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Carbon pricing and energy efficiency improvement – why to miss the interaction for developing economies? An illustrative CGE based application to the Pakistan case

Arshad Mahmood *, Charles O.P. Marpaung

Energy Field of Study, School of Environment, Resources and Development, Asian Institute of Technology (AIT), Klong Luang, Pathumthani 12120, Thailand

HIGHLIGHTS

- Carbon tax & energy efficiency progress possibly cause GDP loss & rebound effects.
- The interaction of the two policy measures can reduce these unintended effects.
- The impact of CT for Pakistan found fairly moderate with high emissions reduction.
- Coordinated implementation approach further lower GDP loss with less energy demand.
- CT showed potential of reducing emissions of local pollutants even at a higher rate.

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ABSTRACT

Carbon/energy taxes and energy efficiency improvement are studied well in the recent years for their potential adverse impacts on economy, especially for lost production and international competitiveness, and rebound effects. However, little attention has been paid to investigate them jointly, which can not only prevent fall of energy services cost and thereby rebound effect but reduce the associated macroeconomic costs. This study thus employs a 20 sector CGE model to explore separately the impacts of carbon tax and its coordinated implementation with energy efficiency improvement on the Pakistan economy. The country underwent enormous pressure of energy security issues as well as climate change fallouts in the last couple of years and can be regarded as a suitable candidate for energy/environmental conservation policies to be considered at a broader context with more concrete efforts. The simulation results show that the impact of carbon tax on GDP is negative but resulting reductions in pollutant emissions are relatively high. Moreover, the GDP is expected to grow comparatively positive when analyzed with improvements in energy efficiency, with even higher decline in energy consumption demand and so emissions. This simultaneous economic and environmental improvement would thus have positive implications regarding sustainable development of the country.

1. Introduction

The potential impacts of greenhouse gases reduction at both national and international level, generally under the most elegant and logical mechanism of computable general equilibrium (CGE) models, are well studied in the recent decades. The real need for use of the CGE modeling approach for such investigations primarily stems from its capabilities of capturing interlinkages between economic development, environmental quality, and social progress, as well as the feedback effects for different policy initiatives (Naqvi, 1998; Yang, 2001).

In the existing climate literature, both market-oriented instruments (such as taxes, tax exemptions, and subsidies etc.) and other non-market regulatory measures (e.g. mandated targets) are found to be analyzed (see for instance O'Ryan et al., 2005; Wissema and Dellink, 2007; Loisel, 2009; Xu and Masui, 2009; Lu et al., 2010; Dai et al., 2011). The macroeconomic costs especially in terms of GDP loss of these policy implementations are mostly observed positive (IPCC, 2007). Exceptions include, though viewed difficult to sustain, revenue neutrality approach where climate tax regime coincides with appropriate fiscal adjustments by lowering other distortionary taxes (such as taxes on labor and capital) in the system, thus generating double

* Corresponding author. Tel.: +66 888 728 007.
E-mail addresses: arshadpk2007@gmail.com (A. Mahmood), cmarpaung@ait.ac.th (C.O.P. Marpaung).

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dividend effect of improving both environment and economy simultaneously (Baranzini et al., 2000).

On the contrary, the energy efficiency improvement is considered a powerful and cost-effective way to promote sustainable development through a collective realization of economic growth, cleaner environment, and social development (WB, 2009). The recent international studies also portray a very bright purview of energy efficiency growth in climate emissions mitigation. IEA, for example, estimates that in achieving the 450 scenario (where policies are assumed to be introduced in a way so that atmospheric GHGs concentration stabilizes at 450 parts per million—ppm of CO_2 equivalent), when compared with the new policy scenario, 76% in 2020 and 43% in 2035 of the world energy-related CO_2 emissions reduction will take place solely due to energy efficiency growth (IEA, 2010a). In addition, in developing countries where energy use per unit of GDP is already very high compared to their developed counterpart (IEA, 2010b), the prospects of energy efficiency improvement even at a higher rate can never be ruled out.

The energy efficiency growth though remained on international forefronts since quite a long (including the more recent developments such as Eco-efficiency and Factor 10), the associated possibility of rebound or take-back effects is generally not given the due consideration (Grepperud and Rasmussen, 2004). The rebound effect formally known as Khazzoom–Brookes Postulate (Saunders, 1992) defines that energy efficiency improvement may result in increased demand for the services energy helps to provide and therefore erode partially or wholly the likely energy saving gains. The demand effects stem from increased supply of energy services which consequently decreases the effective energy prices (for more recent analyses on rebound effect, see e.g. Grepperud and Rasmussen, 2004; Hanley et al., 2006, 2009; Allan et al., 2007; Anson and Turner, 2009; Turner, 2009 etc.).

