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Carbon intensity changes in the Asian Dragons. Lessons for climate policy design

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ABSTRACT

There is a growing political interest in carbon intensity targets because they are the basis for climate pledges from relevant developing countries such as China. They may be also the basis for policy designs in developed countries like EU members. This paper develops a comprehensive econometric study on the main drivers of national emissions intensity in emerging countries in East Asia. This regional focus responds to their pivotal position in global economic growth and remarkable trends in carbon emissions intensity. The main hypothesis of this paper is that the nature of economic growth has a major effect on carbon intensity trends that deserves some attention. Accordingly, the novelty of this paper is to examine the contribution of "intensive" and "extensive" GDP growth for carbon intensity abatements. Labour productivity is revealed to be the main factor responsible for major carbon intensity reductions by Asian Dragons. Whereas household energy per capita and industrial energy per worker contributed in the opposite direction. Consequently, intensity targets may become "meaningless" for real climate action contributions if they do not take into account labour productivity trends.

1. Introduction

The Copenhagen Accord (UNFCCC 2009) delivered what was probably the first international commitment from developing countries to take action against climate change. The Paris Agreement in 2015 reinforced the involvement of developing countries so that they have to notify the UNFCCC Parties their "nationally determined contributions" (NDCs). These communications usually include autonomous national mitigation actions to cut emissions intensity (e.g. 60%–65% in China by 2030 compared to 2005) or emissions relative to baseline (e.g. 29% in Indonesia by 2030). In addition to reporting information on mitigation, adaptation and support, the agreement requires international review on the information submitted by each Party by including mechanisms "that promote compliance in a non-adversarial and non-punitive manner" (Paris Agreement, Art. 13 Transparency).

Some authors have advocated in favour of the adoption of emission intensity targets by developing countries (usually an upper limit on CO_2 per GDP). Marschinski and Edenhofer (2010) provide an excellent survey and discussion of these issues. These authors found there may be several reasons in favour of the adoption of emission intensity targets: they could facilitate the adoption of binding emission restrictions by developing countries as long as (i) they are compatible with high economic growth, (ii) they contribute to the reduction of cost-uncertainty of any emission commitment and (iii) they introduce the right incentives for low-carbon economic development.

In any case, the adoption of emission intensity targets by developing countries might be compatible with high emission growth levels. For instance, China shows a huge reduction in carbon intensity coupled within a huge increase in carbon emissions from 1990 to 2011 (−70% and +256% respectively; data from World Bank). Consequently, intensity targets may become "meaningless" for a real climate action contribution. The aim of this paper is to show how and why important reductions in carbon intensity may be simultaneous with very significant rises in emissions by developing countries. To that end, the paper conducts a comprehensive econometric study on the main drivers of national emissions intensity in Asian Dragons. Their important productivity and income growth are moving the center of gravity of the global energy system in favour of this region (IEA, 2013). As a consequence, countries like China represent nowadays more than a quarter of global carbon emissions thus becoming a key player in international climate talks.

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The main contributions of this paper are twofold. First, it enlarges the empirical evidence as long as there are few studies concerning this issue and most of them take the form of index decomposition studies. Second, the paper questions if the nature of economic growth has a major effect on carbon intensity trends in fast growing developing countries. It examines the contribution of extensive (input accumulation) and intensive (technological change) economic growth for carbon intensity abatements. That represents the main novelty of this research as it deviates from common practice in the empirical literature (that includes per capita GDP or energy intensity as explanatory variables). This approach will allow us to shed more light on the mechanism behind the main drivers of carbon intensity.

According to our results, the huge improvement in Chinese carbon intensity since the 1990s is due to labour productivity developments. This represents the main value added of this paper because energy efficiency improvements are usually highlighted as the major factor in the empirical literature. In this piece of research there is no clear evidence of energy efficiency improvements as long as the improvement in carbon intensity is simultaneous to a strong increase in industrial energy consumption per worker. Our results suggest that carbon intensity targets might be achieved with none or little additional effort towards emission reduction when countries are in an increasing labour productivity trend like Asian Dragons. These results may contribute to (i) a better scientific-policy interface for both knowledge brokers and policymakers with regard to management of interlinks between ecology (climate change) and economics and (ii) climate policy designs with regard to NDCs by Asian Dragons and for other developing countries exhibiting the same kind of trends.

The next section will review the empirical literature on carbon intensity. Section 3 will provide a description of the data and some preliminary empirical evidence, and Section 4 will describe the methodology. After that, in Section 5, we will show the main results and policy implications. Finally, Section 6 will summarize the main conclusions.

