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Summaries

Economic development, demographics, and renewable resources: a dynamical systems approach

JOHN M. ANDERIES

Conventional wisdom suggests that via technological and demographic adjustment processes an economy will develop through four stages: (1) a low, stable population, high birth and high death rates, and low intensity resource utilization, (2) rapidly increasing population, high birth and low death rates, industrialization, and rapidly intensifying resource use, (3) improved standard of living and technological change accompanied by value shifts that reduce birth rates and reduce resource use intensity (improves environmental quality), (4) stable population with both low birth and death rates and a high quality of life evidenced by high incomes, high environmental quality, and low intensity resource use.

Because this process (or portions of it) has been observed in the past, it is tempting to assume that it will be observed again in developing countries. This leads to the basic policy prescription of encouraging growth, as it will lead to a cleaner environment and reduced population growth. This tacitly assumes that technological and demographic adjustments come at the right time and that there are no strong non-linear effects that could rapidly reduce the productivity of the resource base. It is also tacitly assumed that technological change will relieve pressure on the resource base and buy time for the demographic transition to occur. None of these, in general, need be the case. This raises the two questions addressed in this paper: (1) Under what conditions is a developing economy more or less prone to population overshoot and resource collapse? and (2) Under what conditions can demographic and technological adjustments prevent overshoot and collapse?

To address these questions, I develop a mathematical model that incorporates three main drivers: human population dynamics, renewable resource dynamics, and economic development. The model is kept as simple and general as possible. Using a combination of powerful numerical bifurcation techniques and rescaling arguments, I obtain very general and robust results. This analysis constitutes what I have called 'a dynamical systems approach' in the title.

The key results are as follows. Economic growth and productivity enhancing technological change are fundamentally destabilizing processes that favor overshoot and collapse dynamics. These processes become destabilizing when their dynamics are fast relative to the regeneration rate of the renewable resource base. Overshoot and collapse can be prevented by feedback between increasing *per capita* consumption and decreasing birth rates (the fertility transition). However, the higher the savings rate, the stronger this feedback must be. Finally, in the absence of a global feedback to individual decisions (e.g. agents make fertility decisions based on global variables such as world population rather than on *per capita* quantities such as the cost of raising children), the qualitative behavior of the model is independent of technology that reduces the impact of renewable resource production on the environment. Such technology serves only to scale the magnitude of the overshoot and collapse or the size of the long-run sustainable population if overshoot is avoided.

Taken together, these results suggest that economic growth and technological change actually increase, rather than decrease, the importance and urgency of the role of demographic factors in preventing renewable resource degradation. In terms of development policy, the model suggests that the rate of growth of the capacity of the population to exploit the resource base should be calibrated to the regeneration rate of the resource base. Actively addressing social processes that influence the strength of the linkage between *per capita* consumption, birth rates, and investment patterns must happen either *before* or *more rapidly than* economic growth and technological change are promoted if eventual population overshoot and resource degradation are to be avoided.

Flexibility mechanisms and credit discounting

SUNGWHEE SHIN and SANG-CHUL SUH

Climate change is one of the major issues in discussions about the global environment. Since the year 1992 when the UN Framework Convention on climate Change was adopted, several milestones in the climate negotiations were established. The Kyoto Protocol was adopted in December 1997 to establish a legally binding target for developed countries. At the Conference of the Parties (COP) 4th session (Buenos Aires, November 1998), the Parties adopted the so-called 'Buenos Aires Plan of Action', setting out a program of work both to advance the implementation of the Convention and to flesh out the operational details of the Kyoto Protocol. Despite the US' withdrawal from the Kyoto Protocol in March 2001, the

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Parties succeeded in adopting the Bonn Agreements on the Implementation of the Buenos Aires Plan of Action at the COP 6 part II (Bonn, July 2001), registering political agreement on key issues under the Buenos Aires Plan of Action. At the COP 7 (Marrakesh, November 2001), the legal text called the Marrakesh Accord was adopted to make the Protocol ready for ratification based on the Bonn Agreement.

