Environment and Development Economics 12: 351–357 © 2007 Cambridge University Press
doi:10.1017/S1355770X07003555 Printed in the United Kingdom

Summaries

Energy system change and external effects in climate change mitigation

DENNIS ANDERSON and SARAH WINNE

There are many studies of the engineering and economic feasibility of a low carbon energy system being achieved over the present century. The many studies of industry, governments and scholars point to scenarios of global carbon emissions from energy use in the range from ≤ 0 to 60 gigatons per year by 2100, as compared with approximately 6 gigatons per year today. Such extraordinary divergences stem from the types of the energy systems assumed for the scenarios, and on the various economic factors and policies that determine the directions of technology development and choice.

This analysis seeks to show how the process of technological innovation may be simulated using a simple non-linear model with complex dynamics. It shows that the process of technological development and switch is exceptionally sensitive to both the initial conditions, which include the stimulus provided by policy in the early phases, and to the underlying parameters. Because the processes of innovation and technological substitution are cumulative, dynamic, and highly non-linear, it is possible on the one hand for innovations, even those holding much promise, to fail completely if a policy is too tentative or reversed too early. On the other hand, if the process takes root, innovations can bring about transformations with benefits out of all proportion to the costs of providing the initial stimulus. It is also shown that dynamic models of energy system change offer a novel perspective on national and international environmental policies and their social and environmental impact.

The model results reveal that policies may have a larger than expected influence on the rate of innovation and the uptake of carbon-neutral alternatives. It is also possible that the option value of policies to support innovation would be greatly amplified by the existence of tipping points or threshold effects in technological innovation. If the effects of a policy take root, the overall social benefits – the sum of the positive externalities of innovation, and the negative externalities of pollution avoided – may be out of all proportion to the strength and duration of the initial impetus. But the effects of the policy will only take root if the policy signal is sufficiently

strong and the policy is sufficiently durable. Otherwise, and depending on the underlying parameters, the dynamic process may spiral inwards, no matter how promising the technological alternatives might be, and lead to nothing.

Economic integration, environmental harmonization and firm relocation

EDWARD B. BARBIER and PATRIK T. HULTBERG

The paper explores how economic integration, combined with environmental policy 'harmonization', may affect the plant location decisions of competing firms. There is currently disagreement as to whether or not the failure of two or more integrating regions to 'harmonize' their environmental standards will actually lead to the relocation of 'dirty' industries to 'pollution havens' in the region that has the less stringent environmental policies. Our paper's contribution to this debate is that we show that environmental harmonization and economic integration do matter to the incentives for an industry to relocate plants abroad. However, what appears to matter *per se* is not the imposition of stricter unilateral regulations and standards in the domestic economy, but whether the difference in environmental policies between the domestic economy and a foreign country with which it is integrating translates into greater *relative* difference in the environmental costs of production in the two countries.

We illustrate this outcome through the standard modeling framework for analyzing economic integration, consisting of a world with two countries (or regions), with one firm in each country (region). We employ this model to analyze three economic integration scenarios: bilateral trade agreements, partial economic integration, and full integration, including complete 'harmonization' of environmental policy across the two regions. Through numerical simulation, we apply the model to two policy contexts: (i) greater economic integration between the United States and Mexico under NAFTA, and (ii) enlargement of the European Union to include Central and Eastern European countries (CEEC).

In the case of NAFTA, a bilateral trade agreement causes US firms to relocate to Mexico as export (tariff) costs decline and the countries grow. This outcome is magnified if partial economic integration were to take place; lower export costs combined with foreign investment encouragement further induce US firms to leave America. However, if environmental harmonization is achieved as under full economic integration

https://doi.org/10.1017/S1355770X07003555 Published online by Cambridge University Press

we do not expect to see such firm movement, although American subsidiaries may be established in Mexico. Thus the eventual effect on the location of US firms hinges crucially on the extent of environmental policy harmonization.

Similar results in the NAFTA case of US firms moving to Mexico apply to the case of whether a firm within the European Union should relocate to the CEEC region. However, this is not true in the case of a CEEC firm relocating to existing EU countries. As EU enlargement occurs, a CEEC firm is unlikely to relocate within the present EU borders unless the environmental policies in the CEEC region are brought into line with EU standards. If the goal is to raise production in the CEEC region, then simultaneously lowering tariff barriers and maintaining the relative environmental cost disparity may achieve this. However, if the goal is to improve the European environment, then the opposite policy choices are required, maintaining tariff barriers and harmonizing environmental policies. Achieving both goals concurrently may be difficult.

