STEG POLICY BRIEF

MODELLING STRUCTURAL TRANSFORMATION WHEN NATURE MATTERS

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STEG STRUCTURAL TRANSFORMATION AND ECONOMIC GROWTH

Modelling Structural Transformation when Nature Matters†

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Contemporary development policy for low-income agrarian nations rests heavily on old structural transformation models that ignore how nature can impact agriculture and other sectors, and vice versa. Direct efforts should be made to incorporate these feedback effects between environmental and economic outcomes into theories of structural transformation. This affects a number of important policy areas. Agricultural R&D policy must increasingly recognise the need for a reorientation towards adaptation in the face of climate change. Incorporating capital and technology into agricultural production becomes increasingly important once we recognise the costs of expanding into virgin land. The value of rural infrastructure policies changes when including the environmental impacts that these investments may have. This policy brief discusses policies and investment strategies incorporating bidirectional linkages with the natural environment that could lead to a green rural transformation.

Modelling structural transformation to date

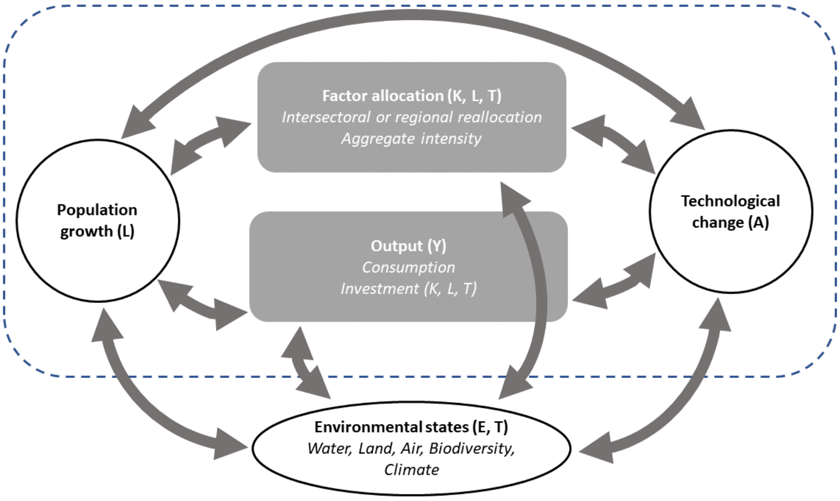
The simplest model of structural transformation has just two sectors, a 'backward' agricultural sector and a 'modern' industrial or capital-intensive one. In this model, income growth arises from exogenous technological change in the industrial sector and population growth, which together induce capital accumulation in the non-agricultural sector. At the same time, falling relative food prices reduce the returns to labour and capital in agriculture, inducing factor reallocation out of the agricultural sector. One can enrich the model by introducing investment in labour-augmenting human capital formation, geographic migration, trade frictions, land as a third quasi-fixed factor of production mainly used in the agricultural sector, or by endogenising the rate and/or factor-bias of technological change. The key model predictions carry through regardless because underlying this model is a very strong assumption: nature exerts no influence over factor accumulation and productivity and, more generally, that economic processes are independent of changes in the natural environment.

Bringing in the environment

To understand the relationship between structural transformation and the environment, we need to relax this untenable assumption and allow climate and environmental conditions to both affect and be affected by the structural transformation process. The simple model described above must be augmented: environmental factors become arguments in the production function, and these new arguments (together with technological change, and labour and land allocation) become endogenous. The resulting model may be more complicated but describes the world much more realistically. Figure 1 below summarises the bidirectional feedback inherent to a more realistic formulation of the economic growth process and its interplay with the natural environment.

† This policy brief is based off the pathfinding paper, Structural Transformation, Agriculture, Climate, and the Environment, written by Christopher B. Barrett, Ariel Ortiz-Bobea, Trinh Pham, a revised version of which is forthcoming in the *Review of Environmental Economics and Policy*.

Figure 1: The interplay between the environment and economic growth



The first step is to understand how structural transformation affects the environment. Because changing agricultural productivity and associated factor allocation typically drive structural transformation, we focus on impacts originating from agricultural transformation, acknowledging that other channels exist.

The next step is to understand the channels through which environmental conditions affect the economic variables in the model, in particular the stocks of and returns to land, labour, and capital, as well as technological change. We have a growing body of evidence on how these channels operate.

Familiar policies need to be rethought

Once we recognize the bidirectional feedback between structural transformation and the environment, we need to rethink a number of familiar development policy prescriptions. Should we continue to pursue policies designed to promote technological change among smallholder farmers (by spending more on agricultural R&D) and to increase the integration of factor and product markets (through investments in communications, transportation, or institutional infrastructure)?

Agricultural R&D

Local agricultural R&D investments remain important in low- and middle-income countries; they were the main driver of lower food prices in Africa between 1991 and 2011 (not trade or the diffusion of technologies developed elsewhere). In addition, the rates of return on agricultural R&D in sub-Saharan Africa remain high, suggesting continued underspending. Although there remains a major role for policies promoting agricultural R&D, policymakers face a host of new and complex issues. Agricultural R&D may need to shift towards adaptation research, which is especially needed for climate change, increased risk of drought, flooding (especially with sea water), and pathogens and pests whose ranges are shifting. Even in temperate zones where warmer temperatures should physiologically stimulate more rapid crop growth, warming-induced changes in pathogen and pest pressures increasingly compel 'defensive' investments to protect crops, generating difficult trade-offs among productivity-enhancing investments such as inorganic fertiliser or improved seeds among liquidity constrained small farmers. But will this reorientation of crop and livestock research reduce the returns to agricultural R&D and make it less attractive to donors?

