Article

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Resource Scarcity and Innovation: Can Poor Countries Attain Endogenous Growth?

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, including appropriate market responses to scarcity. This indirect constraint of resource scarcity may help explain the disappointing growth performance of many poor countries.

INTRODUCTION

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 (1–4). 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. 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 (5). 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 (5–8). 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 (9), "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."

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 (7) 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." 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 (10) shows that many low-income and lower middle-income economies, especially those displaying low or stagnant growth rates, are highly resource-dependent. 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% or more of their export earnings come from a few primary commodities. 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. A recent cross-country analysis by Sachs and Warner (11) confirms that resource-abundant countries, i.e. countries with a high ratio of natural resource exports to GDP, have tended to grow less rapidly than countries that are relatively resource poor.

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. Recent efforts to extend endogenous growth models to incorporate environmental considerations have generally focused on the short- and long-run implications of pollution and its disutility (12, 13). However, for some years resource economists have explored the effects of resource scarcity on growth (14, 15). 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 (15).

Barbier (16) extends this analysis to an endogenous growth economy. He combines Stiglitz's exhaustible resource model (15) and Romer's endogenous growth model (2) to determine whether natural-resource scarcity is necessarily a binding constraint on growth. The results of the analysis are fairly conclusive: although technological change is endogenous, it is still effectively resource-augmenting. 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 (17) points to another potential relationship between innovation and resource availability. 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 (9) and Pack (7) 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" behavior. 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 (17–19). Second, endogenous growth theory notes that capital, especially

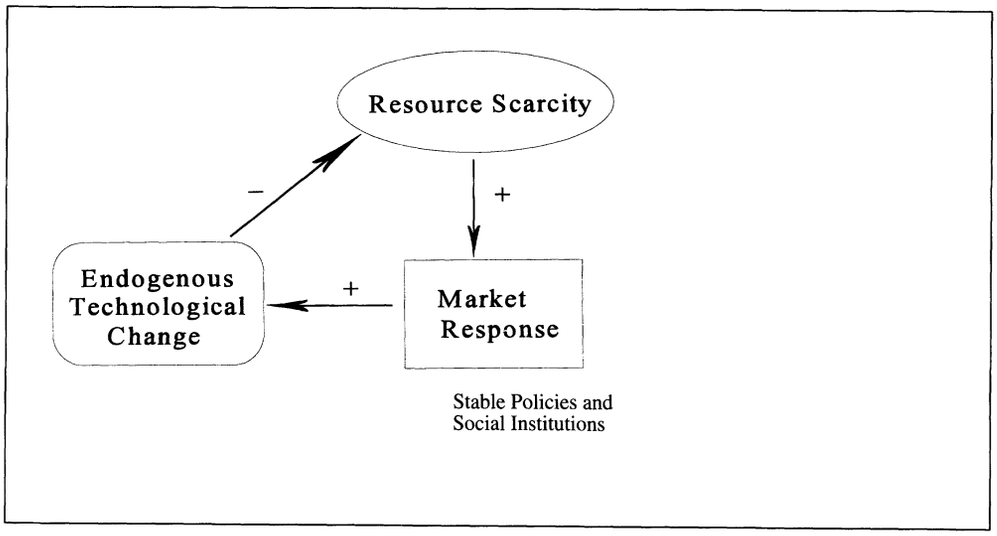

Figure 1. Endogenous technological change and resource scarcity: Conventional view.

