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ESSAYS ON GROWTH OF THE AGRICULTURE AND FOOD INDUSTRY SECTORS

by

Alejandro O. Onofri

A DISSERTATION

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Philosophy

Interdepartmental Area of
Major: Agricultural Economics

Under the Supervision of Professor Lilyan Fulginiti

Lincoln, Nebraska

May, 2002

UMI Number: 3078609

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GRADUATE COLLEGE
UNIVERSITY OF NEBRASKA

ESSAYS ON GROWTH OF THE AGRICULTURE AND FOOD INDUSTRY SECTORS

Alejandro O. Onofri, Ph.D.
University of Nebraska, 2002

Adviser: Lilyan Fulginiti

This dissertation combines elements of the endogenous growth, industrial organization, and international trade theories to study the productivity growth of the agriculture and food industries. The objective of the study is to determine appropriate roles for government intervention in those sectors. In particular, this thesis tries to shed light on the role of public investments in infrastructure and research (R&D) and the importance of trade liberalization for productivity and, consequently, welfare growth.

The effects of public investments and trade policies are rationalized within the context of the endogenous growth theory. In particular, Chapters 2 and 4 adopt 'AK' models of growth. While Chapter 2 studies the effects of public investment in infrastructure and research (public inputs) on productivity, Chapter 4 studies the effects of commercial policies and trade liberalization on productivity. In both cases, there are external effects that imply increasing returns to scale (i.e., nonconvexities), increasing incentives to capital accumulation and growth. Chapter 3, in contrast, adopts a patent race (Shumpeterian) model to study the evolution of market structure and incentives to innovate. The intensity of R&D competition affects the rate at which innovations arrive

and, consequently, the productivity growth rate of the economy or sector under consideration. Again, external effects are present when innovations are publicly provided.

The empirical findings provide little evidence about the contribution of public inputs and trade liberalization to productivity of US agriculture and the Argentine food industry, respectively. In the first case, the results are non-consistent with the theory of the firm. In the second, while the 'openness' variable impacts positively on capital accumulation, it does not affect productivity. Nevertheless, theoretical findings highlight a potential role for government investment in R&D by affecting the pricing of new technologies and, consequently, increasing the incentives to R&D investments by private firms.

ACKNOWLEDGMENTS

There are many people I would like to thank on my journey through the Ph. D. program. First, I would like to express my gratitude and most sincere appreciation to my adviser, Dr. Lilyan Fulginiti, for her guidance and constructive criticism necessary for the successful completion of this research. Thanks are also given to Dr. Konstantinos Giannakas for his encouragement and valuable comments. I would like to add my appreciation to Dr. Richard Perrin, Dr. Wesley Peterson and Dr. Matthew Cushing for serving in my supervisory committee and their helpful suggestions.

Additionally, I would like to express my special gratitude to my wife, Marilés Faggella, for her love, support and patience during all these years in Lincoln; and to my mother, María Ana Benko, for her teaching and confidence in me.

Finally, I also wish to thank all my friends in Lincoln for the good moments we had together. My wife and I had a wonderful time sharing all these years in the USA with them.

Alejandro Onofri

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Chapter 1

Introduction

This dissertation combines elements of the endogenous growth, industrial organization, and international trade theories to study the productivity growth of the agriculture and food industries. The main objective of the study is to determine appropriate roles for government intervention in those sectors. In particular, this dissertation tries to shed light on the role of public investments in infrastructure and research and the importance of trade liberalization for productivity and, consequently, welfare growth.

The studies of productivity growth and development are closely related. The development of a particular sector is important for the whole economy if it can contribute to the development of other sectors. When a particular sector or industry is considered, the study of the determinants of productivity growth is relevant for economies (regions, countries) mainly based on this sector or industry. As has been emphasized by recent development economic studies, if this sector or industry exhibits spillovers to other sectors, the whole economy can benefit from them and productivity growth of a particular sector may increase aggregate welfare.

Spillovers and externalities in general are key elements in endogenous growth theories. Endogenous growth theory arose as a response to empirically unsustainable results by the classical models of growth (Solow, Ramsey). According to these models, growth is exogenously given by an unexplained rate of technical change. Classical models, thus, try to explain growth without actually giving the reasons for it. Endogenous

growth theories, in contrast, incorporate into the models the reasons for technical change to take place.

