

How can we gauge energy poverty?

A multidimensional approach

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ABSTRACT

This paper presents a new approach to measuring energy or fuel poverty for developed countries. As such, it develops a multidimensional energy poverty index (MEPI), which can evaluate energy poverty from a multidimensional angle. The MEPI is composed of three attributes (dimensions) of energy poverty in developed countries: energy costs, income, and energy efficiency of housing. We apply this measure to gauge energy poverty in Japan after the 2000s, focusing on the year of the Great East Japan Earthquake and the Fukushima nuclear accident. Based on unique microdata, the results show that energy poverty has been aggravated in Japan since the 2000s. Analyzing the situation by household type, we can categorize mother-child and single-aged households, in particular, as vulnerable to energy poverty. In addition, the results indicate the severe impact of energy price hikes after the Fukushima accident on energy poverty aggravation, especially for vulnerable households.

Keywords: Energy poverty, fuel poverty, Great East Japan Earthquake, housing, measurement, multidimensional poverty, vulnerability

JEL: D63, I32, Q49

1. Introduction

Over the past decades, energy (or fuel) poverty has become a serious policy concern in developed countries (e.g., Boardman, 2010).¹ In concept, energy poverty can be described as the condition of lacking the resources necessary to meet basic energy needs, following the definition of food poverty given by Greer and Thorbecke (1986). The concept of energy poverty is typically divided into “availability” and “affordability.” As such, the lack of access to modern types of energy (e.g., electricity) is usually the central point in the context of developing countries (IEA, 2010), while various issues that prevent people from satisfying their basic energy needs, specifically the affordability issue, are the focus of developed countries. Even in these countries, energy poverty can be a major social issue that affects millions of households and individuals, and may cause hardships, negative health impacts, and additional carbon emissions (Hills, 2012). More than 20 years have passed since the seminal book of Boardman (1991) was

¹ In this paper, the term of “energy poverty” is synonymously used to “fuel poverty” for simplicity. The term of “energy poverty” is more suitable for the context of Japan, as well as Germany’s, because the problem in both countries is mainly caused by higher expenses for electricity (for the situation in Germany, see, Schuessler, 2014).

published; however, there is not sufficient literature on energy poverty in developed countries (Boardman, 2010; Bouzarovski et al., 2012; Brunner et al., 2012).²

Concerning energy poverty, Japan faces an unparalleled situation among developed countries. After the Great East Japan Earthquake and the Fukushima nuclear plant disaster in March 2011, nuclear power plants have hardly been operating for several years, causing Japan to become much more dependent on fossil fuel imports, especially liquefied natural gas, for electricity generation. Moreover, the government encourages renewable energy production using measures such as a feed-in tariff (FIT) scheme. These factors have already increased Japan's energy costs, despite a recent plunge in international energy prices, and eventually increased the burden on households (METI, 2014a, 2014b, 2015). Adding to the “denuclearization” movement, the government introduced a kind of carbon taxes on fossil fuels to tackle climate change, and also raised the consumption tax to sustain the social security systems. All of these factors have

² The UK, however, is exceptional and several studies have been published since Boardman's classical work (1991). In recent years, there are further studies, such as Boardman (2010), Chawla and Pollitt (2013), Hills (2011, 2012), Moore (2012), and Waddams Price et al. (2012). There is also literature on other European Union (EU) countries such as Austria (Brunner et al., 2012), Germany (Schuessler, 2014; Heindl and Schuessler, 2015), Spain (Phimister et al., 2015), and a comparative study across the EU (Thomson and Snell, 2013), whereas there are almost no studies outside the European countries, such as in Japan.

increased the energy costs in recent years, which are passed on to the households in the form of higher energy prices, especially for electricity.

Apart from the problems of energy costs, there is another issue relating to energy poverty in Japan, as the share of low-income households is increasing, reflecting Japan's aging and sluggish economy in the decades (MHLW, 2012a, 2012b). Particularly, vulnerable households, such as lone-parent-with-dependent-child (ren), elderly, and single-person households, are much more sensitive to rising living costs, including higher energy expenses. From these points of view, the energy poverty problem could be a difficult issue for Japan over the middle- or long-term.

