Resource Scarcity, Institutional Adaptation, and Technical Innovation:

Can Poor Countries Attain Endogenous Growth?

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Summary

Endogenous growth models have revived the debate over the role of technological innovation in economic growth and development. The consensus view is that institutional and policy failures prevent poor countries from generating or using new technological ideas to reap greater economic opportunities. However, this view omits the important contribution of natural resource degradation and depletion to institutional instability. Rather than generating automatic market and innovation responses, worsening resource scarcities in poor countries can lead to social conflicts and frictions that disrupt the institutional and policy environment necessary for successful innovation. This indirect constraint of resource scarcity may help explain the disappointing growth performance of many poor countries.

In recent years there has been a vigorous debate about the role of technological innovation in long-term economic growth. At the debate's forefront are new theoretical models in economics that have been termed "endogenous" or "new" growth theory.[2] A key feature of these models is that technological innovation - the development of new technological ideas or designs - is endogenously determined by private and public sector choices within the economic system rather than being exogenously available to the system (as assumed in more conventional neoclassical growth models).[3] This endogenous innovation overcomes diminishing returns to physical capital, thus allowing per capita accumulation of capital and economic growth to be sustained at a positive rate indefinitely.[4] In other words, if public and private sector investments in human capital and innovation are "optimal" then it is possible for an economy to attain a perpetually constant rate of growth in output and consumption.

The current debate over the role of innovation in economic growth has fostered empirical investigations across countries and regions to determine the extent to which long-term economic growth rates fit the predictions of endogenous growth or neoclassical growth theories.[5] The cross-country comparisons of growth rates have pointed to an important issue for analysts: Why is it that the long-term economic growth rates of poor countries as a group are not catching up with those of rich countries?

According to the endogenous growth school, the answer is fairly straightforward. Poor countries fail to achieve higher rates of growth because they fail to generate or use new technological ideas to reap greater economic opportunities. In particular, according to Romer, "the feature that will increasingly differentiate one geographic area (city or country) from another will be the quality of public institutions. The most successful areas will be the ones with the most competent and effective mechanisms for supporting collective interests, especially in the production of new ideas."[6]

Even some critics of this endogenous growth explanation concede that institutional and policy "failures" are an important reason for the inability of poor countries to attain high growth rates. For example, Pack argues that "the potential 'benefit' of backwardness is that, if countries could capitalize on their backwardness, they could enjoy a rapid spurt of catch-up growth." However, he also states that "the benefits from backwardness do not accrue automatically but result from purposive activities on the part of individual firms within a general favorable policy environment. This includes a stable macroeconomic policy and institutions designed to facilitate the identification and absorption of technology."[7] Consequently, the inability of poor countries to "take off" economically "can be attributed to failed policies and weak institutions."

We agree here that institutional and policy failures in poor economies are important explanations of their inability to innovate sufficiently to achieve higher long-term growth rates. However, we make an additional point: in many poor economies the depletion and degradation of natural resources - such as croplands, forests, fresh water and fisheries - contribute to this institutional instability and disruption. Resource scarcities can cause social conflicts that disrupt the institutional and policy environment necessary for producing and using new ideas and for absorbing useful knowledge from the rest of the world. Thus we argue that in many cases resource scarcities have their most important effect on developing economies, not by directly constraining economic growth, but by indirectly affecting their potential to innovate.

Resource Scarcity, Innovation, and Social Ingenuity

Barbier shows that many low-income and lower middle-income economies - especially those displaying low or stagnant growth rates - are highly resource-dependent.[8] Not only do these economies rely principally on direct exploitation of their resource bases through primary industries (e.g., agriculture, forestry, fishing, etc.), but over 50 percent or more of their export earnings come from a few primary commodities (see Appendix A). These economies tend to be heavily indebted and experiencing dramatic land use changes - especially conversion of forest area to agriculture - as well as problems of low agricultural productivity, land degradation, and population carrying capacity constraints.

On the whole, endogenous growth theorists have not been concerned with the contribution of natural resources to growth or with innovation's role in overcoming resource scarcities.[9] However, for some years resource economists have explored the effects of resource scarcity on growth.[10] They have usually employed neoclassical growth models that assume exogenous rather than endogenous technological change. The results have been generally optimistic: even under conditions with exponential population growth and with exhaustible and limited supplies of natural resources that are essential to production, sustained growth and a long-run steady-state level of positive per capita consumption are attainable.[11]

Barbier extends this analysis to an endogenous growth economy.[12] He combines Stiglitz's exhaustible resource model and Romer's endogenous growth model to determine whether natural resource scarcity is necessarily a binding constraint on growth.[13] The results of the analysis are fairly conclusive: although technological change is endogenous, it is still effectively resource-augmenting.[14] Sufficient allocation of human capital to innovation will ensure that in the long run resource exhaustion can be postponed indefinitely, and the possibility exists of a long-run endogenous steady-state growth rate that allows per capita consumption to be sustained, and perhaps even increased, indefinitely.

