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PRICE AND INCOME ELASTICITY OF ELECTRICITY CONSUMPTION IN HUNGARY

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Abstract

The electricity consumption of a country is influenced by several parameters of the national economic structure, the level of societal advancement and the economic climate. Indicators based on the rate of GDP and electricity consumption are widely used for characterizing the productivity of an economy. In this paper, the electricity consumption of the household and productive sectors is analyzed based on reference electricity consumption (proportional to GDP) and the relationship between consumption and the price of electricity is presented for Hungary during the period from 1995 to 2010. We provide estimates of price and income elasticity of demand for electricity.

Key words: electricity intensity, income elasticity, price elasticity, reference electricity consumption

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1. Introduction

Prior to the 1980s, energy prices were influenced by subsidies that were much lower for residential than for industrial customers; consequently, prices were far from cost covering. After the political changes in 1989, reorganization of the energy market was inevitable in Hungary. Price regulation in the electricity supply industry was determined by the Pricing Act in 1990 (Act, 1990) and the Electricity Act in 1994 (Act, 1994).

In the Pricing Act, two types of energy products were defined: products with free prices and products with regulated prices. As a result of the legislation, the prices of products with free prices rose quickly, while products with regulated prices kept their fixed prices until 1997. The aim of the Electricity Act was electricity price regulation that allowed reliable electricity supply at "reasonable" prices, where the prices were to be determined by a formula and cover the justified costs.

Companies were expected to improve efficiency and reduce cost. In accordance with the Electricity Act, the Hungarian Energy Office (HEO), as a pricing authority, could review the electricity prices at each level.

The control of the utilities was based on three indicators: the domestic industrial sales price index, the exchange rate of Hungarian Forints versus US Dollars, and an index expressing fuel price movements. According to the HEO publications, the regulation led to an increase in real prices of 50 to 80 percent relative to its 1994 level, according to the customer category. In 1995, the prices had higher residential rates than industrial rates. The nominal price of electricity was nearly three times higher in 1999 than in 1995 (Hungarian Energy Office, 2010).

Introducing universal service in 2008, a new era started in the price regulation of electricity supply. Large and non-residential customers could buy electricity only from competitive market traders at the price derived from market demand and supply, while small customers could buy electricity in the framework of universal service. A new price regulation period started in 2009 for electricity system use.

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The main characteristic of the retail market was its dual structure, even after the market opening in 2003 (administrative and free price segment). However, the relative weights of the two segments have considerably shifted since 2008. The public utility supply at administrative prices was replaced by universal service in 2008, to which a much narrower circle of consumers was entitled. In 2009, 60 percent of end-users' consumption took place in the free market, while 40 percent of end-users bought electricity at administrative prices. In 2009, domestic prices were average in the residential customer segment, compared to the prices of the European Union; however, large industrial customers had to pay the highest prices for electricity (Hungarian Energy Office, 2011).

From the point of view of the sustainable development, the energy efficiency considerations have priority. In the literature of the economics of energy these considerations have become a favourite topic for analysis (Li and Li, 2014; Milfelner, 2014; Yang and Wang, 2014). The economic effects of regulations for energy production and consumption, and the price and the income elasticity of demand for energy have been studied by several researchers (Baranzini and Sylvain, 2013; Frondel, 2011; Havranek and Kokes, 2015; Karimu - Brännlund, 2013; Li et al., 2014; Lin – Prince, 2013; Nakajima and Hamori, 2010). The price (and income) elasticity of demand for electricity measures the responsiveness of the quantity demanded to the change in its price (income). The aim of this paper is to estimate price and income elasticity of electricity consumption in Hungary.

2. The main characteristics of electricity consumption in Hungary

Electricity consumption is one of the main components of the price elasticity of electricity demand. As we can see in Fig. 1, net electricity consumption significantly increased in Hungary, from 475 GWh in 1925 to 36 235 GWh in 2012. However, three significant slowdowns can be found on the graph of net electricity consumption. Fig. 1 shows a marked decrease of 62.25 percent from 1940 to 1945 when the Second World War was in progress.

A moderate decrease occurred in the early 1990s when the economic and political system changed in Hungary due to a regime change. The Hungarian Electricity Company (Magyar Villamos Művek Tröszt – MVMT) conducted six electricity companies and organized the technical and economic management of the entire Hungarian electricity system before the regime change.

