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Simulating the effects of tax exemptions on fertiliser use in Benin by linking biophysical and economic models

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ABSTRACT

The sluggish increase in the area productivity of staple crops is a major factor causing increased dependence of African countries on food imports. The increased use of mineral fertiliser may dramatically improve the food balance of many countries and result in lower food prices, higher food supply and consumption, and improved food security and nutritional status. In Benin, West Africa, political measures to improve farmers' access to fertiliser are biased in favour of cotton production. This article simulates the impact of universal tax exemptions for fertiliser use on crop yields, food balances, and the use of land resources for the most important staple crops in Benin using a crop growth model and an agricultural sector model. The simulation results indicate that tax exemptions on fertiliser use could have positive effects on physical productivity and would increase food security until 2025 as compared to a baseline scenario. At the same time, the pressure on land resources would not be aggravated, so that better access to fertiliser may help to curb excessive cropland expansion in Benin.

1. Introduction

The growth of area productivity in Africa's agriculture is below the world average. Increases in production are largely achieved by expanding agricultural areas. For instance, the land area used for cereal crops increased by more than 60% between 1985 and 2005, whereas yields increased by 20% only, barely reaching 1.4 metric tons per hectare. By contrast, cereals area worldwide expanded by less than 7% during the same period, whereas average yields increased by almost 30% (FAOSTAT, 2009) to 3.3 metric tons per hectare. An important reason for this divergence in productivity is the insufficient use of fertiliser in Africa. Whereas almost 70 kg of nitrogen were applied per hectare of arable land worldwide in 2005, only 16 kg were applied in Africa (FAOSTAT, 2009). This resulted in 22 kg of nitrogen being lost annually per hectare of cultivated land (IFDC, 2003).

The problem seems to be widely acknowledged by both African governments and the international donor community (Chianu et al., 2008), and most development policy agendas include suggestions about how incentives can be created to promote small-scale farmers' increased adoption of agricultural practices that enhance the fertility of soils (Agwe et al., 2007). In particular, the case for increased use of mineral fertilisers is largely emphasised on the grounds that, among the Green Revolution technology packages, fertiliser has been responsible for an important share of agricultural productivity growth. In Asia, it contributed 50% to crop yield growth and contributed an estimated one-third to the growth of cereal output worldwide (Morris et al., 2007). Beyond its effects on agricultural productivity and food security, the 'Borlaug hypothesis' (Borlaug, 2000) claims that the use of fertiliser and other yield-increasing inputs will contribute to curbing excessive expansion of cropland, as fertiliser can be viewed as a land-saving form of technical progress. Higher productivity on existing farmland will reduce farmers' incentives to expand cultivation into forests or savannahs (Angelsen and Kaimowitz, 2001).

Opposing this view is another extreme view, according to which the promotion of increased mineral fertiliser use will result in cropland expansion. This is based on the assumption that most regions of Sub-Saharan Africa represent a 'Boserupian' environment. As long as arable land is abundantly available, farmers will not intensify farming until forests or other land reserves have almost disappeared (Boserup, 1965). As increased use of mineral fertiliser raises yields and agricultural profits, farmers will clear more forest or savannah, further increasing pressure on land resources. Which of the two predictions will dominate depends on several factors. First, even if land is abundantly available, the expansion of cropland comes at a cost, as turning forest or savannah into cropland is very labour-intensive. The opportunity costs of cultivating additional land also increase with the general scarcity of land and a rising trend in the price of low-skilled off-farm labour. On the other hand, a higher integration of subsistence

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farmers into local, national, and world markets will dampen or even prevent the price-depressing effect of local productivity improvements. Barbier and Burgess (2002) provide an extended survey of studies and models on the economics of cropland expansion, shifting cultivation, and deforestation. Careful, theory-based, empirical research is the necessary next step for designing public interventions for specific contexts (Takasaki, 2006; Timmer, 2005). Empirical studies have been conducted on the issue using cross-national samples (Angelsen and Kaimowitz, 2001); however, the number of single-country assessments has been limited due to methodological and, in particular, data availability problems (Morris et al., 2007).

The current paper offers an assessment of the promotion of fertiliser use in Benin, West Africa on cropland expansion. Biophysical simulation methods are used to assess individual crop responses to fertiliser use. Based on this, endogenous fertiliser use functions are estimated and calibrated against fertiliser use and yield data using regional (commune level) agricultural statistics. These functions are implemented within an agricultural sector model that is used to simulate crop supplies and land use patterns until 2025.

The article is organised as follows. First, the use of fertiliser in Benin as well as prices and policies are discussed. As a major result, the magnitude of regional quotas for fertiliser to which farmers have access at reduced prices and under conditions of commodity credit are estimated. Next, results of simulations on yield response to fertiliser use are presented for major food crops in Benin. From these point simulations, non-linear approximations are derived, which are used in a regionalised multi-market model for Benin's food sector (BenIMPACT). To address the policy issues at hand, fertiliser use above the regional quotas of subsidised fertiliser is calibrated to the base year of BenIMPACT on the basis of observed yields, market prices, and the physical yield functions. Thus, fertiliser use is an endogenous choice variable for farmers. After the calibration of quotas, a baseline simulation up to the year 2025 is compared to a change in fertiliser policy involving tax exemptions.