However, working largely outside of economics, Homer-Dixon points to another potential relationship between innovation and resource availability.[15] He argues that an economy's supply of "ingenuity" may itself be constrained by resource scarcities, especially in low-income countries. Homer-Dixon defines ingenuity as the stock of "ideas applied to solve practical social and technical problems."

In Homer-Dixon's analysis, an increase in the level of "technical" ingenuity is similar to the technical innovation discussed by endogenous growth theorists. These theorists, he notes, "are mainly interested in technical ideas such as manufacturing techniques, industrial designs, and chemical formulas, especially those developed and applied within the firm." But the supply of this technical ingenuity depends on an adequate supply of "social" ingenuity at many levels of society.

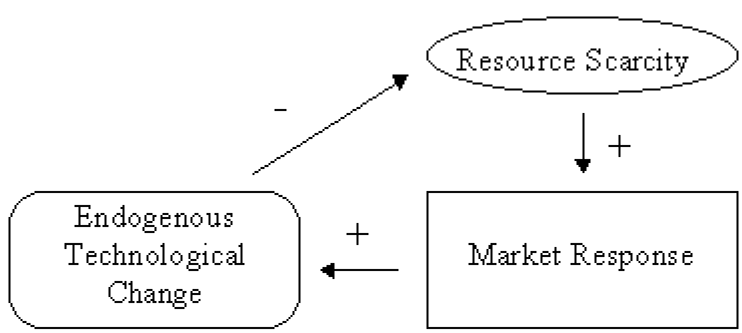
Social ingenuity, according to Homer-Dixon, consists of ideas applied to the creation, reform and maintenance of institutions "such as markets, funding agencies, educational and research organizations, and effective government." If operating well, "this system of institutions provides psychological and material incentives to technological entrepreneurs and innovators; it aids regular contact and communication among experts; and it channels resources preferentially to those endeavors with the greatest prospects of success." The process of generating and implementing social ingenuity is both separate from and necessary for technical innovation. Therefore, in agreement with the institutional arguments of Romer and Pack above, Homer-Dixon identifies social ingenuity as a precursor to technical ingenuity.

Homer-Dixon further describes two mechanisms by which resource scarcity can limit both the total supply and the rate of supply of ingenuity. First, increased scarcity often provokes competitive action by powerful elite groups and narrow social coalitions to defend their interests or to profit from the scarcity through "rent-seeking" behaviour.[16] These actions - which Homer-Dixon calls "social friction" - can hinder efforts to create and reform institutions and can generally make it harder to focus and coordinate human activities, talents, and resources in response to scarcity. Moreover, severe scarcity sometimes causes social turmoil and violence, which can directly impede the functioning of ingenuity-generating institutions, such as markets.[17] Second, endogenous growth theory notes that capital, especially human capital, is essential to the generation of innovation.[18] Yet, Homer-Dixon argues, resource scarcity often reduces the availability of human and financial capital for the production of ingenuity by shifting investment "from long-term adaption to immediate tasks of scarcity management and mitigation."

Evidence from Poor Economies

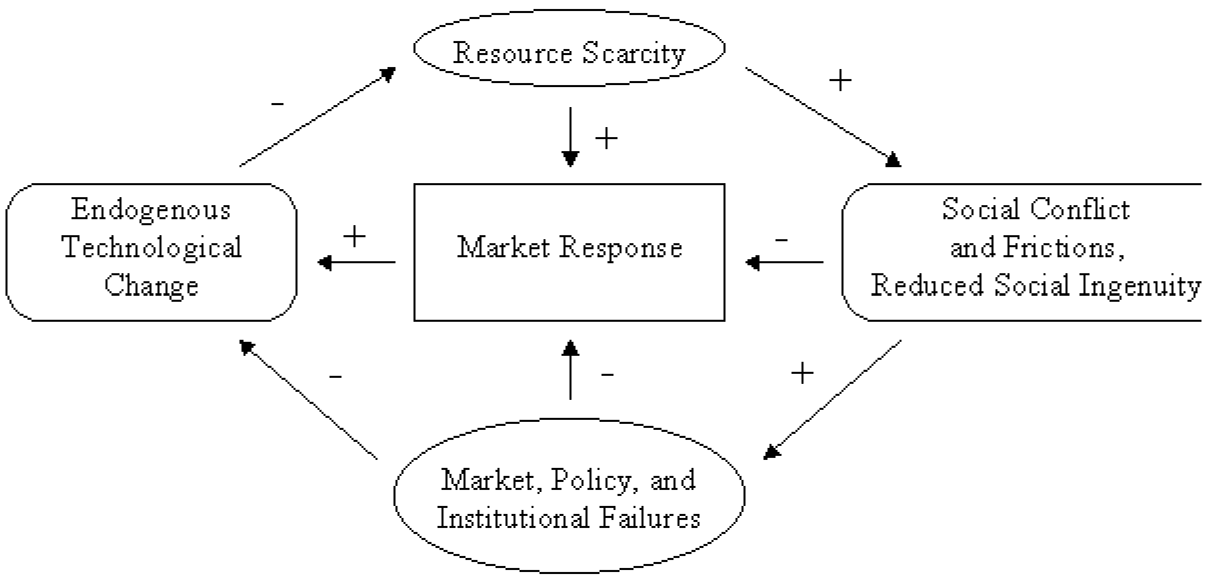
Figure 1 illustrates the contrast between the two views of the innovation process proposed by endogenous growth theory and Homer-Dixon. According to the former view (Figure 1.a), market responses to natural resource scarcity automatically induce endogenous technological change that leads to resource conservation and substitution, and in turn, to the amelioration of scarcity. However, as noted above, this view assumes that stable economic policies and social institutions exist to facilitate endogenous innovation. This assumption may not be valid for many poor economies.

