Universidade Estadual de Londrina

VANESSA GUAZZELLI SAMPAIO

THE ROLE OF INVESTMENT IN ECONOMIC GROWTH

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Dissertação de mestrado apresentada ao Departamento de Economia da Universidade Estadual de Londrina, como requisito parcial para a obtenção do Título de MESTRE em Economia Regional.

Orientadora: Profª. Dra. Joanna Georgios Alexopoulos

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BANCA EXAMINADORA

____
Orientadora: Profa. Dra. Joanna Georgios Alexopoulos
Universidade Estadual de Londrina – UEL

____
Prof. Dr. Renato Nozaki Sugahara
Universidade Estadual de Londrina – UEL

____
Prof. Dr. Marcelo da Silva Bego
Universidade Estadual de Londrina – UEL

Londrina, 28 de fevereiro de 2020.

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RESUMO

Este trabalho teve como objetivo estudar como o agente representativo de uma economia, ao tomar a decisão de investimento em cada setor, afeta o crescimento de longo prazo da economia. Para isso, foi desenvolvida uma extenção do modelo neoclássico de crescimento com dois setores, o agrícola e o não agrícola e uma pequena economia aberta. Para encontrar o equilíbrio competitivo foi utilizado o Problema do Planejador Social. Os resultados analíticos encontrados indicam que a escolha do setor para investir possui comportamentos semelhantes ao alterar os valores da participação do capital em cada setor e a dotação de terra dos países. Nesse sentido, houve uma tendência de aumento de capital em cada setor. Em relação à terra, os países com maiores dotações tendem a alocar mais volume de capital investido nos dois setores. A diferença entre a quantidade de capital em cada setor, no entanto, é muito pequena. Além disso, ao alterar os parâmetros do modelo no estado estacionário, o investimento não passa por mudanças que podem ser consideradas significativas.

Palavras-chave: Crescimento econômico. Investimento. Modelo neoclássico de crescimento. Modelo de Ramsey. Setor agrícola.

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ABSTRACT

This thesis aimed to study how the representative agent, when making the investment decision in each sector, affects the long term growth of the economy. For this, an extension of the neoclassical growth model was developed with two sectors, the agricultural and the non-agricultural and a small open economy. To find the competitive equilibrium, the Social Planner Problem is used. The analytical results indicate that the choice of sector to invest has similar behavior when changing the values of capital participation in each sector and the country's land allocation. In this sense, there was a tendency of capital increase in each sector. In relation to land, countries with larger land endowments tend to allocate more volume of capital invested in both sectors. The difference between the amount of capital in each sector, however, is very small. Moreover, by changing the parameters of the model, in steady state, the investment does not undergo changes that can be considered significant.

Keywords: Economic growth. Investment. Neoclassical growth model. Ramsey model. Agricultural sector.

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1 INTRODUCTION

A few years ago much has been discussed about the importance of agricultural productivity in a country compared to the rest of the world and its role in the industrialization process of each country. Many works such as Matsuyama (1992) seek to explain and analyze how the impairment of agricultural productivity would affect the growth process of a country with different hypotheses regarding work and labor mobility. One of the main focuses of Matsuyama (1992) work is the impact of economic openness on economic growth. Da-Rocha and Restuccia (2006) developed a model with two sectors, agricultural and non-agricultural, and studied how they relate and the importance of agriculture in economic growth within a closed economy. Given this, the question arises is how investment affects economic growth in a context in which only the commodities market is open?

Facing this question, we seek to answer how investment choice in each sector affects long-term economic growth, considering an agricultural sector and a non-agricultural sector. The central hypothesis is that the share of investment earmarked for agriculture means that more machinery and equipment is being employed in this sector allowing labor to relocate to the non-agricultural developing this sector and generating greater economic growth.

To achieve this goal we developed an extension of Ramsey - Cass - Koopmans neoclassical growth model (developed in Ramsey (1928), Cass (1965) and Koopmans et al. (1963)). The base model is an endogenous savings growth model. It assumes that there are a finite number of agents in the economy and time is infinite. Moreover, another hypothesis is that agents are homogeneous, therefore, one can analyze the problem of a representative agent. We also assume complete markets.

The non-agricultural good supply in perfectly elastic in our model. This comes from the fact that we consider for commodities a small open economy. Households don't choose leisure, they choose each sector investment in capital per period. Therefore, the focus of this work is on the choice of capital, not of labor, in contrast to most of the productions studied.

The small open economy just open for the commodities, this ultimately affects the productivity of the non-agricultural sector, as part of agricultural production is used as input in this sector. Given this fact, one can still analyze how changes in household consumption of agricultural goods affect non-agricultural productivity.

To find the competitive equilibrium of this economy, the social planner problem was assembled and solved in order to find Pareto's optimal and efficient allocations. This method makes it possible to find feasible allocations by maximizing the welfare function. We can use it because our model assumes complete markets, and therefore, according to the Welfare Theorem, the competitive equilibrium found is Pareto efficient and the theorem ensures that this competitive equilibrium solution is equivalent to solving the Social Planner Problem. This is one of main contributions of this work. Among the works that explain the issue of agricultural productivity, investment, economic growth and economy openness, ours differs by the way in which we solve the problem to find the competitive equilibrium through the Social Planner Problem.

We find that the choice of sector to invest has similar behavior when the values of capital participation in each sector and the country's land allocation are changed. In this sense, there was a tendency of capital increase in each sector. In relation to land, countries with larger land endowments tend to allocate higher volume of capital invested in both sectors. The difference between the amount of capital in each sector, however, is very small. Moreover, by changing the model parameters in steady state, the investment doesn't change significantly.

For detailing all this, the thesis is divided into five chapters, the present chapter being the introductory part, the second chapter revisit the literature already carried out in the area which motivated the research, the third detail the two-sector neoclassical growth model with agricultural goods and open economy, the fourth bring the analytical results and chapter five presents the conclusion.