In this paper, we model the international climate negotiations with a game-theoretic framework. In the usual cooperative game perspective, the non-agreement situation is regarded as a Nash equilibrium of a non-cooperative game and an international treaty as a Pareto optimum outcome resulting from a cooperative game. However, we consider the climate negotiations as a non-cooperative game where each country chooses its amount of abatement. The outcome of negotiations can be regarded as a self-enforcing agreement. And the self-enforcing agreement is one of the interpretations of the concept of Nash equilibrium. Therefore, we use the Nash equilibrium as a solution concept. On the other hand, since the effect of the abatements are realized in the remote future while the actions are taken at present, the situation is essentially static. Thus we model the climate negotiations as a one-shot game.

We interpret the UN Framework Convention on Climate Change as a Nash equilibrium outcome of an international abatement game where only domestic abatement is allowed. In the equilibrium, due to the positive externality of abatement activity, the abatement level is short of the optimal level (proposition 1). The Kyoto Protocol is interpreted as a Nash equilibrium outcome of a game where flexibility mechanisms are introduced. The abatement through flexibility mechanisms should be supplemental to domestic abatement. This is called the supplementarity condition. Using the flexibility mechanisms, each country can reduce the costs by performing abatement activities in other countries where the abatement cost is lower. As the abatement cost becomes lower, the abatement level becomes larger and the welfare level of each country improves in comparison to that under the UNFCCC (proposition 2).

Many developing countries have difficulties in adapting to climate change and implementing policies geared to GHG emissions reduction. They have requested financial assistance and technology transfer. In the recent Bonn Agreement, it was determined that 2 per cent of the certified emission reductions issued for a clean development mechanism project activity would be used to assist developing country Parties that are vulnerable to the adverse effects of climate change to meet the costs of adaptation. This is a tax on the clean development mechanism project activities. This has the effect of raising the cost of the foreign abatement and reducing the amount of abatement.

We propose the introduction of credit discounting on foreign abatement. This has the effect of increasing the amount of abatements and the level of welfare. We think that the issue of financial assistance needs to be addressed in the form of a separate fund independent of the flexibility mechanisms.

The introduction of credit discounting on foreign abatement improves efficiency. It has the effect of increasing the amount of the required abate-

ment. It also has the effect of relaxing the supplementarity condition by implicitly allowing the foreign abatement to increase. Through these two effects, when the discount factor is close to 1, the credit discounting can improve the welfare of participating countries (proposition 3). Moreover, in some cases, as was shown in the numerical example, credit discounting can be more effective than the simple removal of the supplementarity condition in improving efficiency.

Our analysis also implies the limited ability of international agreements such as the UN Framework Convention on Climate Change and the Kyoto Protocol to prevent climate change. They may seem to be intended to be mechanisms of international environmental regulation, but, in fact, they just serve as a communication device that helps participating countries to find a laissez-faire equilibrium.

Getting incentives right?: a comparative analysis of policy instruments for livestock waste pollution abatement in Yucatán, Mexico

ADAM G. DRUCKER and UWE LATACZ-LOHMANN

This research builds on the extensive theoretical and empirical work that suggests that under certain circumstances the use of economic instruments, as opposed to command-and-control (CAC) instruments, applied to farm waste management issues can result in significantly lower compliance costs for any given level of environmental quality.

The pig farm sector of Yucatán, Mexico, and its potential compliance with the recently promulgated Mexican environmental legislation are analysed through the construction and use of farm-level environmental economic linear programming models, capable of identifying optimal abatement strategies for different farm sizes under various policy scenarios. Four different representative farm size LP models, five different policy scenarios and five treatment/abatement strategies are considered. The models draw upon the literature regarding the modelling of farm waste management in the context of environmental regulation, and primary and secondary data regarding the characteristics of the Yucatec pig sector, geohydrological, agronomic and regulatory framework conditions.

