Energy Policy 92 (2016) 279–285

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Short communication

Does energy efficiency improve technological change and economic growth in developing countries?

Nicola Cantore [a,*], Massimiliano Calì [b], Dirk Willem te Velde [c]

[a] UNIDO, Department of Policy Research and Statistics, Austria
[b] World Bank Group Trade and Competitiveness Global Practice, World Bank, United States
[c] International Economic Development Group, Overseas Development Institute, United Kingdom

HIGHLIGHTS

- Total factor productivity is an accurate proxy of technological change.
- Energy efficiency triggers total factor productivity especially in manufacturing.
- Technological change via energy efficiency in manufacturing is an engine of growth.

ARTICLE INFO

Article history:
Received 9 July 2015
Received in revised form
28 January 2016
Accepted 29 January 2016

Keywords:
Industrial energy efficiency
Total factor productivity
Growth

ABSTRACT

Does a trade-off exist between energy efficiency and economic growth? This question underlies some of the tensions between economic and environmental policies, especially in developing countries that often need to expand their industrial base to grow. This paper contributes to the debate by analyzing the relationship between energy efficiency and economic performance at the micro- (total factor productivity) and macro-level (countries' economic growth). It uses data on a large sample of manufacturing firms across 29 developing countries to find that lower levels of energy intensity are associated with higher total factor productivity for the majority of these countries. The results are robust to a variety of checks. Suggestive cross-country evidence points towards the same relation measured at the macro-level as well.

1. Introduction

Energy efficiency is one of the key emissions reduction policy tools to reach the ambitious 2° stabilization target resulting from the Copenhagen Consensus (World Bank, 2010). However many countries are concerned about a trade-off between energy efficiency and economic performance. That is the case especially for developing countries, which often need large increases in energy production and consumption to keep up with the expansion of their economies. Bolstering this view is a widespread perception among development economists that environmentally friendly growth policies represent a threat more than an opportunity to further development (Dercon, 2012).

Unfortunately, systematic evidence on such a trade-off is still scant both at the micro- and macro-level. This paper uses energy intensity – a popular measure of inverse energy efficiency – to help shed light on the impact of energy efficiency on economic performance. It does so by considering total factor productivity (TFP) as an indicator of economic performance. TFP is a good proxy of the capacity of a country/firm to generate technological change, as it determines the amount of output that can be produced by a given quantity of inputs together. As emphasized by Hulten (2000, p. 60) technological change reflects: “spillover externalities thrown off by research projects, or it may simply reflect inspiration and ingenuity” (Hulten, 2000). The hypothesis to be tested in this paper is that a reduction in energy intensity – or equivalently an increase in energy efficiency-triggers productivity and technological enhancement in the use of non-energy inputs. The mechanism by which energy efficiency may increase firms' productivity is well explained by the Porter and van der Linde's hypothesis. This hypothesis claims that firms which are able to reduce energy costs induced by higher energy prices, adapt to these new conditions by investing in innovation processes based on the use of other inputs such as capital and knowledge (Porter and van der Linde, 1995).

* Corresponding author.
E-mail address: n.cantore@unido.org (N. Cantore).

http://dx.doi.org/10.1016/j.enpol.2016.01.040
0301-4215/© 2016 Elsevier Ltd. All rights reserved.

The paper focuses on the manufacturing sector because it is the sector with the highest R&D intensity and with the biggest impact in terms of innovation (Young, 1996). In this way the paper investigates if, beyond environmental improvements, energy efficiency can also contribute to economic development by boosting technological change in the most important innovation incubator, the manufacturing sector.

The positive impact of an energy intensity reduction on total factor productivity is tested at micro-level. We use a large sample of firms across 29 developing countries from the World Bank Enterprise Survey to analyze the relation between energy intensity and a key measure of firms' performance, i.e. TFP over a short time frame per country (3 years). While this time frame is dictated by the data availability, it is more challenging to identify significant relationships amongst variables which might be time varying. Despite this challenge, the results suggest that a reduction in energy intensity has a strong and positive impact on TFP even in the short-run across most countries in the sample.

From a microeconomic perspective the paper represents an original contribution to a long standing literature trying to explain TFP determinants (e.g. Edwards, 1997, Barro, 2001, Acemoglu et al., 2004). To the best of our knowledge only one paper analyzes the impact of energy intensity on TFP using micro data (Sahu and Narayanan, 2011), but focuses only on India. Our study represents the first attempt in the TFP literature to analyze this relationship using a wide sample of developing countries. In addition the study complements an analysis using similar data to investigate the relation between energy intensity and firms' profitability (Cantore and Calì, 2011).

