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Energy structure, energy policy, and economic sustainable development

Li-Ju Chen [a,*], Lee-Jung Lu [b], Meng-Yi Tai [c], Shih-Wen Hu [a], Vey Wang [a]

[a] Department of Economics, Feng Chia University, Taichung 40724, Taiwan
[b] Department of Leisure Management, Tungnan University, New Taipei City 222, Taiwan
[c] Department of Applied Economics, Fo Guang University, Yilan County 26247, Taiwan

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ABSTRACT

While the burning of fossil fuels produces large amount of CO_2 and damages the environment, the production and consumption of green power emit less CO_2 and benefit the environment, such as refining agricultural wastes as bioenergy. However, the share of green power to total energy tends to be low due to the low private cost, i.e., excluding the external cost, of fossil fuels and the high production cost of green power. To reduce the total emission of CO_2, it is necessary to modify the energy structure and internalize the external cost by taxing the use of fossil fuels. This study finds: 1) the economy will benefit from the development and the increasing usage of bioenergy, rather than fossil fuels, in the long run; 2) a higher energy tax will reduce the use of fossil fuels, which will yield an uncertain effect on economic growth and social welfare in the long run; 3) a rise in income tax has ambiguous effect on economic growth and social welfare in the long run; and 4) the income tax maximizing social welfare is higher than that maximizing economic growth rate, and the energy tax maximizing social welfare is also higher than that maximizing economic growth rate.

1. Introduction

In February 2014, the World Health Organization (WHO) cautioned that the air pollution in Beijing should be regarded as a "crisis". The air pollutants in Beijing are mainly from the burning of coal in factories and families. Together with a surge of auto vehicles, the thick haze day occurs more frequently in recent years. London has had serious air pollution in the 1950s, which was caused by a heavy consumption of fossil fuels since the industrial revolution. The mixture of mist and smoke dust remained on the ground, and damaged human beings' respiratory system. There were 10 severe smog events during 100 years before the 1950s in London. The gravest one happened in 1952 that the UK government was forced to regulate the usage of different fuels and set the standards of smoke emission for factories, for example, City of London (Various Powers) Act in 1954, and Clean Air Act in 1956 and 1968.

Fossil fuel is the main energy source nowadays, but there are two challenges when using fossil fuels. One is the limit of its storage, which will increase the energy price and give rise to the concern of energy security; the other is its damage to the environment, especially the emission of greenhouse gas. Energy policies therefore focus on retraining consumption of fossil fuels at the demand side, and developing alternative energy sources at the supply side. To decrease the dependence on the fossil fuels, the development of low-pollution green power has been taken into account. Green power includes solar power, hydroelectric power, wind power, and bioenergy. These powers can be obtained directly from nature, and generate less pollution during the transformation and

* Corresponding author. Tel.: +886 4 24517250x4486; fax: +886 4 24518737.
E-mail address: chenlj@fcu.edu.tw (L.-J. Chen).

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consumption process. Besides, the renewable characteristics allow green power to have unlimited resources. Therefore, many countries are developing green power industries, which can supply sufficient electric power and reduce carbon simultaneously.

Among the various types of green power, bioenergy attracts the authorities that many countries subsidize the related R&D and encourage its use. For instance, EU specified 6% of total exhausted fuels by auto vehicles to be bioenergy, and it will be 10% in 2020. To attain this aim, several European countries import yellow beans and palm oil as materials to produce bioenergy from Brazil, Argentina, Indonesia and Malaysia. Similarly, the US government passed Energy Independence and Security Act in 2007, which requires the annual production of ethanol to reach 7.5 billion gallons in 2012 and 36 billion gallons in 2022.

Bioenergy transforms industrial or agricultural products and wastes into useful fuels and electric power without generating pollutants. Take hydrogen power as an example. Hydrogen exists in water (H_2O) and hydrocarbon (e.g. CH_4, C_2H_6, and C_3H_8). It releases electric power when combined with oxygen, and recovers to hydrogen during the restoration process. Using hydrogen power can lessen the greenhouse effect because there is no CO_2 produced during consumption. Moreover, it can be obtained from agricultural wastes, and improve the air. Based on these features, hydrogen power is an ideal alternative energy source. In 2012, fossil fuels, like oil, natural gas and coal, share over 50% of the energy sources in most countries (as shown in Table 1). To improve the environment, every country should increase the use of low-pollution green power.