Figure 1.a. Endogenous Technological Change and Resource Scarcity: Conventional View



According to an alternative view based on Homer-Dixon's analysis (Figure 1.b), in some poor countries resource scarcity itself contributes to an unstable social and policy environment at local, regional, and national levels. Scarcity exacerbates social friction and conflict, which results in an undersupply of social ingenuity. Social friction and conflict interferes directly with the smooth functioning of markets, while the reduced supply of social ingenuity perpetuates market, policy, and institutional failures. These failures in turn undermine the innovation process, in particular by disrupting the ability of poor economies to generate sufficient human capital, to build research and development capacity, to exploit existing technological knowledge available domestically and internationally, and to produce and disseminate new technologies throughout the economy. In short, while resource scarcity often induces mitigating market and endogenous technological responses, it can also disrupt the stable social and policy environment necessary for these responses to occur automatically.

Figure 1.b. Endogenous Technological Change and Resource Scarcity: Alternative View



The latter view is well-illustrated by the examples of Bangladesh and Haiti. The United Nations Population Fund predicts that Bangladesh's current population of 122 million will grow to 223 million by the year 2025.[19] Cropland is already extremely scarce at about 0.08 hectares per capita; and since virtually all the good agricultural land has already been exploited, population growth will almost cut this figure in half by 2025.

Research shows that this land scarcity has spurred agricultural innovation.[20] In addition, according to Goletti, "removal of impediments to trade and distribution of irrigation equipment" and the "liberalization of import of irrigation equipment in 1988 has resulted in a wider spectrum of minor irrigation equipment available to farmers." Although there has been a substantial reduction in Bangladesh's overall grain deficit, Goletti nonetheless notes that "in comparison with other low-income Asian countries, Bangladesh has one of the lowest records in terms of agricultural growth rate."[21]

In his analysis of agricultural production in Bangladesh in the 1970s and 1980s, Boyce suggests that, during this period, the "binding technological constraint" on further increases in productivity was innovation to control flood and irrigation waters. But water control is, to a large extent, a public good that requires institutions to permit and guide collective action. In rural Bangladesh, this institutional innovation was largely blocked by struggles among social groups over the distribution of power and wealth. Although Boyce does not make the point directly, it is clear from his analysis that these struggles were sharply aggravated by worsening scarcities of land and water.

Boyce shows that powerful landlords were reluctant to hire seasonally idle labor for the construction of water-control projects because they feared the potential for unrest when large groups of the rural poor work together. Government efforts to mobilize local resources for water control, through the construction of tanks, wells, and irrigation canals, were distorted to benefit large landowners. For example, landowners sought to control wells to permit monopoly pricing and to gain rights to adjacent cropland. At the same time, poorer groups threatened by the increased economic and political power of landowners with access to the well water often sabotaged new tubewells.

In Haiti, scarcities - especially of forests and soil - have also inflamed distributional struggles that obstruct social and technological innovation. Wallich notes that over 90 percent of the country has been denuded, leaving it "bereft of natural resources crucial to economic survival." This scarcity exacerbates the poverty of Haitian rural communities and produces significant profit opportunities for powerful elites, which deepens divisions and distrust between rich and poor. In one case, the Haitian army blocked a reforestation project by destroying its tree seedlings, because the army and the notorious Tonton Macoutes feared the project would threaten their highly profitable control of forest resource extraction by bringing disgruntled rural people together. In general, Wallich argues that "wealthy landowners had little incentive to raise their opponent's standard of living, and peasants saw no reason to improve their husbandry as long as those above them stood ready to extract whatever surplus they might produce."[22]

There are few cross-country studies examining the effects of unstable social and policy environments on economic and technological responses to natural resource scarcity. One exception is an analysis by Deacon that attempts to test empirically across 120 countries for three possible causes of deforestation: growth in income, population pressure, and insecure property rights as reflected in correlations between deforestation and measures of political turmoil and repression.[23] Deacon finds the latter two causes to be the most significant, and he suggests that the overall results of his analysis "are broadly consistent with the hypotheses that deforestation results both from population growth - and the increased competition for land and natural resources that accompanies it - and from political environments that are not conducive to investment."

