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Research paper

Environmental pollution as engine of industrialization

Angelo Antoci[a], Marcello Galeotti[b,*], Serena Sordi[c]

[a] Dipartimento di Scienze Economiche e Aziendali, University of Sassari, via Muroni 25, 07100 Sassari, Italy
[b] Dipartimento di Statistica, Informatica, Applicazioni 'G. Parenti', University of Florence, viale Morgagni 59, 50134 Firenze, Italy
[c] Dipartimento di Economia Politica e Statistica, University of Siena, piazza San Francesco 7, 53100 Siena, Italy

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ABSTRACT

This paper analyzes the dynamics of a small open economy with two sectors (a farming sector and an industrial one), heterogeneous agents (workers and entrepreneurs) and free inter-sectoral labor mobility. Labor productivity in the first sector is negatively affected by environmental pollution generated by both sectors, whereas in the second sector it is positively affected by physical capital accumulated by entrepreneurs. Through a global analysis of the non-linear three-dimensional dynamic system of the model we derive conditions under which industrialization generates a decline in workers' revenues in both sectors.

1. Introduction

There is general agreement that industrialization is an integral part of the economic growth process in developing countries and that it produces improvements in the welfare of economic agents, exactly as happened in Europe in the nineteenth century due to the Industrial Revolution (see, e.g., Lewis [24]; Ranis and Fei [31]; Bade [3]; Lucas [29]). However, an increasing number of contributions in literature deals with the negative impact on welfare of environmental pollution and depletion of free access-natural resources which, in some cases, accompany industrialization processes. López [27] documented cases of structural changes triggered by the degradation of natural resources in Latin America and Sub-Saharan Africa. He introduced the term 'perverse structural change' to refer to structural changes of this type, which are characterized by a) environmental degradation and b) stagnant or declining wages of unskilled labor force in both farming and non farming sectors. The decline in the unskilled labor remuneration due to environmental degradation is documented by several works in literature (see, e.g., Bresciani and Valdés [6]). Environmental degradation lowers the opportunity cost to work in non agricultural sectors and may fuel a development process of the type described in this paper. Other examples of structural changes catalyzed by environmental degradation have been observed in regions that have grown at high rates in recent years. In several small or medium size rural areas of Africa, China and India, environmental degradation is becoming a key issue and citizens are forced to change their behavior to defend themselves against the pollution effects of the industrialization process (see Economy [13]; World Bank [42]; Dhamodharam and Swaminathan [11]; Boopathi and Rameshkumar [5]; Deng and Yang [10]; Holdaway [22]; Chuhan-Pole et al. [8]). This is well described by the case study of Reddy and Behera [33], where the economic costs of water pollution due to industrial activity in the rural communities located in the industrial belts in Andhra Pradesh, South India, is evaluated. The cost estimates revealed that the impact of industrial pollution on

* Corresponding author.
E-mail addresses: angelo.antoci@virgilio.it (A. Antoci), marcello.galeotti@dmd.unifi.it, marcello.galeotti@unifi.it (M. Galeotti), serena.sordi@unisi.it (S. Sordi).

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rural communities is quite substantial in monetary terms,[1] and is not compensated by the increase in the share of revenues deriving from the employment in industrial polluting sectors.

The purpose of this paper is to make a contribution to a better understanding of the interactions between environmental pollution, process of industrialization and workers' welfare. To this end, we analyze the dynamics of a small open economy where there are only two sectors (a farming sector, in short, 'F-sector', and an industrial sector, in short, 'I-sector'), free labor mobility and heterogeneous agents (farmers, 'F-agents', and industrial entrepreneurs, 'I-agents'). The latter are characterized as follows. F-agents are endowed only with their own working capacity and use it either in the F-sector, for the production of farming goods, or as employees of I-agents in the I-sector. In turn, only I-agents are able to accumulate physical capital, which is entirely employed in the I-sector to produce, jointly with the labor force provided by F-agents, industrial goods.