Against this background, there are two scopes for this paper. The first is to suggest a novel approach for gauging energy poverty for developed countries like Japan. We reconsider the definitions of energy poverty and propose a new measure of energy poverty from the perspective of multidimensional poverty (Atkinson, 2003; Bourguignon and Chakravarty, 2003; Alkire and Foster, 2011). In the field of poverty research, it is common to recognize that poverty is a multidimensional phenomenon (e.g., Duclos et al., 2006). As such, this paper presents a unique measure of energy poverty in a multidimensional setting, which is both adequate and applicable to the energy poverty problem for developed countries such as Japan.

The second purpose of this paper is to analyze the past and present situation of energy poverty in Japan, especially around the year of the Great East Japan Earthquake and Fukushima accident. There are no studies about this issue

in Japan, although my empirical results show sure signs of energy poverty in Japan, particularly for low-income and vulnerable households (e.g., Okushima, 2016). This paper applies a new approach to evaluating the situation of energy poverty in Japan after the 2000s, which is an invaluable subject for study, from multidimensional poverty perspectives.

The remainder of the paper is organized as follows: section 2 reviews the concepts and definitions of energy poverty, and suggests a new measure of multidimensional energy poverty; section 3 illustrates and discusses the results, and the final section provides concluding remarks.

2. Methodology

Several decades passed since Boardman's seminal book (1991) was published and there is still room for progress in the measurement of energy poverty. Boardman (1991) suggests the first quantified definition of energy poverty for the UK; households are in energy poverty when they are unable "to have adequate energy services for 10% of income." This definition is known as the "10% measure" in this research field. Specifically, this measure defines a household in energy poverty as one that needs to spend more than 10% of their income on energy costs. The energy costs include energy expenses for space heating, water heating, lights and appliances, and cooking, but exclude those for driving cars. The 10% measure has been widely used in previous studies (e.g., Pachauri et al., 2004; Boardman, 2010; Heindl and Schuessler, 2015; Phimister et al., 2015), although it has drawbacks. Most notably, with the 10% measure, it is possible that rich households

who are overconsuming energy would be identified as energy poor (Hills, 2011, 2012). Therefore, the UK government now uses another two-dimensional measure, the low income high cost (LIHC) indicator (Hills, 2012), along with the 10% measure. The new LIHC indicator, nonetheless, is also being criticized by researchers. For example, Heindl and Schuessler (2015) prove that the LIHC indicator has counter-intuitive dynamic properties, which may cause false policy implications, and they recommend the so-called “capped 10% measure,” that is, applying the 10% measure just for the lower income strata to avoid the above-mentioned drawback.

Going back to the root of the definition, Boardman (1991), the *de facto* founder of the energy poverty measurement, focuses on the three factors, namely energy price, low income, and energy efficiency (of the house), for considering the energy poverty problem in developed countries. Other seminal studies by Hills (2011, 2012) also stress three main drivers of energy poverty, such as fuel prices, low income, and energy efficiency. Both studies indicate that energy poverty is a kind of multidimensional poverty in its nature, rather than the unidimensional problem of energy costs or income.

In this context, the paper develops a multidimensional approach to evaluating “the energy poverty in developed countries,” such as in Japan. Its approach is closely related to the recent literature on multidimensional poverty measurement, such as Atkinson (2003), Bourguignon and Chakravarty (2003), and Alkire and Foster (2011). In recent years, theoretical and empirical poverty research in a multidimensional setting has developed, albeit mainly for developing

countries, although there are studies on developed countries, such as Peichl and Pestel's (2013a, 2013b), which evaluate multidimensional affluence or well-being for Germany and the US.

This paper suggests a new kind of comprehensive measure of energy poverty in the multidimensional poverty framework. The methodology itself is described as follows. Let us assume a population with n households ($i = 1, \dots, n$), and $d \geq 2$ dimensions (attributes) of poverty ($j = 1, \dots, d$). Subsequently, we can define the matrix of achievements in a multidimensional setting:

$$\mathbf{Y} = \left[y_{ij} \right]_{n \times d} \quad (1)$$

where y_{ij} is the achievement of household i in dimension j .