Climate variability and flexibility in resource access: the case of pastoral mobility in Northern Kenya

NANCY MCCARTHY and MONICA DI GREGORIO

This paper explores the links between climate variability and patterns of herd mobility in northern Kenya, an arid to semi-arid environment subject to high climatic variability and a high probability of droughts. Based on a theoretical model of flexible, 'fuzzy' access rights, we hypothesize that herd mobility will be higher when climate conditions are more favourable across the relevant region within which herds migrate. We also hypothesize that mobility will be greater when there is greater spatial and seasonal variability across the region. In other words, we expect mobility to be lower during a drought year, particularly in areas where poor rainfall is evenly distributed across the region. To undertake the analysis, we use data collected on household-level herd mobility in six different regions of northern Kenya during the drought year of 1991–1992 and the 'normal' rainfall year of 1999–2000. Herds are separated into two types; more mobile herds comprised mostly of adult males and dry females (satellite herds), and less mobile herds comprised mainly of pregnant and newly lactating females, very young animals and sick animals (base herds).

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To proxy rainfall and its distribution, we use information on normalized difference vegetation indices (NDVIs). We construct measures of average NDVI, as well as measures of spatial and seasonal variation in NDVI. Whereas average NDVIs are indeed higher in the non-drought year for all communities, interestingly there is no simple relationship between spatial and seasonal variation and drought vs. non-drought conditions. Results indicate that mobility is indeed greater in the normal vs. drought year. Additionally, satellite herd mobility is greater precisely in those areas where NDVI indicates greater spatial variability, whereas base herd mobility is only affected by seasonal variability.

We also econometrically estimate the determinants of household-level mobility during the normal year of 1999–2000, as data were only complete for that year. Here again, both long- and short-distance mobility are greater in areas with relatively high NDVIs, and long-distance mobility is positively related to spatial heterogeneity. Additionally, results indicate that younger household heads with more large ruminants but with fewer assets are likely to be more mobile. While share-livestock contractual arrangements should enable households with older heads and fewer livestock to benefit from economies of scale of herd mobility, it appears that the costs of monitoring those who actually migrate with the animals currently outweigh the benefits of engaging in such contracts.

Furthermore, our evidence suggests that base camp herd mobility is limited particularly during drought years. Policies to improve tenure security and resource management should first focus on settled areas. Perhaps more interesting in the short term, evidence suggests a potentially valuable use of satellite image information to help target areas where mobility is limited by the distribution of rainfall, e.g. those areas receiving not only generally low rainfall but also where the distribution of that rainfall is spatially homogeneous.

Dynamic household models of forest clearing under distinct land and labor market institutions: can agricultural policies reduce tropical deforestation?

YOSHITO TAKASAKI

This paper develops four agricultural household models of forest clearing – as both an input for current production and an investment in future

https://doi.org/10.1017/S1355770X07003555 Published online by Cambridge University Press

production – over two periods under distinct land and labor market institutions. The first two models in which the farmer sells cleared land address the 'sell-out effect' hypothesis in the literature – accelerating forest clearing by poor colonists in Latin America who are bid off the land by wealthy large holders. The second two models consider the case where the sell-out effect is nil or no land market exists, for example in Sub-Saharan Africa. In each of these two sets of models, a benchmark case with a perfect labor market and a more realistic case with no (or imperfect) labor market are investigated.

The examination of impacts of agricultural price, wage, and land price on farmers' forest clearing decisions reveals the following relationships. First, when well-functioning labor markets eliminate the scarcity of labor, agricultural and non-agricultural subsidizations, respectively, are likely to encourage and discourage forest clearing (*static substitution effect*). The latter pro-forest relationship is stronger among Sub-Saharan African peasants than Latin American colonists as non-agricultural subsidization also results in the augmentation of land prices which promotes forest clearing to sell (*sell-out effect*). Second, when labor markets are imperfect, the prospect for forest protection through agricultural subsidization is greater in Latin America than in Sub-Saharan Africa because its static substitution effects are counteracted not only by its *income effect* – higher demand for consumption and leisure at the expense of forest clearing – but also by its pro-forest sell-out effects as farming becomes more attractive than land selling. Third, among Sub-Saharan African peasants, labor adjustment to smooth consumption over time (*consumption smoothing effect*) counteracts income effects, making agricultural subsidization even less likely to discourage forest clearing. Fourth, when Latin American colonists use soil in a more sustainable manner, subsidizing agriculture and eliminating land price distortions are more likely to discourage land selling and thus forest clearing. In particular, if local land prices are positively affected by agricultural subsidization, sustainable soil management needs to be combined with the elimination of land market distortions for agricultural policies to effectively reduce deforestation.