In our formalization, the state of the economy is described by three variables which are defined as follows. $N \in [0, \bar{N}]$ ($\bar{N} - N$, respectively) represents the labor force employed in the F-sector (in the I-sector, respectively), P the stock of accumulated pollution, and K the aggregated stock of physical capital accumulated by I-agents. Labor productivity in the F-sector is negatively affected by the stock of pollution P, while in the I-sector it is positively affected by the physical capital stock K. The dynamics of K, N and P are represented by a three-dimensional dynamic system. The accumulation process of K is built on a Solow [39]-type capital accumulation mechanism (see, among the others, Guerrini [17]; Guerrini and Sodini [18]; Brianzoni et al. [7]). The labor allocation N evolves according to a payoff monotonic evolutionary dynamics (see Weibull [41]). More specifically, we assume that workers have to choose, in each instant of time, between two strategies: working in the F-sector or working in the I-sector. The payoff of the first strategy is the per capita output in the resource-dependent sector, while the payoff of the second strategy is the wage rate earned in the I-sector, which is assumed to coincide with the marginal productivity of $\bar{N} - N$. Finally, we assume that the accumulation of the stock P of pollution is positively affected by the production activities of both sectors.

We show that in such a framework environmental pollution can be the engine of the industrialization process. In fact, if the environmental impact of the I-sector is high enough relative to that of the F-sector, a self-reinforcing process of industrialization, driven by negative externalities, may be observed. The expansion of the I-sector generates a reduction in labor productivity in the F-sector via an increase in the stock of pollution and therefore leads workers to move from the resource-dependent sector towards the industrial one. The consequent further expansion of the I-sector generates an extra increase in the pollution level from which follows a further reduction in labor productivity in the F-sector, and so on. This expansion of the I-sector, at the expense of the F-sector, may be associated with a decrease in workers' revenues. When this happens – which requires a sufficiently small labor force and a polluting impact of the I-sector higher than that of the F-sector – the transition of labor from the natural resource-dependent sector towards the industrial sector can be classified as a perverse structural change, in the sense of López [27]; namely, a structural change associated with growing problems of environmental degradation, declining or stagnant wages and perpetuation of poverty.

The evolutionary dynamics of labor allocation driven by environmental degradation were also treated in Antoci et al. [2], although in a rather different context. In particular, in the latter contribution, labor productivity in the resource-dependent sector was assumed to be determined by the stock of a renewable natural resource and not to be negatively affected by pollution. Furthermore, the production technology in the resource-dependent sector was described by the function proposed by Schaefer [38], widely used in modeling production processes based on the exploitation of natural resources such as fishery and forestry. In the present paper, we assume a decreasing return technology which, in our opinion, is more suited to describe production processes in farming. This change in assumptions leads to quite different results in the dynamic analysis of the model. In particular, in Antoci et al. [2], the stationary state in which both sectors coexist can be attractive only if it corresponds to a structural change which improves workers' welfare. In the present paper we show that, if interior stationary states exist, one of them is always attractive, even if it corresponds to a structural change which reduces workers' welfare. Furthermore, differently from Antoci et al. [2], all the dynamic regimes that may be observed under the model analyzed in the present paper are fully described.

The structure of the paper is the following. Section 2 introduces the model. Section 3 contains a detailed analysis of the dynamics generated by the dynamic system of the model. A few concluding and summarizing results are finally given in Section 4. A mathematical appendix at the end of the paper supplies proofs for all lemmas and theorems.

2. Set up of the model

In the small open economy with two sectors we model in this paper, the prices of both goods are exogenously determined and, without loss of generality, we assume that they are both equal to unity.

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

$$Y_F = \frac{\alpha N^{\beta}}{(1+P)^{\gamma}} \qquad 1 > \beta > 0, \ \alpha, \gamma > 0 \tag{1}$$

$$Y_I = (\bar{N} - N)^{\delta} K^{1-\delta} \qquad 1 > \delta > 0, \ \bar{N} > 0 \tag{2}$$

[1] The costs of damage would be much higher if social and health costs were accounted for.