The effects of public investments and trade policies are rationalized within the context of the endogenous growth theory. In particular, the models presented in chapters 2 to 4 are based on two types of endogenous growth models, namely 'AK' and Schumpeterian models. Chapters 2 and 4 adopt 'AK' models of growth.[1] While Chapter 2 studies the effects of public investment in infrastructure and research on productivity, Chapter 4 studies the effects of commercial policies and trade liberalization on productivity. In both cases, there are external effects that imply increasing returns to scale (i.e., nonconvexities), increasing incentives to capital accumulation and growth.

Chapter 3, in contrast, adopts a patent race (Shumpeterian) model to study the evolution of market structure and incentives to innovate. This branch of the endogenous growth literature is closely related with industrial organization models that study competition in research and development (R&D). The intensity of R&D competition affects the rate at which innovations arrive and, consequently, the productivity growth rate of the economy or sector under consideration. Again, external effects are present in these models if innovations cannot be perfectly protected by intellectual property rights or they are publicly provided. Additionally, increasing returns exist in R&D activities because of the nonrival nature of research and, therefore, nonconvexities are the common factor in the three essays of this dissertation.

[1] "AK" is the general name for models of growth that adopt production functions that imply nondecreasing returns to capital. The origin of the name comes from the adoption of simple Cobb-Douglas production function like $y = AKL^{1-\alpha}$. That is, the production function is linear in capital.

I. Nonconvexities

Nonconvexities play an important role in new theories of growth. They are generally due to the presence of nonrival goods. Following Romer (1990), nonrivalry can be interpreted in two ways. First, nonrival factors of production are valuable "inputs that can be used simultaneously in more than one activity." Under this definition, public goods, like public infrastructure for instance, are nonrival inputs that can be used by many producers at the same time. Alternatively, one can define a nonrival input as that input that can be used repeatedly in the same activity. With this definition, a new chemical process, for example, is an input that can be used more than once in the production of a certain product. In this case, nonconvexities are intrinsically associated with this input: there is a high cost of producing the first unit, but the cost of producing subsequent units is zero. In any case, since the presence of nonrival inputs generates nonconvexities, the production function can be characterized by increasing returns to scale, a key factor in new theories of growth.

Under the traditional or neoclassical model of growth, production functions are assumed to be well behaved, which implies nonincreasing returns to scale. With this assumption, factors of production exhibit decreasing returns. Physical capital is accumulated until the value of the marginal product is equal to its price. Then, without technical change, accumulation of physical capital eventually stops. When this happens, growth also stops. Productivity growth is thus exogenously given in this kind of model. With increasing returns, in contrast, continuous growth is possible.

The existence of increasing returns to scale may be inconsistent with the assumption of perfect competition. In some cases, this assumption is eliminated and

imperfect competition is introduced in the models. This is associated with the second definition of nonrival inputs given by Romer, i.e. an input that can be used repeatedly in the same activity. Given the decreasing average cost curve implied by research activities, firms must have some degree of market power, which allows for positive profits, in order to be engaged in research activities. This is the focus of Chapter 3, in which it is assumed that research activities are not profitable for all private firms when more than one firm is doing research. In this case, one firm will monopolize the market and lose incentives to invest in research. Then, there is a need for government intervention.

On the other side, increasing returns can be due to external factors like, for instance, public goods. Externalities, in this case, arise from nonrival inputs more closely related with the first definition of Romer, i.e. inputs that can be used simultaneously in more than one activity. If this is the case, firms still observe a nondecreasing average cost curve and the assumption of perfect competition is valid. This kind of external effect is present in models of chapters 2 and 4.

II. Public Policies to Stimulate Growth

The existence of external effects highlights the necessity of public intervention to stimulate growth. Recent models of growth have emphasized the possibility that individual firms cannot internalize external effects unless there is a coordination of investments by the public and private sectors. This is closely related to the notion of poverty traps and the 'big push,' concepts introduced by development economists of the 1940s and 1950s[2], but recently reintroduced more formally by Murphy et al. (1989). In

[2] See, for instance, Rosenstein-Rodan (1943), Nurkse (1953), and Fleming (1955).

this model, 'industrialization' (or development) can be achieved only if there is coordination of investment by many firms such that a big push occurs, allowing the economy to move out from a poverty-trap equilibrium.

