are considered negative externalities for future generations. The main questions of this paper are "What is the impact of the depletion of non-renewable resources on sustainable economic development?" and "Under what conditions will current efforts of employing renewable resources state negative or positive externalities for future generations?" Finally, the research findings based on qualitative analysis clarifies the reasons and the extents of taking sustainability into account as well as points to difficulties of implementing strategies for a sustainable economic development.

Keywords: Depletable Resources, Economic Development, Non-renewable Resources, Non-sustainable Externalities

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Introduction

The recent fluctuations of the oil price exemplify the influence of non-renewable resources on global current economic development. Not only are consumers highly concerned about the price of oil, but most companies consider any rise as a major threat for their profits. Pessimists argue that development is limited by available resources, a rising price of oil indicates a soon exhaustion of this resource and as a consequence the collapse of economic growth. The optimists argue that development is unlimited. They look at the price of oil from a more dynamic perspective via examining the effects of price mechanisms for the aggregate supply of a good and its effects for substitute goods. Both approaches have merit as well as flaws in their argumentation as will be explained subsequently. Through the price mechanism both perspectives provide essential insights for a better understanding of non-sustainable externalities and sustainable development.

Another point is the correlation between development and sustainability. It is reasonable that people are more concerned with the development during their life time and not so much with the long-term development. Only during the last decades have people become more and more aware of the impact of their economic activities as well as their live style on following generations, but in order to grasp the meaning of sustainability for development properly it is necessary to set the time horizon closer to eternity. Similar to investors citizens as well as governments have to decide whether to invest into the future, i.e. consume less so as to win future benefits, or enjoy higher consumption now. This holds significance both for companies which are mostly concerned with the interests of their stock-holders and governments which must consider the interests of their citizens. Companies seek to increase their competitiveness and invest for example into new technologies which also means that they have to use some of their revenues and by doing so reduce the returns for their financiers stock holders. Similarly governments face the trade-off between redistributing resources to the people rather than investing in their countries´ future economic competitiveness.

When analyzing global sustainable development, this principle can be applied by arguing that people have to choose between current and future consumption. So far economic development is characterized by the depletion of resources and the pollution of the environment, but most scholars agree on that we can not continue forever in this manner, because pollution and depletion will result in serious consequences for the future development. But one needs to distinguish between different forms of resources that are input into the development process, i.e. renewable and non-renewable resources. Furthermore both the time-path of depletion and the scale of pollution determine their impact on a sustainable development. Obviously it is possible to enjoy a faster contemporary development at the expense of the reduction of the capability for future development by depleting non-renewable resources and irreversibly polluting the environment.

This paper proposes to show the arguments of two schools regarding the significance of natural resources for economic development and will further expand this discourse by applying the concept of sustainable development in order to suggest a framework for non-sustainable externalities. The aim is to answer the questions "What is the impact of the depletion of non-renewable resources on sustainable economic development?" and "Under what conditions will current efforts of employing renewable resources state negative or positive externalities for future generations?" Finally the paper will show theoretical considerations concerning the formulation of a strategy towards sustainable development.

Pessimists vs. optimists

The pessimists argue that development is limited by the availability of natural resources, and they see the current development approaching towards a near end due to a nearby exhaustion of employed resources. According to them population grows exponentially, whereas the resources and food supply is fixed.[1] Hence an (1) insufficient provision of food for an increasing world population is one limiting factor in the near future.[2] Pollution will further limit the availability of food. Another limiting factor is (2) the depletion of natural resources.[3] As a result raw materials will become extremely expensive and the depletion of non-renewable resources will lead to a sudden collapse of economic

[1] Meadows, 1972, p. 123-128
[2] Asafu-Adjaye, p.230-232
[3] Meadows Dennis L., *The Limits to Growth*, Pan Books Ltd., London, 1972, p.55

development instead of a smooth transition.[4]

Daly assumes that we sooner or later will have to consume only renewable resources, but the transition towards this ´cycle-stage´ will probably last a much longer time than expected. Furthermore it is questionable whether we will reach a steady state as Daly argues, because due to the input of energy from renewable resources and technological progress there might still be a positive economic development in the far future.[5] The false predictions in the pessimistic view result partly from the fact that the stocks of natural resources are treated as static, e.g. the productivity of land for the provision of food. The authors acknowledge that technological progress could possibly compensate increased consumption and usage rates of non-renewable resources, but development as shown in the world development model would still come to an end due to pollution and population growth. Therefore they claim pollution and population control.[6]