The rebound effect though has a sound theoretical basis, no consensus exists on its magnitude. It varies widely ranging from near zero to well above 100%—the phenomenon, typically occurs in selected instances in the medium to long term, is commonly cited as 'backfire' in the literature and used to exhibit increase in overall energy consumption. The estimates of direct rebound effect (energy savings forgone solely due to increased welfare) fall generally below 30%, unlike indirect effects (arise from income gains which subsequently stimulate consumption and energy demand) and economy-wide rebound effects which are found to vary quite substantially. For example, the economy-wide rebound effect estimates reported by the CGE studies over time range from an insignificant 15% to an alarming 350%. The inconclusive results produced by these studies thus further dispels the notion that energy efficiency by itself can help halt global GHGs emission accumulation in the atmosphere (Greening et al., 2000; Saunders, 2000; Dimitropoulos, 2007).

Since governments tend to announce policy packages, simultaneous analysis of different climate policy instruments thus becomes even more important. The energy efficiency improvement which instigate rebound effects and therefore offsets the potential energy savings can be complemented with appropriate carbon/energy pricing either through taxation or emission trading scheme so that energy services costs do not fall. This will not only lesson the rebound effects but also reduce the negativities associated with carbon/energy taxes especially in terms of lost production and international competitiveness (UKERC, 2007; Turner and Hanley, 2011). Hanley et al. (2009) quotes Birol and Keppler (2000) who also viewed technology and relative price related policies as complementary, and go on further to assert that combination of energy policies involving taxes with revenue recycling to reduce other distortionary taxes and efficiency stimuli can potentially generate a genuine double dividend of bolstering economy and environment simultaneously. Similar arguments are put forward by Hanley et al. (2006) where it is emphasized that policies designed to stimulate energy efficiency cannot, in and of themselves, be relied upon for environmental improvements; rather to ensure such improvements, energy efficiency improvements may have to be combined with other polices meant to discourage greater energy consumption.

Existing CGE studies use climate policy instruments especially energy efficiency and emission taxation separately to analyze for their potential effects. No attention has been paid particularly for developing countries where much room is available to exploit the energy efficiency improvements to investigate them jointly (a relatively analogous investigation is Brannlund et al. (2007), where an econometric model is used to examine the impacts of exogenous technological progress in terms of an increase in energy efficiency on Swedish households consumption choice and thereby emissions of pollutants including CO_2; necessary changes in CO_2 tax are then proposed to neutralize the rebound effect and keep CO_2 emissions at their initial level). The present study, therefore, attempts in the direction and try to comprehend the joint effects of energy efficiency and carbon tax policies for Pakistan.

This analysis is also of special interest in that there has been a lack of any climate discussion in the recent years under CGE framework for Pakistan. The two pioneer projects could be spotted in the field by the authors include Shah and Larsen (1992) and Naqvi (1998). The former is a World Bank study where a dynamic model is used to analyze the impact of a US$10 carbon tax on manufacturing industries as a whole and separately for apparel and leather products industries of Pakistan for the period 1966–1984. Distributional implications are also calculated by using 1984–1985 Household Income and Expenditure Survey data. The later study, however, used a static model built around 1983–1984 social accounting matrix for short-run policy simulations and analyzed mainly the price dynamics related to energy sector, and tried to capture the interlinkages between economy, energy and equity for the country. In this background, the present study therefore intends to examine implementation of climate policies for their potential economic and environmental effects and thereby compliment and improve the current literature by including recent assessments for a big developing country, Pakistan.

The rest of the article is categorized as follows. The next, Section 2 gives a brief description of the current energy/environment situation of the country. Section 3 provides introduction and theoretical setting of the dynamic model build for this study. Section 4 explains sources, structure, and construction of the database and the parameters exogenously defined in the model. The scenario formulation and simulation results are discussed in Section 5, whereas Section 6 is devoted for sensitivity analysis to check the robustness of the results. Finally, Section 7 presents summary and major conclusions of the analysis. The mathematical formulation (equations) of the model is presented at the end in Appendix A.

2. Energy/environment situation of Pakistan

Pakistan is basically an energy deficient country. The per capita TPES and electricity consumption for the country, in the year 2010, were estimated at mere 0.49 toe and 457 kWh; against the average TPES of the world, OECD and Asian countries (excluding China) at 1.86, 4.39, and 0.68 toe and average electricity consumption at 2892, 8315, and 806 kWh per capita, respectively (IEA, 2010a). Overall electrification rate was observed at 67%, much below than world average electrification rate of 81%, with a total of