NON-LINEAR MODELING OF THE NATURAL GAS CONSUMPTION USING THE WEIBULL MODEL

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Overview

Natural gas has consumed as a major energy source in many countries. According to IEA(2011), natural gas will take up to 22.5% of world total primary energy supply by 2030. Moreover, economic production of unconventional gas and Fukusima accident make us reconsider the future energy mix. Therefore, the present might be a 'turning point' of natural gas demand.

Kim(2010) and Kim *et al*.(2010) asserted that the energy-growth hypothesis, that is the relationship between energy consumption and economic growth can be represented by an S-shaped curve. Following this argument, we investigated whether this hypothesis is valid for natural gas. Energy Information Administration predicted linear rising of natural gas demand in International Energy Outlook 2009, while Gutiérrez *et al*.(2005) argued that there is a possibility of non-linear shape in the consumption change of natural gas. Gutiérrez *et al*.(2005) used Gompertz innovation diffusion model to analyze Spanish natural gas demand. In this context, we applied the Weibull growth model to analyze the natural gas consumption of seven energy-consuming OECD countries; Canada, France, Germany, Japan, Korea, U.K., the U.S.

Methods

We used the Weibull growth model as mentioned above. The Weibull model is one of s-shaped curves. Because there is no restriction on the inflection point, the Weibull and the Richards model are known as flexible s-shaped curves. The Weibull model and Weibull distribution are also generally applied in social sciences and survival analysis. The equation applied in this study is as follows.

$$NG_t = \phi_1 + (\phi_2 - \phi_1)\exp\left[-\exp(\phi_3)GDP_t^{\phi_4}\right]$$

where NG_t denotes the natural gas consumption per capita at time t, GDP_t denotes gross domestic product (GDP) per capital at time t, ϕ_1 is the upper asymptote, ϕ_2 is the lower asymptote, ϕ_3 is a shape parameter, and ϕ_4 is a location parameter.

Results

The total primary energy supply (TPES), natural gas consumption, and population data were gathered from IEA(2012) and GDP were obtained from Penn World Table version 7.1(https://pwt.sas.upenn.edu/). The estimation result of the upper asymptote and the U.S. are presented in Table 1, Figure 1 and 2.

Table 1. Estimation results of the upper asymptote

	Asymptote	Standard Error	t-value	P-value
Canada	3.2837	0.0546	60.09	<2e-16
France	0.8252	0.0351	23.49	<2e-16
Germany	1.1825	0.0257	45.99	<2e-16
Japan	5.0130	9.736	0.515	0.609
Korea	1.1173	0.1137	9.828	1.65e-09
U.K.	1.8039	0.0526	34.29	<2e-16
The U.S.	2.8180	0.0455	61.937	<2e-16

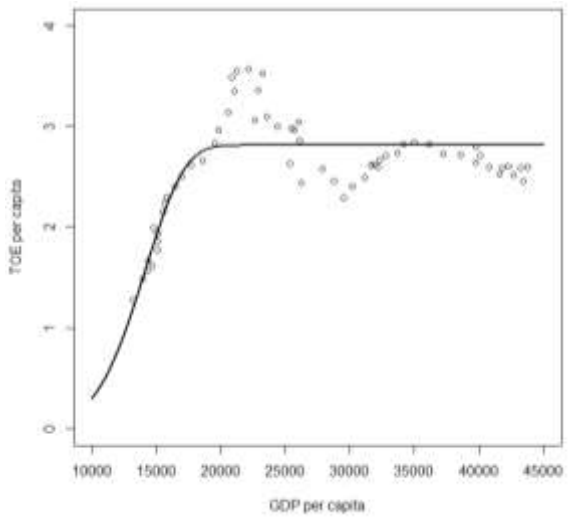

Figure 1. Estimation results for the natural gas consumption of the U.S.

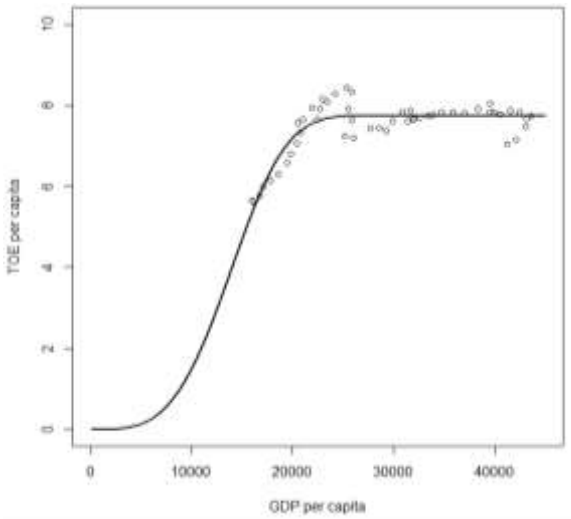

Figure 2. Estimation results for TPES of the U.S.

As results, we could figure out that the natural gas consumption is well described by the Weibull growth model. In Japan case however, the estimated curve was not a sigmoid. The reason is assumed that Japan has operated the energy policy to utilize more fossil fuels.

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