A brief comparison with reality shows that this scenario is as unlikely to happen as the predicted time point of occurrence as well as its short-term emergence. For several reasons the usage rate of oil for example did not grow exponentially: A more efficient consumption of oil due to new technologies as well as higher prices reduced overall consumption rates as demand adjusted to price changes. In addition oil consumption as a source of energy is increasingly replaced by substitutes, i.e. a shift of energy consumption towards renewable resources such as solar energy. From a historical perspective this pattern of transition can be observed in previous times, for example the unexpected diminishing importance of coal. The transition from the utilization of non-renewable resources towards the input of renewable resources will occur more or less smoothly depending on whether the shift will be accomplished before those resources are exhausted or not. Sooner or later people will have no choice but employ renewable forms of energy, because non-renewable resources are indeed limited, either in terms of supply or by relative prices. This is particularly important when recalling the concept of sustainability and its long-term time horizon. In order to maintain or even increase the levels of consumption and production it is necessary to fulfill the criterion of sustainability. Not oil itself, but the input of energy is important for economic development. [7,8]

In contrast to the above shown approach a more optimistic perspective stresses that the depletion of natural resources will not conflict with future economic development, because (1) a rising price stipulates the search for new deposits as well as (2) increases the profitability of alternatives, i.e. substitute goods. Finally an increased price for example for oil will enlarge the world's known reserves of respective resource.[9] Barnett and Morse assume that technological development produces substitutes for scare resources, reduces the relative prices of these goods and expands the total amount of economic reserves.[10]

In order to illustrate this pattern a closer look at renewable resources is worthwhile. Other than minerals, food is a renewable resource and therefore the price indicates the comparable rate of food consumption and food supply as the underlying mechanism of scarcity rather than depletion. Although food is considered as a renewable resource, over-consumption could also lead to the total depletion of certain species and in this way fail to meet the definition of sustainability. If people consume rare species at a faster rate than these can reproduce their stock, then those species would become extinct.[11] Similarly the Malthusians and the Club of Rome emphasize that development stagnates when maximum food production is reached. Simon in contrast argues that in the short-run it is indeed possible that supply shortfall will occur, but in the long-run an increased price level will boost food production. Rising food prices make the application of new technologies profitable and agricultural output could be amplified.[12, 13]

For non-renewable resources the situation is likewise. There is a distinct pattern of a fluctuating oil price and new discoveries in the past which demonstrates the strong correlation between oil

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[4] ibid, p.66
[5] Asafu-Adjaye, p.232
[6] Meadows, 1972, p. 132ff.
[7] Arndt H.W., *The rise and fall of economic growth*, The University of Chicago Press, Chicago, 1978, p. 142ff.
[8] Simon Julian L., *The Ultimate Resource2*, Princeton University Press, Princeton, 1996, Chapter1
[9] Arndt, p. 143
[10] Barnett H. and Morse C., *Scarcity and Growth*, Resource for the Future, Washington, 1963
[11] Bartelmus Peter, p.12
[12] Simon, Chapter 6
[13] Kahn, p. 4-11

demand and supply, because a stable high oil price encourages the oil companies to spend more money and risk exploring oil in new regions. Many scholars argue that the biggest oil fields still lie undiscovered in deeper layers. Hence an unexpected shock in the demand for oil can not be covered in the short run, but through market mechanisms the supply will adjust to its demand in the long-run.[14]

Furthermore oil as a resource of energy is substitutable and similar to other predictions about diminishing reserves of non-renewable resources, for example coal, the forecasts for oil repeatedly turned out to be false. Instead of decreasing oil reserves due to its depletion, the oil reserves have in fact increased during the last centuries.[15] When the oil price increases and remains at a higher level, the employment of substitute resources becomes more cost-effective. Together with a technological progress, for example cheaper solar cells, energy production will shift towards cheaper energy sources and oil demand will decrease. Possible substitutes among others are tidal power, ocean thermal power, geothermal power, wind power, fuel cells, conventional solar power, or geo-pressurized methane and alcohol.[16] Further arguments against a total depletion of oil include decreasing populations in the developed countries and therefore reduced demand, the spreading utilization of renewable energy sources, a more efficient employment of oil as well as the artificial production of oil.[17] In addition it is likely that totally new forms of energy deployment will be developed in the future as historical experiences suggest.