A multidimensional poverty approach considers poverty as a shortfall from a threshold (cut-off) for each attribute (Bourguignon and Chakravarty, 2003). Let z_j denote a threshold regarding dimension j , and define dimension j 's specific poverty, that is, the deprivation of attribute j , regarding household i if $y_{ij} < z_j$. Following Alkire and Foster (2011), we can construct the 0-1 matrix of dimensional poverty, $\mathbf{g}_{ij} = \left[g_{ij} \right]_{n \times d}$, whose elements are defined by $g_{ij} = 1$ when $y_{ij} < z_j$ and $g_{ij} = 0$ otherwise. In other words, $g_{ij} = 1$ means that household i is poor in dimension j or deprived in attribute j , and $g_{ij} = 0$ vice-versa.³

Subsequently, \mathbf{g}_i means household i 's dimensional poverty (deprivation) vector

³ Notably, the matrix can be defined in the case of ordinal or categorical data; "deprived" needs to be separated from "not deprived" using these types of data (Alkire and Foster, 2011).

and $c_i = |\mathbf{g}_i|$ counts the number of dimensional poverty of household i , which shows how many dimensions household i is poor in.

For measuring energy poverty in a multidimensional setting, we first need to define the dimensions or attributes that can specify the condition of “energy poverty in developed countries.” This choice is essential for multidimensional poverty analysis, and cannot become free to the researchers’ value judgment. Here, we define three dimensions of energy poverty in developed countries: the first is the dimension of “energy” or “energy cost,” the second is “income,” and the third is the “efficiency of housing.” Specifically, the share of energy cost to income in each household represents the first attribute, y_{i1} , the income the second attribute, y_{i2} , and the age of their housing the third attribute, y_{i3} . For equalization, the energy costs and income are divided by the square root of household size. Although this choice of dimensions is by no means perfect and there is room for improvement, I consider it reasonable and acceptable in the context of energy poverty measurement for developed countries, as it also matches the original concept of energy poverty such as Boardman (1991), as previously mentioned.

Consequently, after the selection of dimensions, the threshold z_j for each dimension j needs to be defined. In this paper, the threshold for “energy” is defined as $z_1 = 0.1$; the threshold for “income,” z_2 , is the boundary income between the third decile and the fourth decile; the threshold for “energy efficiency

of housing,” z_3 , is whether their houses are built after 1980 or before 1979. The reasoning for this is discussed in the next section.

Moreover, we need to define the “energy poverty in developed countries” in a multidimensional setting. The choice of dimensions and thresholds is not enough to identify the households in energy poverty. As such, we require identification of poverty. Following Alkire and Foster (2011), we set up an identification function, $\rho(y_{ij}; z_j)$, which maps from household i ’s achievements, y_{ij} , and thresholds, z_j , to an indicator variable in such a way that $\rho(y_{ij}; z_j) = 1$ when household i is energy poor, and $\rho(y_{ij}; z_j) = 0$ otherwise. In this paper, the “intersection” approach is used for identifying the energy poor (Atkinson, 2003; Alkire and Foster, 2011). Formally, household i is in energy poverty, $\rho(y_{ij}; z_j) = 1$, if and only if $c_i = |\mathbf{g}_i| = 3$. Otherwise, household i is *not* in energy poverty, $\rho(y_{ij}; z_j) = 0$, when $c_i = 0, 1, 2$. In other words, we identify that household i is energy poor if only they are poor in all three dimensions. This “intersection” approach also matches Boardman’s (1991) original idea of energy poverty, which focuses on all the three dimensions.

Finally, we can define a multidimensional energy poverty index (MEPI). In terms of “aggregation,” this paper uses the simple headcount ratio, H , which measures the extent of poverty in the society by the number of the “poor,” q , to the total population, n ,

$$H = q / n \tag{2}$$

where $q = \sum_{i=1}^n \rho(y_{ij}; z_j)$. The headcount ratio is categorized as one of the FGT measures (Foster et al., 1984), widely used as a general income poverty measure.⁴ H is what we call the MEPI.

3. Empirical result

This section evaluates the situation of energy poverty in Japan after the 2000s, applying the new measure, the MEPI. The analysis focuses particularly on the change in energy poverty in the period before and after 2011, the year of the Great East Japan Earthquake and the Fukushima nuclear plant disaster.