2 LITERATURE REVIEW

Many authors have investigated the role of agricultural productivity in a country's industrialization process. Several theoretical models and methodologies were developed seeking this explanation. Matsuyama (1992) studied the importance of economic openness and its impacts on the relationship between agricultural productivity and economic growth. For this, the author develops two models of endogenous growth with two non-homothetic preference sectors, where the income elasticity of demand for the agricultural good is less than one, and growth occurs with the concept of learning-by-doing only in the manufacturing sector. First model assumes a closed economy and the second an open. Their results showed a negative relationship between agricultural productivity and economic growth for an open economy, unlike for a closed economy, where the relationship is positive.

Seeking to study structural changes, Ngai and Pissarides (2007) builds a multi-sectoral growth model to analyze how sector productivity growth rates change the structure of the economy and also to show how these structural changes don't change de economy's aggregate ratios. The production functions of these sectors are similar, what differentiates one sector from another is the growth rate of total factor productivity. The author find that workers move to sectors that present low total factor productivity when the elasticity of substitution among end goods is lower, or lower than one.

Chen and Liao (2015) uses a two-sector model derived from Ramsey model to find which sector with technological change can generate the reallocation between sectors and cause structural changes observed in the US data, from 1820 to 2011. Several conclusions are drawn from this article, including that growth in agricultural productivity is of fundamental importance to richer countries in promoting long-term structural change. This is due to the fact that in the long run agricultural productivity growth allows the increase of capital destined to non-agricultural activities and decreases the capital destined to agricultural and, besides, the completeness between labor and capital does not significantly affect the percentage of employment in the agricultural sector. Using the data, the developed model responded satisfactorily to what was observed in the real economy in the sense that growth in agricultural productivity can generate structural changes, while in relation to non-agricultural productivity the resulting behavior of the model contrasts with that observed in real data.

Also investigating the relationship between agriculture and development, Gollin et al. (2002) builds a structural transformation model that seeks to explain why industrialization occurs at different times and speeds, and to study how the agricultural sector influences labor supply for non-agricultural sector. For this, a version of the neoclassical growth model with agricultural and non-agricultural goods is used. One of the results found by the authors is that, if the growth rate of agricultural productivity is low, industrialization will be slow.

Results presented in Matsuyama (1992), Chen and Liao (2015), Gollin et al.

(2002) and Ngai and Pissarides (2007) are in line with what has already been observed in the literature. Agricultural productivity growth is a fundamental component to achieve economic development and that, therefore, low productivity in this sector may justify the fact that some countries are poor. Another important result is that countries that began the development process late have a faster growth, with the exception that the overall development process is slow, considering that the mobility of workers to the non-agricultural sector is also slow.

Just as Matsuyama (1992), Gollin et al. (2002) verifies the negative relationship between agricultural productivity, per capita product and the share of workers employed in agriculture, the same correspondence is verified between the two sectors. The author also notes a positive association between agricultural productivity and the movement of farm workers to other sectors of the economy. This result reaffirms the data results, where poor countries have higher product per worker in the non-agricultural than agricultural sector. Using the model developed by Gollin et al. (2002), Saravia et al. (2014) calibrated the model to nine South American countries and inferring the period in which each country began its industrialization. The authors also found that low agricultural productivity slows down the industrialization process, in line with previous research results. In addition, their results were in line with the growth trajectory observed in the data for each country and also with the discrepancies between them.

Another article that uses the neoclassical growth model with two sectors is Irz and Roe (2005) that also study how agricultural productivity interferes with industrialization and its relationship with economic growth. It differentiates from previous models, since aggregates the particularities in the production and consumption of agricultural goods. The agricultural sector produces not only consumer goods, but subsistence goods. The production function of agricultural goods has fixed inputs, i.e., decreasing returns to capital and labor are assumed. In addition, part of the non-agricultural sector's final goods comes as input to agricultural production, reversing the logic commonly used in the models. In relation to elasticity, food demand is inelastic and industrial goods demand is elastic. Also, considering that part of the agricultural production is food, there is a fixed minimum consumption for agricultural goods.

Results pointed out that in the transition dynamics of the model the growth rate of agricultural productivity affects the speed of capital accumulation. In addition to this qualitative analysis, the author also calibrated data for low-income countries and found that a slight variation in agricultural productivity, significantly impacts the country's growth and industrialization speed. This fact further indicates that low productivity coupled with high food prices limits savings.

In order to investigate the importance of trade opening between countries Teignier (2018) construct another growth model with characteristics similar to the one presented above. In that case, the economy also has two sectors (agricultural and non-agricultural), but agricultural production is intended for consumption only, while goods from industrial production can be used for both consumption and investment. In addition, the author also works with a small open economy, where commodities prices are exogenous. The possibility of trade between countries allows countries with low agricultural productivity to export other types of goods and import food, so that, it is not necessary to invest in the low productivity sector. Applying the model to Great Britain and South Korea, the author found that trading internationally is important to increase the speed of transformation of the non-agricultural sector in Britain and had a significant role in the process of structural change that took place in South Korea. In addition, it should be noted that trade would have further contributed to South Korea if the government had not adopted policies to guard the agricultural sector.

Kose (2002) it also work with a small open economy to analyze how shocks in world prices (capital, primary and/or intermediate goods, and the real interest rate) affect the generation and spread of economic fluctuations in developing economies. The author develops a version for developing countries of a multi-sector dynamic stochastic model of specific factors. Results show that world price shocks significantly affect fluctuations in business cycles for developing countries. In line with models with more than one sector, Canton (2002) showed that the economy's growth rate is higher when the population allocates its time to qualify in environments of greater uncertainty, i.e., accumulating more human capital than physical capital. These results were achieved through a two-sector endogenous growth model based on the Lucas Jr (1988) and Uzawa (1965) model.

Back to work focused on analyzing the relationship between the agricultural and non-agricultural sectors, Da-Rocha and Restuccia (2006) uses a two-sector RBC model, where work is indivisible. They calibrate data for the United States. Results indicate that a significant increase in the percentage of the population working in the agricultural sector significantly increases fluctuations in aggregate production. Ireland and Schuh (2008) also uses a two-sector Real Business Cycle model to study the effect of different types of shocks on macroeconomic variables. Authors used post-war United States data and identified that the slowdown in productivity in the 1970s was due to the consumer goods sector. Moreover, their results pointed to the fact that the investment slowdown occurred after this first period and was more persistent in relation to the slowdown caused by consumer goods.