Serious shortcomings associated with the recently introduced CAC legislation, which establishes stringent concentration-based standards for discharges, are identified. It is shown that it will be extremely difficult and

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expensive to comply with (cost: US$41.8 million per annum). An alternative mass-based CAC approach, which instead regulates nitrogen applications to land, has compliance costs of US$3.5–US$9.4 million per annum. This cost saving is attributable to additional abatement procedures being permitted, in this case land applications of slurry rather than only treatment *per se*. An environmentally equivalent economic instrument approach results in additional cost savings of 22–25 per cent as a result of exploiting the non-homogenous abatement costs between farm sizes.

It is concluded that the new CAC legislation should be abandoned, as it will be neither environmentally effective not economically efficient. Under the alternative CAC approach considered, the most cost-effective level of abatement is achieved at the 600 kgs of nitrogen (N)/ha per annum application level. This results in a compliance cost of US$5.0 million per annum. However, a leaching charge – applied to land applications – of US$4/kg of N estimated to have been lost would achieve similar environmental quality for only US$3.9 million per annum. The leaching charge has the added advantage of generating US$4.2 million per annum in tax for financing any increased administrative costs, as well as for improving enforcement capabilities. Improved enforcement needs to be combined with fine levels up to 17 times higher than at present, if these are to provide an economic incentive for compliance for some of the larger firms. Finally, it is interesting to note that Yucatec pig farms are currently making sub-optimal use of their wastes, costing the sector US$15.6 million in net revenues forgone from treatment and by-product use/sale. As farm gross margin would, with optimal waste management, still be higher under both the alternative CAC and economic instrument approaches than at present, their political acceptability is increased.

A CGE framework to evaluate policy options for reducing air pollution emissions in Chile

RAÚL O´RYAN, SEBASTIAN MILLER, and CARLOS J. DE MIGUEL

In the past decade Chile has had the highest economic growth rate in Latin America. This has brought many benefits, such as reduction of absolute poverty, increase in consumption and overall income. Additionally, air quality in Santiago – with 40 per cent of Chile's population – has also improved in the period, despite a doubling of economic activity. Nevertheless there are still health problems each winter due to high levels of air pollution, and a significant 50 per cent reduction in emissions is being proposed. Additionally other cities are in non-compliance and it is expected that measures will soon be taken. Industry is complaining that

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costs are high and economic activity and employment will be negatively affected. The government has not evaluated these impacts and finds it difficult to obtain support for the measures, in particular with the current slowdown in economic activity.

This paper evaluates the macroeconomic, environmental, sectoral, and distributive impacts of improving air quality in Chile. A systematic approach to evaluating these impacts is presented and applied. Specifically a computable general equilibrium model is used to evaluate the impact of a 10 per cent and a 50 per cent reduction in PM-10 emissions using both a tax on emissions and a tax on fossil fuels.

Macroeconomic impacts on GDP, consumption, investment, and trade of a 10 per cent reduction are not significant. However a 50 per cent reduction imposes an important 1.5 per cent fall in GNP. Winners and losers are identified: sectors that produce cleaner energies are the most favored, while the oil industry and transport sector are the most negatively affected. This impact is relatively asymmetric: loser sectors lose more (in percentage terms) than winner sectors gain. With a 50 per cent reduction loser sectors see the value of their output fall more than 50 per cent.

The instrument used matters, since a tax on emissions is substantially less costly to the losing sectors than the tax on fuels. Additionally, alternative compensation mechanisms – reduction in corporate taxes and VAT – have been evaluated to maintain government savings. It is shown that this affects the distributive impact of the policies.

In conclusion, the use of a general equilibrium framework suggests that for a small reduction the government need not be concerned about the aggregate impact of environmental policies. However for reductions similar to those currently required in major cities the impact will be significant, suggesting that a slow phase-in of reductions is required. Additionally complementary instruments can be designed that would allow reducing the distributive impacts.