3.1 Data

This paper tackles the theme using unique microdata of household income, expenditure, and characteristics, including their housing status, with the sample of around 50,000 households covering the entire Japan. The dataset is created on my own from the anonymized data based on the 2004 National Survey of Family Income and Expenditure; the anonymized data is provided by the National Statistics Center for its research purposes. The dataset allows to perform an in-depth analysis of energy poverty, focusing on the households' detailed characteristics.

⁴ The headcount ratio, however, has some well-known problems; e.g., it pays no attention to the “depth” of poverty. It evaluates the marginally poor the same as the miserably poor. For more information on poverty measures in general, see, e.g., Sen (1997) and Haughton and Khandker (2009), and for the FGT measure in a multidimensional setting, see Alkire and Foster (2011).

For the purpose of this study, we need to perform two types of modifications on the data. The first is seasonal adjustment. The anonymized microdata are based on the National Survey of Family Income and Expenditure, whose expenditure data was collected in autumn (from September to November). It is notable that energy poverty is aggravated in winter, above all in January, the coldest month in Japan. Hence, seasonally adjusted expenditure data need to be constructed with the help of another governmental household survey, the Family Income and Expenditure Survey of 2004, which has smaller samples but has a monthly data. In particular, we construct seasonally adjusted data on household expenses for three energy goods (electricity, gas, and kerosene) using the monthly figures for the same energy goods from the Family Income and Expenditure Survey 2004. As such, the annual average expenditure data and the winter average data are obtained.⁵ Second, the data were extended to the latest period of 2013 with the help of the Family Income and Expenditure Survey, which includes monthly or annual data on the income and expenditure of Japanese households by income decile group. Using these data, I construct extended data on household income and expenditure by each income decile from 2004 to 2013. As a result, it is possible to historically examine energy poverty in Japan after the 2000s, drawing fully upon the strength of the original dataset and the official Family Income and Expenditure Survey.⁶

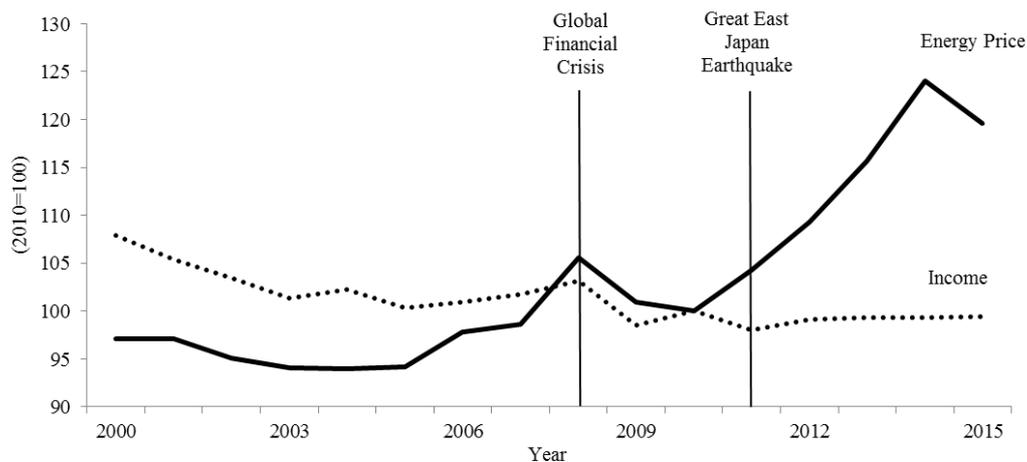
⁵ Unlike expenditure data, the income-related and other variables are on a yearly basis; therefore, no seasonal adjustment is required.

⁶ For more details about the dataset, see also Okushima (2016).

The dataset includes a large sample of 47,797 households (43,861 two-or-more-person households and 3,936 one-person households) covering the entire Japan. They have been anonymized with no detailed information about the living places. For the superiority of this dataset, each household has a sampling weight which is designed to replicate the whole population of Japan. Therefore, in this paper, we use these “replicating” weights in all calculations so as to obtain unbiased estimates on poverty rates in Japan.

