Technology in helping the problem of resource scarcity

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Introduction

A recurring theme in economics has been the economic growth fueled by an increasing consumption of finite resources that ultimately results in those very same resources unable to cope with its greater productive use. Resources here are any essential inputs to the economic process and are restricted to energy carriers, products of photosynthesis and other industrial raw material extracted from the natural environment. Such a practice is unsustainable and instigates the need for resource innovation so as to figure out how to generate growth with fewer resources. Much of economics runs around this one basic problem of resource scarcity and the aim of this paper is to emphasize on how human beings have created technologies or developed innovative methods to meet the challenges of limited resources available. More specifically this paper will review how technological innovation has made the problem of resource scarcity less onerous.

The notion of scarcity as a constraint on economic growth goes all the way back to Malthus.(Malthus 1798, 1946). Only in recent decades has scarcity been seen as a driver of innovation and thus a driver of economic growth. There have been actual instances of resource scarcity and even exhaustion usually limited to a particular resource or country. However technological innovation in these instances have allowed for the resulting issues of scarcity to be rectified. For example natural fertilizer, guano and nitrate deposits from the West coast of South America were largely exhausted by the end of the 19 th century. However superphosphate from bones and mineral apatites

were a replacement for natural guano. Similarly, synthetic nitrogen-based fertilizers from coke-oven gas, calcium cyanamid and finally synthetic ammonia provided an alternative source of fixed nitrogen for agriculture (and military explosives). The search for alternatives to natural nitrates was deliberate and well-organized. Germany led this scientific search, with the objective of breaking the British monopoly control over the Chilean sources of nitrates (Smil, 2001).

Scarcities have not proven to be obstacles to economic growth. Far more often they have been stimulants to innovation that, in case after case, has led to new applications, new markets and accelerated growth rather than inhibiting it. An emerging scarcity is environmental assimilative capacity for wastes and pollutants. As it happens, most of the pollutants of concern, regionally and globally, are direct consequences of the use of fossil hydrocarbon fuels, especially coal. There is now a worldwide search for technological `fixes' for the various environmental problems, from smog, acidification to global climate warming. But the most promising solutions involve reduced emissions, either by capture, treatment or storage of pollutants or by more efficient use of energy.

Technical change is a dynamic process which includes the creation of new knowledge and technology, and the adoption of new technology by firms (Chavas et al, 1997). This technological change allows for increased production of outputs with the same amount of resources, or the use of fewer resources to produce the same amounts as before. In this way technological progress plays a vital role in the reduction of resource scarcity.

It must be kept in mind that the improvements in technology do not

augment the reserves of these resources, but rather augments the efficiency with which these resources are being used. A focal point in resource scarcity concerns the incentives for the discovery of reproducible technologies to substitute for finite natural resources that are being exhausted. According to Robson (1980) the date of innovation is random but can be brought forward through expenditures on research. However, according to Harris and Vickers (1995) the urgency to innovate increases as the stock of these already scarce resources dwindles. Looking at both statements intuitively it makes sense to think of technological innovation as being driven by the severity of its need as well as the expenditures needed to fuel its progress. Market responses to natural-resource scarcity automatically induce endogenous technological change that leads to resource conservation and substitution, and in turn, to the amelioration of scarcity (Barbier & Homer-Dixon, 1999). Regardless of its source of provocation technological innovation plans cannot be set by countries in advance but will have to be done as they evolve with resource extraction. The idea of technical progress resolving the scarcity issue may seem simple but in reality the cost of acquiring any new knowledge and adapting it to local conditions, the adoption process of new technology may be slow. These lags between R&D investment and its payoff can vary with each technology and each industry (Chavas et al, 1997)

The most motivated to discover technologies are the importers of these scarce resources. Not only do they desire to overcome the problem of finite stocks but also according to Harris and Vickers (1995), to reduce their dependence upon resource producers, who often enjoy a considerable degree of monopoly power over them. The scarcer their stocks of natural

resource the greater will be their R&D efforts. It must also be kept in mind that innovation is exogenous and costly which explains why the possessors of large resource endowments are apprehensive towards its pursue*. Robson mentions that innovation and depletion should have opposing effects on growth as more efficient innovation leads to a slower rate of exploitation of the resource. Similarly, a larger output share for the depletable resource can lead to less innovation and a faster rate of exploitation.

As mentioned earlier technological innovation is endogenous, and is determined by private and public sector decisions, rather than exogenously brought about into the economic system. If investment by these sectors is optimal then a constant growth rate of output and consumption can be maintained in the economy. Despite there being exponential population growth and scarce natural resources that are essential to production, technological innovations can allow for sustained growth and a long-run steady-state level of positive per capita consumption subject to certain conditions. These conditions as stated by Barbier and Homer-Dixon (1999) are that stable economic policies and social institutions should exist to facilitate endogenous innovations. There is a growing realization that solutions to ongoing and emerging threats to freshwater ecosystems and water resources require collaborative approaches that engage scientists, policy makers, the private sector, and other stakeholders (Chavas, 1997). Contributions by both sectors to technology have had a large and positive effect on productivity. For Chavas more specifically private R&D has a strong short-term effect on productivity (after 5 to 10 years) and basically little longer term effect. In contrast, public R&D has a small short-term impact on

productivity, but a larger positive impact in the longer term (after 15to 22 years).

Technology and research based knowledge trickles down or is transferred to and translated by policy makers and natural resource managers (Stelzer & Kashian, 2014). models of knowledge transfer have been mentioned as participation, integration, learning, and negotiation. Such partnerships are essential to obtain sustainable outcomes.