Studying how the endowment of a specific factor influences the long-term performance of a country's economy, Guilló and Perez-Sebastian (2007) develops a neoclassical growth model with an open economy and two sectors that have fixed specific factors, like natural resources, in their production. The authors were able to show that how the country allocates a particular factor between the two sectors can explain why countries with similar endowments have divergent income levels. Moreover, when this factor is employed in the sector with lower labor participation, income tends to be higher in the long run.

In order to investigate if neoclassical growth models can explain the sectoral patterns of the currently rich countries, Gollin et al. (2004) builds an extension to the neoclassical model with an agricultural sector that fails to unravel the differences between agricultural and non-agricultural productivity. They argue that this intersectoral differences can explain the different income levels across countries, but in this first model developed its isn't taked into account intersectoral disparities between rich and poor countries. The authors then construct a model that incorporates domestic production to take into account the relative particularities of each country in relation to others. The results indicate that this new model explains better the differences in productivity among sectors and income levels between countries.

Restuccia et al. (2008) uses a two-sector general equilibrium model to investigate how agriculture interferes with per capita product disparities among countries. The authors find that in addition to differences in productivity across economies, barriers to inputs that improve agricultural productivity, as well as blocking labor mobility, lead to significant disparities between countries in both employment and labor productivity in the agricultural sector.

Given the above, a model for a small open economy with two sectors, agricultural and non-agricultural, is developed to study how the investment decision of a representative agent in this economy affects the long-term growth rate.

3 THE MODEL

The model developed below is based on the neoclassical endogenous growth model. It presupposes a small economy open only for commodities, that is, the price of this good is determined by the international market. In addition, the model has a representative agent, households, who choose how much they will consume of agricultural and non-agricultural goods and how much capital they will invest in each of these sectors. Still, these two sectors each have a representative firm. To find the competitive equilibrium of this economy is used the problem of the social planner, mathematically and computationally solved recursively through the Belmann equation.

3.1 HOUSEHOLDS

The representative agent of this economy maximizes its utility by choosing how much to consume of the agricultural and non-agricultural goods and capital for the next period. The subjective discount factor is $\beta \in (0,1)$; the price of agricultural good is P_t, the price of non-agricultural good is normalized to 1; r_t is the interest rate that pays for capital and its depreciation is given by δ.

So the representative household solves the problem:

$$\max_{\{c_t^A, c_t^N, k_{t+1}\}} \sum_{t=0}^{\infty} \beta^t u(c_t^A, c_t^N) \tag{3.1}$$

subject to:

$$P_t c_t^A + c_t^N + k_{t+1} = (1 + r_t - \delta)k_t \tag{3.2}$$

and the restriction of non-negativity of both consumption and investment:

$$c_t^A, c_t^N, k_{t+1} \geq 0 \tag{3.3}$$

It is worth explaining the investment function: $i_t = k_{t+1} - (1-\delta)k_t$ and the functional form assumed for utility is: $u(c_t^A, c_t^N) = \frac{\{(1-\varphi)(c_t^A)^\mu + \varphi(c_t^N)^\mu\}^{\frac{1-\sigma}{\mu}}}{1-\sigma}$, where φ is the relative (share) preference on non-agricultural good (the closer to one, more the agent prefers to consume non-agricultural good over the agricultural good), σ is the risk aversion preference and μ is the coefficient that governs elasticity between both goods. Also, μ shows how concave the utility function is between the two goods, yet how convex the agent's indifference curve is. Taking into account that $0 < \mu < 1$, higher μ is more the goods are substitute for the representative agent, while lower μ is more the goods are complementary.

3.2 Non-agricultural sector

To produce non-agricultural goods, firms require capital and a share of agricultural production (X_t). The static non-agricultural firm's problem is to maximize profit each period:

$$\max_{\{K_t^N, X_t\}} \Pi_t = F(K_t^N, X_t) - r_t K_t^N - P_t X_t \tag{3.4}$$

Where the functional form of the production function for the representative non-agricultural firm is: $Y_t^N = (K_t^N)^\alpha X_t^{1-\alpha}$.

3.3 Agricultural sector

To produce agricultural goods, firms require capital and a fixed factor land T that is an endowment previously given. The dynamic agricultural firm's problem is:

$$\max_{\{K_t^A\}} \sum_{t=0}^{\infty} \frac{1}{1+r_t} \Pi_t = \max_{\{K_t^A\}} \sum_{t=0}^{\infty} \frac{1}{1+r_t} (F(K_{t-1}^A, T) - r_t K_t^A) \tag{3.5}$$

Where the functional form of the production function for the representative agricultural firm is: $Y_t^A = T(K_{t-1}^A)^\gamma$, in which it can be noted that differently from the non-agricultural firm that has constant returns to scale, the agricultural firm has decreasing returns to scale, as $0 < \gamma < 1$.

3.4 Social Planner Problem

The model has complete markets, so, according to the two Welfare Theorems, the solution to competitive equilibrium is Pareto efficient and, even if there is a representative agent, this solution is the same as the Social Planner problem. In this sense, the problem of the social planner is to maximize the utility function of the representative agent (social welfare) by choosing allocations, restricted to the fact that these allocations are necessarily feasible. Thus, we can write as follows:

$$\max_{\{c_t^A, c_t^N, k_{t+1}\}} \sum_{t=0}^{\infty} \beta^t u(c_t^A, c_t^N) \tag{3.6}$$

subject to resources constraints ∀t:

1. $$c_t^N + k_{t+1} = F(K_t^N, X_t) + (1-\delta) k_t \tag{3.7}$$

2.

$$c_t^A + X_t + b_{t+1} = F(K_{t-1}^A, T) + R_t b_t \tag{3.8}$$

3.

$$k_t = K_t^N + K_t^A \tag{3.9}$$

Where b are the country's reserves. If $b_{t+1} > 0$ then the country is exporting, i.e., increasing its reserves. If $b_{t+1} < 0$ then the country is importing, i.e., decreasing its reserves. R_t is the international interest rate given exogenously.