One characteristic of this movement is the presence of externalities. Externalities can imply that one firm does not have the appropriate incentives to adopt new technologies. Krugman (1993) exemplifies this situation with pecuniary external economies. If the domestic market is small, the acquisition of a new technology that implies incurring high fixed costs is not profitable unless many firms do that. If many firms invest, the size of the domestic market can be enlarged and unit costs of production can be substantially reduced. In this case, there is a need for coordination of public investments.

Another interesting example is provided by Murphy et al. (1989) in relation to investment in "jointly used intermediate goods," such as infrastructure. Investments in infrastructure are in large proportion composed of high fixed costs. According to Murphy et al, "each industrializing firm that uses it helps defray this fixed cost and so brings the building of the infrastructure closer to profitability." This is because infrastructure is a nonrival input of production. Thus, "each user indirectly helps other users and makes their industrialization more likely." Cooperation between the private sector and the government is, in this context, a way of generating productivity growth.

The three models of growth presented in this thesis are then different approaches to study the evolution of productivity in agriculture and the food industry in relation to the existence of externalities, nonconvexities, and the type of relationship between economic (private and public) agents. Chapter 2 studies the 'push' on productivity

growth provided by public investments in research and infrastructure. In Chapter 4, trade policies (liberalization) are the trigger that simulates private investment and growth. Finally, in Chapter 3, the competitive pressures that public research investments make on a private firm are the reason for increasing incentives to private investment. The following section presents an introduction to these models.

III. Overview

As previously mentioned, productivity growth at a sector level and appropriate forms of government intervention are studied from the point of view of recent endogenous growth theories, using also elements of the trade and industrial organization literatures. Productivity growth of the agricultural sector is the object of study in Chapter 2. The model presented is based on increasing returns to scale due to the presence of public inputs, such as public infrastructure and R&D investments. The engine of growth, as in the example given by Murphy et al, is the cooperation between government and farmers. This cooperation generates productivity growth, which is endogenous to the model.

One of the pioneer studies in the endogenous growth literature has been that by Romer (1986). In this paper, Romer specifies a production function $F(k_i, K, x_i)$, with k_i and x_i firm-specific inputs (x can be seen as a vector of inputs) and K an input external to the firm ("the level of knowledge" defined as a function of the "firm-specific knowledge" k_i). By assuming that F is increasing in K and linearly homogeneous in k_i and x_i, a perfectly competitive equilibrium is still possible, but the factor k_i no longer exhibits

diminishing returns. Consequently, permanent endogenous growth of output per capita is allowed.

Barro (1990) has developed a similar model where K can be interpreted as the stock of public capital. The intuition is that publicly provided capital (like roads, sewer capital, etc.) has positive effects on private production affecting the productivity of the firm-specific inputs. Public capital is assumed a public input that can be used by additional producers without cost. Consequently, total stocks of public goods enter in the production function of each individual firm. With these assumptions, two necessary conditions for the hypothesized endogenous growth are the existence of increasing returns to scale over all inputs and the existence of constant returns to scale over factors that can be accumulated (private and public capital). A weaker requirement, alternative to the second condition, is a positive impact of public capital on the demand for private capital. Although not ensuring continuous growth, the presence of this nonrival input would imply a positive government contribution to growth.

Following these approaches, known as 'AK' models of growth, the model developed in the second chapter focuses on productivity growth of the agricultural sector. In that context, public infrastructure and public research and development (R&D) investments are considered public quasi-fixed inputs of production allowing for increasing returns to scale and nondecreasing returns to private capital. In this way, private capital accumulation does not stop and continuous growth is possible.

The government contribution to growth can be tested using duality theory. Thus, for the hypothesized endogenous growth to be true, the two mentioned necessary conditions can be tested through the estimation of a value function. This estimation is

particularly relevant for the case of the U.S. agricultural sector, which has exhibited an average rate of productivity growth of about two percent over the last fifty years (Ball et al (1997)). The hypothesized endogenous growth can be checked for this case in which the U.S. government plays an essential role by providing public R&D and infrastructure services.