3.2 A brief overview

This subsection gives a brief overview of Japan’s situation after the 2000s. Figure 1 describes the changes in energy prices and household income in Japan from 2000 to 2015. Here, “energy price” means a composite index of CPIs (consumer price index) for electricity, gas, and other fuels with the 2010 weights. The figure shows that domestic energy prices climb gradually in the 2000s, except after the global financial crisis, although the trend spikes after 2011, the year of the Great East Japan Earthquake and the Fukushima accident. As previously mentioned, nuclear power plants have almost all shutdown and Japan became more dependent on fossil fuel imports with the higher international energy prices and weaker yen after 2011 (METI, 2014b, 2015). However, the domestic energy price has dropped in 2015 due to the plunge in international energy prices; nonetheless, the price is higher than in 2013.



Note: “Energy price” is a composite index of CPIs for electricity, gas, and other fuels with the weights of 2010. “Income” is the annual average income of all workers’ households derived from the Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications, Japan.

Figure 1. Trends in domestic energy prices and household income after 2000

In addition to these difficult conditions on energy prices, we can identify the continuous decline of income in the same period, reflecting Japan’s aging and sluggish economy (MHLW, 2012a, 2012b). As such, the figure depicts the gradual decrease of household income, as well as a sharp decline after 2008, the starting year of the global financial crisis, and a leveling after 2012. At just the sight of such figures, we can well understand that the situation regarding energy poverty has been aggravated since the 2000s.

3.3 Results

This subsection shows the empirical results of energy poverty in Japan after the 2000s using unique microdata. The first shown is the result of

dimensional-poverty for “energy” in Japan using the so-called 10% measure (Figure 2). Here, the 10% measure (M_1) is,

$$M_1 = \frac{1}{n} \sum_{i=1}^n c\left(\frac{E_i}{I_i} > 0.1\right) \quad (3)$$

where n is the total number of households, E_i is the energy cost (energy expenditure) of household i , I_i is the household income i , and $c(\cdot)$ is an indicator function that takes the value 1 if the condition in parentheses is true and 0 otherwise. Energy costs include energy expenses for electricity, gas, and other fuels (kerosene), but exclude that for driving cars. As explained in the previous section, the 10% measure is commonly used for measuring energy poverty in developed countries such as the UK, although this paper uses this measure just for gauging dimensional-poverty for energy, one of the attributes of multidimensional energy poverty. This means that the threshold for “energy,” z_1 , is given by 0.1.

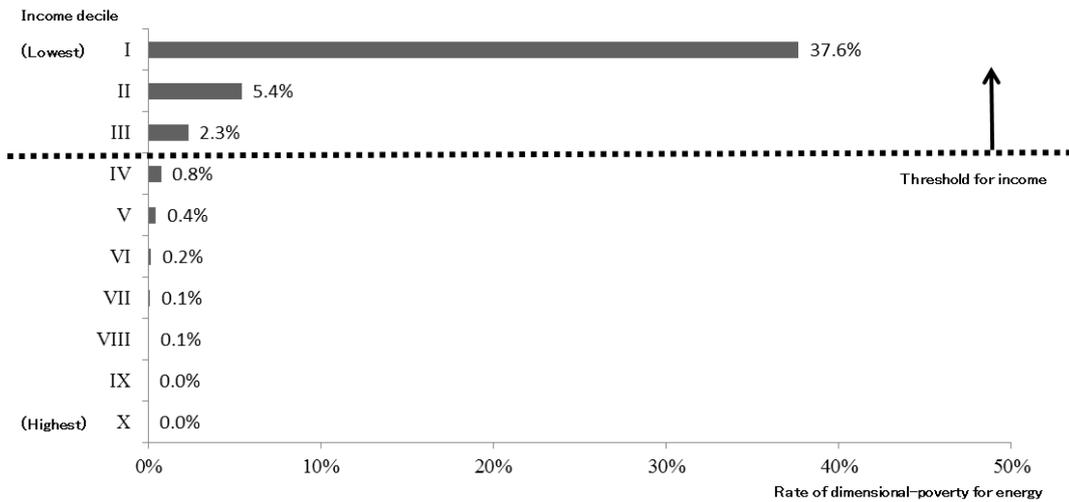


Figure 2. Rate of dimensional-poverty for energy by income decile group

Figure 2 shows the rates of dimensional-poverty for energy (the energy deprivation rates) in the base year 2004, by income decile. The income is equivalized with the square root scale; in other words, the household income is divided by the square root of household size. This indicates that the rates in the lower income decile groups are high. On the other side, the rates in the higher income groups are negligible, especially above the fourth decile. As explained, the threshold regarding the dimension of income, z_2 , is given by the boundary income between the third and fourth income deciles in this paper, which is shown by the dotted line in Figure 2. Consequently, the result confirms the validity of such threshold.