Isolating K_t^N in 3.9 and replacing in 3.7, and also c_t^N in 3.7 and c_t^A in 3.8 and replacing in 3.6 we find that the social planner problem is:

$$\max_{\{k_{t+1}, K_t^A, X_t, b_{t+1}\}} \sum_{t=0}^{\infty} \beta^t u(c_t^A, c_t^N) \tag{3.10}$$

where:

$$c_t^N = F(k_t - K_t^A, X_t) + (1-\delta)k_t - k_{t+1} \tag{3.11}$$

$$c_t^A = F(K_{t-1}^A, T) + R_t b_t - X_t - b_{t+1} \tag{3.12}$$

Thus, the state variables of the model are: k_t, K_{t-1}^A, b_t and the control variables: $k_{t+1}, K_t^A, X_t, b_{t+1}$

3.4.1 Solving the social planner problem

To solve the social planner problem it is necessary to write it recursively. Recursive competitive equilibrium is analogous to sequential competitive equilibrium. Recursively writing, through the Bellman equation, enables the solution of the mathematical and computational problem. Bellman's equation unravels the problem to be solved by changing the objective function.

Recursively the state variables are: k, K_{-1}^A, b and control variables: k', K^A, b', X. Bellman's equation for our model is then:

$$V(k, K_{-1}^A, b) = \max_{\{k', K^A, b', X\}} u(c^A, c^N) + \beta V(k', K^A, b') \tag{3.13}$$

where:

$$c^N = (k - K^A)^\alpha X^{1-\alpha} + (1-\delta)k - k' \tag{3.14}$$

and

$$c^A = T(K_{-1}^A)^\gamma + Rb - b' - X \tag{3.15}$$

Denoting u_{c^N} as marginal utility relative to non-agricultural consumption and, similarly, u_c^A relative to agricultural, optimum conditions are:

$$\frac{\partial V}{\partial k'} = -u_{c^N}(c^A, c^N) + \beta V_1(k', K^A, b') = 0 \tag{3.16}$$

$$\frac{\partial V}{\partial K^A} = -u_{c^N}(c^A, c^N)\alpha(k - K^A)^{\alpha-1}X^{1-\alpha} + \beta V_2(k', K^A, b') = 0 \tag{3.17}$$

$$\frac{\partial V}{\partial b'} = -u_{c^A}(c^A, c^N) + \beta V_3(k', K^A, b') = 0 \tag{3.18}$$

$$\frac{\partial V}{\partial X} = -u_{c^A}(c^A, c^N) + u_{c^N}(c^A, c^N)(1-\alpha)(k - K^A)^\alpha X^{-\alpha} = 0 \tag{3.19}$$

Where V_1, V_2 and V_3 are the partial derivatives of V with respect to k', K^A and b' respectively and we need to find these derivatives. For this purpose the Benveniste - Scheinkman Theorem, found in Benveniste and Scheinkman (1979) is used. Thus, we assume that:

$$k' = f(k, K_{-1}^A, b) \tag{3.20}$$

$$K^A = g(k, K_{-1}^A, b) \tag{3.21}$$

$$b' = h(k, K_{-1}^A, b) \tag{3.22}$$

$$X = j(k, K_{-1}^A, b) \tag{3.23}$$

Applying the theorem we find:

$$V_1(k, K_{-1}^A, b) = u_{c^N}(c^A, c^N)\{\alpha(k - K^A)^{\alpha-1}X^{1-\alpha} + 1 - \delta\} \tag{3.24}$$

$$V_2(k, K_{-1}^A, b) = u_{c^A}(c^A, c^N)\{T\gamma(K_{-1}^A)^{\gamma-1}\} \tag{3.25}$$

$$V_3(k, K^A_{-1}, b) = u_{c^A}(c^A, c^N)R \tag{3.26}$$

Replacing 3.24 in 3.16, 3.25 in 3.17, 3.26 in 3.18 we have:

$$u_{c^N}(c^A, c^N) = \beta u_{c^N}(c^A_{+1}, c^N_{+1})\{\alpha(k' - K^A_{+1})^{\alpha-1}X'^{1-\alpha} + 1 - \delta\} \tag{3.27}$$

$$u_{c^N}(c^A, c^N)\{\alpha(k - K^A)^{\alpha-1}X^{1-\alpha}\} = \beta u_{c^A}(c^A_{+1}, c^N_{+1})\{T\gamma(K^A)^{\gamma-1}\} \tag{3.28}$$

$$u_{c^A}(c^A, c^N) = \beta u_{c^A}(c^A_{+1}, c^N_{+1})R \tag{3.29}$$

Still, rearranging the terms of the equation 3.19 we have:

$$u_{c^A}(c^A, c^N) = u_{c^N}(c^A, c^N)(1-\alpha)(k - K^A)^{\alpha}X^{-\alpha} \tag{3.30}$$

The equation 3.27 shows how the representative agent of this economy changes the consumption of non-agricultural good over time, i.e., it is the Euler Equation of non-agricultural good for this agent. Equation 3.29 is the Euler equation for the agricultural good for this same agent, i.e., shows how the agent changes the consumption of the agricultural good over time. The equation 3.30 shows how the agent chooses its consumption between agricultural and non-agricultural goods, given the marginal productivity of the portion of agricultural production destined to the production of non-agricultural good (X).

3.4.2 The Steady State

In steady state, from the equation 3.27 we find that:

$$1 = \beta\{\alpha(k - K^A)^{\alpha-1}X^{1-\alpha} + 1 - \delta\} \tag{3.31}$$

And yet, from the equation 3.29 we find the condition of existence of the steady state where: $\beta R = 1$ and therefore the international interest rate is $R = \frac{1}{\beta}$ in the steady state.

Substituting the generic form of the utility function for its functional form we have that the marginal utilities in relation to agricultural and non-agricultural consumer goods are:

$$u_{c^A} = \frac{1}{\mu}\left[\frac{\{(1-\varphi)(c^A)^\mu + \varphi(c^N)^\mu\}^{\frac{1-\sigma}{\mu}-1}}{1-\sigma}\right]\mu(1-\varphi)(c^A)^{\mu-1} \tag{3.32}$$

$$u_{c^N} = \frac{1}{\mu}\left[\frac{\{(1-\varphi)(c^A)^\mu + \varphi(c^N)^\mu\}^{\frac{1-\sigma}{\mu}-1}}{1-\sigma}\right]\mu\varphi(c^N)^{\mu-1} \tag{3.33}$$

Thus, the ratio of marginal utilities is:

$$\frac{u_{c^A}}{u_{c^N}} = \frac{1-\varphi}{\varphi}\left(\frac{c^A}{c^N}\right)^{\mu-1} = \frac{1-\varphi}{\varphi}\left(\frac{T(K^A)^\gamma + (R-1)b - X}{(k-K^A)^\alpha X^{1-\alpha} - \delta k}\right)^{\mu-1} \tag{3.34}$$

Here, the country has no need to trade with the outside because it is in a steady state. So $b = 0$ and the term $(R-1)b = 0$, no longer appearing in the equation.

