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Summaries

Undesirable growth in a model with capital accumulation and environmental assets

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In this paper we present an original neoclassical growth model in which work effort and accumulation are boosted by negative externalities. This idea is evidently different from the emphasis placed on positive externalities by current endogenous growth models.

In this model welfare depends on three goods: leisure, a free environmental renewable resource, and a good that can be produced by combining physical capital and labor. The latter can be used in three ways: as a substitute for the free resource, to satisfy needs different from those satisfied by the free resource, and for investment in physical capital. The stock of the resource is negatively affected by an increase in the level of economic activity, because of the negative externalities caused by the production process. Households react to the deterioration of the environmental resource by increasing labor supply and accumulation, so as to be able to consume (both in the present and in the future) an increased amount of the good that can substitute for the resource. In its turn, this brings about a further deterioration of the environmental resource. As a result, the economy converges to a long-run equilibrium path characterized by an inefficiently high level of market production and by an inefficiently low endowment of the environmental resource.

The main motivation behind the construction of such a model is to provide a formal structure for the enormous quantity of literature and knowledge (i) on the environmental, social and cultural fractures generated by growth, and (ii) on the fact that—paradoxically—these cleavages may stimulate growth. By interpreting the resource as the capacity of the natural and social environment to provide welfare to the agents, we refer to a debate that has traversed two centuries of industrial history. Although it is deeply rooted in modern culture and spreads through numerous disciplines, it has never penetrated the 'mainstream' of economic theory. The intention here, therefore, is to propose a point of view on the growth process which tends to bridge a profound cultural rift between economics and the other social sciences.

In the pure-market economy under consideration, growth goes 'too far'. Indeed, the long-run equilibrium of the economy is characterized by (i) an

inefficiently high level of production, (ii) an excessive portion of households' time devoted to market activities, and (iii) an inefficiently low stock of environmental resource. Moreover, a lower discount rate worsens the well-being of the future generations. This is because agents who are more concerned about the future protect themselves (and their descendants) against the deterioration of the environmental asset by accumulating more capital, thus contributing to a rise in production and to reduced environmental quality. Hence, the agents' attempt to safeguard their future welfare on an individual basis causes a reduction of all agents' long-term well-being as an unintended result of their defensive strategies. This result reverses the traditional environmentalist explanation of the problems of sustainability based on the selfishness of the present generation, that is, on its too high discount rate.

On Heyes' IS–LM–EE proposal to establish an environmental macroeconomics

PHILIP A. LAWN

Ten years ago, Daly (1991) made a plea for an environmental macroeconomics. Despite an expanding literature on 'green' national accounting and the efforts of ecological economists to measure the sustainable net benefits of a growing macroeconomy, it is only recently that Daly's plea has been adequately answered. This has been achieved with the incorporation by Heyes (2000) of an 'environmental equilibrium' or EE curve into the familiar IS–LM model. However, the IS–LM–EE model proposed by Heyes is incomplete. By extending Heyes' model to include the role of technological progress and the sustainable net benefits of economic activity, this paper shows that conclusions regarding the desirability of expansionary fiscal and monetary policies depend largely on four key aspects. They are: (a) the means by which the macroeconomy is manipulated to ensure it operates on an EE curve; (b) the extent of any resource-saving and/or pollution-reducing technological progress; (c) the impact on the sustainable net benefits of economic activity, not just the impact on real output; and (d) whether a nation is initially operating at an optimal macroeconomic scale—i.e., a physical scale that maximizes a nation's sustainable net benefits. While the extended IS–LM–EE model is used in this paper is also far from complete (e.g., the model assumes a macroeconomy that is closed to international transactions), it does not alter the fact that environmental concerns should not remain the exclusive domain of microeconomic analysis. They should also be incorporated into macroeconomic models, thereby opening the door to a whole new branch of macroeconomics.

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On the implications of technological innovation for environmental policy

IAN W.H. PARRY

In recent years economists have examined how environmental policies might affect the incentives for firms to invent and adopt cleaner production technologies that reduce the future costs of pollution control. The link between environmental policy and technological innovation raises a number of important policy questions. First, how does the impact on technological innovation affect the overall net benefits to society from environmental policies? Second, how does the role of innovation affect the appropriate choice among different types of policy instruments that can be used to limit emissions, such as tradable emissions rights and pollution taxes? Third, what are the implications for the appropriate stringency of environmental regulations? Fourth, should environmental policies be supplemented by other policies targeted directly at promoting more innovation, such as research subsidies or clean technology prizes?