Subsequently, Figure 3 shows the housing conditions of the households derived from the dataset. Due to data limitations, it can only be checked whether they own or rent their houses, and the age of their houses if they own them. After the oil shocks of the 1970s, the Japanese government first established the energy conservation standards for housing in 1980.⁷ In other words, there was no regulation in Japan regarding energy efficiency for housing before 1979. Based on this fact, we decide the threshold in the dimension of energy efficiency of housing (the third attribute), z_3 ; the households living in their own houses built before 1979 or living in rented houses are categorized as in “dimensional-poverty for energy efficiency of housing” in this analysis.⁸ Figure 3 indicates higher proportions of households living

⁷ Comparing thermal insulation, it improves by 30% before and after the 1980 standard (METI, 2011).

⁸ There is the difficulty of how to consider the case of rented houses. Because of data limitations,

in the built-before-1979 houses for lower income deciles and vice-versa.

Additionally, it is noteworthy that the rates of households living in rented houses are high in the lower deciles, with more than 40% in the lowest decile group.

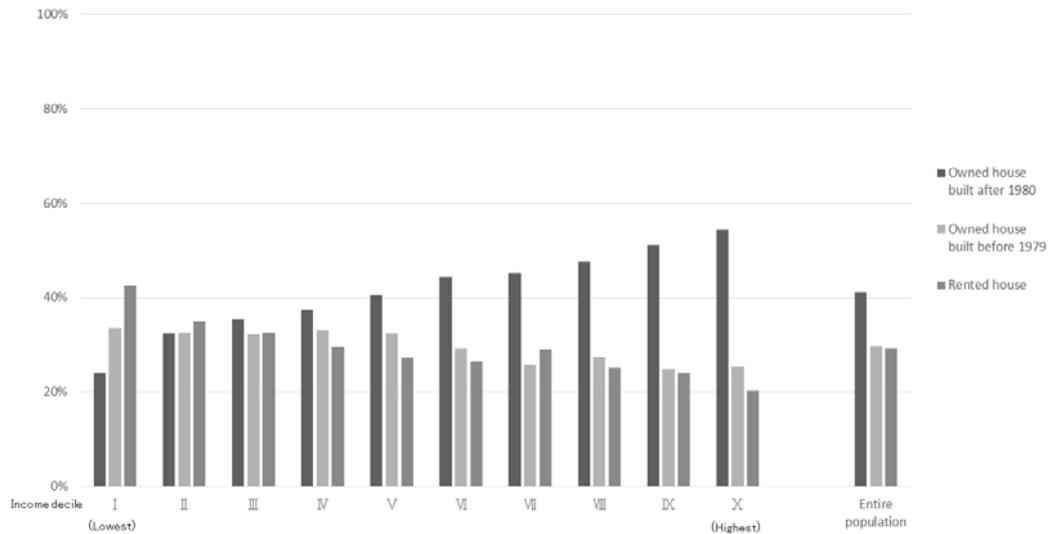


Figure 3. Housing conditions by income decile group

The new MEPI is presented subsequently, Figure 4 representing its concept. As previously explained, the MEPI has three dimensions: “energy,” “income,” and “energy efficiency of housing.” Moreover, the threshold for energy is set as $z_1 = 0.1$; the threshold for income, z_2 , is the boundary income between

we can check the age of housing only if they own their houses. Hence, this paper defines the households who live in rented houses as in dimensional-poverty for energy efficiency of housing due to their incapability of energy-saving investments, following the argument such as Boardman (2010).

the third and the fourth deciles; the threshold for energy efficiency of housing, z_3 , is whether they live in their own houses built after 1980 or not. We identify household i as (multidimensional) energy-poor if only they are poor or deprived in all three dimensions. The shaded area in Figure 4 corresponds to the condition of multidimensional energy poverty in the analysis.

