MACROECONOMIC IMPACTS OF ENERGY EFFICIENCY IMPROVEMENT

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Overview

Improving energy efficiency is a powerful and cost-effective tool to promote economic growth as well as reduce energy consumption and greenhouse gas emissions. This study aimes to enhance our understanding on the macroeconomic effects of energy efficiency improvement in OECD countries and key emerging economies. We adopt a global computable general equilibrium (CGE) model and construct a dataset on energy efficiency improvement in key regions including the United-States (US), European Union (EU), Japan, Russia, China, India, Brazil and the rest of the world.

We examine key policy demensions of improving energy efficiency from the perspective of economic output, energy demand and intensity, non-fossil fuel mix, employment, as well as CO_2 emissions and intensity. Our contribution is two-fold. First, this study integrates energy efficiency indicators estimated from historical data into a macroeconomic model. Second, this study points out whether the current policies implemented by key partners can be improved to reduce energy use and emissions without making any regions worse off, and how to achieve economic growth together with emissions abatement and energy transition (Severin 2014).

Methods

In this article, we use observed resource producitivity data to estimate yearly average energy efficiency changes by energy source and region (Wei and Liu 2016). This estimation is based on a time series data on value added and energy resources provided by the World Input-output Database 1995-2009 (WIOD, Timmer 2012). We aggregate the time series data of the 40 WIOD regions into 8 regions, i.e., United States, European Union, Japan, Russia, China, India, Brazil, and Rest of the World; and the 35 WIOD sectors into 11 sectors.

The estimated yearly average energy efficiency changes are assumed to continue until 2040 in a CGE model GRACE (Aaheim and Rive 2005; Liu and Wei 2016), to produce a business-as-usual (BAU) scenario, where the regional GDP, primary fossil energy consumption, and electricity generation are calibrated roughly to that used in the New Policies Scenario of World Energy Outlook 2015 (IEA 2015). We assume that the efficiency improvement of energy used by households follows the average of total production activities in a region.

We consider two alternative energy efficiency scenarios. One is optimistic assuming the energy efficiency increases smoothly from 2012 until 2040 when it becomes 10% higher than the BAU case for all sectors and regions. On the opposite, the other scenario is pessimistic assuming the energy efficiency changes smoothly to become 10% lower than the BAU case in 2040.

Results

First, GDP growth is positively related to energy efficiency changes. The more energy efficiency gains, the more GDP growth. Compared to the BAU scenario, the annual GDP growth rates of the optimistic scenario in US, EU, Japan, and China can be improved by around 0.04-0.05 percentage points, while the annual GDP growth of the pessimist scenario decreased by around 0.05-0.06 percentage points. Brazil's annual GDP growth rate is deviated more significantly from the BAU case, with an increase of 0.07 percentage points and a reduction of 0.09 percentage points in the optimistic and pessimistic scenarios, respectively. However, India and Russia's GDP growth rates are much less sensitive to the energy efficiency changes in both cases.

Second, primary energy is used less (or more) in the optimistic (or pessimistic) scenario. In the optimistic scenario, all developed regions use less energy over time and the energy demand is reduced markedly in the developing

regions. In the pessimistic scenario, the energy demand change compared to the BAU is much stronger in all the countries. By combining the changes in GDP and primary energy use, the impact of energy efficiency on energy intensity of GDP is also significant.

Third, the reduction in the energy demand derived from energy efficiency improvement comes from mainly renewables in all the countries, with the smallest contribution from the coal demand. Although the share of non-fossile fuels in the primary energy consumption increases along with energy efficiency improvement, the ratio in the optimistic scenario is lower compared to the BAU. On the countrary, countries may overshoot their targets on the share of non-fossil fuels/renewables in the pessimistic scenario.

Forth, in the BAU case, the INDC targets of carbon intensity in China and India (reduction by 60-65% compared to 2005 level in China and by 33-35% compared to 2007 level in India) are not binding because energy efficiency improvement reduces energy demand meanwhile encouraging further GDP growth. In particular, China's CO_2 emissions in the optimistic scenario is estimated to peak in 2030, five years ahead of the BAU case. When energy is used less efficient than the BAU, carbon intensity targets become binding in both countries. However, for Brazil, the emissions from fossil fuels are increasing. Hence, it has to reduce emissions from other sources to fulfil its INDC target of reducing emissions by 37% in 2025 compared to the 2005 level. Except Japan, energy efficiency in the US and EU helps reduce absolute emissions in the optimistic scenario in 2040 compared to the BAU.

Last, energy efficiency will shift employment from mining and energy to manufactuirng and services. Except India, all the countries benefit from the net job creation in optimistic scenario in 2040 compared to the BAU.

Conclusions

Energy efficiency can help reduce energy demand, boost GDP growth, and achieve climate mitigation target. However, energy efficiency targets need to be aligned with renewable and climate targets.

This analysis shows that energy efficiency effects mainly reduce the demand of renewables rather than fossil fuels, this may conflict with the targeted share of non-fossil fuels/renewables in primary energy consumption. Countries need to implement a strong policy on the control of fossil fuel energy consumption while improving energy efficiency.

Energy efficiency can significantly contribute to achiving a relative climate target in terms of emissions per unit GDP. In this sense, energy efficiency may overlap with relative climate targets adopted by some emerging countries. However, energy efficiency may not lead to absolute emissions reduction because of increased consumption of fossil fuels in some countries. Effective climate policy instruments need to be combined with the energy efficiency target in this case.

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