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ANALYSIS

Environmental efficiency and labour productivity: Trade-off or joint dynamics? A theoretical investigation and empirical evidence from Italy using NAMEA

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ABSTRACT

In this paper we test an adapted EKC hypothesis to verify the relationship between 'environmental efficiency' (namely emissions per unit of value added) and labour productivity (value added per employee). We exploit NAMEA data on Italy for 29 sector branches and 6 categories of air emissions for the period 1991–2001. We employ data on capital stock and trade openness to test the robustness of our results.

On the basis of the theoretical and empirical analyses focusing on innovation, firm performances and environmental externalities, we would expect a positive correlation between environmental efficiency and labour productivity — a negative correlation between the emissions intensity of value added and labour productivity — which departs from the conventional mainstream view. The hypothesis tested is a critical one within the longstanding debate on the potential trade-off or complementarity between environmental preservation and economic performance, which is strictly associated with the role of technological innovation. We find that for most air emission categories there is a positive relationship between labour productivity and environmental efficiency. Labour productivity dynamics, then, seem to be complementary to a decreasing emissions intensity in the production process. Taking a disaggregate sector perspective, we show that the macro-aggregate evidence is driven by sector dynamics in a non-homogenous way across pollutants. Services tend always to show a 'complementary' relationship, while industry seems to be associated with inverted U-shape dynamics for greenhouse gases and nitrogen oxides. This is in line with our expectations. In any case, EKC shapes appear to drive such productivity links towards complementarity. The extent to which this evidence derives from endogenous market forces, industrial and structural change, and policy effects is discussed by taking an evolutionary perspective to innovation and by referring to impure public goods arguments.

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1. Introduction

In this paper we test the hypothesis of an 'adapted' 'Environmental Kuznets Curve' (EKC) in which the correlation between labour productivity (value added per employee) and environmental efficiency (emissions per unit of sectoral value added) is the link being analysed. The dynamic relationship between the abovementioned 'efficiencies' is a core, if not the primary, element behind the observed macro EKC trend. The role of technological (eco-) innovation as a latent factor in this relationship has been highlighted in empirical and theoretical contributions (Karvonen, 2001).

Here we specify an empirical model for an examination of an original NAMEA (National Accounting Matrix with Environmental Accounts) sector-level time series panel dataset. Emissions per added value is used as a proxy for environmental efficiency/productivity (environmental intensity of value added generated). The underlying assumption is that the core direction of economic change is towards higher mechanisation (capital/labour ratios) (Pasinetti, 1981) and higher labour productivity, testing whether environmental efficiency is positively or negatively related to labour productivity dynamics (Femia and Panfili, 2005).

Empirical analyses of joint economic and environmental productivity at sector level are quite rare due to the paucity of (panel) environmental data. This constitutes an added value of our paper. We argue that firm-based studies (Mazzanti and Zoboli, 2008, in press) and sector-based analyses provide highly complementary evidence, given that the former focus on specific issues and allow greater detail, whereas the outcomes of the latter are more of general flavour (Table 1a).

The paper is structured as follows. Section 2 provides a theoretical framework for the empirical analysis and describes the dataset. Section 3 presents the panel-based regression results. Section 4 discusses the factors that support the emerging stylised fact of a joint economic and environmental productivity, offers some interpretations and discusses some open issues. We expect to find robust statistical evidence of the 'double productivity/efficiency hypothesis', i.e. an inverse relationship between emissions intensity and labour productivity, although an articulated set of differences across different pollutants and between industry and services may emerge.

2. Environmental efficiency and labour productivity: theoretical and empirical issues

2.1. *Building stylised facts with NAMEA variables*

The Italian NAMEA dataset provides sector-level data on value added (VA), full-time equivalent employees (*N*), and emissions for 9 air pollutants (*E*) for several sector branches (Tables 1a and 1b). Using NAMEA variables we can directly define three kinds of efficiency/productivity indicators.

The first indicator is *E*/VA, the emission intensity of value added, which represents the 'economic efficiency of emissions' at branch level (for each emission category). This indicator is a commonly used indicator in analyses of 'decoupling' and EKC.

Table 1a – Descriptive statistics

Variable	Mean	Min	Max
VA/*N*	53.10	10.77 (B, 1992)	286.70 (CA, 1997)
K/*N*	148.26	22.89 (F, 1992)	852.66 (E, 2001)
Trade openness	1.07	0 (F, and most services)	8.01 (CA, 2001)
CO_2/VA	685.58	4.30 (CA, 1997)	9081.41 (E, 1997)
CH_4/VA	2.49	0.0019 (J, 2001)	38.17 (A, 1990)
NO_x/VA	2.23	0.0347 (CA, 2001)	29.83 (E, 1991)
SO_x/VA	2.56	0.00074 (CA, 2000)	61.01 (E, 1990)
NMVOC/VA	2.28	0.01 (M, 2001)	16.1 (DF, 1990)
PM_{10}/VA	0.325	0.0029 (CA, 1997)	2.76 (E, 1990)

Its meaning in terms of environmental–economic efficiency is discussed elsewhere (Mazzanti et al., 2008). A decrease of this indicator means improved environmental efficiency.

The second indicator is *E*/*N*, the average units of the pollutant produced per employee in the branch. Being based on quantity, and not value, it can be taken as an indicator of 'technical emission efficiency', and as reflecting the production technology of the branch.[1]

The third indicator directly computable from NAMEA is value added per employee (in the branch), VA/*N*, which is a frequently used 'economic efficiency/productivity' measure.

In order to find a relationship between these three efficiency/productivity indicators we employ the following accounting identity equation:

$$E/VA^{*}VA = E/N^{*}N \quad (1)$$

By simple algebraic transformations we arrive at the following relationship:

$$E/VA = E/N^{*}1/(VA/N) \quad (2)$$

In Eq. (2), the 'economic efficiency of emission', *E*/VA, depends on the interaction between 'technical efficiency of emission' (*E*/*N*), and 'economic (labour) productivity' (VA/*N*). There is a direct relationship between *E*/VA and *E*/*N*, and an inverse relationship between *E*/VA and VA/*N*. Any increase in labour productivity (VA/*N*) for a given technical emission efficiency (*E*/*N*) will reduce the emission per unit of VA. i.e. will increase the 'economic efficiency of emissions'. Similarly, any reduction (increase) in *E*/*N*, for a given labour productivity VA/*N*, will reduce (increase) *E*/VA, i.e. improve (worsen) the 'economic efficiency of emission'.

In terms of changes over time, for an increasing VA/*N* in Eq. (2), *E*/VA will not change if *E*/*N* increases at the same percentage rate as V/AN. If *E*/*N* increases at a faster rate than VA/*N* (i.e. if, on a technical level, the increase in VA/*N* requires a more than proportional increase of *E*/*N*) then *E*/VA will eventually increase (worsening emission efficiency). However, in the case that *E*/*N* increases at a lower rate than VA/*N* (or even improves with an increasing VA/*N*), an inverse relationship between *E*/VA and VA/*N* will prevail, indicating that

[1] Given the level of aggregation of NAMEA production branches, E/N can also reflect composition effects, i.e. the combination of different E/N in, for example, different industries in the branch DK 'Machinery' of NAMEA.