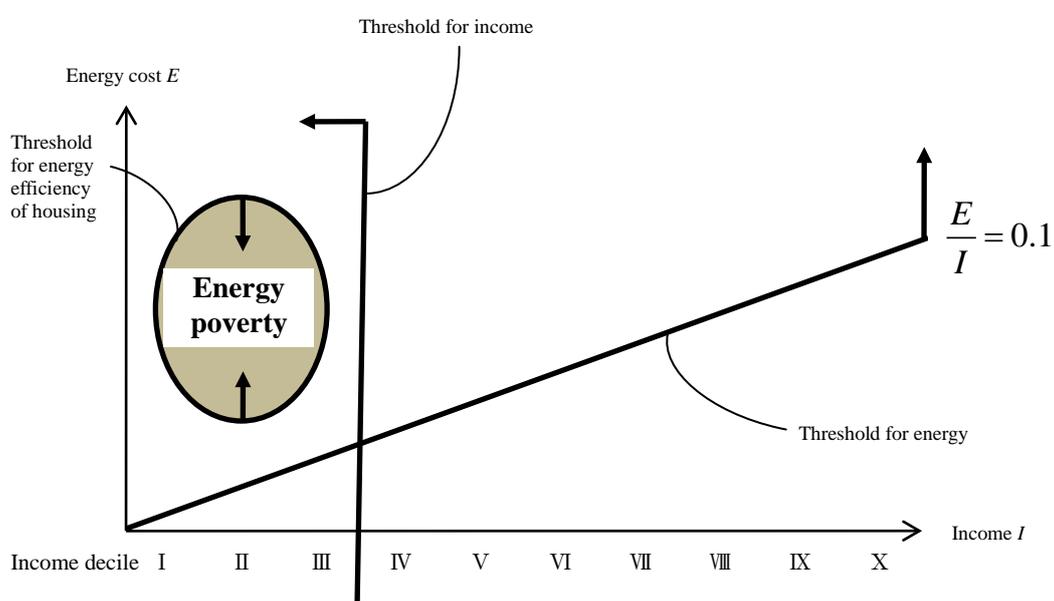


Figure 4. Concept of multidimensional energy poverty

This paper gauges multidimensional energy poverty in Japan after the 2000s using the MEPI, with the results presented in Table 1. We calculate the energy poverty rates in the two cases: the annual case where the energy costs for y_{it} are calculated on an annual-average basis, and the winter case where energy costs are calculated on the winter-average basis. Table 1 shows, in the annual case, that the energy poverty rates gradually increase: 3.2% in 2004, 4.1% in 2007, 4.5% in 2010,

and 5.3% in 2013; in the winter case, 5.5 % in 2004, 6.8% in 2007, 7.4% in 2010, and 8.4% in 2013. We can appreciate that the energy poverty rates in winter are much higher than the annual ones, while in both cases there is a gradual increase in the 2000s and a more significant one after 2011, reflecting the escalation of energy costs after the Fukushima accident.

Table 1. Energy poverty rates in Japan

| | Annual base | | | | Winter base | | | |
|---------------------|-------------|------|------|------|-------------|------|------|------|
| | 2004 | 2007 | 2010 | 2013 | 2004 | 2007 | 2010 | 2013 |
| Energy poverty rate | 3.2% | 4.1% | 4.5% | 5.3% | 5.5% | 6.8% | 7.4% | 8.4% |

This paper also identifies the types of households which are vulnerable to energy poverty. Table 2 illustrates the proportion of energy-poor households by household type. From the results, mother-child and single-aged households are categorized as vulnerable. Even in 2004, before the “great surge” in international energy prices, more than one-tenth of households, specifically 11.9% of mother-child and 11.3% of single-aged households, are energy-poor in the annual case. After the earthquake, in 2013, the energy poverty rate of mother-child households rises to 18.2%, and that of single-aged households to 16.4%. When evaluated in winter, the energy poverty rates become worsening. The result shows that around a quarter of mother-child and single-aged households are in energy poverty in 2013.