To explore further the hypothesis "that political turmoil and repressive governments are harmful to investment," Deacon looks for "corroborating evidence by examining data for ordinary investment to see if investment rates are associated with the same variables that are related to deforestation." He used simple correlation coefficients between investment as a share of gross domestic product of a country and the variables representing political turmoil and repressive governments that were included in the deforestation analysis. For low and middle income countries, Deacon finds that "the political variables associated with deforestation tend also to be negatively associated with ordinary investment." In particular, the strongest (negative) associations were between investment and guerilla warfare, revolutions, constitutional changes, military executives (i.e. dictatorships or juntas) and circumstances in which the senior executive of government was not chosen by elected representatives.

Thus although very preliminary in its results, Deacon's analysis supports at least indirectly the hypothesis that across poor countries social and political instability is highly correlated both with low levels of productive investments generally and also with resource scarcity (in this case greater deforestation). Although he suggests that "rapid population growth and the consequent dilution of land and other natural resources in a country" may be important factors promoting "political unrest and the instability or repression it may cause," Deacon is unfortunately not able to analyze explicitly this key relationship.

The Romer-Stiglitz Model Revisited

The above examples provide some evidence supporting the hypothesis that resource scarcity in poor countries may, at the very least, be negatively associated with low levels of social and technological innovation, and in some instances, be the cause of social friction and conflict that undermines innovative responses to scarcity. To explore the implications of this hypothesis more formally, Barbier modified the basic Romer-Stiglitz model of an endogenous growth economy to allow for the possibility that innovation might be "constrained" by increased resource scarcity (i.e., a faster rate of resource depletion).[24] He considers two scenarios for the model based on different starting assumptions.

First, Barbier assumes that the long-run rate of innovation will exceed any adverse effects of resource scarcity so that net innovation is still positive. The outcome, in this case, is that the economy continues to exhibit long-run endogenous growth, although at a slower rate than predicted by the basic Romer-Stiglitz model. Nevertheless, this scenario implies that sufficient - albeit "constrained" - endogenous technological change can occur to avert resource exhaustion and to sustain growth in per capita consumption indefinitely. As in the case of the basic Romer-Stiglitz model, therefore, an "optimistic" outcome is possible.

Second, Barbier assumes that the long-run effects of resource scarcity will just offset additional innovation; that is, increased resource scarcity will so disrupt social and technical innovation that there is no net generation of innovation.[25] However, he then shows that such a constraint on long-run innovation does not necessarily mean that the economy collapses. Sufficient accumulation of technical know-how may occur to avert complete exhaustion of the resource stock in the long run. In this scenario, resource scarcity is still not a binding or "absolute" constraint: the economy can eventually settle into a long-run steady state in which per capita output and consumption remain constant indefinitely.

This second scenario may be somewhat comforting, because it implies that even low-income economies may avoid dire consequences from resource scarcity. Nonetheless, the implications of Barbier's analysis is that low-income economies trapped in the second scenario will fall beyond others. Although a low-income economy facing scarcity-induced constraints on innovation may avoid binding resource-scarcity constraints, it will not be able to match the long-run rates of endogenous technological change and growth displayed by other economies that either face no resource-scarcity constraints, or only limited constraints, on innovation.

In short, the adverse effects of persistent resource depletion and degradation on social institutions and technical innovation may be one reason why certain low-income economies display long-run rates of growth that are consistently lower than the growth rates of newly industrializing and advanced economies.

Conclusion

We have argued that some poor economies may face resource-scarcity constraints on their economic development that have not been adequately explored in the theoretical or empirical literatures on growth, natural resource scarcity, or innovation. To date, analysts have generally addressed separately the relationships between, on the one hand, resource scarcity and growth and, on the other, innovation and growth. This separation has prevented analysts from seeing important linkages among these relationships.

Resource depletion and degradation in poor economies may have their most inimical effect not by directly constraining growth but by indirectly affecting the potential of these economies to innovate. This process may explain why poor economies, particularly those that are heavily resource dependent, are failing to achieve high rates of growth and sustained economic development. We have presented preliminary theoretical and empirical evidence to support this hypothesis, which merits further research.