2. Fertiliser policy, use, and costs in Benin

Benin's agriculture is dominated by the production of staple crops by subsistence farms and the production of seed cotton for export. These two sectors receive different attention in terms of agricultural policy. This is especially true for programs aiming to increase fertiliser use, which are closely linked to cotton production (Adégbidi et al., 2000). As cotton accounts for roughly 90% of Benin's export earnings, policy measures in this sector have typically aimed at ensuring a constant and sufficient supply of seed cotton to the local cotton processing plants. The most important tool for stabilising cotton supply is a contract farming system within which fertiliser is supplied to individual farmers on the basis of a commodity credit scheme and at pan-territorial prices that involve tax exemptions and transport subsidies. The defining feature of this commodity credit system is that the costs for inputs delivered to cotton producers are later deducted from the cash payments for the cotton delivery to the company. The delivery of inputs and the collection of cotton produced are jointly managed by a corporatist system involving producers, cotton processors, and governmental agencies (IFDC, 2005; World Bank, 2002, 2004). The required amount of fertiliser for cotton production needs to be estimated beforehand by this corporatist system, which is why the amount of subsidised fertiliser available in Benin depends directly on how much and where cotton is planted and processed.

Economically, this policy can be classified as a fertiliser quota that is adapted annually to the expected expansion of regional cotton areas. The price for fertiliser that is sold within this quota (the 'in-quota price') is uniform across regions (pan-territorial) and also across the various types of fertilisers, regardless of differences in marketing costs and quality. This uniformity resulted in pan-territorial prices of FCFA 95 to FCFA 235 (FCFA 1000 = €1.52) per kilogram over the period of 1992–2007, with the price doubling in 1994 after the devaluation of the FCFA. Whereas this pan-territorial price is typically higher than the border prices of the various varieties of fertiliser, it is considerably lower than the prices that farmers must pay outside the fertiliser quota system (referred to as the 'over-quota' price). The pan-territorial 'in-quota' price is implicitly subsidised by not applying import duties and value added tax (VAT) and, if necessary, by subsidising import credit, transportation, and distribution among farmers. In terms of the magnitude of tax exemptions granted to fertiliser sold within the cotton system, Adégbidi et al. (2000) estimated that import duties applied to fertilisers stood at approximately 29% until 2000. From 2000 onwards, member states of the UEMOA (*Union Economique et Monétaire Ouest Africaine*), including Benin, adopted a common import duty on fertilisers of not more than 7%. The VAT applied in Benin is 18%. In addition to lifting import duties, the government may provide a variable subsidy depending on the levels of the world market prices of fertilisers to ensure the politically desired level of the pan-territorial price. From 2000 to 2004, Honfoga (2006) estimated that this subsidy amounted to 4.6% of the total cost of fertilisers imported for the cotton sector. For the agricultural season 2008–2009, it was expected to increase to 32%, which corresponds to a subsidy of 111.34 FCFA per kg. To manage costs from foregone taxes and subsidies, the pan-territorial price was lifted to 235 FCFA/kg for the agricultural season of 2007–2008 (http://www.aicbenin.org).

In contrast to prices, quantities of fertiliser used by farmers are much more difficult to monitor. According to official statistics, national consumption reached a peak of approximately 95,000 tons in 1999. However, the decline in world market prices for cotton led to stagnating cotton areas, with officially recorded fertiliser use subsequently falling to 62,000 tons in 2007. On the other hand, information on the commune level suggests that the application of fertiliser per hectare has remained stable at approximately 45 kg during the last decade, with large differences between communes. Applications of 50 kg per hectare and more are frequently recorded in the Northern and Central regions, whereas for most regions in the south, no use of the input is reported (see Table 10 in Appendix A). Unfortunately, figures reporting fertiliser use per crop are not available for this study. The International Fertiliser Development Center (IFDC) claims that the cotton sector accounts for 96% of fertiliser consumption in Benin (IFDC, 2005). As a consequence of the fertiliser quota system, there appears to be a strong link between fertiliser use that is officially recorded, and cotton area. Fig. 1 shows a close association between the share of cotton in total cropland and the use of fertilisers per hectare, using commune-level data for the period of 2001–2004.

It is, however, likely that farmers allocate portions of the fertiliser earmarked for the cotton system to other crops depending on the profitability of these crops relative to cotton. This is supported by Camara and Heinemann (2006), who claim that Benin has experienced a high growth in the use of mineral fertilisers as compared to other African countries. Even though fertiliser use outside of the cotton system may be much more expensive, farmers in regions without a fertiliser quota and no access to cheaper fertiliser might find it profitable to apply fertiliser to other crops. Surveys by Minot et al. (2000) and Adégbidi et al. (2000) indicate that maize, rice, and vegetables are the food crops that receive the largest share of fertilisers. Estimations by Adégbidi et al. (2000) suggest that the rate of application of fertiliser on maize and rice is likely in the range of 50–100 kg ha^{-1} in cotton-producing communes. In other areas of the country, the rate varies between 0 and 75 kg ha^{-1} for these crops. For cotton, a rate of