博士論文要旨

Essays on Energy and Macroeconomic Dynamics

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This thesis is based on three papers that investigate the role of energy price and technology in macroeconomic dynamics. Because of the small share of energy in production, it may seem that energy plays only a minor role in accounting for macroeconomic phenomena. However, there are several reasons why energy should not be ignored in macroeconomic analyses. First, although the share of energy in production is small, it is well known that capital stock and energy are complementary in the short run. This implies that energy price shocks could have a large negative impact on aggregate variables. Second, a number of empirical studies show that the sharp rise in the relative price of oil (or, more generally, energy) led to economic recessions in major developed countries, at least prior to the mid-1980s. The seminal work in this field (Hamilton, 1983) shows that increase in oil prices preceded all but one U.S. recession between 1948 and 1972. Third, the declining effect of oil price shocks on output after the mid-1980s in the United States and other developed economies is reported by several studies, notably Blanchard and Gali (2008) and Katayama (2013). Because the diminished effect of oil price shocks can be a good candidate in accounting for the reduced volatility of aggregate variables, it is essential to document the role of energy in what economists are calling the "Great Moderation." These topics are further investigated in each chapter as follows.

Chapter 2 begins by describing the benchmark model based on that developed by Kim and Lougani (1992), who incorporate energy as a third input into an otherwise standard real business cycle (RBC) model. Since it is such a simple model, the justification for some assumptions such as no residental energy consumption, no possibility of stockpiling energy, and zero net exports are discussed with some data observations. Extension of the benchmark model is also discussed in details to address some energy-related issues presented in Chapter 3. The first extension is the inclusion of energy-saving technological change. In Chapter 3, it is examined to what extent the improvements in energy-saving technology are attributed to the declining energy intensity observed following the first oil crisis in Japan. The second extension is the introduction of endogenous capacity utilization. It is also investigated whether the modified model can do a better job than a standard RBC model with energy in accounting for the severe recession observed after the first oil crisis.

Substitutability between energy and other inputs (especially capital stock) is also reviewed in Chapter ??. This substitutability is important since it is expected that low substitutability between energy and other inputs would cause a serious decline in output in response to increases in relative price of energy. A number of previous studies, using translog cost function, show that energy and capital stock are complementary whereas energy and labor, and capital and labor have good substitutability.

Based on the discussion in Chapter 2, Chapter 3 consists of three applications of the benchmark model and its extension to the energy-related economic phenomena in Japan and the United States. Japan's economy showed a considerable decline in energy dependence following the first oil crisis in 1973. In particular, the energy–Gross National Product (GNP) ratio (real energy use divided by real GNP) stood at 2.7% in 1973 but subsequently declined sharply. By 1988, it had fallen to approximately 1.4%, i.e., almost half the 1973 value, and has shown only a slight upward trend since then.

Against this background, the first application examines quantitatively the reasons behind the drop in the energy–GNP ratio observed in the 1970s and 1980s using a simple neoclassical growth model with energy as a production input. The substitution effect is the first candidate investigated to possibly account for the sharp drop in the energy–GNP ratio in 1973. When the relative price of energy rises, energy is substituted with other inputs such as labor and capital. In turn, as value added increases, we would expect the input of energy per unit of value added, or the energy–GNP ratio, to decrease. The simulation result using the actual time series of the relative price of energy shows that the substitution effect alone is weak and cannot account for the decline in the energy–GNP ratio.

The second candidate investigated as a possible explanation for the decline in the energy–GNP ratio, focusing more on a long-term perspective, is improvements in energy-saving technology. The measured level of energy-saving technology as a residual in the production function shows that energy-saving technology substantially improved after the first oil crisis. In addition, including the estimated series of energy-saving technology as an additional exogenous variable into the benchmark model successfully generates a simulated energy–GNP ratio path consistent with the actual data.

The second application focuses more on a specific macroeconomic episode, the severe recession after the first oil crisis in Japan. The standard RBC model with energy is well known to be unable to generate large drops in the value added observed following the energy-price increases in the 1970s, although previous empirical studies have confirmed the importance of energy prices. Against this background, the chapter's discussion first confirms that the standard RBC model taking the actual relative price of energy as an exogenous variable fails to account for the Japanese economy's sluggishness after the first oil crisis. This failure implies that a strong mechanism to amplify the effect of the sharp rise in the relative price of energy is essential to generate the severe recession observed after the first oil crisis.

In this application, following Greenwood et al. (1988), the endogenous capacity utilization rate is incorporated in the benchmark RBC model and examined to determine to what extent capacity utilization amplifies the effect of sharp rises in the relative price of energy upon value added and other aggregate variables. It is shown that the capacity utilization model successfully generates a large negative effect from a sharp rise in the relative price of energy. In addition, the analysis shows that stagnation in total factor productivity (TFP) growth in the benchmark RBC model was spurious due to the declining capacity utilization rate. It further demonstrates that the purified TFP series, in which the effect of time-varying capacity utilization is removed from TFP in the benchmark model, shows steady growth even after the first oil crisis.

The third application emphasizes the role of improvements in energy-saving technology upon the "Great Moderation," referring to the mitigated volatility of output and other aggregate variables that began in the mid-1980s in the United States. Several reasons for the "Great Moderation" have been discussed in previous studies, which can be broadly divided into two groups. The first group focuses on the importance of the reduced volatility of exogenous shocks, and is known as the "good luck" hypothesis. For instance, Arias, Hansen, and Ohanian (2007) show that output volatility declines simply because the volatility of TFP became approximately half its original value. The second group focuses on structural changes. Jaimovich and Siu (2009) claim that demographical change can account for approximately one-fifth to one-third of the "Great Moderation" observed in the United States. McConnell and Perez-Quiros (2000) emphasize the role of better inventory management, whereas Clarida, Gali, and Gertler (2000) underscore an improvement in monetary policy.

To examine the role of improvements in energy-saving technology on the "Great Moderation," the time path of energy-saving technology is estimated via the methodology employed in Chapter 2, then fed into a standard RBC model. The simulation results show that the impulse response of value added to a 10% energy-price shock is mitigated from -2.47% to -1.66% due to improvements in energy-saving technology. Out stochastic simulation also shows that the volatility of GNP decreases by about 25 percentage points in response to energy price shocks due to improvements in energy-saving technology. These simulation results indicate that improvements in energy-saving technology have a non-negligible effect on the "Great Moderation."