Renewable and Sustainable Energy Reviews (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Economics of climate change and green employment: A general equilibrium investigation for Turkey☆

Gunes Kolsuz[a,*], A. Erinc Yeldan[b]

[a] Bilkent University, Department of Political Science and Public Administration, Turkey
[b] Bilkent University, Department of Economics, Turkey

ARTICLE INFO

JEL classification:
C68
O44
Q56
Q58

Keywords:
Climate change
Green jobs
Computable general equilibrium
Turkey

ABSTRACT

This paper quests for the intrinsic complementarities among environmental pollution abatement, induced technological innovation to combat human-induced climate change, targeted expansions for green employment, and enhanced welfare through gains in private income. Utilizing data from the Turkish economy, we implement an applied general equilibrium model to study the synergies between environmental abatement instruments and policies towards sustaining green jobs. Our results are indicative that by a proper mix of environmental taxation and technological and institutional innovations, Turkey can serve as an example for a host of developing countries in setting the stage for a pro-employment and eco-friendly, sustained growth path. We further show that for the successful implementation of a carbon emissions mitigation strategy, elimination of the burden of existing labor taxes and factor market distortions are crucial. Our analysis suggests that complemented with a strategy of substitution of environmental taxes against the existing distortionary labor taxes, costs abatement on domestic income and employment could be negligible.

1. Introduction

Accumulated evidence on the extend and nature of human-induced climate change calls for more intensive research on environmental-friendly, sustained growth and patterns of induced technological innovations together with enhanced job opportunities and social welfare. According to the *Intergovernmental Panel on Climate Change* (IPCC), for our planet to have a 50% chance of avoiding an undesirable rise in the global average temperature by 2° (Celsius), concentrations of greenhouse gases ought to be stabilized at 450 ppm (parts per million) of carbon dioxide equivalent (CO_2e). This means a total carbon budget of 870–1240 gigatons of CO_2e for the future viability of our planet.

Yet, many argue that the global target of 450 ppm is already too high. The Wild World Foundation (WWF) argue, for instance, that we should not allow for a rise in average global temperature by more than 1.5 °C. Instead, the WWF calls for a concentration limit of 400 ppm CO_2e to have a better chance of maintaining the rise in global temperatures at less than 2 °C. Having GHG concentrations that already reached to 496.2 ppm by 2012, and given the fact that the rise in the average global temperature has already surpassed 0.8 °C over the last century, the WWF calls for immediate action that goes beyond the standard instruments of taxes and subsidies for mitigation.

Instruments of environmental policy thus far consisted mainly of carbon tax-cum-subsidies, as well as administering energy markets often through high taxes both on the user and also the supplier side. However, it is now a well-documented observation that price instruments, administered through the market optimization alone, will not suffice to achieve the broad objectives of controlling global GHG concentrations, nor maintaining a sustainable and eco-friendly growth path. Part of the problem is due to the fact that development of new eco-friendly technologies typically involve positive spillovers in the form of agglomeration effects, knowledge diffusion, cross-firm externalities and industry-wide learning; and yet, the decentralized optimization embedded in the laissez-faire actions of the markets may fail to capture these positive spillovers, and competitive equilibrium may fail

☆ Findings of this research rely in part on the background paper to Turkey's contribution the United Nations Conference on Sustainable Development, Rio +20, Rio de Janeiro, 2012. Previous versions of the paper had been presented at the 5th World Congress of Environmental and Resource Economists, Istanbul, 2014 and the 17th World Congress of the International Economic Association, Jordan, 2014. Author names are in alphabetical order, and do not necessarily reflect authorship seniority. We are grateful, without implicating, to three anonymous referees of this journal and to Sema Bayazit, Aziz Bouzaher, Sebnem Sahin, Sherman Robinson, Erika Jorgenson, Mike Toman, Kirk Hamilton, Craig Meisner, Martin Riser, Sevil Acar and Erol Cakmak, for their comments and suggestions.

