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Impact of government subsidies on household biogas use in rural China

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HIGHLIGHTS

- We evaluate empirically the impact of biogas subsidies on household biogas energy use in rural China.
- Results indicate that biogas subsidies did promote the construction of biogas digesters.
- We also find that biogas subsidies were correlated negatively with average time of digester use.
- The results suggest that the net effect of the current subsidy policy on rural household biogas use was near-negligible.
- A 10 percentage point increase in the subsidy-cost ratio leads to merely 1.15% increases in biogas use.

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ABSTRACT

In this paper, we evaluate empirically the impact of biogas subsidies on household biogas energy use in rural China. Special attention was given to the problem of sample selection bias in assessing the impact of subsidies on biogas energy use because biogas subsidies often change the propensity for installing biogas digesters. Using data from a large-scale household survey, the results indicate that biogas subsidies did promote the construction of biogas digesters. The results suggest that a 10 percentage point increase in subsidy-cost ratio would lead to a 3% increase in digester installations. We also found that biogas subsidies correlated negatively with average time of digester use. A 10 percentage point increase in the subsidy-cost ratio would result in a 4.3% reduction in the average working time of digesters. These results suggest that the net effect of the current subsidy policy on rural household biogas use was near-negligible. Indeed, a 10 percentage point increase in the subsidy-cost ratio resulted in a mere 1.15% increase in biogas use. These findings indicate that biogas subsidies have possibly not been targeted effectively at households that would actually prefer to use biogas energy.

1. Introduction

The development of biogas energy in China has been accompanied historically by significant government subsidies. As a renewable energy, biogas has been treated as an essential component of the sustainable energy system in rural China. To promote biogas energy use, China's central government, alone, has invested over 24.8 billion Yuan from 2001 to 2010. Over 70% of these subsidies were directed at rural households, primarily in the form of subsidies for the installation of small-scale biogas digesters (MOA, 2010). In addition to the energy issue, these subsidies for biogas use were expected to play an important role in reducing pollution from livestock and poultry production in rural areas and mitigating greenhouse gas emissions in China.

Given the size of the biogas subsidies in China, the economic consequences and efficiency of these subsidies have been discussed widely in policy circles. On the one hand, the number of biogas digesters in rural China increased dramatically with the support of the subsidy program, at an annual rate of 17.1% from 2001 to 2009 (MOA, 2010). On the other hand, the biogas subsidy program was not always successful. Case studies have shown that many small-scale biogas digesters have not achieved satisfactory performance, and many biogas projects have been discontinued, indicating potential losses of government resources (Han et al., 2008; Wang, 2011).

Importantly, due to the rigidity of the subsidies in practice, the current subsidy policy may generate economic inefficiencies. Under the current subsidy scheme, all households from the areas

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included in the program were eligible to apply for a subsidy with no screening process. Consequently, many households who prefer "high quality" fuels, such as electricity, according to the "energy ladder" theory (Leach, 1992; Barnes and Floor, 1996), have been attracted to install biogas digesters. This is especially true for wealthy households in richer areas where local governments also provided substantial amounts of co-funding. Those households tended to build small biogas digesters with the incentive of the government subsidy, but then rarely used them. In contrast, many households with high demand for biogas energy are excluded from the program, either because the subsidy program does not yet cover the areas where they live or because they are unable to match the subsidy for the installation of the biogas digesters. Given that the national budget for biogas subsidies is limited, redistributing funds across regions and among different households could significantly improve the economic efficiency of the use of the government funds.

Previous studies relating to household biogas use focused mainly on the impacts of biogas subsidies on the construction of biogas digesters, but there are few systematic investigations on the impacts of these subsidies on household biogas production. Anecdotal evidence has linked China's growth in rural biogas production to several governmental support programs, including biogas subsidies (Chen et al., 2010, 2012; Jiang et al., 2011; Gosens et al., 2013). In their survey, Qu et al. (2013) found that government programs played an important role in promoting household biogas digester installation in rural China, through both direct subsidies and indirect tools, such as biogas technology training. However, the literature lacks a complete evaluation of the effectiveness of biogas subsidies at the household level. Largely because of data limitations, few studies have isolated the impact of these subsidies on the construction and use of biogas digesters (Wang and Li, 2005; Qu et al., 2013). In this paper, we examine the extent to which government biogas subsidies have contributed to the development of household biogas use in China's rural areas.