This paper provides a discussion of these policy issues by pulling together the results from a number of recent papers. We begin by sketching out how the traditional analysis of pollution control might be extended to incorporate the impact of technological innovation, and to what extent the overall net benefits to society from pollution control policies might increase when the gains from induced innovation are taken into account.

The paper then discusses how different emission control instruments, including emissions taxes, auctioned emissions permits, and grandfathered emissions permits, provide incentives for innovation. Whether the economic performance of these instruments differs or not for practical purposes depends on several factors, including the ability of innovators to appropriate the spillover benefits to other firms of new technologies, and the amount of innovation that might occur during the period over which policy is set.

We then discuss the optimal stringency of environmental regulation. Even though the net economic benefits from pollution control policies can be greater when we allow for their impact on inducing innovation, this does not necessarily justify tightening pollution control regulations. Moreover, a more direct way to increase innovation would be to buttress environmental policies with additional research supplements. We discuss some strengths and weaknesses of alternative policies for doing this, including research subsidies, technology prizes, and relying on the patent system. The case for relying on the patent system is stronger if the government is poorly informed about the potential costs and benefits to society of research projects; but in cases where the patent system is

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ineffective at preventing other firms from imitating new technologies, subsidies and prizes might be a useful complement to pollution limitations. The final sections of the paper discuss some important qualifications to the discussion and summarize some lessons for the design of environmental policies.

Land tenure and the management of land and trees: the case of customary land tenure areas of Ghana

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As population increases and forestland becomes scarce, shifting cultivation of food crops becomes unsustainable, because of the declining fallow period. As a result, in hilly areas, agroforestry devoted to commercial trees, such as cocoa, has become more profitable than shifting cultivation. We also observe that land tenure institutions in customary land areas have been evolving towards individualized ownership.

We hypothesize that the individualization of the land ownership system arose because work effort for planting trees is rewarded by strong individual land rights under customary land tenure rules. Moreover, the expected increase in land rights after tree planting provides sufficiently strong incentives to plant trees and manage tree fields. Unlike the case of tree planting, however, fallowing of food crop fields does not require labor effort and, hence, tends to weaken land rights. Thus, we hypothesize that stronger land rights at the present period lead to larger proportions of fallow land in the shifting cultivation area.

This study statistically explores the effects of land tenure institutions on land use and management, using household data collected from ten selected villages in cocoa growing areas of Western Ghana. First we demonstrate that to the extent that future land rights are strengthened after tree planning when the land rights are initially weak, the incidence of tree planting tends to be equalized across different land tenure institutions. Second, we test these hypotheses empirically by estimating tree planting, fallow choice, and net revenue functions.

In our sites, various land tenure institutions with different land rights coexist, such as allocated family land, inherited land, appropriated village land, land received as gift and land under tenancy. Our findings show that while there is a tendency for more secure land rights to have a positive effect on tree planting, their effect is not of overwhelming importance. In

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other words, the traditional land tenure institutions are generally not inefficient with respect to the decision to plant trees. However, we have obtained evidence that land allocated by the extended family, which is characterized by weak land rights, is less often left fallow, indicating some inefficiency of land use in shifting cultivation area under the customary land tenure systems. We find that net revenue and labor use in both mature cocoa fields and young cocoa and food crop fields are not significantly affected by land tenure institutions. These results support the hypothesis that management intensity of cocoa fields tends to be equalized, due to the establishment of secure land rights after tree planting, regardless of the manner of land acquisition.

It must be also pointed out that the development of cocoa agroforestry enhances not only the intensity and efficiency of land use from the private point of view but also improves social efficiency as trees grown on sloped fields reduce soil erosion and increase tree biomass. Considering such environmental benefits and private benefits which accrue to poor cocoa farmers, public efforts should be directed towards the promotion of profitable agroforestry systems through research, extension, and improvement of marketing systems.

Excess capacity and sustainable development in Java Sea fisheries

DALE SQUIRES, ISHAK HAJI OMAR, YONGIL JEON, JAMES KIRKLEY, K. KUPERAN, and INDAH SUSILOWATI

Excess fishing capacity and overfishing, which are global problems, are also major problems in the Java Sea. Using quantitative methods developed to support the FAO International Plan of Action for the Management of Fishing Capacity, the paper estimates excess fishing capacity in the Indonesian purse seine, mini purse seine, and longline fisheries of the Java Sea. The paper also estimates the number of vessels to decommission to reduce the excess capacity. The paper then discusses the role of license limitation programs, which limit the number of vessels in a fishery, and issues that arise in implementation of such programs. The quantitative methods and fishery management issues discussed can help other nations meet their commitments to the FAO International Plan of Action.