In 1992, in preparation for privatization, the Hungarian Electricity Company was transformed into a two-tier system (Hungarian Electric Company Ltd., MVM Rt.), restructured and partly divided into eight power companies, six distribution companies and a transmission company (Kessides, 2000). In 1995, electricity providers such as ELMŰ, ÉMÁSZ, DEMASZ, DÉDÁSZ, TITÁSZ, ÉDÁSZ and other Hungarian power plants were all privatized and transformed into independent public limited liability companies. Net electricity consumption decreased by 16.07 percent between 1989 and 1993 (Fig. 1). The third decline in net electricity consumption took place during the second half of 2008, as a result of the economic crisis, when the increase in demand for electricity temporarily broke. Net electricity consumption decreased by 5.04 percent in 2009 (Fig. 1). The total electricity consumption did not reach the pre-crisis level during 2012.

Electricity intensity is the ratio of gross electricity consumption and gross domestic product. Gross electricity consumption is greater than the previously examined net electricity consumption by the network losses. If production increases in any economy, then demand and consumption of energy also increase. As we can see in Fig. 2, the nature of the change in gross electricity consumption is similar to the change in GDP. Fig. 2 shows that the electricity intensity gradually increased from 1960 to 1991 because production modernization materialized in only some sectors before the change of the political system. However, after the transformational crisis, the electricity intensity decreased due to the cut-back of the energy-intensive sectors and application of modern technologies.

The aim of the following section is to present an estimate of price elasticity of electricity consumption for the household and productive sectors in Hungary. The period examined for electricity elasticity follows the change of the economic and political system, which took place from 1992 to 2011 or 1995 to 2010, depending on the availability of data. The sum of electricity consumption of households, industry and services gives the major proportion of net electricity consumption.

The ratio of household, industry and service sector electricity consumption to the net electricity consumption is between 85 and 90 percent, depending on the years between 1992 and 2012 (Fig. 3). There was no considerable re-arrangement within the structure of net electricity consumption. Therefore, the households and productive sectors are considered the two main electricity consumers in the examination.

3. Reference electricity consumption calculated with GDP

In this section, reference electricity consumption is defined and used to investigate electricity consumption by the productive and household sectors in Hungary between 1995 and 2010.

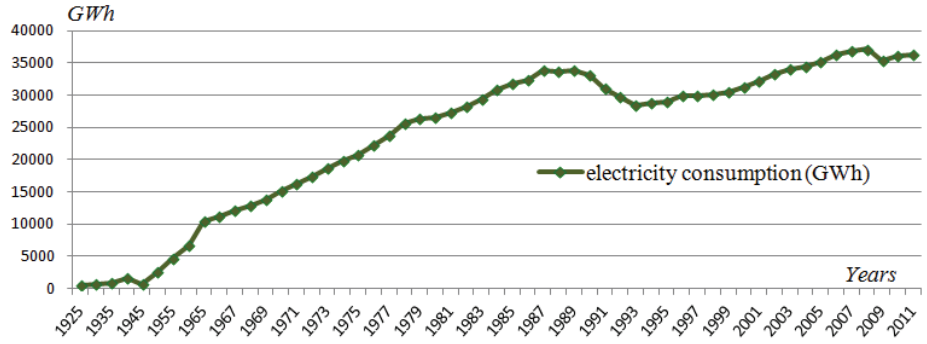

Fig. 1. Net electricity consumption in Hungary between 1925 and 2011 (MAVIR and MEKH, 2012)

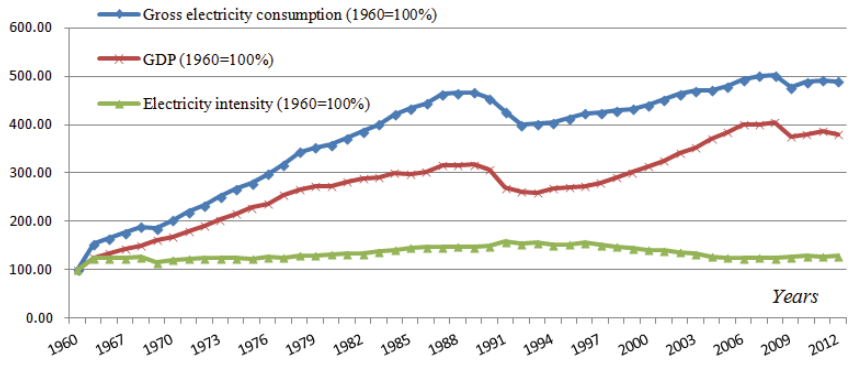

Fig. 2. Change in the gross electricity consumption, the GDP and the electricity intensity in Hungary between 1960 and 2012 (1960=100%) (MAVIR and MEKH, 2012)