Equation 3.34 in 3.28:

$$\alpha(k-K^A)^{\alpha-1}X^{1-\alpha} = \beta\frac{1-\varphi}{\varphi}\left(\frac{T(K^A)^\gamma - X}{(k-K^A)^\alpha X^{1-\alpha} - \delta k}\right)^{\mu-1} T\gamma(K^A)^{\gamma-1} \tag{3.35}$$

Equation 3.34 in 3.30:

$$\frac{1-\varphi}{\varphi}\left(\frac{T(K^A)^\gamma - X}{(k-K^A)^\alpha X^{1-\alpha} - \delta k}\right)^{\mu-1} = (1-\alpha)(k-K^A)^\alpha X^{-\alpha} \tag{3.36}$$

From these equations we find the optionally the values of k, K^A and X in the steady state. Remembering that $b = 0$, from the equation 3.36 we can see that choosing to consume more of the agricultural good implies a decrease in the supply of agricultural inputs in non-agricultural production, which in turn alters the productivity of the sector.

4 ANALYTICAL RESULTS

4.1 Long Term Analysis

For a more in-depth analysis of steady state, it is analyzed below how this economy behaves by varying the parameters $\alpha, \gamma, \mu, \varphi$ and T, that is, the participation of capital in non-agricultural production, in agriculture, the parameter that shows how the agent exchanges consumption between the two goods, the preference for non-agricultural good and the country's land allocation.

The following five figures have 4 graphs each one that show the behavior of model variables when parameter values are changed. First graph, *a*, shows the variation in production for each sector; the second, *b*, exposes the capital allocation between sectors; graph *c* shows the behavior of agricultural sector while graph *d* the non-agricultural sector when one of the model parameters varies, ceteris paribus. The figures refer to variation of parameters α, γ, T, μ and φ respectively.