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Community natural resource management: the case of woodlots in Northern Ethiopia

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Common property resources (resources owned and managed by a given community) are important sources of timber, fuel wood, and grazing land in developing countries. However, unrestricted access by community members or ineffective use regulations result in overexploitation of the resources. Alternative solutions to the problem of overexploitation of these resources have been proposed, including privatization, state regulation, and community collective action. Community resource management institutions and organizations to enforce them are now receiving greater attention as a viable alternative to privatization and state regulation. However there is inadequate evidence on the determinants of collection action and its effectiveness in managing common property resources in developing countries.

This paper evaluates the nature of community management of woodlots and identifies the determinants of collective action and its effectiveness in managing woodlots, based on a survey of 100 villages in the northern Ethiopian region of Tigray. Results are based on analysis of descriptive information to investigate the nature of community resource management, and on econometric analysis to identify the determinants of collective action and its effectiveness.

We find that, although current benefits received by community members are limited, the woodlots contributed substantially to community wealth. Benefits from woodlots and average intensity of woodlot management are higher and problems of management less on woodlots managed at the village level than those managed at the higher municipality level. However, the level of woodlot management was not an important determinant of collective action or its effectiveness after controlling for other factors. The significant variables that explain collective action or its effectiveness include population density, proximity to markets, and intervention by external organizations.

The community labor contribution for woodlot management increases with an increase in population density up to a certain level after which it starts to decline, suggesting that there is an inverted U-shaped relationship between collective action and population density. This result indicates that land scarcity relative to labor encourages collective action up to an intermediate population density level, while there is the negative effect of incentive problems when population grows to a higher level. Market access detracts from collective action suggesting that higher opportunity cost of labor and/or increased exit options undermine collective resource management. Despite the prevalent role of external organizations in initi-

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ating the establishment of community woodlots, external organizations reduced local effort to protect woodlots and tree survival, suggesting that the role of external organizations needs to be demand driven and complementary to local effort.

The development impact of genetic use restriction technologies: a forecast based on the hybrid crop experience

TIMO GOESCHL and TIMOTHY SWANSON

Advances in biotechnology have made available gene-manipulation techniques that enable the protection of genetic material from unauthorized use and the prevention of self-supply of commercial seeds by farmers. These developments allow the providers of improved crops to capture a greater share of the benefits created through their innovations. These techniques have become knows as 'Genetic Use Restriction Technologies (GURTs)', but are more widely known under the epithet 'terminator genes'.

This paper forecasts the potential impact of widespread adoption of GURTs by the providers of high-yielding varieties of seeds on yield growth in developing countries. To do so, it assesses two effects of these new technologies. The first is the extent to which capturing a greater share of the benefits resulting from their innovation will stimulate industry to invest more in research and development. This effect will drive yield growth in the most technologically advanced countries with ready access to these innovations. The second is the extent to which the technological protection of value-adding traits afforded through GURTS will impact on the speed at which yield gains will diffuse from the most-advanced agricultures to those of developing countries. These two effects together will determine the overall impact of GURTs on yield development in developing countries.

These forecasts are based on a particular hypothesis, which is that GURTs will replicate across most staple crops the experiences that were made with a previous use-restriction technology (hybridization) in only a few crops. The estimation of impacts is carried out as a simulation and is based on parameters estimated for hybrid seeds over a 38-year period. The results show that, ultimately, all countries will gain from a widespread adoption of GURTs because of the stimulation of R&D. For most developing countries, however, the point in time at which these gains begin to materialize is far into the future, for some probably in excess of 40 years.

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The paper also illustrates that the impact of GURTs on developing countries' yields will vary considerably. Specifically, those countries that currently have the lowest yields would be most adversely affected in their future yield development by the widespread use of GURTs.