* Corresponding author.
E-mail addresses: gunes.kolsuz@bilkent.edu.tr (G. Kolsuz), yeldane@bilkent.edu.tr (A.E. Yeldan).

http://dx.doi.org/10.1016/j.rser.2016.12.025
Received 5 November 2015; Received in revised form 31 October 2016; Accepted 3 December 2016
1364-0321/

achieving the social optimum.[1]

More importantly, decentralized laissez faire market equilibrium based on private optimization faces the danger of *path dependence*; that is, firms may be caught up specializing in dirty technologies. Path dependence of innovation may lead firms to innovate towards maintaining dirty technologies Aghion [4,7]. Firms with a history of dirty innovations tend to follow that path, creating path-dependence in the long run. Thus, Aghion warns that with a narrow set of instruments, limited only to carbon taxes and energy prices, it will take a very long time for the clean innovations to catch up with the dirty technologies; and calls for complementing the carbon tax with broader set of macroeconomic policy instruments that involve interventions towards "green technologies", as well as "green employment" [7].

Lozschel noted that for global climate change modeling the traditional approach of regarding technical progress a purely exogenous variable is misplaced [8]. In contrast, firms will tend to generate endogenous responses to policy shocks through adopting corporate investment in R & D to innovate in technologies to minimize the tax burden. Such responses may take the form of knowledge spillovers (Goulder and Mathai [9]); optimization on investment and R & D effort (Nordhaus [10]; Buonanno, et al., [11]); and spillover effects through conglomerations (Griliches [12]; Goulder and Schneider [13]).

In nutshell, while it is generally understood that tighter environmental standards will be costly, Porter and van der Linde [14] confirm, with a series of case studies, that properly designed regulation via a broad spectrum of market-based instruments such as taxes and/or cap-and-trade emissions allowances can in fact stimulate innovations. This notion, later to be known as the *Porter hypothesis*, suggests that the evidence is more supportive of the "weak" version (i.e., stricter regulation leads to more innovation), rather than the "strong" version of the hypothesis (i.e., business performance follows stricter regulation with a win-win outcome) [15,16].

This paper is a follower of this broad literature with an application to the Turkish micro and macro economic data. It extends this strand by incorporating the nature of labor markets and opportunities of green employment into the policy analysis. Thus, what is pursued is a simultaneous achievement of sustainable patterns of growth together with environmental pollution abatement, increased employment opportunities, and a higher rate of private income. This triple-dividend of "win-win-win" strategy framework rests on rationalization of the public taxation structure by way of replacing the distortionary tax burden on labor, and utilization of the tax funds to stimulate innovations towards greener technologies.

Various applications of the triple dividend had been noted in the literature.[2] It is the purpose of this paper to present a real-world application of this conceptualization to the Turkish economy. In terms of greening, Turkey's economy is characterized by low, albeit rapidly increasing environmental footprint. Contrasted against the OECD economies and the world at large, Turkey displays a medium role in terms of gaseous emissions (see Table 1). As of 2012, Turkey's per capita CO_2 emissions stand at 4.04 tons, it scores significantly below the OECD average of 9.68 tons. In comparison the global average of 4.51 tons per capita, Turkey is seen almost around the median.

Yet, if Turkey's missions are contrasted on the basis of *carbon efficiency*, that is, CO_2 emissions per $ GDP, Turkey's scores are observed to be less successful. In 2012 Turkey's CO_2 emissions per $ GDP was 0.49 kg. This was 0.31 among the OECD countries; while the world average was 0.58. If a comparison is made over to the 1990 levels, we observe that carbon efficiency improved significantly across the world and the OECD members, while for Turkey one observes a rise from 0.47 in 1990 to 0.49 in 2012 (kg/$GDP). As such, these trends reveal that Turkey has not yet *decoupled* its economic growth from rising energy use, a process that has been underway in advanced economies for more than two decades. In fact, Aşıcı, provides strong evidence that "*the economic growth path taken in the 2003–2009 period has gradually become both more energy and pollution intensive as compared to the 1995–2002 period*" (Aşıcı. [24]) Some of the reasons beyond this increase of pollution intensity are due to domestic fiscal policy. A recent CGE modeling work by Acar and Yeldan studied the effect of fiscal subsidies on coal on aggregate CO2 emissions and found that elimination of these subsidies could have reduced gaseous emissions by 5.5% over the base run trajectory through 2015–2030 [25].