Figura 4.1: Economy behavior varying α

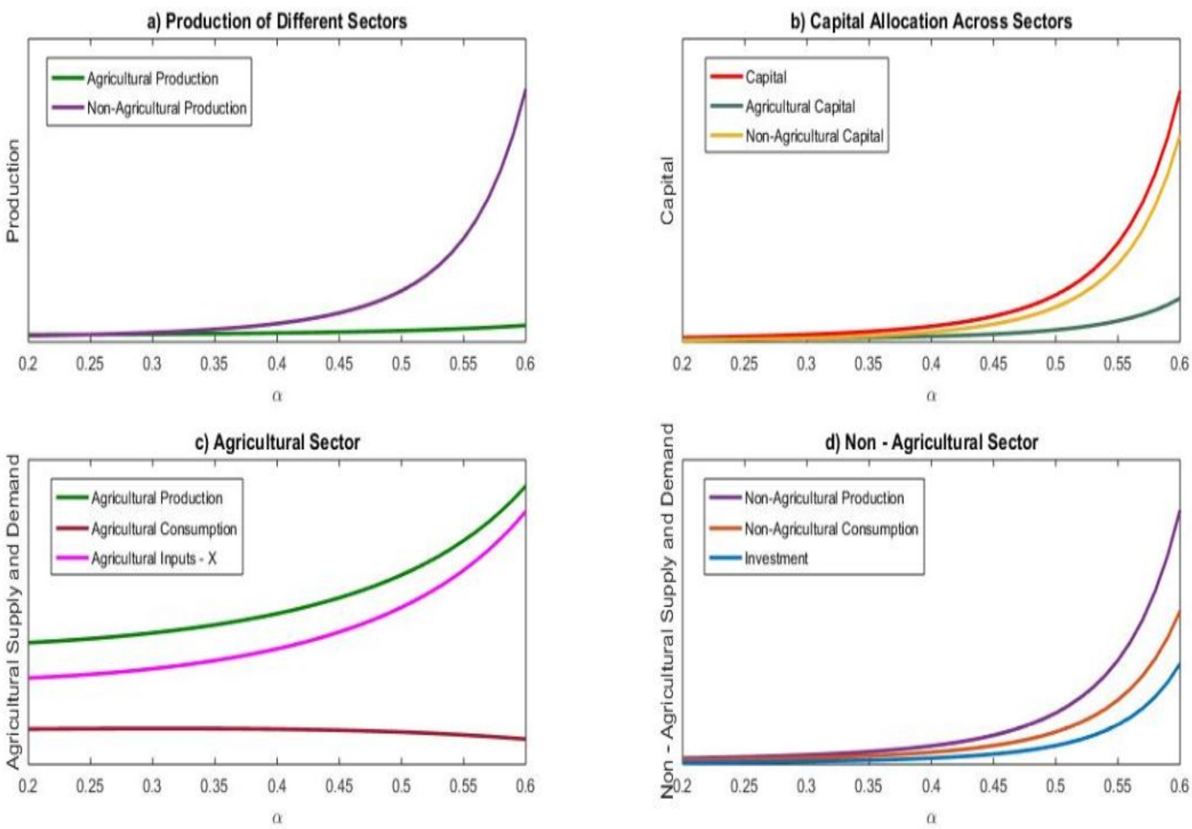

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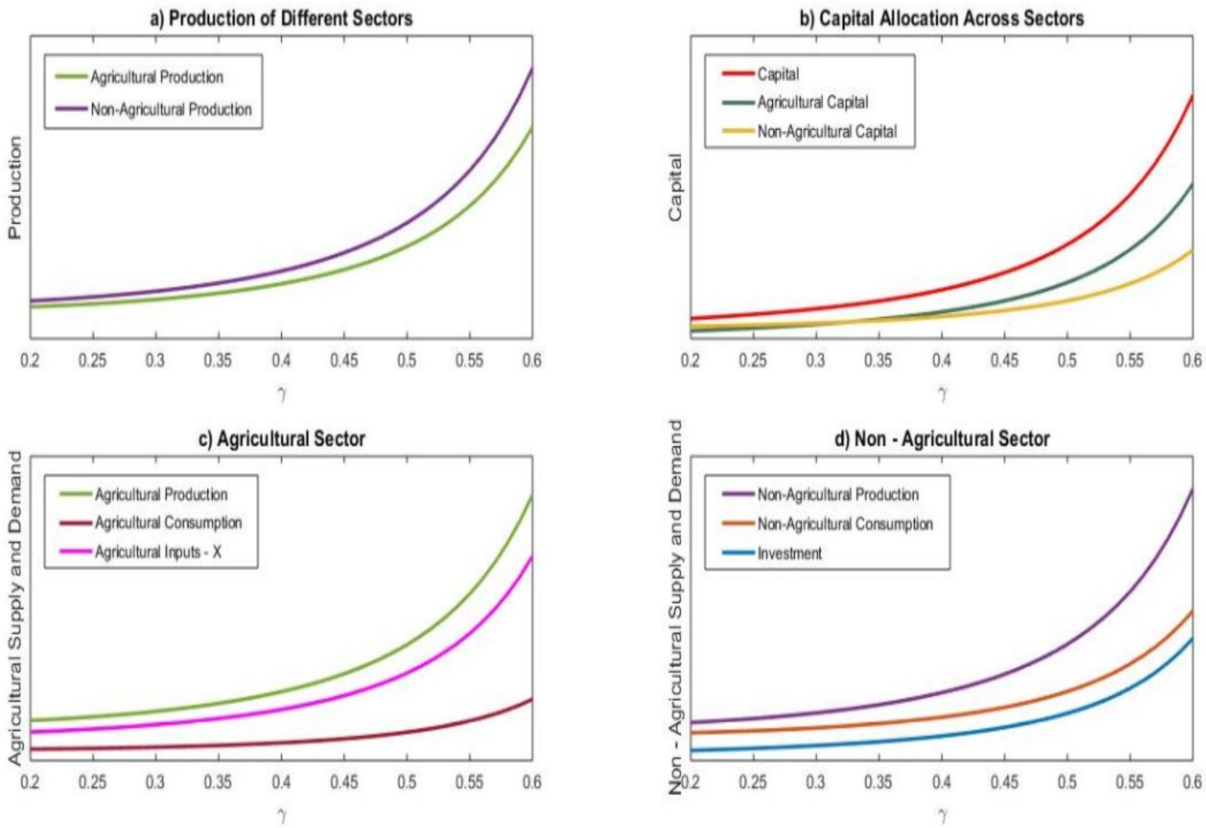
Figure 4.1 shows how the economy reacts when capital participation in non-agricultural good production varies, that is, when the productivity of this sector varies. In the graphic *a* is possible to observe that an increase of α causes non-agricultural production to grow almost exponentially while in agriculture has an almost negligible increase. This is justified in the following graph, *b*, where it is shown that the amount of capital used in industrial sector production increases faster than in the agriculture sector.

Still in relation to the figure 4.1, looking at the agricultural sector, in graphic *c*, by increasing the share of capital, the agricultural consumption suffers a slight fall, while production, accompanied by the amount of agricultural inputs increase. The explanation for this increase in agricultural inputs is due to the fact that if a smaller portion of production is consumed by the households, a larger amount is available for the industrial firms. Also, as is already expected by the fact that manufacturing production has constant returns to scale, higher the α lower the agricultural input productivity and, consequently, greater the demand for this input by the firm. Now looking at non-agricultural sector, α increases also generates an expand in non-agricultural consumption and production. In addition, investment increases, however less than consumption and production, but it also increases.

Figura 4.2: Economy behavior varying γ



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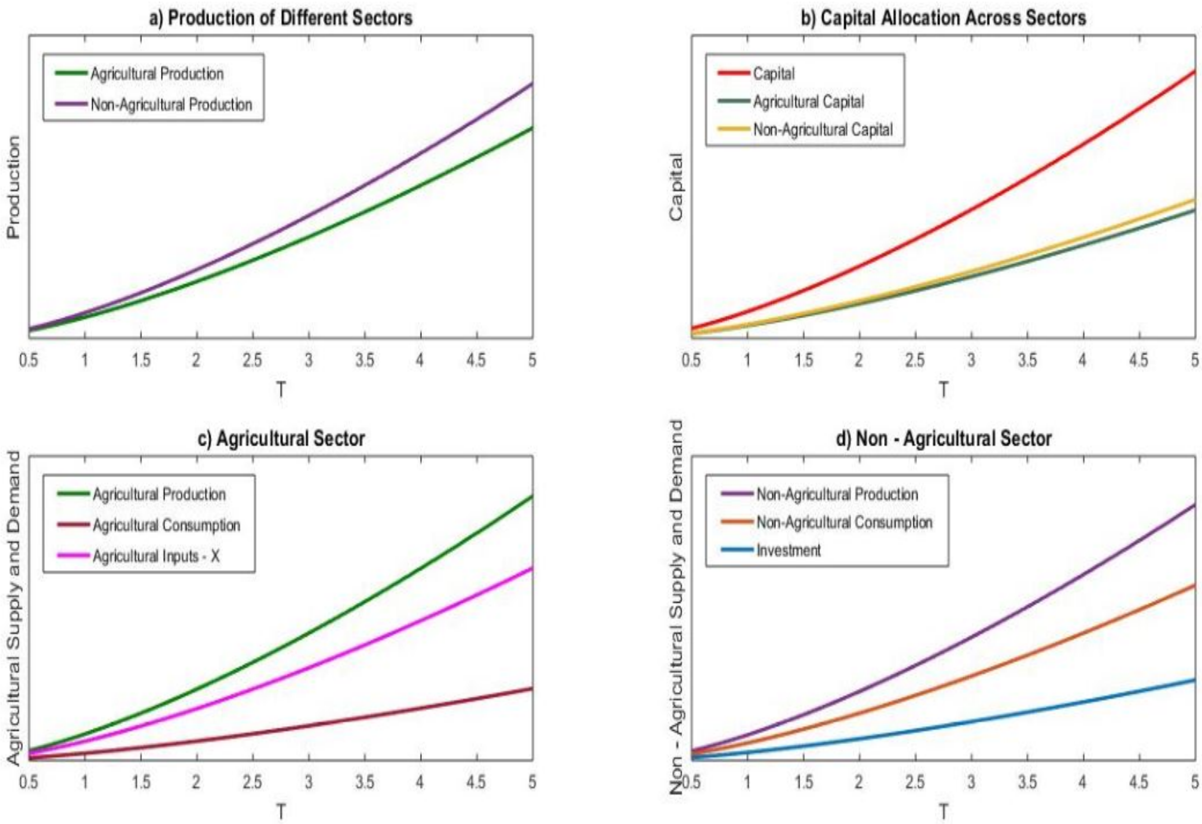
In the figure 4.2, explained by the increase in the share of capital on agriculture, it is noted that as agricultural productivity increases, production of both sectors increases, being that the non-agricultural sector has a slightly larger increase. Moreover, it is noticeable that the amount of capital employed in both sectors also increases, justifying the increase in production, although graphically we can see that the increase in capital is greater in agriculture.