Environmental costs and their impact on the net present value of a hydro-electric project in Kerala, India

V. SANTHAKUMAR and ACHIN CHAKRABORTY

This paper makes an attempt to incorporate the environmental losses into the cost–benefit analysis of a hydro-electric project in Kerala, India. This project if implemented would lead to the submergence of 2,800 hectares of tropical forests, and the dislocation of about 200 forest dependent families. The major

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environmental losses are due to the destruction of forests. These losses are the benefits to be forgone on account of non-timber forest products, carbon sequestration, wildlife habitat, bio-diversity, and so on. This forest is also used extensively for extracting reed – a raw material used by traditional artisans and newspaper industry. We have identified all such potential losses, made approximate estimates of some of them based on market prices, preventive expenditures, and estimates made by other researchers in similar contexts elsewhere. Thus the value of non-timber forest products such as honey and fuel wood is estimated using market prices, loss of reed by estimating the value addition in traditional and modern industries, and benefits on account of carbon sequestration and biodiversity by using some global estimates made by other researchers. We have also discussed other potential environmental gains and losses associated with this dam project, and elaborated the reasons of neglecting them in this cost–benefit analysis.

However, it was clear that we will not be able to account for all the use and non-use values of the environment in this analysis. Thus we have reckoned the net benefits of the project after taking into account the estimated environmental costs as the opportunity cost that society has to bear if it decides not to construct the project on account of the non-estimated values of environment. It was felt that this opportunity cost gives a more direct indicator of the social trade-off involved in the decision on the project, and this indicator can be an input into the public debate and political and administrative decisions.

The benefit of power production from the project is taken here as the social cost (i.e., direct plus environmental costs) of the alternative method of power production. In this case, such alternative project is taken to be a thermal project, and, since the estimation of the social cost of thermal power is beyond the scope of this study, we have done a sensitivity analysis of the net benefits of the hydroelectric project under different hypothetical costs of thermal power. This showed that the social trade-off involved in this project crucially depends on the social cost of the alternative energy. Similarly we have also carried out a sensitivity analysis of the different discount rates on the cost–benefit estimates of the project. It was found that reducing discount rates with environmental considerations would only enhance attractiveness of this hydroelectric project. The analysis has also compared the compensatory forest project designed by the planners of this hydroelectric scheme with the estimated environmental losses on account of forest loss.

Though limited in its scope, we feel that this exercise provides insights on the operational procedures that are involved in the environmental cost–benefit analysis of a concrete project in a developing country, where adequate data and resources, needed for the detailed valuation of each environmental loss associated with the project, are normally not available.

On the use of cost–benefit analysis for the evaluation of farm household investments in natural resource conservation

HANS HOOGEVEEN and REMCO OOSTENDORP

Farm households in developing countries are generally credit constrained. This inability to borrow forces them to simultaneously take production, consumption, and investment decisions, and implies (in the absence of savings) that any investment goes at the expense of current consumption.

Starting from this observation it is argued that even when the net present value of an investment project increases, farmers without access to credit may be *less likely* to adopt. Farmers with access to credit, however, will be more likely to adopt (as expected). The reason behind this phenomenon is that higher future prices for agricultural produce or land *may increase the discount rate* of farmers who cannot borrow. As a result the investment becomes less attractive. This phenomenon may lead to perverse investment reactions with increased price incentives.

As the paper shows that an increase in the net present value for a conservation project is no indisputable indication of whether a farm household will be more likely to adopt such a project, it follows that in situations of imperfect credit markets, cost–benefit evaluations of soil conservation measures yield insufficient information on their attractiveness for adoption by farmers. Only if a well-functioning credit market is present are unambiguous results generated. Unfortunately such a situation is the exception rather than the rule, especially in developing countries.

The paper deals with two extreme situations: no credit markets and perfect ones. Both situations are unlikely to exist in a real world situation, which is probably best characterized by a situation of *restricted* credit markets. But also in this situation, the derived results remain valid. When farm households can borrow money, they fall under the perfect credit market regime; when they are restricted under the no market one. This means that the chances of a perverse investment response are reduced, but not eliminated.

Whether or not such responses occur is an empirical matter. Their likelihood will be decreased when increases in land or agricultural output prices are accompanied by the provision of access to credit. An empirical case study from Bénin finds evidence for the existence of perverse investment responses to price increases. It calls for care in the interpretation of cost–benefit results that have been obtained for households with limited access to credit (e.g. the poor) or in environments where credit markets are malfunctioning.