We estimated empirically the impacts of biogas subsidies on digester installations and biogas digester use using data from 1099 households in rural China. First, we used a subsidy-cost ratio (that is, a ratio between the amount of lump-sum subsidies and total construction costs of a biogas digester) as a measure for the intensity of effective subsidies. In China, biogas subsidies are one-time lump-sum subsidies and vary only across regions. It is possible that these subsidies are systematically correlated with other regional-level factors, such as climatic conditions, that also impact both the construction and use of biogas digesters. Thus, simply using absolute values of these subsidies as an explanatory variable is unlikely to provide a consistent estimate. The subsidy-cost ratio avoids this concern and can reflect the relative subsidy intensity for an individual household.

Second, we used the operating time of an individual digester as an indicator of biogas production. Measuring biogas production of household digesters is notoriously difficult, due in part to the fact that rural households often use diverse fermentative raw materials to generate biogas. Additionally, climatic conditions, such as local temperatures, can be crucial determinants of biogas yields. Generally, biogas digesters are more effective and can function actively for longer periods in southern than in northern China, due simply to regional differences in temperature. In cold weather, especially in prolonged cold winters, digesters are unable to generate stable energy. To control for this, we normalized the operating time of an individual digester by the maximum working time of a digester under local natural conditions.

Third, we corrected for the problem of sample selection bias when assessing the impact of biogas subsidies on the use of biogas energy because these subsidies can influence not only the use of biogas digesters but also the propensity for installing biogas digesters. Using data from biogas users only or evaluating the effects of the subsidies on the construction of digesters and the use of digesters separately is less likely to provide a consistent estimate. Thus, we used Heckman sample selection models in our empirical application.

Our results indicate that biogas subsidies did increase biogas digester installations. They suggest that a 10 percentage point increase in subsidy-cost ratio would lead to a 3% increase in the construction of biogas digesters. We also found that biogas subsidies correlated *negatively* with biogas digester operating times. A 10 percentage point increase in the subsidy-cost ratio would result in a 4.3% reduction in the average operating time of digesters. Our simulation analysis suggests that the overall effect of the current subsidy policy on rural household biogas use was near-negligible. The findings indicate that biogas subsidies have possibly not been targeted towards households that would, in fact, prefer to use biogas energy.

The contributions of this study are threefold. First, it adds to the recent debate on China's energy policy, which has focused on the impacts of energy subsidy reform (Lin and Jiang, 2011; Liu and Li, 2011; Wang et al., 2011; Wang et al., 2012a, 2012b). Second, it contributes to recent evaluations of biogas subsidies by isolating the effects of subsidies on the construction of biogas digesters and their use (Qu et al., 2013). Finally, the study fits into the considerable extant literature about rural household energy demand and the policies that influence it in China and other developing countries (Barnes and Floor, 1996; Bentzen, 2004; Paul and Bhattacharya, 2004; Heltberg, 2004; Chen et al., 2006; Jin, 2007; Walekhwa et al., 2009; Wang and Zhang, 2012; Lee, 2013).

The remainder of this paper is organized as follows. We first provide a brief description of China's biogas subsidy polices in Section 2. We then present the econometric specifications in Section 3. Data and variables used in the empirical analysis are described in Section 4. The estimation results are presented in Section 5. In Section 6, we simulate the efficiency of the subsidies, based on the parameters obtained in Section 5. Section 7 concludes with a discussion of policy implications.

2. Background: Biogas energy subsidy in China

The use of biogas energy in rural China has a long history. The rapid development of small-scaled household biogas digesters in China began in the 1970s. The number of biogas digesters increased dramatically from 1973 to 1979. During the period of 1984–2000, however, household biogas energy experienced a slow growth with an annual rate of increase of 4.6% (Chen et al., 2006). Since 2000, the number of biogas digesters in China has enjoyed a rapid and sustained growth.

The Chinese government has implemented a series of policies to spur the use of biogas energy since 2000. They included the "Administration Method of Small-scale Public Facilities Funds for Rural Areas," issued by the Ministry of Finance in 2001, which emphasized the subsidization of rural biogas projects (MOF, 2001). As part of this act, the Ministry of Agriculture enacted a trial subsidy standard, placing emphasis on central and western China where rural energy shortages were frequent and the ecological environment was vulnerable (MOA, 2002). Each county included in the pilot program received no more than 0.6 million Yuan per year from central governmental funds. The subsidy standard varied across regions, with 500 Yuan per household in western China, 400 Yuan per household in central China, and 300 Yuan per household in eastern China (Table 1).

In 2003, the government issued the "Administration Methods of National Bonds for Construction of Rural Biogas (trial)," which highlighted the subsidization from central governmental funds (MOA, 2003). The policy was implemented to increase the level of

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