By increasing γ, agricultural production increases, followed by an almost proportional increase in agricultural inputs for industrial production. The consumption also increases, but very little compared to the expand of inputs. The behavior of non-agricultural sector variables is similar to the previous case where α was varied. Both production and consumption increase, as does investment, but more subtly when compared to other variables.

Figure 4.3 shows that larger the land endowment of a country, greater will be its output from both the agricultural and non-agricultural sectors. The output from non-agricultural sector is higher than agricultural sector because, by having more land, the country tends to increase its production of agricultural inputs for industry. This condition means that although food production increases, this increase is much lower than agricultural input production. Occur, therefore, an expansion in the consumption of manufactured goods due to the increase in production of this sector. It can also be noted that there is growth in capital in both sectors and that this growth is almost identical. Investment, when land allocation is higher, tends to increase as well, but as in previous cases it is smooth.

Figura 4.3: Economy behavior varying T



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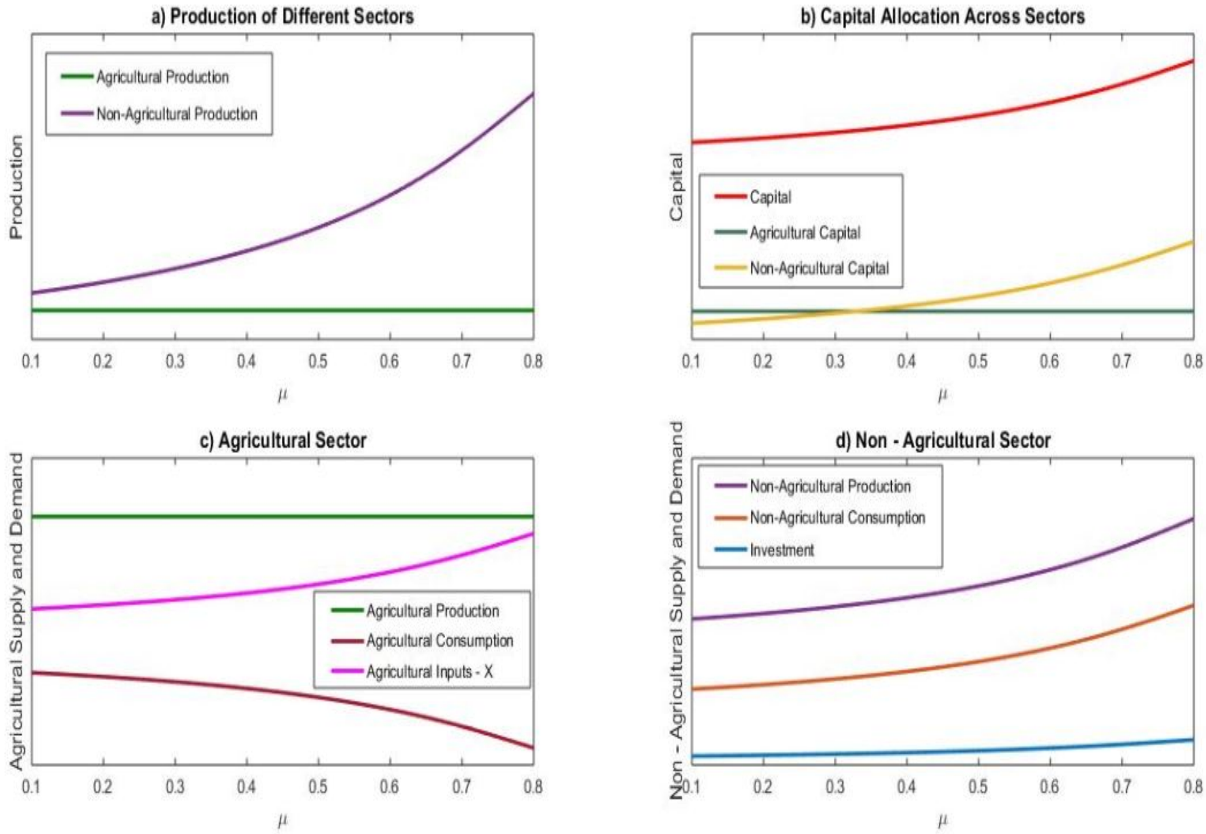
We can conclude that a country with greater land endowment prefers allocate more resources for agricultural inputs for industry than increase commodities production. It demonstrates a greater preference for non-agricultural goods to the detriment of agricultural. It doesn't mean that commodities consumption decreases, but it increases much less than manufactured goods consumption and agricultural inputs production, as can be seen in graphs *c* and *d* of figure 4.3.

The figure 4.4 provides us with information about the economy behavior for different elasticities among the representative agent goods. The closer to 1 is μ, the greater the substitutability between goods for the agent. On contrary, the closer to zero this value is, the more characteristics of complementary goods they will have. Taking this into account, when μ is higher, agricultural production does not change while non-agricultural production increases. This is because the agent decides to invest more in capital from the industrial sector while capital destined for agriculture remains constant. Conversely, the lower value of μ, lower the interest in investing in the non-agricultural sector, and from a point of view, even if the agricultural capital drive does not change, industrial capital may become less than it.