A policy implication of our result is that the likelihood of a positive conservation response to increased prices is increased when higher land or

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agricultural output prices are accompanied by the provision of access to credit. It follows that in addition to well-known policies that could lead to enhancing investment in soil conservation—varying from increases in the demand for land to the abolishment of price controls on agricultural produce—the introduction of credit markets should be considered. Especially if one intends to induce the poor to invest in soil conservation, introducing credit markets is an important consideration.

Transferring the benefits of avoided health effects from water pollution between Portugal and Costa Rica

DAVID N. BARTON and SUSANA MOURATO

Transferring estimates of the economic benefits of environmental improvements from developed to developing countries is a common practice in benefit–cost analyses by international development agencies. Very few studies have been conducted on the reliability of transferring estimates of health effect benefits, and to our knowledge this is the first study between a so-called developed and developing country. This paper compares willingness to pay (WTP) of beach visitors to avoid three different illness symptoms due to polluted bathing water in Costa Rica and Portugal.

Results of the contingent valuation surveys show consistent, but diverging valuation of health effects. Portuguese and Costa Ricans consistently valued gastroenteritis more highly than eye irritation and coughing, in that order. However, the sign and significance of explanatory variables are consistently different across country samples for the different models of WTP to avoid symptoms.

The sources of divergence between WTP to avoid illness symptoms in Costa Rica and Portugal were difficult to control for, even under conditions favourable to testing benefit transfer. Differences in survey implementation on the ground, unexpected differences in population characteristics, and problems with statistical treatment of WTP responses, while reported here, are not always available in the published valuation literature. This study points out some of the problems in not having, or ignoring, such study design and estimation issues when conducting non-experimental benefit transfer.

Nearly all our tests reject the hypotheses of equality of unconditional and conditional mean WTP across country samples. The hypothesis of the WTP function parametres being drawn from the same overall population is also rejected. Surprisingly, access to more site-specific information (e.g. through a census) did not reduce transfer error in our study, contrary to

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popular intuition. WTP estimates transferred from Portugal to Costa Rica were generally between 87 and 130 per cent higher for the different models: e.g., about 99.7 per cent for unadjusted parametric mean WTP, 119.9 per cent for simple income-adjusted WTP, and 129.4 per cent for WTP conditional on a function of demographic explanatory variables. A simple adjustment by GNP/capita drastically reduced transfer error to around 5.5 per cent. However, unless samples are nationally representative, this rather common type of adjustment to valuation estimates is deemed haphazard and low benefit transfer errors are coincidental. A comparison of our results with benefit transfer reliability between five EU countries in a recent study (EC, 1999), show that transfer errors from Portugal to Costa Rica are about twice as high as average transfer errors between EU countries.

Whether transfer errors are unacceptable in a policy context must be determined on a case by case basis by the decision maker in question. Transfer errors observed here are typically smaller than those observed for epidemiological risk functions. Our results would indicate that the transfer of benefits for pollution-related health effects between countries such as Portugal and Costa Rica is still quite 'unhealthy' for policy decision making. However, survey-based valuation studies in developing countries are relatively cheap and estimates of the value of health end-points in developed countries still quite scarce. In light of large transfer errors found in this study, we therefore think efforts to obtain primary valuation estimates at the policy site in the developing country may be well spent, provided basic validity criteria for CV studies are met. The trade-offs between good experimental versus policy-applied study designs, and between primary study validity and benefit transfer reliability, is a common dilemma in the benefit transfer literature, and one well illustrated by our results.