When wage or land price is sufficiently high relative to output price, Latin American colonists become specialized forest clearers who clear forest just to sell without undertaking farming. It is shown that the elimination of land price distortions is likely to reduce deforestation among forest clearers and this policy, as well as agricultural subsidization and better soil management, encourages them to undertake farming. As forest clearers start farming in a more sustainable manner, subsidizing agriculture and eliminating land price distortions also better mitigate deforestation under this activity shift when labor markets are imperfect.

In conclusion, price transfer and technological transfer for soil management targeting poor colonists, both farmers and forest clearers, and policy reforms eliminating land price distortions are recommended to arrest tropical deforestation in Latin America. On the other hand, policies promoting non-agricultural activities among poor farmers are needed for forest protection, especially in Sub-Saharan Africa.

Beyond the Environmental Kuznets Curve: a comparative study of SO_2 and CO_2 emissions between Japan and China

YUE YAGUCHI, TETSUSHI SONOBE, and KEIJIRO OTSUKA

There is a belief that environmental protection cannot be achieved without sacrificing economic development to a significant extent. This is probably why the majority of developing countries prefer industrial development to environmental protection. There are exceptions, however, among which the post-war high growth era in Japan is a notable example. Japan succeeded in reducing the emissions of sulfur dioxide (SO_2) drastically, while enjoying sustained economic growth from the 1960s to the 1980s. China has experienced rapid economic growth and serious environmental deterioration in the last two decades. The Chinese government, however, did not pay serious attention to its environmental deterioration such as air pollution caused by the SO_2 emissions until recently. As a result, over one hundred thousand Chinese people still suffer from and even die of respiratory diseases annually. Given these contrasts between the two countries, a question arises as to what factors led to the difference in environmental policies between Japan and China in their respective high growth periods.

This study is the first systematic attempt to test statistically the contrasting hypotheses on the emission of SO_2 and CO_2, and energy consumption in Japan and China for the last few decades. We postulate the hypotheses that local governments have incentives to internalize the local external diseconomies caused by SO_2 emissions by reducing SO_2 emission per energy use, but not the energy use and the global external diseconomies caused by CO_2 emissions. To substantiate our hypotheses, we decompose emissions of SO_2 and CO_2 into two factors: the emission factor (i.e. emission per energy use) and energy consumption. The results show that the prefectures in which past energy consumption was high and, hence, air pollution was serious, tend to reduce the emission factor of SO_2 significantly in Japan, while we do not find such a tendency in China. There is also evidence that neither per capita income nor past energy consumption affects the CO_2 emission factor and energy consumption significantly in both Japan and China, implying that an individual country has few incentives to reduce CO_2 emissions. Thus, in order to reduce global warming, concerted international efforts are critically called for.

https://doi.org/10.1017/S1355770X07003555 Published online by Cambridge University Press

Benefits and costs to China of a climate policy

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In future agreements to cut greenhouse gases, a Chinese commitment will probably be essential. Committing for China is easier if the cost is low and the benefit to China is high. We discuss the cost and benefit to China of taking on a climate commitment. In assessing costs and benefits we discuss environmental benefits versus economic costs, while political considerations are left aside. We argue that a climate commitment gives significant environmental benefits to China since a commitment reduces other air pollution problems as well. Comparing benefits to economic costs produces striking results. We find that China may reduce its CO_2-emissions by 17.5 per cent without suffering a welfare loss. Half of the benefit is related to improvements in agricultural yields, a new quantified impact in this type of literature. We also discuss the distributional impact of a climate commitment. In general, the distributional impact is not averse.

https://doi.org/10.1017/S1355770X07003555 Published online by Cambridge University Press