It can also be noted that higher the μ, more individuals tend to increase the consumption of non-agricultural good and to decline of agricultural good. Moreover, with this decrease in agricultural consumption, the production of inputs for the industry increases, as the production of this sector does not change. The investment in this case has an even sluggish increase compared to the previous cases, being practically insignificant.

Figura 4.4: Economy behavior varying μ



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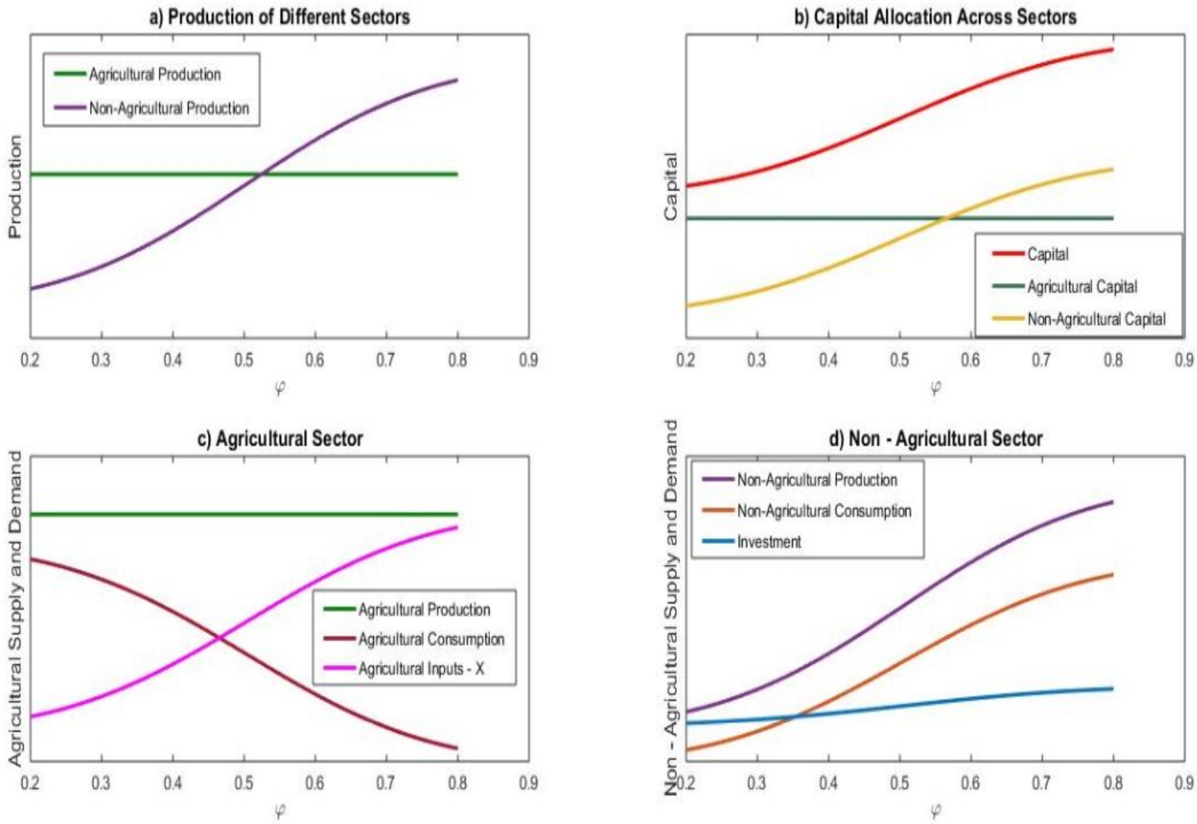
Finally, when analyzing the relative preference of households for non - agricultural goods, φ, it is possible to observe in figure 4.5 that the production of agricultural sector does not change. Manufacturing tends to increase higher value of this parameter. Industrial production tends to increase at increasing rates while it is lower than agricultural production. When it exceeds this level it continues to grow but at decreasing rates. This is because if φ is closer to one, then the agent will prefer to consume non-agricultural goods over agricultural ones. This fact is also reflected in the inputs production, which tends to increase considering the latter case. These findings help to understand why manufacturing output increases when φ is higher. As with μ only the capital of non-agricultural sector increases and, again, steady state investment rises very smoothly.

Figura 4.5: Economy behavior varying φ



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From this analysis it is possible to conclude that by varying the model parameters, the amount of investment does not change significantly when the economy is in steady state. The same cannot be said for the other variables. It could be observed that higher values of these parameters (without elaborating the meaning each of them at this point in the text), more households tend consume more of the industrial good than the agricultural good.

Regarding the investment decision in each sector, it was possible to observe that with exception of households preferences parameters, there was a tendency of capital increase for both sectors, but in different proportions and orders. In the analysis of land allocation, the agent allocates amounts almost identical to the sectors. For changes in the share of capital in each sector, as expected, the representative agent tends to allocate more capital to the sector with the largest share, but in case of α increases the difference between sectors is larger compared to γ.

5 CONCLUSION

This thesis aims to understand the role of investment in economic growth. The investment decision determines how much capital this agent spends on the agricultural and non-agricultural sectors. Through the social planner problem we solve the competitive equilibrium an extension of the neoclassical growth model.

We find that the sector choice to invest has similar behavior when changing the values of capital participation in each sector and the country's land allocation. In this sense, there was a tendency of capital increase in each sector. For α and γ, as expected, the representative agent of this economy tends to invest more in sector that is demanding more capital to produce. Even more, in case of α increases the difference between the amount of capital earmarked for non-agricultural sector relative to the agricultural is even greater when compared to the inequality generated by γ increases.

In relation to land, countries with larger land endowments tend to allocate more volume of capital invested in both sectors. The difference between capital amount in each sector, however, is very small. Moreover, by changing the parameters of model in steady state, investment has no changes that can be considered significant. A suggestion for future work is to calibrate the model for data from different countries with different economic structures and at different transition phases.

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