Another challenge facing agricultural R&D policy is the increasing role played by the private sector. Historically, agricultural R&D has been publicly or philanthropically funded, generating public goods that rendered technological change quasi-exogenous. Now many of the most promising agrifood innovations involve digital and genetic innovations that rely largely on private finance. This raises important public policy issues involving intellectual property rights, market concentration, and the legal and economic infrastructure needed to support the diffusion of innovations financed by the private sector. How will the privatisation of agricultural R&D affect the environmental impacts of agricultural technological change and the distributional impacts of R&D? Will publicly funded agricultural extension systems be able to adapt to increasingly sophisticated digital and genetic technologies protected by intellectual property?

Decoupling food production from the land

Meeting the increased demand for food in the coming decades will require agricultural technological change, but will we also need to convert more land to agricultural use? This may be unwise, at least from an environmental perspective, given the many, largely adverse effects of agricultural land conversion on the environment (through GHG emissions, infectious disease ecology, and loss of biodiversity). Policymakers should explore decoupling food production from the land, for several reasons. First, demand is shifting in ways that make decoupling both more attractive and more feasible: consumers in high-income countries are flocking to plant-based and cellular substitutes for traditional animal source foods (ASFs). Consumers in Africa and Asia may well follow a similar pattern, given income growth, urbanisation, and post-pandemic interest in shorter food supply chains. Second, the technologies needed to make this shift feasible are increasingly accessible to low- and middle-income countries. Advances in synthetic biology now enable a company to design bacteria or yeast to turn inexpensive feedstock, for example distillers' grain, into more complex proteins than beer or cheese, the viable fermentation-based businesses already widespread in low-income countries. Production costs for these systems are falling fast and seem to scale easily, offering countries facing strong growth in food demand alternative food production systems that could free land for other uses (for example, energy and environmental services). There are already signs of analogous changes in horticultural production. Controlled environment agriculture (so-called 'indoor' or 'vertical' farming based on aero-, aqua-, or hydroponic methods) has been exploding in Asia, providing urban consumers with pan-seasonal localised supply chains delivering consistent-quality, high-value, short-cycle leafy greens and fast-growing fruits. These shifts toward 'de-agrarianised' food production may accelerate as technological change in the renewable energy sector drives down electricity costs, and as increased water scarcity proves more easily managed in compact indoor spaces than in large open fields.

Decoupling food production from land also makes it easier for rural landowners to use land to generate non-agricultural income streams. One option is renewable energy production, although the possibility of expanded rural power generation raises a host of underexplored regulatory and infrastructure questions. Another is sequestration of greenhouse gases in trees, soils, and cover crops. Sequestration for revenue generation relies on carbon taxes and emissions trading systems, along with the necessary verification technologies. It is not viable currently as the global average carbon price remains too low for it to cost-effectively reduce emissions. But the literature on climate-smart agriculture demonstrates that there may be a tipping point where GHG sequestration becomes a viable income source for rural landowners in Africa and Asia. Working out the necessarily institutional and technological details, the distributional and local general equilibrium effects if windfalls accrue mainly to (wealthier) landowners, and the balance of payments implications remain underexplored research topics. Land can also provide ecosystem services, payments for which have grown to an estimated $40 billion annually worldwide and have clearly demonstrated favourable environmental impacts when well designed. But a range of design flaws continue to impede broad inclusion and broader economic gains to rural communities, and these schemes are more likely to work effectively where gains from trade are large and transaction costs are low.

If countries are to establish viable non-agricultural revenue streams for rural lands, land tenure issues become especially salient, requiring attention from policymakers. If land increasingly generates income by remaining idle, or by simply hosting renewable energy generation structures, increased contestation for lands might ensue. This might increase the value of surveys to establish clearly who owns which rights in what lands.

Rural infrastructure

Investment in communications, electricity, and road infrastructure has long been considered a key policy instrument for stimulating agricultural productivity growth and facilitating non-farm enterprises in low-income rural areas. Infrastructural improvements clearly boost incomes and the absolute returns to capital, labour, and land in rural areas. But structural transformation depends on the relative returns across factors and sectors, and we have little understanding of how infrastructure affects these returns and accelerates the movement of factors into more productive uses.

More importantly, infrastructure investment has consequences for the environment. Rural roads, for example, are widely believed to accelerate deforestation. Although there seems a consensus that newly built roads in remote forested areas cause deforestation, the evidence has been mixed on the effects of road improvements, and road expansion in regions that have substantial prior clearing may attract development away from areas that are extensively forested and thus could help reduce deforestation. The expansion of road networks, therefore, must be considered cautiously or even reduced if to remote forested areas.

More generally

Current policy prescriptions for low-income agrarian nations still rely heavily on models of structural transformation that ignore the central role nature plays in agriculture and other sectors. Broad acceptance of the prominent role human behaviour plays in environmental change should now stimulate efforts to expressly incorporate bidirectional feedback between nature and the stocks of land, labour, and physical capital, as well as TFP growth, into theories of and empirical research on structural transformation, and policies aimed at accelerating that transformation. However, both research and policy face several formidable challenges, including the scarcity of high-quality data for low-income countries, especially longitudinal data; the difficulties of inferring causality when both the economic variables and the environmental are treated as endogenous; and our poor understanding of the details of the underlying mechanisms that link environmental variables to socioeconomic outcomes. Addressing these problems is essential if policy and investment strategy are to effectively support structural transformation through a changing environment.