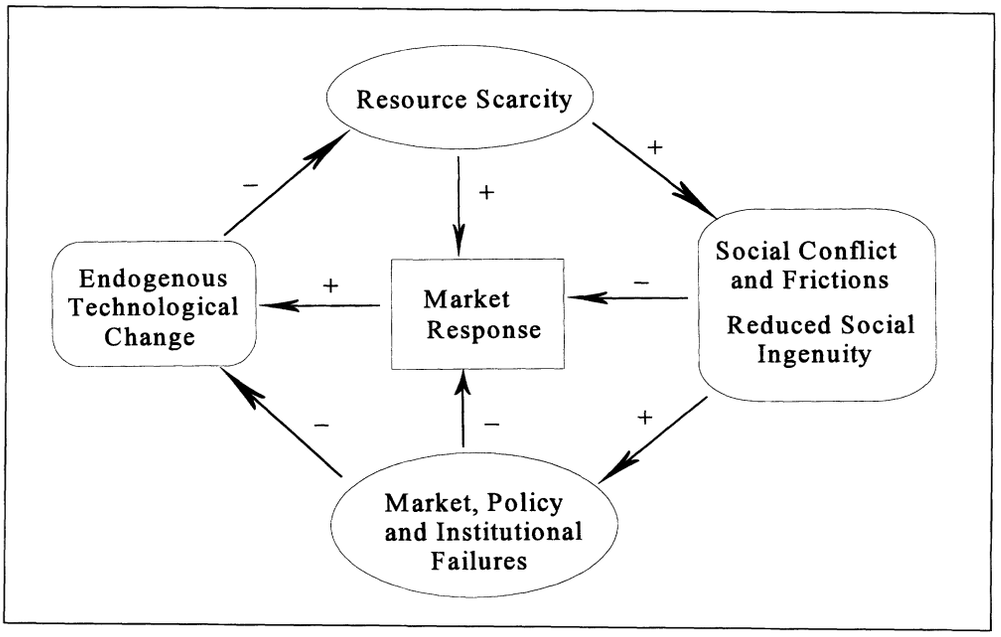

Figure 2. Endogenous technological change and resource scarcity: Alternative view.

human capital, is essential to the generation of innovation (2). Yet, Homer-Dixon (17) 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

Figures 1 and 2 illustrate the contrast between the two views of the innovation process proposed by endogenous growth theory and Homer-Dixon. According to the former view (Fig. 1), 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.

According to an alternative view based on Homer-Dixon's analysis (Fig. 2), 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.

The latter view is well illustrated by the examples of Bangladesh and Haiti. The United Nations Population Fund (20) predicts that Bangladesh's current population of 122 million will grow to 223 million by the year 2025. Cropland is already extremely scarce at about 0.08 ha per capita; and since virtually all the good agricultural land has already been exploited, population growth will cut this figure almost in half by 2025.

Research shows that this land scarcity has spurred agricultural innovation (21). In addition, according to Goletti (22), "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."

In his analysis of agricultural production in Bangladesh in the 1970s and 1980s, Boyce (21) suggests that the "binding technological constraint" on further increases in productivity was innovation to control flood and irrigation waters. But, to a large extent, water control is a public good that requires institutions to permit and guide collective action. In rural Bangladesh during this period, the necessary 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 (23) notes that over 90% 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 deepen 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 bring disgruntled rural people together and thereby threaten their highly profitable control of forest-resource extraction. 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."

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 (24) that attempts to test empirically across 120 countries for 3 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. Deacon finds the latter 2 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.

Finally, recent literature that has examined the structural economic dependence of poor countries on exploiting their natural-resource base have also pointed to a number of possible

fundamental linkages between environment, innovation, and long-term growth that may explain the poor growth performance of these countries. For example, Barbier (16) demonstrates some of the possible influences of resource depletion on innovation and growth in a resource-dependent economy, which vary depending on the strength of the type of feedback effects between resource scarcity and innovation identified by Homer-Dixon (see Fig. 2). The limitations of resource-based development have also been explored by Matsuyama (25) and Sachs and Warner (11). Matsuyama shows that trade liberalization in a land-intensive economy could actually slow economic growth by inducing the economy to shift resources away from manufacturing, which produces learning-induced growth, towards agriculture, which does not. Sachs and Warner extend the Matsuyama model to allow for full "Dutch disease" influences of a resource-based economy; i.e., when an economy experiences a resource boom, such as in its mineral or oil-based sector, the manufacturing sector tends to shrink and the nontraded goods sector tends to expand. The authors' theoretical and empirical analyses indicate that a key factor influencing endogenous growth effects is the relative structural importance in the economy of the less innovative natural-resource based sectors as opposed to the more innovative manufacturing sector.

To summarize, despite the relative abundance of natural-resource endowments in many low-income countries, many of these economies remain in a fundamental state of underdevelopment and cannot generate sufficient long-term economic growth to "take off". Recent evidence is beginning to point to important links between resource exploitation in these economies and their inability to innovate and grow rapidly. One possible link is that overdependence on resource exploitation itself may mean that the economy remains 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. However, many of the examples cited above also suggest that within the dominant resource-based sectors of the economy, incidences of resource scarcity and conflicts over resource use and allocation can be sufficiently severe to cause widespread social unrest, friction and even violent conflict. The result is continual disruption of the stable institutional and policy environment necessary for investment in human capital and innovation, as well as for achieving efficient and sustainable management of the natural-resource base that is necessary for generating the rents for such long-term investment and 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 literature 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.

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