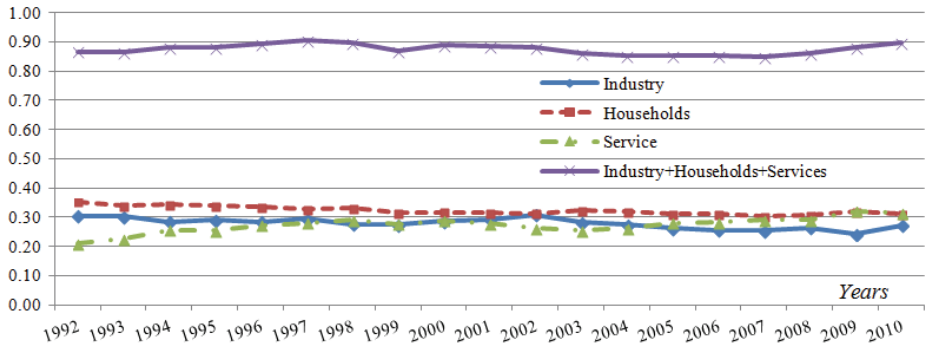

Fig. 3. The ratio of household, industry and services sectors' electricity consumption to net electricity consumption in Hungary between 1992 and 2010 (MAVIR, 2012)

Reference electricity consumption in time t (REC_t) is quantified using electricity consumption ($EC_{base\ year}$) in base year 1995 and GDP in each year between 1995 and 2010 by (Eq. 1):

$$REC_t = EC_{base\ year} \cdot \frac{GDP_t}{GDP_{base\ year\ t}}. \quad (1)$$

The actual and reference values of electricity consumption for the productive and household sectors can be observed in Fig. 4 and Fig. 5. The reference electricity consumption was greater than the actual electricity consumption for both the household and productive sectors for each year of the study period. This means that the actual electricity consumption was less than the expected value calculated based on the change in real GDP. The gap between actual and reference electricity consumption of the productive sector exceeded the consumption gap of the household sector each year between 1995 and 2010.

The rate of actual and reference electricity consumption of the productive sector increased between 1995 and 2010. Reference electricity consumption of the productive sector was 25.42 percent larger than actual electricity consumption in 2010. The change in the reference and actual electricity consumption gap for the productive sector shows that electricity consumption per gross domestic product decreased, which is in line with the change in electricity intensity.

In the case of the household sector, the difference between actual and reference electricity consumption increased between 1995 and 2007, with the gap reaching 3370 GWh in 2007. After 2007, the previously examined difference decreased until 2009, and it increased again in 2010.

4. Price elasticity of demand for electricity consumption between 1995 and 2010

In this section of the study, we provide an estimate of the long-run price elasticity of the household and productive sectors' demand for electricity. The price elasticity of electricity consumption (*EC*) shows the percentage change in quantity of electricity purchased for a one percent change in its price.

Three types of price elasticity of demand can be distinguished, elastic, unit elastic and inelastic, depending on whether the absolute value of the price elasticity is larger than, equal to or smaller than one, respectively. The price elasticity of energy is generally inelastic because energy is a necessity for households and firms. This means that if the value of the energy price increases by one percent, then energy consumption decreases by less than one percent. Actual electricity consumption depends on several factors such as the price of electricity, income per capita, the quantity of net imported energy, and the amount of capital stock (Eq.2):

$$D(EC) = f(p, y, V) \tag{2}$$

where *D(EC)* is the demand for electricity, *p* is the real price of electricity, *y* is income, and *V* is the set of other determinants of electricity demand. In our calculation, we used a double log model and assumed that the demand for electricity is a function of price and income. We determined reference electricity consumption for the household and productive sectors using the base year electricity demand and taking into account the change in real GDP, as described in section 3. The price elasticity of electricity consumption for the household and productive sectors separately is calculated using Eq. (3):

$$\log \frac{EC_t}{REC_t} = \beta_0 + \beta_1 \cdot \log \frac{p_t}{p_{base\ year}} + u_t \tag{3}$$

Yanagisawa (2012) provided a similar estimation of price elasticity of energy demand using the reference calculation of energy consumption for different sectors in Japan. Our calculation is made by using nominal and real price individually. The change in the consumer price index is considered in the real price calculation.