Despite the divergent opinions of scholars, there are difficulties in measuring the actual total oil reserves. Therefore it is open to discussion whether we are soon reaching the main peak of oil depletion. Otherwise we are just experiencing another intermediate peak in the long line of previous peaks. As Daly explains, even if we can not measure the total amount of oil resources oil is still a finite resource.[18] Oil would only be infinite, as Simon suggests, under the condition that oil could be reproduced artificially at a faster rate than our current rate of consumption.[19] For the purpose of this paper it is not necessary to deepen the analysis over the actual time-path of oil depletion and determine the peak of oil depletion, as far as this is possible anyway. Nevertheless the debate between the pessimists and the optimists provides significant insights.

The following conclusions from the discourse between the optimists and pessimists are relevant for the subsequent argumentation: First, the intrinsic characteristic of non-renewable resources is that these resources are finite, because our current rate of oil consumption exceeds the time that it takes to restore its initial stock. This stands in contrast to the criterion of sustainability and therefore the input of oil at the current rate states an example of non-sustainable development. Second, it is unlikely that the world economy is close to a total collapse due to a nearby depletion of the input resources. The world economy will rather face the burden of increasing costs, for example due to a rising oil price level. It is very likely that a crises caused by an escalating oil price will be overcome by the employment of substitutes which provide for example comparatively cheaper energy. Long before any raw material approaches its final depletion, its price would gradually increase and at the same time demand will decrease.

Natural resources and Sustainability

In the next step the correlation between natural resources and sustainability is shown. In general the criterion of sustainability both for renewable and non-renewable resources is that the stock of the resource remains the same over time. Until this condition is met development remains non-sustainable. In order to stay focused one must recall the final criterion, namely compare the time to depletion and the time to recovery of respective resources. For renewable resources with their characteristic of regenerability this seems to be feasible whereas for non-renewable resources there are barriers. For this purpose the focus of the next section lies on non-renewable resources and on the limits of oil as a future energy resource.

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[14] Salo S. and Tahvonen O., *Oligopoly equilibria in nonrenewable markets, Journal of Economic Dynamics and Control*, 2000, table 1, see appendix;

[15] Tahvonen Olli, *Economic Sustainability and Scarcity of Natural Resources: A Brief Historical Review*, Resources for the Future, Washington, 2000, p.4

[16] Simon, Chapter 12

[17] Simon, Chapter 11

[18] Daly Herman, *Steady State Economics*, Island press, 1991, p. 282-289

[19] Simon, *Epilog: "My critiques and I"*

A sustainable development in the very long-run is only possible when the input of resources does not reduce the available amount of respective resource at any given time. Indeed development in the very far future is only possible under the criterion of sustainability, because without a change of the current economic production process, non-renewable resources will approach exhaustion sooner or later. In the ideal situation people would only employ resources if they are able to reproduce them or employ resources that are reproduced by the earth itself. Bartelmus argues that two factors are important when taking the depletion of non-renewable resources into account. One is the life expectancy of a resources and another is the discount rate caused by depletion. Oil can be reproduced artificially, but the restoration of the stock or the transition towards exclusively employing renewable resources causes costs. In order to maintain economic growth in the very long-run it is necessary to take these costs into account which would increase the retail price. The ideal retail price in terms of sustainability would include the costs of maintaining the stock of natural resources.[20]

This shift will be a major challenge for the global economy whereas the main obstacle will be to provide enough energy for all economic processes. Oil is not the ultimate resource of energy, even though it seems to be as the current point of time. There are indeed other ways of providing energy without diminishing natural resources. Technological progress makes the employment of solar cells successively cheaper. Oil is likely to loose its importance in the long run as its depletion progresses. Today there are already many ways how to extract energy and these technologies will play a more and more important role for the provision of energy in the future. Furthermore there will probably be new technologies for getting energy that are unknown so far. This pattern of inventing new technologies and substitution can be observed over the last hundred years of human evolution and is likely to be continued in the future. The above mentioned points about the underlying mechanisms mark the keystones for the final part. The last chapter explains non-sustainable externalities in the context of the depletion of non-renewable resources.

Non-renewable resources and inter-generational externalities

The transition from the current situation towards economic processes along with the input of substitute resources embodies costs. Those costs are investments in a new technology, the establishment of new facilities for energy extraction, the promotion of energy saving technologies and so forth. In this context the author argues that there are negative externalities that emerge from current economic processes and which cause costs for future generations. Externalities are costs or benefits caused by economic activity which do not take into account the interests of an uninvolved party. The costs that emerge from previous depletion of non-renewable resources and affect future generations without being taken into account by the causing actors are called non-sustainable externalities. In principle this includes both non-renewable as well as renewable resources depending on the time-path to depletion of respective resource, but is particularly significant for non-renewable resources. During the transition process oil can still be depleted without causing negative externalities. In the strict sense this would state an example for non-sustainable development, but not automatically mean non-sustainable externalities. Finally it is possible that there are no negative or even positive externalities if the transition from employing non-renewable resources towards the input of renewable resources is accomplished before respective resources´ depletion. Whether there are negative or positive externalities depends on the time until the resource is finally depleted.