Valuing marine parks in a developing country: a case study of the Seychelles

LAURENCE F. MATHIEU, IAN H. LANGFORD, and WENDY KENYON

Developing countries often face the problem of managing important natural resources, which provide benefits in the form of tourist income, but incur maintenance cost. This study examines the case of Marine National Parks (MNPs) in Seychelles where, at the time of the study, maintenance

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costs exceeded income from tourists visiting the parks. The contingent valuation method was used to elicit stated preferences, in terms of willingness to pay amounts, for paying an entrance fee to visit an MNP for a sample of 300 tourists visiting Seychelles from a range of countries of origin. Rather than simply calculating a mean WTP amount for an 'average' visitor, we investigated how country of origin, visitor expectations and motivations and socio-demographic factors influenced the way respondents constructed their preferences.

We found that overall, the average WTP amount as an entrance fee per person was 61 Rupees, which exceeds the current entrance fee of 50 Rupees. However, there were significant differences in the WTP amounts which were pledged to different MNPs, suggesting that a uniform pricing policy would not be the most economically efficient way of generating increased revenue for the parks, but that different entrance fees should be charged. We note that relatively low WTP value pledged for entering an MNP compared to other studies may due to the high travel costs experienced by visitors, even after travelling to Seychelles, as the MNPs are not located close to tourist centres.

A number of factors predicted higher or lower WTP amounts, including the motivations expressed by respondents for protecting marine resources, the expectations and reasons for visiting Seychelles expressed by respondents, and the activities they undertook whilst on holiday. However, country of origin proved to be a highly significant factor in predicting stated WTP, even after accounting for differences in income between respondents, which was partly explained by the different motivations and expectations of visitors from different countries of origin. For example, visitors from Yugoslavia were likely to refuse to pay an entrance fee in principle, believing that the Government of Seychelles should fund maintenance of the MNPs. Yugoslavians were also more likely to be motivated by protecting MNPs for the sake of visitors, and be interested in the good weather found in the Seychelles. In contrast, visitors from the UK were interested in good weather, but also unspectacular scenery, and were more likely to be motivated by protecting marine parks to make them available to future generations and pledged significantly higher WTP amounts.

We conclude that respondents are showing a mixture of consumer and citizen preferences in their stated WTP amounts for protecting MNPs in the Seychelles. Consumer preferences are linked to direct use of the MNPs for their own benefit, whilst citizen preferences include motivations such as protecting resources from destruction for the sake of future generations and biodiversity. Further, the combination of citizen–consumer attitudes expressed by respondents is partly determined by county of origin, potentially reflecting different cultural and social norms.

Hedonic pricing in Windhoek townships

MICHAEL NOKOKURE HUMAVINDU and JESPER STAGE

In property markets in developed nations, attractive or unattractive attributes of the traded properties affect the sales prices of the properties. This is true not only for structural attributes of the properties, such as the number of rooms in the house or the quality of the building materials used. Location-specific attributes such as the distance to the city centre, and environmental quality factors such as a pleasant view or a high level of traffic noise, frequently have an impact on property prices as well. This forms the basis for the hedonic pricing method, which can be used for policy evaluation because it provides an idea of the value which, for example, maintaining a beautiful wilderness area or a low level of traffic noise will provide to people living nearby.

This study applies the hedonic pricing method to the township areas in Windhoek, the capital city of Namibia, where municipal authorities have pursued a programme of selling plots of land to settlers in order to encourage them into a formalized economic situation. We find that in the same fashion as for more affluent neighbourhoods in developed countries, attractive and unattractive attributes of the properties affect property prices considerably. The quality of the sold house, the distance to the city centre, the distance to the nearest major market and the distance to the nearest taxi pickup point all affect prices. Environmental quality also appears to have a large impact on property prices: properties located close to a garbage dump sell at considerable discounts compared to other properties, while properties located close to the Goreangab conservation and recreation area rate premium prices.

The hedonic pricing method provides a useful tool for evaluation of urban planning policies, and our results thus indicate that town planning for the more or less informal settlements in developing country cities could benefit considerably from keeping track of property sales, in the way that municipal authorities in Windhoek have done. Moreover, issues of environmental quality have frequently been neglected in what little town planning does take place for such settlements in most cities. The results from Windhoek – where inhabitants in poor neighbourhoods clearly attach considerable importance to such issues – indicate that this is a serious omission.

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