2. Carbon intensity in the empirical literature and the nature of economic growth

Carbon intensity is envisaged by some researches as a good proxy for valuing national emission reduction potentials (Yi et al., 2011): the larger the emissions intensity, the more room for improvement on emissions may be available (through enhanced economic development, energy efficiency or greening the energy mix). In this context, carbon intensity targets are seen as a good political tool to reduce emissions, as we mention in the introduction to this paper. Actually, carbon intensity is recognized by the OECD (2002) as a relative decoupling measure on carbon emissions where decoupling will occur if the growth rate of carbon intensity is positive but lower than the growth rate of GDP over a given period. This measure can be estimated as the ratio of carbon intensity between two selected periods, in that decoupling takes place when the ratio is lower than 1. That ratio may be used as a basic indicator intended to track single-country performance in a cross-country comparison.[1]

Xu and Ang (2013) provide a recent survey for understanding and identifying the key elements that explain the changes in aggregate carbon intensity. Xu and Ang (2013) review 80 papers that appeared in peer-reviewed journals from 1991 to 2012. They found that the empirical studies were mainly concerned with the evolution of total emissions, and only a few studies analysed carbon intensity (they transformed the results from the literature into carbon intensity values in order to compile a database for comparative analysis). The empirical literature usually identifies four main factors to explain carbon intensity: the structure of the economy, the energy intensity, the fuel mix and the carbon coefficient (carbon-to-energy ratio). Xu and Ang (2013) conclude that energy intensity is the main contributor to reductions in aggregate carbon intensity in most countries, both in developing and developed countries. Similar results are found for the industrial sector alone, where fuel switching towards clean energy sources was less prevalent in the developing countries, whereas the impact of structural change is also marginal.

For the particular case of Chinese carbon intensity, Fan et al. (2007) reach similar conclusions: the overwhelming contributor to the decline of energy-related carbon intensity is the reduction in real energy intensity, whereas the fossil fuel mix and renewable energy penetration play minor roles. Their findings are in accordance with previous results in the literature (e.g. Wu et al., 2005, 2006; Wang et al., 2005). Analogous results are reported in Zhang et al. (2009) for 1991–2006 (a similar period to one analysed in this paper). They provide some information offering possible explanations for the minor impact of fuel switching and structural changes: on the one hand, coal still is the leading energy supply, accounting for about 70% of the total energy demand; on the other hand, the industrial sector is the biggest contributor to energy consumption, accounting for >60% of total energy consumption.

Accordingly, Steckel et al. (2011) conclude that Chinese policy measures to reduce emissions must concentrate on the reduction of energy intensity and especially carbon intensity, "while the effects due to growth of GDP and population are either hard to control, judged to be unavailable for political reasons, or face moral controversies". Recent papers such as Bithas and Kalimeris (2013) and Kepplinger et al. (2013) have proposed new indicators of energy intensity to better account for energy efficiency. Kepplinger et al. (2013) analyse the energy intensity index (i.e. the fixed-base index of energy intensity constructed from the relation of the index of energy use to the index of output), and they argue that this indicator would better capture the dynamics of energy efficiency. By his side, Bithas and Kalimeris (2013) argue that energy/GDP per capita represents a better approximation than energy intensity to the "energy requirements of real world production process" by taking into account not only technological developments but also the demographic evolution. Their conclusions are less "optimistic" than usual in the literature with regard to global decoupling trends. In this paper we will introduce the reflections raised by Bithas and Kalimeris (2013) although in a different way (e.g. energy consumption per worker, energy consumption per capita) as it will be explained in the next sections.

We know from our previous survey that divergences in carbon intensity trends are explained largely by differences in energy intensity. However, the main hypothesis of this paper is that the nature of economic growth has a major effect on carbon intensity trends that deserves some attention. The debate about the nature of economic growth in the fastest-growing Asian economies is whether it was driven by productivity growth or massive factor accumulation (Sarel, 1995). In other words, whether the source of GDP growth was driven by intensive or extensive growth, respectively. Authors such as Krugman (1994), Kim and Lau (1994) and Young (1992, 1994, 1995) argue that Asian Miracle of relatively high growth was mainly due to extensive growth, i.e. driven by an extraordinary growth in inputs like labour and capital. This doesn't mean the complete absence of technological change or gains in efficiency (Sarel, 1995; Sickles and Cigerli, 2009). In fact, Irmen (2005), based on a neoclassical model with endogenous technological change, shows that periods of extensive growth through capital accumulation may be a precursor to periods of intensive growth. When the economy switches into intensive growth period, i.e. it changes to an innovation regime, the growth of labour productivity accelerates along the transition to the steady state (Irmen, 2005; Travaglini, 2012). As a result, Irmen (2005) points out Tigers may have switched into a regime of endogenous technical change in recent years as past capital accumulation has rendered labour sufficiently expensive. This is also consistent with rising R&D expenditure in these countries (e.g. China has increased the number of Patents seven times from

[1] Environmental decoupling is one of the main objectives of the OECD Environmental Strategy, along with the Green Growth initiative and material flow analysis.