In the second part of the paper we test if the positive impact of energy reduction on TFP tested at micro-level is confirmed at the macro-level through a statistically significant impact on GDP per capita at country level. A long standing literature clearly states that growth of the manufacturing sector and industrialization are key engines of overall economic growth (Kaldor, 1966). Manufacturing generates forward and backward linkages with other non-industry sectors boosting economic growth. If at micro-level we prove that energy intensity reduction has a positive impact on TFP (and consequently on technological change) of the manufacturing sector, this should clearly be reflected in a statistically significant relationship between GDP per capita and energy intensity. As emphasized by (Ladu and Meleddu, 2014, p. 1): “TFP is employed as a measure of economic growth and therefore of technological change”. We explore this relationship across a large sample of developing countries over the period 1980–2010.

This analysis contributes to the literature on the relationship between energy consumption and growth and on their causal relationship (e.g. Lee and Chang, 2008, Ozturk and Acaravci, 2010). This issue has an important policy relevance in the context of climate change policies. In case of a positive relationship between energy consumption and growth, energy savings to reduce emissions should be interpreted as a barrier to growth. Costantini and Martini (2010) point out that in this field, findings have been mixed depending on the functional form, the econometric approach and the data. However only a few studies specifically focus on energy intensity and its impact on GDP per capita. Kepplinger et al. (2013) show that industrialized countries tend to have lower energy intensity suggesting that energy efficiency is achieved through technological advancements. Sun (2003) compares different paths of energy intensity and GDP per capita in 7 developing countries over the period 1973–1995 and finds that GDP increases have an ambiguous correlation with energy intensity depending on differences in the adopted datasets. This paper is original in testing the energy reduction/GDP per capita relationship for a wide set of developing countries with an econometric approach that addresses various concerns that may bias the cross-country relationship.

Finally to the best of our knowledge this is the first paper testing the relationship between energy intensity and economic performance across developing countries combining analyses at both micro- and macro-level. The paper also provides an original contribution as the literature has tended to focus on country specific or global analyses, rather than a targeted group of low income countries, which are important for the international development debate.

The paper is organized as follows: the next section contains the methodology at micro- and macro-level, Section 3 describes data Section 4 discusses results in the light of the policy debate and Section 5 concludes.

2. Methodology

2.1. Methodology at micro-level

The idea of the microeconomic analysis is to examine the impact of energy intensity on TFP at firm level controlling for a number of other factors that may influence this relationship. The paper adopts a standard definition of total factor productivity deriving from the very popular Cobb Douglas production function (Solow, 1957). In particular:

$$TFP \equiv \frac{y}{k^{\alpha} l^{\beta}} \tag{1}$$

where $y = TFPk^{\alpha}l^{\beta}$, TFP is total factor productivity, k is capital (value of equipment in local currency units), l is labour (number of workers) in a standard KL production function. α and β as in economics textbooks represent output elasticities, that is percentage changes of output y deriving respectively from a percentage change of capital and labour. With a KLEM production function (e.g. Goulder and Schneider, 1999) TFP is expressed as:

$$TFP \equiv \frac{y}{k^{\alpha} l^{\beta} e^{\theta} m^{\delta}} \tag{2}$$

KLEM production function also includes e energy (cost of energy) and m materials (cost of raw materials) beyond capital k and labour l as inputs. ϑ and δ respectively represent output elasticity of energy and materials. Other than being quite a standard way of proxying for total factor productivity (Jesus, 1997), this definition allows to maximise the number of observation given the data available.[1]

Though there are several definitions of energy efficiency measures, energy intensity is a quite popular adopted indicator (see among others Geller et al. (2006)). In this study we adopt energy intensity as a proxy of energy efficiency as “energy intensity measures are often used to measure energy efficiency and its change over time….[E]nergy-intensity measures are at best a rough surrogate for energy efficiency. This is because energy intensity may mask structural and behavioural changes that do not represent “true” efficiency improvements” (EIA, 2003). Energy intensity is simply the ratio of energy input to industrial output; an economic-thermodynamic type of efficiency measure. Following Subrahmanya (2006) and in line with data availability, the measure of energy intensity is defined as:

$$EI = EC/TS \tag{3}$$

Where EI is energy intensity, EC is consumed energy, TS is total sales. EC represents a monetary value rather than physical value of

[1] A popular extension of this definition is to adjust the value of total sales by the net value of stock and inventories at the end of the year. As in this case the number of observations available would drop substantially, this adjustment is not performed in the present study.