Electricity consumption and the change in price are the determining factors in calculating the price elasticity of the household and productive sectors' demand for electricity. The household and productive sectors' electricity consumption as a percentage of net electricity consumption ranged from 73.11 percent in 2009 to 86.24 percent in 1995 (Hungarian Energy Office, 2012).

There was not a significant change in household electricity consumption, as it increased by 13.78 percent between 1995 and 2010. However, the nominal price of electricity for households increased significantly by 489.5 percent during the investigated period (Fig. 6). The productive sector's demand for electricity increased by 4.58 percent and the price of electricity rose from 6.03 HUF/kWh to 26.95 HUF/kWh (Fig. 6).

According to our calculation, log-linear function fits better in the case of the nominal price rather than the real price. The absolute value of the long-run price elasticity of electricity is smaller than one, which means that electricity demand is price inelastic (Table 1).

The absolute value of the price elasticity is smaller for the household sector than for the productive sector, and they are both relatively low. This means that an increase in sales price has relatively low impact on electricity consumption. Our result is in accordance with the study of price elasticity of Hungarian households' electricity consumption, based on a questionnaire survey of 1000 households.

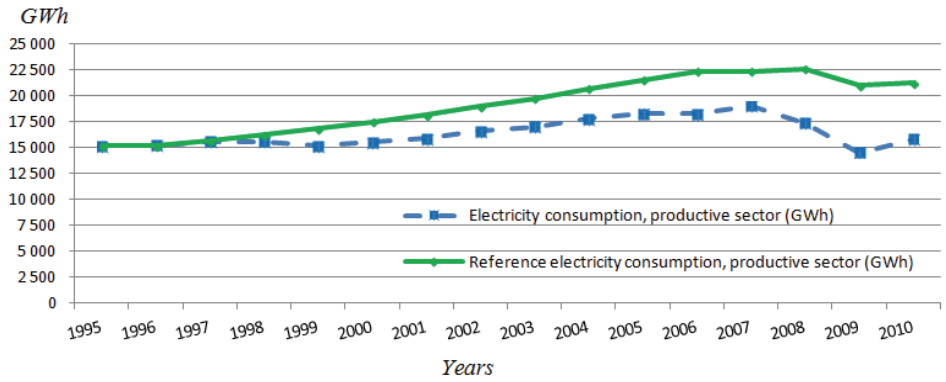

Fig. 4. Actual and reference electricity consumption of the productive sector in Hungary between 1995 and 2010 (Hungarian Energy Office, 2012)

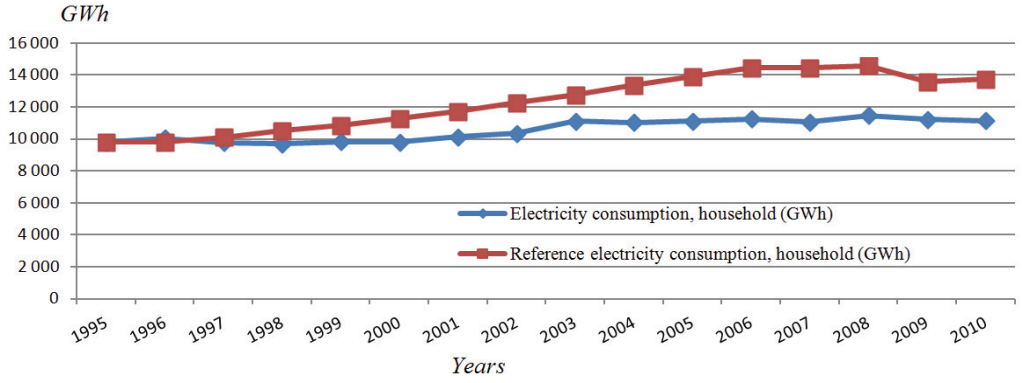

Fig. 5. Actual and reference electricity consumption of households in Hungary between 1990 and 2010 (Hungarian Energy Office, 2012)

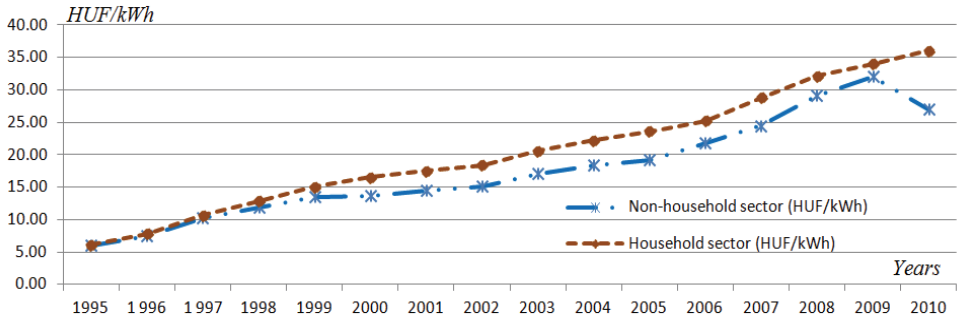

Fig. 6. The nominal price of electricity consumption for the household and productive sectors in Hungary between 1995 and 2010 (Hungarian Energy Office, 2012)