Monopolization and the regulation of genetically modified crops: an economic model

ALISTAIR MUNRO

Alongside many other potential risks, both scientific and social, the introduction of genetically modified organisms (GMOs) into the market place has brought with it conjectures about the possibility of monopolization in food supply. Recent, rapid increases in concentration in the global agrotechnology industry have added to these fears. The aim of this paper is to clarify the conditions under which transgenic food technology is likely to lead to lower consumer welfare because of monopolization. The paper stresses the fact that monopolization in itself is not a cause of welfare loss, since the usual route to monopoly control for a new technology is via greater efficiency compared to the existing technology. Instead, the risks of welfare loss arise through the possibility of greater variability in output and through the possibility of predation. The likelihood of greater variability in output is unclear given historical precedents and given that reasons for the adoption of GM technologies by farmers include the desire to reduce output variability. Predation occurs when the GM producer initially sets the prices of its products deliberately low in order to clear non-GM crops from the market, then subsequently raises prices in order the reap the benefits of its monopoly power. Predation may not be profitable for the GM producer. However, the paper shows that predation is most likely to be a threat to welfare when: (1) there is only one GM producer; (2) the cost advantage of its product over traditional varieties is not large; (3) there is pre-existing uniformity in the varieties being grown; (4) the monopoly price of the crop is high relative to the competitive value; (5) there is an absence of publicly supported *in situ* and *ex situ* conservation; (6) total storage costs are high; and (7) farmers have high discount rates for future income, possibly because of poorly functioning capital markets. Many of these risk factors are likely to be higher for tropical crops grown in developing countries than for temperate crops grown in richer nations. Public policies to counter the threat of predation include: (1) subsidies to storage or investment in public storage systems, either *ex situ* or *in situ*; (2) greater punishment for firms engaging in predatory pricing; (3) structural

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changes to the seed industry, such as breaking up the leading suppliers of GM products; and (4) the introduction of greater competition amongst GM technologies. The last of these options is likely to be highly controversial since it would involve either weakening patent laws or relaxing the regulations governing the introduction of new GM crop varieties.

Potential economic impacts of terminator technologies: policy implications for developing countries

C.S. SRINIVASAN and COLIN THIRTLE

Terminator technology prevents farmers from saving and reusing seed by incorporating a gene that causes sterility. Understandably, it has been seen as an unethical or immoral technology that threatens the livelihood of millions of farmers, especially resource-poor farmers in developing countries. However, from the seed companies' viewpoint, the fact that farmers save and replant seed (and sell seed to each other), only buying new varieties from the seed company ever five to seven years, is a serious disincentive to investing in R&D. For open- or self-pollinating crops, the companies' revenues are only about 20 per cent of what they would be if seed were purchased every year, as it is for hybrid crops like maize. Although intellectual property rights legislation and patents have increasingly circumscribed the use of farm-saved seed, they offer expensive and imperfect solutions. The cost of IPR litigation runs into millions of dollars each year. It is against this background that terminator technology can be seen as a technological solution to the problem of appropriating the returns to R&D investments. In the context of changes in PVP laws that circumscribe the use of farm-saved seed and the contractual arrangements, which have come into vogue for transgenic varieties, the terminator technology represents only a better technique of enforcement of IPRs, rather than a change of principle governing what is legitimately appropriable. The technology has emerged because the existing institutional mechanisms for enforcement are inadequate, expensive to use, and imperfect. It promises to drastically reduce the transaction costs for enforcement of IPRs.

This study presents a model, which shows that the technology producers' revenues from open-pollinating varieties are less than 30 per cent of what they are for hybrids, where seeds are bought each year. Estimates confirm that private investment is dependent on the strength of intellectual property right protection. As a result of the lower level of

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appropriability, private seed companies invest far less in open-pollinating crops. Comparisons of open-pollinating crops and hybrids suggest that investment in hybrids is two to three times higher (per unit of value). As a result of the higher R&D intensity, new technologies increase yields (output per unit of land) more rapidly for hybrids. The terminator gene would bring open-pollinating varieties into line with F1 hybrids, for which seed cannot be saved and the increased investment should raise yield increases to levels similar to those for hybrid crops.

Thus, in the current situation, where public funding for agricultural R&D is hard to sustain, there are clear benefits to securing greater private sector participation. However, the potential gains must be set against the possible ecological and environmental costs. It is also clear that any redistributing from poor farmers to the seed companies is regressive. However, the seed market is becoming increasingly concentrated and the international agricultural research centres and national public sector institutions may have difficulty in providing viable alternatives to the private sector varieties. If the private sector does opt for the terminator technology in the future, there may be high avoidance costs, so this study considers the policy changes that would be needed in developing countries to succeed in using private sector technologies that may incorporate terminator technology.