Chapter 3 focuses on the productivity of the agricultural sector from a different perspective. The relation between public and private R&D expenditures is the point of analysis. A patent race model is adopted. Without intellectual property rights (IPRs), the government provides the farmers with new technology by choosing the level of expenditure in applied and basic research. This situation would be similar to the one explained in Chapter 2. However, if IPRs are introduced such that applied research is excludable, firms providing inputs to the agricultural sector have incentives to research and make innovations that give them positive profits. In this context, if the government also produces applied research, there is strategic interaction between the government and the private innovation sector. The way they interact can affect farmers' welfare.

Note that a nonrival input (R&D) is also present in Chapter 3. Private applied research is nonrival, although it becomes excludable with the IPRs. Public R&D is a pure public good, which means that it is nonexcludable and nonrival. Thus, government's behavior could affect not only the arrival rate or size of innovations, but also the pricing of new technologies. Clearly, farmers can exhibit welfare changes due to this interaction. This chapter then tries to shed light on the optimal form of government intervention in the research market.

The focus of Chapter 4 is on the productivity of downstream markets (food industry) and the dynamic effects of trade liberalization. There is an important discussion in the international trade literature about these effects. The increasing interest in these possible medium- and/or long- run effects are accompanied by the debate on the relationship between openness and growth that originated with the development of the new models of growth. These dynamic effects have to do with increased competition, faster technical change, investment creation, and economies of scale (Corden (1984), Baldwin and Venables (1995)). Chapter 4 centers then on possible investment creation effects as a reason for productivity increases due to freer trade.

Following Baldwin (1992), an 'AK' model of growth is adopted, introducing static and dynamic effects of liberalization. The static effects are the traditional efficiency gains pointed out by the international trade literature. The dynamic effects have to do with investment creation. Freer trade raises the returns to capital and induces capital accumulation, which, in turn, increases output. With increasing returns to scale, there is an increase in productivity.

The effect on investment can be associated with the idea of the 'big push.' If the domestic market is small, and trade is not free and costless, commercial liberalization can be a signal for domestic firms to adopt a new technology. According to this, preferential trade agreements and integration can produce dynamic gains that more than compensate possible losses due to trade diversion.

Finally, the effects of trade liberalization are applied to the case of the Argentine food industry. This case is of particular interest for a number of reasons. First, the Argentine economy is a recent example of liberalization. This liberalization process has

the characteristic of being preferential because Argentina is member of the South American Common Market (Mercosur). Thus, the attractiveness of studying the effects of a liberalization process in a context of a regional trade arrangement (RTA) relates with the controversy about gains and losses due to preferential trade agreements. Mercosur has not been the exception in terms of discussion of RTA's effects.

The second reason for studying the Argentine food industry is the recent increase of foreign direct investment in the sector. In general, the whole economy has experienced high levels of foreign investment in the 1990s due to macroeconomic stabilization, less government intervention, privatization, and openness. Nevertheless, the food industry has been one of the most benefited sectors. This constitutes a stylized fact that may be due, among other things, to induced capital accumulation in a sector with comparative advantages.

Chapter 2

Measuring the Impacts of Public Inputs on Productivity Growth

I. Introduction

Neoclassical models of growth (Solow, Ramsey) have been widely criticized because they cannot explain productivity changes. According to these models, growth is exogenously given by an unexplained rate of technical change. As a response, endogenous growth theories prove that continuous growth is possible because of the existence of non-rival inputs of production (i.e., inputs that can be used by many firms at the same time or by the same firm repeatedly without additional cost). In these models, two necessary conditions for endogenous growth are: increasing returns to scale over all inputs, and positive impacts of non-rival inputs on the returns to investment. The main contribution of this study is to introduce a dynamic model of productivity measurement that incorporates public goods (non-rival by definition) as external factors to the firms. It also rationalizes the provision of public inputs by a benevolent social planner that internalizes the effects of them. Estimable functions that allow testing the necessary conditions for endogenous growth are obtained.