Table 2. Energy poverty rates by household type

| | Annual base | | | | Winter base | | | |
|---------------|-------------|-------|-------|-------|-------------|-------|-------|-------|
| | 2004 | 2007 | 2010 | 2013 | 2004 | 2007 | 2010 | 2013 |
| Mother-child | 11.9% | 14.5% | 15.8% | 18.2% | 19.0% | 22.2% | 23.6% | 25.8% |
| Single-aged | 11.3% | 13.7% | 14.3% | 16.4% | 17.1% | 20.8% | 22.0% | 24.5% |
| Aged | 3.7% | 4.9% | 5.6% | 6.9% | 7.2% | 9.2% | 10.3% | 11.7% |
| Single-person | 3.2% | 4.0% | 4.2% | 4.8% | 5.5% | 6.5% | 6.9% | 7.6% |
| Other | 1.6% | 2.2% | 2.5% | 3.1% | 3.1% | 4.0% | 4.5% | 5.2% |

Note: Mother-child households are composed of a single female parent and an unmarried child (or children). Single-aged households consist of one person who is 65 years old or over. Aged households are households with two or more persons who are 65 years old or over.

Table 2 also indicates the surge of energy poverty rates before and after 2011. Even in 2010, before the earthquake, 15.8% of mother-child and 14.3% of single-aged households are in energy poverty in the annual case. After the earthquake, in 2013, the energy poverty rate of mother-child households increases to 18.2%, and that of single-aged households to 16.4%.

The results prove that the energy price rise and the lowering income in the 2000s stifled the livelihood of households in Japan, especially for vulnerable households, such as mother-child and single-aged. In addition, energy price hikes after 2011 have further aggravated the situation of energy poverty in Japan. In 2013, roughly one fourth of vulnerable households are energy-poor in the winter estimate.

4. Conclusion

The question is how to gauge the energy poverty in developed countries from a multidimensional perspective. As the classical paper on multidimensional poverty, Atkinson and Bourguignon (1982) emphasize that there are a lot of cases in poverty measurement where a single dimensional index cannot represent the situation comprehensively. Therefore, this paper suggests a new measure to evaluate energy poverty in developed countries from a multidimensional angle, the MEPI, which is composed of three attributes (dimensions) concerning energy poverty in developed countries: energy costs, income, and energy efficiency of housing. The MEPI is a practical alternative to traditional energy poverty measures, and is applicable to numerous cases.

The paper applies the measure to gauging the situation of energy poverty in Japan throughout the analyzed period, including before and after the Great East Japan Earthquake and the Fukushima nuclear accident, that is an invaluable case in point. The empirical results, based on unique microdata, show that energy poverty has been aggravated since the 2000s. Looking at the situation by household type, we can categorize mother-child and single-aged households, in particular, as vulnerable to energy poverty. Additionally, the results show the severe impact of energy price hikes after the Fukushima accident on energy poverty aggravation, especially for vulnerable households.

Recently, the international energy prices are at a low level, which might ease the situation of energy poverty in Japan to a certain extent. They might also alleviate the difficulty of vulnerable households to a certain degree. However, the

unique characteristics of Japan, such as a persisting sluggish economy, nuclear plant shutdown, rising FIT charges, need for higher carbon pricing, etc. are reducing the positive effects.⁹ In this context, we might consider some countermeasures to redress energy poverty, such as social tariffs, from the poverty and distributive perspectives. Moreover, it is essential to introduce effective measures for promoting energy-saving investments that specifically target low-income and vulnerable households (e.g., Boardman, 2010).

Future research is necessary, especially on the definition of energy poverty. In the case of multidimensional poverty indices, it is of great importance how to select the dimensions of poverty. As such, Kakwani and Silber (2007) emphasize that researchers have to decide “what matters” in the target problems for themselves, and Boardman (2010) claims that the choice of definition should be pragmatic. In this paper, we develop a multidimensional energy poverty index focusing on three dimensions: energy costs, income, and energy efficiency of housing, which reflects the traditions in this research field since Boardman (1991), and is reasonable as a multidimensional measure of energy poverty in developed countries. Nevertheless, we can consider another type of multidimensional energy poverty index e.g. including a dimension of wealth or subjective judgment.

Finally, I believe that the new measure, MEPI, and its findings will have important implications for future practices of tackling energy poverty in Japan, as well as in other developed countries.

⁹ See also my previous study for the latest situation (Okushima, 2016).

Acknowledgments

This research was supported by the Grant for Environmental Research Projects from the Sumitomo Foundation. The author would like to thank his colleagues, students, and the staff of the National Statistics Center for their assistance with this research.

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