For example environmental pollution respectively the utilization of nature is a negative externality when the asset nature is irreversibly diminished. A continued excessive pollution will lead to a partial extinction of nature and this will have backlashes for the future development. The costs caused by not restraining from excessive pollution in order to allow the nature to recover are negative externalities or non-sustainable externalities for future generations. But if the rate of pollution falls short compared to the time that the nature needs to recover then there are no negative externalities for future generations. Farming is an example for the utilization of nature which has under normal conditions no negative effects for subsequent generations. The usage of chemicals could increase the current productivity, but in the future cause serious damage and make farming impossible for many years. The restoration of the soil due to the use of chemicals could cause costs for the following generation and this would state non-sustainable externalities.

Oil as an example for non-renewable resources is of highest interest when analyzing economic

[20] Bartelmus Peter, *environment, growth and development*, Routledge, London, 1994, p. 45-52

development, but substitutes such as solar or wind energy are already in use and reduce its significance for sustainable development especially in the long-run. In the strict meaning of sustainability any depletion of natural oil stands in contrast to a sustainable development, but in line with the idea of non-sustainable externalities the depletion of oil needs to be compared with the time path until its final depletion. In this sense there are positive external effects respectively no externalities for future generations when the transition towards the employment of renewable substitutes can be accomplished before or just in time of the final oil depletion. In such a case there are no costs for future generations in terms of a reduction of their economic growth and/or investments to substitute oil with alternative energy sources. Contrariwise there are negative externalities when the shift from the oil depletion can not be accomplished before other resources can substitute the role of oil. Oil in the aftermaths can still be used, but this needs to be produced artificially in order to be in compliance with the concept of sustainability. Likewise there would still exist non-sustainable externalities if oil would be substituted by other non-renewable resources, for example uranium. Again this would not fulfill the criterion of a sustainable development and sooner or later there need to take place a transition away from the use of another non-renewable resource in order to avoid negative externalities. In the latter case the costs for future generations to shift energy extraction towards the employment of renewable resources are called non-sustainable externalities. In order to avoid this development it is necessary that for each non-renewable resource the transition towards the employment of renewable substitutes need to be accomplished before the time path to depletion is reached.

The implications for the economy is less clear-cut, because for most non-renewable resources it is impossible to determine the time to depletion, as the empirical experiences with oil clearly show. This is for several reasons: The rate of depletion changes over time according to the development of new technologies, new discoveries of oil fields, changes upon consumer behavior and changes of the structural framework of the global economy, for example the implementation of various environmental regulations. Hence it is impossible to determine whether future generations will face positive, negative or no externalities. The investment into renewable resources for the purpose of energy extraction states under above mentioned conditions an example for positive external effects. If the substitution of oil is accomplished long before oil is depleted, then future generations could further continue depleting oil until the oil price exceeds the costs of employing substitutes. This situation would not fulfill the condition of sustainability, but embody positive external effects. In this context can investments into making the employment of renewable resources marketable as well as the development of new technologies be considered as positive externalities for subsequent generations.

Many governments subsidize the installation of solar panels and other investments for the employment of renewable resources for the purpose of energy extraction. The tax payers in these countries make their contribution to the transition towards the employment of renewable resources, but it is difficult to determine whether this investment is timed well or not. This question leads to the last part which aims to point out difficulties for politicians to implement a policy of sustainability.

One final comment on natural resources for the economic development is worthwhile to be mentioned. Natural resources are important for development, they are needed as crucial inputs in many economic processes, but they are often imported from outside. This is noteworthy, because it shows that many countries spend huge amounts of resources in form of money for the import of natural resources such as oil, minerals and others. Even though their economies are highly efficient and show a high rate of productivity. On the other hand there are countries with plenty natural resources that even showed negative developments. This phenomenon was extensively examined in economics and is labeled as the Dutch disease. Today we know that free deployability of natural resources seldom contributes to economic development, but even could hinder it.[21]

[21] Barbier Edward B., *Natural resources and economic development*, Cambridge University Press, Cambridge, 2005, p. 1-3

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Research model