Many other papers have focused on the effects of public goods on private production, and most of them have found positive impacts[1]. For example, Aschauer's (1989) pioneer work estimates a single production function for the U.S. economy

including public infrastructure as a factor of production. Lynde and Richmond (1992) and Berndt and Hansson (1992) have also used duality theory to estimate the role of infrastructure in private production in the U.S. and Sweden, respectively. Nadiri and Mamuneas (1994) estimate the impacts of public capital and research and development (R&D) on the cost structure of twelve U.S. manufacturing industries, and Morrison and Schwartz (1996) study the regional effects of public infrastructure on the U.S. manufacturing sector. Both papers adopt a dual approach and find, in general, positive effects of public inputs on manufacturing productivity. The last paper also finds increasing returns to scale over all inputs (including infrastructure), but it does not include R&D.

For the agricultural sector, papers like Antle (1983) and Craig et al. (1997) find positive effects of public infrastructure and research on agricultural productivity but their approach is based on estimating a single production function. Binswanger et al. (1993) estimates the impacts of infrastructure and R&D in India. They consider, in a static framework, that public infrastructure investments are regionally allocated toward areas that are more productive. In contrast, the present study develops a dynamic model of productivity measurement. This approach, based on duality theory, maintains producer rationality and allows examination of the impacts of public inputs on producer's behavior.

The model is tested with data for the U.S. agricultural sector. United States agricultural productivity has increased at an annual average rate of two percent over the 1948-1994 period. Some authors have found that productivity growth has been the main

[1] Exceptions are Garcia-Mila and McGuire (1992) and Holtz-Eakin (1994). They find insignificant effects

factor contributing to economic growth of the agricultural sector (Ball et al., 1997). Additionally, the provision of public goods in the form of public research and extension, and infrastructure has been sizable in this country. In an atomistic environment, these public expenditures are traditionally justified because of their low degree of appropriability and high costs. Theoretically consistent firms' dynamic demands for inputs are then estimated for U.S. agriculture including stocks of public capital and R&D as quasi-fixed factors. The existence of economies of scale and the likely positive impact of public inputs on the steady state stocks of private capital can be tested.

There are several reasons to undertake this study. First, the possibility of endogenous growth in the agricultural sector may imply spillovers to other sectors and, in particular, may have important effects on the growth of regional economies based on agricultural activities. Second, Ball et al. (1997) show the increasing use of materials and the decreasing use of labor in the U.S. agricultural sector. Then, by determining the substitution or complementarity between public and private inputs, one may explain the findings by Ball et al. with respect to this evolution of quantities demanded of private factors. Finally, the estimation of shadow prices for public capital and R&D stocks may provide an indicator to policy makers of the optimal provision of public investment.

This chapter develops as follows. Section II presents a summary of the endogenous growth theory involving publicly provided goods and the related testable hypotheses using a dual approach. Section III introduces a dynamic model in which both producers' and government's behaviors are rationalized. The testable hypotheses are then revisited.

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of public infrastructure on private production.

Section IV introduces the empirical model and section V presents the preliminary results. Finally, conclusions and future lines of research are stated in section VI.

II. Growth Theory and Testable Hypothesis

In the neoclassical models of growth (Solow, Ramsey), the rate of growth of per capita output is a decreasing function of the per capita stock of private capital. Without technical change and with a well-behaved neoclassical production function, the level of per capita output converges to a steady state where the growth of per capita private capital eventually stops. This result, implied by the assumption of decreasing returns to capital, has been one of the major criticisms to these models.

As a response to these empirically unsustainable results, endogenous growth theory arose proposing different hypotheses. These theories incorporate into the models the reasons for technical change to occur based on the presence of externalities that originate nonconvexities.

Nonconvexities play an important role in new theories of growth. They are generally due to the presence of nonrival goods. Following Romer (1990), nonrivalry can be interpreted in two ways. First, nonrival factors of production are valuable "inputs that can be used simultaneously in more than one activity." Under this definition, public goods, like public infrastructure for instance, are nonrival inputs that can be used by many producers at the same time. Alternatively, one can define a nonrival input as that input that can be used repeatedly in the same activity. With this definition, a new chemical process, for example, is an input that can be used more than once in the production of a certain product. In this case, nonconvexities are intrinsically associated to