Table 1. Estimates of price elasticity of electricity consumption for the household and productive sectors

		Price elasticity	***R^2***
Household sector	Nominal price	-0.1598	0.8624
	Real price	-0.5174	0.7944
Productive sector	Nominal price	-0.2078	0.8711
	Real price	-0.6835	0.6967

According to that survey's results, the long-run price elasticity of household demand is between -0.15 and -0.25 (Elek and Kézdi, 2003).

5. Income elasticity of electricity consumption

In this section, the aim is to estimate the income elasticity of electricity consumption using two alternative models (Eqs. 3, 4):

$$\log EC_t = \beta_0 + \beta_1 \cdot \log p_t + \beta_2 \cdot \log y_t + u_t \qquad (3)$$

$$\log EC_t = \beta_0 + \beta_1 \cdot \log y_t + u_t \qquad (4)$$

where: EC_t is the electricity consumption in time t expressed as a percentage of the electricity consumption in year 1995, y_t is the real GDP expressed as a percentage of the GDP in year 1995 (base year), p_t is the average end-user real price of electricity expressed as a percentage of the base price, and u_t is the disturbance term.

The used method is ordinary least squares (OLS) applied to the data for the period of 1995 to 2010. The rationale for selecting this period is examining the electricity market after the transmission crisis in Hungary. There was a distinction made between the household and productive sectors' electricity consumption in the calculation of price and income elasticity. The result of the calculation based on the first model shows a strong relationship between electricity consumption and real GDP (Table 2).

The income elasticity is 0.603, which means that if the real GDP per capita representing income increases by 1 percent, then electricity consumption increases by 0.603 percent. According to the calculation results based on the second model, the price and change in GDP have a significant role in electricity consumption. However, the percentage changes in price cause a small change in electricity consumption. The price elasticity is negative and less than one, which shows that the demand for electricity is price inelastic.

There is no significant difference between the income elasticity of household and industrial electricity consumption (Table 3). The long-run

income elasticity of demand for electricity is between 0 and 1 (Table 3). Using the household questionnaire survey, Elek and Kézdi (2003) found that the long-run income elasticity of demand for household electricity is between 0.2 and 0.72 in Hungary.

The short-run income elasticity for household electricity consumption is lower than the long-run income elasticity. The change in the long-run income elasticity is influenced by purchasing electricity equipment.

Table 2. Estimates of income elasticity of electricity consumption using the first model

	Income elasticity	R^2
Electricity consumption	0.603	0.981

Table 3. Estimates of price and income elasticity of electricity consumption using the second log-log model

	Income elasticity	*Price elasticity*	R^2
Household electricity consumption	0.493	-0.089	0.88
Industry electricity consumption	0.647	-0.397	0.69

6. Conclusions

In this paper, our aim was to examine the relationship between price and demand for electricity on the one hand and to analyze the relationship between macroeconomic income and electricity consumption on the other hand. We found that significant macroeconomic effects such as war, change of political and economic system, and financial crisis considerably influenced the net electricity consumption in Hungary between 1925 and 2011.

Electricity intensity has decreased since the mid-1990s and after the transformational crisis, as a consequence of the adaptation of modern production techniques and technologies. Examining the difference between the actual and reference electricity consumption indicated that electricity consumption was lower than the expected values calculated using the change in real GDP for each examined year.

The difference between the actual and calculated reference electricity consumption for the productive sector was larger than for the household sector. The price elasticity was calculated considering the simplified log-log model for the household and productive sectors, respectively. The long-run price elasticity for electricity demand is inelastic. The electricity price for the household and productive sectors significantly increased in Hungary between 1995 and 2010; however, the household and productive sectors' electricity consumption slightly increased.

The amount of GDP is a very strong influencing factor in electricity consumption. The long-run income elasticity is between 0 and 1, indicating that electricity is a normal good and a one percent increase in income causes less than a one percent increase in electricity consumption.

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