With the coming era of low-carbon economy, the technology development in energy industry is essential to economic growth and social welfare. Policies about carbon decrease and energy conservation are promoted and green power industry is thereafter coming into being. Whether to raise the fraction of bioenergy to total energy has an effect on economic growth and social welfare is one of the issues analyzed in this paper.

The negative production externality includes not only the emission of CO_2, but also other environmental pollution, such as water pollution and noise pollution. Pollution is a result of economic activities. Keeler, Spence, and Zeckhauser (1971) and Tahvonen and Kuuluvainen (1991) both argue that prosperous economic activities will bring more pollution. Therefore, it is required to suppress economic activities or increase pollution-preventing facilities to contain pollution. However, these strategies may harm the economy, depending on the size of "environmental production externality". The environmental production externality refers to the influence of environment quality on people's health and production efficiency, and consequently output.

Recently, there is a rich line of literature investigating economic growth with the concern of environmental policies. It has been suggested that environmental policies will increase firm's production cost, decrease the incentive to invest, and harm the economy. Nevertheless, Jin, Choi, and Yu (2009) show no significant short-run damaging impacts of energy conservation on the macroeconomy empirically. The contrary results may be due to the reason that whether the environmental production externality is under consideration or not (Huang & Cai, 1994; Ligthart & van der Ploeg, 1994; Shieh, Lai, & Chen, 2001). In contrast, a relatively larger environmental production externality will allow environmental policies to improve the environment and benefit the economy (Bovenberg & de Mooij, 1997; Bovenberg & Smulders, 1995; Chen, Lai, & Shieh, 2003; Gradus & Smulders, 1993; Smulders & Gradus, 1996).

This paper differs from the literature in containing energy in the production function, while considering the environmental production externality as well. There are two types of energy: green power and fossil fuels. Green power is costly, but associated with less pollution. Since the use of fossil fuels pollutes the environment and its price variation impacts macroeconomic variables (Naifar & Dohaiman, 2013), one can adopt a policy of user charge in order to limit the negative influence of fossil fuels. Through endogenizing the pollution cost shouldered by the whole of society, the burden will fall on those who use the fossil fuels and consequently reduce the utilization of fossil fuels. An energy tax, i.e., Pigou tax, is one of several strategies adopted in reducing the pollution resulting from the use of fossil fuels (Lee & Batabyal, 2002; Lee & Chiu, 2014). Thus, the second issue in this paper is to examine the influence on economic growth and social welfare if the government takes environment protection as the priority task and levies the Pigou tax on fossil fuels.

The remainder of the paper is organized as follows. Section 2 constructs an endogenous growth model with energy, including green power and fossil fuels, as inputs. Section 3 analyzes the effect of government policies on economic growth, while Section 4 analyzes the effect of government policies on social welfare. Section 5 concludes.

Table 1
Consumption structure for energy across countries in 2012.
Source: BP Statistical Review of World Energy 2013.

	Oil (%)	Natural gas (%)	Coal (%)	Nuclear energy (%)	Hydroelectric (%)	Renewable energy (%)	Total (Mtoe)
United States	37.1	29.6	19.8	8.3	2.9	2.3	2208.8
Canada	31.7	27.6	6.7	6.6	26.2	1.3	328.8
France	33.0	15.6	4.6	39.2	5.4	2.2	245.4
Germany	35.8	21.7	25.4	7.2	1.5	8.3	311.7
United Kingdom	33.6	34.6	19.2	7.8	0.6	4.1	203.6
Australia	37.5	18.1	39.1	–	3.2	2.1	125.7
China	17.7	4.7	68.5	0.8	7.1	1.2	2735.2
Japan	45.6	22.0	26.0	0.9	3.8	1.7	478.2
South Korea	40.1	16.6	30.2	12.5	0.2	0.3	271.1
Taiwan	38.6	13.4	37.6	8.3	1.1	1.0	109.4
Total	33.1	23.9	29.9	4.5	6.7	1.9	12476.6