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Agricultural R&D, policies, (in)determinacy, and growth

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ABSTRACT

This paper examines the effects of agricultural subsidy policies on long-run growth. The novelty of this paper lies in its investigation of how the long-run effects of a land productivity conservation subsidy and an agricultural R&D subsidy are affected by the possible emergence of the indeterminacy of equilibria in Rivera-Batiz and Romer's endogenous growth model with elastic labor. The analysis shows that if the technology growth rate is more sensitive to a change in the land productivity conservation subsidy policy than the consumption growth rate, the policy will generally enhance (harm) long-run growth when the balanced growth path is indeterminate (determinate). Furthermore, the agricultural R&D subsidy will enhance (harm) economic growth when the balanced growth path is determinate (indeterminate).

1. Introduction

The role of agricultural technical change as a powerful engine of economic growth has captured the attention of economists engaging in research on the Green Revolution. Research and development (R&D) gives rise to knowledge and innovations that have become a major source of productivity change and economic growth in agriculture in developed countries. There is a wealth of literature that focuses on the relationship between agricultural R&D and economic growth, such as the study by Mellor (1995) that found evidence of a positive correlation between agricultural growth and GDP growth based on a cross-country study involving 51 countries. Lusigi and Thirtle (1997) showed that the effect of agricultural R&D on total factor productivity growth in Africa is also positive and significant. Färe, Grosskopf, and Margaritis (2008) investigated the relationship between productivity growth and R&D expenditure in U.S. agriculture over the 1910–1990 period and the results suggest that U.S. agriculture realized positive productivity growth. Cai, Golub, and Hertel (2017) analyzed the development of a long-run agricultural R&D policy in the face of uncertain economic growth.

Regardless of whether they applied empirical or theoretical models in agriculture, they generally did not consider the theoretical fundamentals of optimization in macroeconomic models. Furthermore, theoretical analysis tends to be lacking in the field of agriculture even though there are large numbers of empirical studies. However, there is a wealth of literature that focuses on the R&D-based endogenous growth model, for example, the studies by Rivera Batiz and Romer (1991), Haruyama and Itaya (2006), Itaya (2008), and Day (2016), to name a few. However, these authors did not consider the issue of agriculture. More recently, the problem of soil erosion in so far as it affects cultivated land has become a major concern (Chatterjee & Ghose, 2016). Differing from Rivera-Batiz and Romer (1991) and Haruyama and Itaya (2006), this paper develops an optimization macroeconomic model to discuss the relationship between agricultural R&D, land productivity conservation, and economic growth.

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The government's public policy in the agricultural sector is important to the development of agriculture. The U.S. Department of Agriculture (USDA) spends $25 billion or more a year on subsidies for farm businesses (Edwards, 2016). Some farm subsidy programs subsidize farmers' conservation efforts, insurance coverage, product marketing, export sales, R&D, and other activities. However, the USDA runs numerous farm conservation programs, which cost taxpayers more than $5 billion a year. The largest is the Conservation Reserve Program, which pays farmers about $1.7 billion a year to keep millions of acres of their lands out of production. On the other hand, the USDA spends about $3 billion a year on agricultural and food research in more than 100 locations (Edwards, 2016).

The basic infrastructure provided by the public sector can lower the cost of agriculture to farmers and at the same time raise agricultural productivity, just as Craig, Pardey, and Roseboom (1997) found evidence of positive effects of public infrastructure and research on agricultural productivity. Itaya (2008) examined the effects of environmental taxation on long-run growth in an infinitely-lived representative agent model of endogenous growth with negative pollution externalities. His analysis shows that environmental taxation generally enhances (harms) long-run growth when the balanced growth path is indeterminate (determinate). Lee and Hsu (2009) found that public investment in agriculture and the productivity of agricultural land exhibit a significant positive relationship in the long run. In addition, government subsidies to resource-intensive industries are found to be ubiquitous. For example, global farm subsidies exceed $500 billion per annum (OECD, 2002). Therefore, our model focuses on two specific policy instruments-a land productivity conservation subsidy, and an agricultural R&D subsidy-and their effect on economic growth.

This paper sets up a Rivera-Batiz and Romer-type (1991) and Haruyama and Itaya-type (2006) R&D-based endogenous growth model with endogenous labor supply and the government's land productivity conservation subsidy and agricultural R&D subsidy, and uses it to explore the effects of agricultural subsidy policies on economic growth.

2. The model

Consider an agricultural economy that grows endogenously owing to R&D being driven by an endogenous labor supply. There are five types of agents in this economy: the final goods firms (i.e., farmers), the intermediate goods firms (i.e., seed breeding companies), an agricultural R&D firm, a government, and the households. The farmer produces an agricultural product using "state-of-the-art" intermediate goods (i.e., seed varieties, planting materials) and labor. Each seed breeding firm in the monopolistically competitive intermediate goods sector develops and holds the technologies of plant breeding, plant biology, seed production, genetic improvement and planting materials, and uses these technologies to produce one kind of seed or planting material. In addition, we assume that any seed breeding firm can pay the R&D cost to secure the net present value of profit associated with the new seed product developed. The agricultural R&D activity is assumed to be characterized by free entry, and technologies can only be created by the use of the agricultural product in research. The government imposes a tax on agricultural income and subsidies to agricultural R&D and land productivity conservation. Households derive utility from consumption and leisure and provide their labor elastically to firms.

2.1. Agricultural output

Agricultural producers hire labor l and varieties of seed or varieties of planting materials (namely, intermediate goods) x_i to produce agricultural output Y which can be consumed or invested. The production function of the agricultural production sector takes the following form:

$$Y_t = V_t l_t^{1-\alpha} \int_0^{A_t} x_{it}^{\alpha} di\,, \quad 0<\alpha<1 \tag{1}$$

where A represents the number of varieties of differentiated seeds that increases over time due to technological progress. $i \in [0, \ A_t]$ is the range of production of seed existing at time t. The total stock of producer durables is related to the aggregate capital stock $K_t = \int_0^{A_t} x_{it} di$. V is land productivity which is related to enhancing agricultural productivity and is exogenous when farmers enforce its optimization. The function of land productivity is as follows (Tai, Chao, Lu, Hu, & Wang, 2016):

$$V = (1+\theta)\left(1+\frac{T}{Y}\right)L \tag{2}$$

where θ is the rate of regeneration of land, L is cultivated land,[1] and T is the government's subsidy policy of land productivity conservation. If the government subsidy is related to the farmer's expenditure on manure, this will enhance the land productivity conservation, because fertile land can produce more goods. For example, in Taiwan the government subsidizes one-third of the manure fee paid by the farmers. Y is agricultural output and the more output that is produced in the economy, the less land productivity conservation there is. There thus exists a negative relationship between output and land productivity conservation. Land productivity conservation allows farmers to maintain or enhance agricultural productivity and the resilience of agricultural systems. Since it has an externality property for the farmer, the farmer needs the government's support to engage in land conservation.[2]

The representative farmer attempts to maximize its profit Π_t as follows:

[1] It is assumed to be an external parameter. Unless the government's policy specifies that the farmland can be released, such land and non-agricultural land cannot substitute for each other.

[2] To simplify the notation, the time arguments will all be dropped.