Data reveal that Turkey's total $CO_2(eq.)$ emissions are at 467.6 million tons as of 2014. Projections by the Sweedish *EcoEquity Institute* suggest that total CO_2 emissions will reach to 680 million tons by 2030 under a scenario of "low committment". In Fig. 1 we display aggregate emissions and its sectoral distribution over 1990–2014. The rapid expansion of the energy combustion in total gasesous emissions can be easily identified from Fig. 1. Of the total 467.6 m tons of CO_2 emissions in 2014, 339 m tons are estimated to be derived from fossil fuel combustion for energy production. Industrial processes also expand their share over this period with an added 62.8 m tons of gaseous emissions.

As indicated above, taxation of energy inputs had been the main policy norm across the OECD. Environmental taxes average around 2.5% as a ratio to the aggregate GDP across the OECD countries, yet with significant divergences ranging from 0.5% in Mexico, and 0.9% in USA to 3.7% in Turkey, 3.8% in Netherlands, and 4.7% in Denmark. Fig. 2 gives a snapshot of the relationship between the burden of the environmental taxes and the average gains in CO_2 abatement for the OECD countries over the last two decades.

The extensive set of observations with continued positive trends in carbon emissions, in spite of the tax burden, is suggestive of the fact that without the accompanying technological innovations the gains in emission abatements will be rather small. Fig. 2 is affirmative of the caution laid by Aghion above (2014) arguing that there is significant path dependence across the polluters globally. Consequently, without additional resort to targeted innovations that could break the chain of *path dependence*, reliance on taxation and market prices alone does not suffice in succeeding viable reductions in emissions [7]. Fig. 3 follows this line with a direct focus for Turkey. The burden of environmental taxes stand at a significant rate reaching to as much as 4% to the GDP across the last decade. Yet, this burden does not seem to have much of an effect on CO_2 abatement, with a secular rise in aggregate emissions at a rate of almost 5% per annum over 1990–2014.

All these reveal the difficulties in associating instruments of abatement to achieve a more stable and controlled environment for energy demand. In such an unstable and abrupt path of energy demand, it is virtually quite hard to project the future path of emissions whether from fuel combustion to generate energy, or from industrial processes. Against this uncertain structure, it is not hard to argue that the current arsenal of Turkish environmental policies that rely mostly on energy taxes will not suffice to achieve significant results for mitigation. Taxing carbon emissions directly to enhance CO2 abatement is traditionally regarded as the most efficient instrument. This verdict had been formulated as early as 1920 by Pigou [26]. However, in the developing world (and even in many today's developed economies) relying solely on the disciplinary penalties of direct carbon taxes to mitigate CO2 emissions will likely not suffice. This is because these economies typically lack the institutional infrastructure to effectively monitor the source of emissions as well as to administer broadly a

[1] For various analytical perspectives to this end, see, e.g., Rodrik (Chapter 4), Aghion et al. [1–4], The original idea rests on Romer and Krugman [5,6].

[2] See, e.g., Kurabayeva, [17]; Bowen, [18], Goulder, [19], and Bovenberg and de Mooij, [20]. Telli, Voyvoda and Yeldan, [21] study rationalization of the tax burden for the Turkish economy in the context of the macroeconomics of the Kyoto Protocole, while Akin and Yeldan [22] focus on macroeconomics of possible integration of the Turkish polluters in to the European carbon market. Adaman et al. [23] explored Turkish urban households' willingness to pay (WTP) for CO_2 emission reductions expected to result from improvements in power production.