Once again looking at the link that overdependence on resource exploitation results in the economy remaining structurally tied to less innovative resource-based sectors, such as agriculture, minerals, oil, and other primary product sectors, and is unable to develop manufacturing and other value-added sectors that can produce learning-induced growth. In poor countries heavy resource dependent sectors have higher incidences of scarcity and conflicts over resource use. The severity of allocations can be enough to create social unrest and even violent conflict. In this way the little amount of stable institutional and policy environment needed to attract investments in innovation is disrupted coupled with the disruption of efficient and sustainable management that would have created the rents need to encourage long-term investment in innovation. Any resource crisis that does occur, its impact will be felt ï¬ rst and foremost by the poorest sectors of the population, for instance should a water crisis occur its impact would fall upon those that are dependent for their livelihoods on rain-fed or irrigated water in arid and semi-arid regions, where 52% of the world’s population lives (UNESCO-WWAP, 2006). Simply put poor countries such as our own will

fail to achieve higher rates of growth because they fail to generate or use new technological ideas to reap greater economic opportunities.

The possibility of technological innovation based solutions might not even be considered as increased scarcity often gives birth to competitive action by powerful elite groups and narrow social coalitions to defend their interests or to profit from the scarcity through “ rent-seeking” behavior (Barbier& Homer-Dixon, 1999). Robson on the other hand believes that if all the rent from the depletable resource is invested efficiently in innovation and capital, while no investment should occur, then consumption is constant.

Truly technological innovation has played an important role. From Lopez-Gun and Llamas point of view thanks to virtual water, many water scarce countries have avoided a water crisis, particularly in politically unstable regions like North Africa and the Middle East. These revolutions of virtual water, groundwater and geographic information systems (GIS) are all created through scientific and technological innovation not in a vacuum but rather with the responsibility of states and other actors to carefully assess their full potential and limitations. Another instance is that of advances in technology, policy and management, such as improvements in pollution control measures (Dolan 1993) and fisheries regulations (Bruch 1999), that have benefited freshwater ecosystems. In China Hybrid corn is an example to demonstrate how innovation can help us overcome scarcity. Fish farming is another example. Intensive fish farming has increased China’s aquatic products supply by 10 times, freshwater aquatic products by 20 times over the last quarter of a century. This has greatly improved the food structure of Chinese people. Technological innovation is not without its flaws, as there is

a cost of adjustment associated with such technologies such as those borne by workers that are displaced as a result (Stier, 1980).

In conclusion innovation can indeed overcome resource scarcity as long as it is joined with government’s support for research, especially for those that of certain nature of public goods. There is also a requirement for qualified scientists and engineers, especially those who understand local needs. There needs to be team work by scientists and engineers coupled with an effective mechanism for knowledge diffusion so that invention and innovation can be used to increase productivity and create wealth.

Recommendations

Pakistan is another developing country where food in security and energy shortages are key indicators of resource scarcity and problems that are associated with it. In order to overcome this problem, technological innovations should be made use of which would help manage and consume these resources much more efficiently. Firstly, Pakistan should move towards more renewable sources of energy to reduce its dependence on other nations. Solar thermal energy is a cost effective resource in Pakistan (Mirza et al., 2003) and it’s consumption by the household sector can be encouraged by subsidizing solar panels. This would greatly reduce the demand for electricity from the government. The government should install small hydro power plants in areas where there is a natural flow of water to provide electricity to communities/villages that have no access to it or where it is not cost effect to install power lines. Secondly, the government needs to take large scale initiatives to not only develop but also promote the use of

technology in large-scale sectors such as agriculture to ensure that producers are made aware of the scarcity of their product and also equip them with the information and ability to use technology to enhance their production capabilities and slow down the rampant process of scarcity, even if it is to a small extent. If such initiatives are streamlined by the government, it will go a long way in ensuring that resources are managed more efficiently and will also pave the way for a technological revolution in rural areas as people become accustomed to it. Thirdly, Allwood and Cullen (2012) argued that emphasis should be put on vehicles and buildings. According to them, vehicles consume a worryingly large amount of natural resources is gas and petroleum. Therefore, if manufacturers start producing lighter cars, that will significantly reduce energy use by almost 75 percent. The production of lighter cars entails not only the physical aspect but also other vehicular aspects such as a smaller engine and less horse power to ensure that the car burns less petrol. Toyota’s production and distribution of hybrid cars in Japan is a perfect example of such an initiative where hybrid cars can be seen just as frequently as normal cars, subsequently saving energy on a large scale. Furthermore, it is essential for governments all over the world to ensure that buildings are built using lesser amounts of steel and cement. Fourthly, industrial waste is a major contributor to scarcity of resources as a large amount of non-renewable resources is wasted during production. Allwood (2012) stated that one-quarter of steel produced goes to waste each year as it is not even used in the production of the final product. Ensuring that such high amounts of industrial waste are cut down will save already existing resources and make production more efficient and eco-friendly. Lastly, it is essential to improve water management and make sure

that water is not wasted. This issue exists all over the world but is most apparent in countries like Pakistan where due to lack of water management systems, a lot of water is lost in transit and there are major issues of over-irrigation in some areas. This essentially means that some areas receive unnecessarily large amounts of water whereas some receive none at all. Ensuring a balances water management system will lead to better management of resources. This can be done by setting up a central regulatory framework that keeps a check on water distribution. Furthermore, this regulatory body should conduct research to evaluate which areas need what amount of water and subsequently make sure that the right amount reaches the right areas, in turn eliminating the concerns with water supply through proper management.

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