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Structural change and inter-sectoral mobility in a two-sector economy

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ABSTRACT

This paper studies the dynamics of a two-sector economy (with a *natural resource-dependent sector* and an *industrial sector*) characterized by free inter-sectoral labor mobility and heterogeneity of agents (*workers* and *entrepreneurs*). In such a context, we analyze the effects of the deterioration of natural resources, caused by the production activity of both sectors, on inter-sectoral movements of the labor force (*structural changes*), on ecological dynamics and on the revenues of workers and entrepreneurs. As in the seminal work by Matsuyama (1992), we obtain that a low productivity of labor in the resource-dependent sector can fuel the industrialization process. However, differently from Matsuyama, in our model the industrialization process may give rise to a reduction in workers' revenues if the contribution to environmental depletion of the industrial sector, per unit of product, is higher than that of the resource-dependent one.

1. Introduction

In 2011, nearly 50% of the population in developing countries lived in areas classified as urban, compared with less than 30% in the 1980s (see [2]). This means that in the last three decades there has been a significant migration from rural to urban areas. This phenomenon is, in many cases, associated to a structural change determined by a movement of labor force and production activities from natural resource-dependent sectors towards manufacturing sectors. It is often argued that structural changes are cause and consequence of economic development and growth (see, e.g., [3–5]), exactly as it happened in Europe in the nineteenth century due to the Industrial Revolution (see, e.g., [6]).

The main reason why many workers leave rural areas is the hope of improving their condition, escaping from a situation of poverty or unemployment, and attracted by a higher wage rate. In economic growth theory, there are two main explanations of the structural changes: the changing of consumption patterns (demand-side) and the technological innovation (supply-side). In the first case (see, e.g., [7]), as income rises, the representative consumer increases manufacture and service demand, and reduces agricultural one; this modifies the production system and, hence, the composition of the labor force. In the second case (see, e.g., [8]), the technological innovation, lower in traditional sectors, rises profits and wages in the secondary and tertiary sectors, with a consequent increase of investments and labor force employment in such sectors.

Whatever is the cause of structural changes, there is general agreement that they are an integral part of the economic growth process in developing countries and that they produce improvements in welfare of economic agents. However, an increasing share of literature deals with the negative

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effects on welfare due to the depletion of free access-natural resources which, in some cases, accompanies them. López [9,10] and Antoci et al. [11–13] argue that environmental degradation, caused by the expansion of the industrial sector, may fuel a self-enforcing process of structural change determined by a decrease in productivity in the traditional resource-based sector. In such a context, the industrialization process is often associated with growing problems of environmental degradation, declining or stagnant wages and the perpetuation of poverty. López [10] refers to these cases as *perverse structural changes*. Natural resources degradation is a serious problem in several developing countries characterized by ill-defined property rights on natural resources and high levels of inequality. Environmental degradation is playing a key role especially in those countries where strong growth rates have been observed in recent years, such as India and China, where many citizens are forced to change their behavior to defend themselves against the pollution effects of the industrialization process [14–19].

This paper analyzes the dynamics of a two-sector economy (with a *natural resource-dependent sector* and an *industrial sector*) characterized by free inter-sectoral labor mobility and heterogeneity of agents (*workers* and *entrepreneurs*). In such a context, we study the effects of the deterioration of natural resources, caused by the activity of both sectors, on inter-sectoral movements of labor force (*structural changes*), on ecological dynamics and on workers and entrepreneurs' revenues. In our model, as in the seminal work by Matsuyama [1], a low productivity of labor in the resource-dependent sector can be the engine of the industrialization process. However, differently from Matsuyama, we assume that the industrialization process generates environmental degradation and, consequently, a reduction in labor productivity in the resource-dependent sector. This may give rise to a self-enforcing process according to which the expansion of the industrial sector generates, via an increase in environmental degradation, a reduction in labor productivity in the resource-dependent sector and therefore leads workers to move from the resource-dependent sector towards the industrial one; the consequent further expansion of the industrial sector generates further environmental degradation and reduction in labor productivity in the resource-dependent sector, and so on. In such a context, the expansion of the industrial sector, at the expenses of the resource-dependent one, may be associated to a decrease in workers' revenues and an increase in entrepreneurs' revenues; that is to an increase in inequality between the two classes of economic agents. Our study starts from the framework proposed by Antoci et al. [13], but introduces some crucial differences. More specifically, in [13], the polluting sector is the industrial sector and not the resource-dependent sector, while in this paper we assume that both sectors negatively affect environmental resources. Furthermore, we augment the model of [13] by introducing inter-sectoral dynamics from one sector to the other; labor allocation dynamics is determined by the difference between the wage rate in the industrial sector and the per capita output in the resource-dependent sector.[1] Augmenting the two-dimensional dynamic system analyzed in [13], by the introduction of inter-sectoral dynamics, we obtain a dynamics which takes place in a three-dimensional box of the plane (K, N, E), where K is the capital stock, N the number of workers employed in the traditional resource-dependent sector, E the stock of an environmental resource. In this context we prove that, differently from [13], the stationary state in which both sectors coexist can be attractive only if it corresponds to a structural change which improves workers' welfare. However we also show, as in [13], that if the contribution to environmental depletion of the natural resource-dependent sector is below a given threshold value, then the trajectories, which always exist, converging to a stationary state specialized in the industrial sector (i.e. where the variable N is zero) lead to a reduction in workers' welfare.

The paper is organized as follows. The model is presented in Section 2. Section 3 contains local analysis, Sections 4 and 5 deal with global analysis, Section 6 introduces a *specialized dynamics* on $N = 0$, Section 7 studies the welfare properties of the stationary states and Section 8 concludes. The proof of Theorem 9 is in the mathematical appendix.

2. Set up of the model

We examine a small open economy with two sectors – a natural resource-dependent sector (the E-sector) and an industrial sector (the I-sector) – free inter-sectoral labor mobility and heterogeneous agents. The production activity in the E-sector is based on a free-access environmental resource, while the production in the I-sector is based on the stock of physical capital accumulated in the economy. Economic agents belong to two different communities, one made of "workers", the other of "industrial entrepreneurs". The former are endowed only with their own working capacity and use it either in the E-sector or working as employees of the industrial entrepreneurs in the I-sector. In turn, the latter, who own physical capital and hire labor force, produce industrial goods.

The economy we consider is *small* and *open*, therefore the prices of the goods produced in both sectors can be considered as exogenously determined regardless of what happens in the economy. For simplicity, it is assumed that entrepreneurs do not invest in the E-sector, the latter being composed of small firms each of which is run by a worker.

The aggregated production functions of the E- and I-sectors are given, respectively, by

$$Y_I = (\overline{N} - N)^{\alpha} K^{1-\alpha} \quad 1 > \alpha > 0, \quad \overline{N} > 0 \tag{1}$$

$$Y_E = \beta N E \quad \beta > 0 \tag{2}$$

where the variable $N \in [0, \overline{N}]$ (respectively, $\overline{N} - N$) represents the labor force employed in the E-sector (respectively, the I-sector) and the parameter $\overline{N}$ represents the size of the population of workers; E is the stock of a free-access natural resource and K is the aggregated stock of physical capital accumulated by the entrepreneurs; the parameter β is a measure of productivity in the E-sector. The production function

[1] In the model of [13], instantaneous adjustment of the labor market is assumed; that is, in each instant of time, the allocation of labor force between the two sectors of the economy is such that the wage rate in the industrial sector equals per capita output in the resource-dependent sector.