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Identification of Market Power in the Hungarian Dairy Industry: A Plant-Level Analysis

Abstract

The objective of this paper is to provide an alternative model which can be used to test for oligopsony market power applying plant-level data. For this purpose, we took into account empirical studies and specific developments in the Hungarian dairy industry and specified a model that provides useful benchmarks for an econometric test of market power. The results of the econometric analysis show that the effects from policy changes in Hungary, as well as from plant specific issues are highly statistically significant, and produce evidence suggesting the exercise of oligopsony market power in the Hungarian dairy industry.

Keywords: Hungarian dairy industry, market power, oligopsony, translog

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1 Introduction

Since the 1980s, numerous studies on New Empirical Industrial Organization (NEIO) have been conducted. These studies paid special attention to measuring market power in agricultural and food markets. In most of these studies, e.g. Schroeter (1988), Azzam and Pagoulatos (1990), and Schroeter and Azzam (1990), evidence of buyer and/or seller market power in the U.S. beef packing industry was produced by interpreting market level data. Morrison Paul (2001), conducting a plant-level analysis, found market power to be present in both the cattle input and beef output market. In contrast to the majority of these studies, Muth and Wohlgenant (1999) could not prove the existence of oligopsony power in the U.S. beef packing industry. A result that was also obtained by Hyde and Perloff (1998) for oligopsony market power in the Australian retail meat sector, and by Quagrainie et al. (2003) for processor power in the Canadian cattle and hog markets.

In the recent past, agricultural economists have started to focus on the analysis of market structure and pricing in the market for raw milk in the Central and Eastern European Countries (CEECs). Perekhozhuk (2007) used a production function framework to investigate production technology and to test for market power in the Ukrainian milk processing industry. Anders (2008) estimated the degree of oligopoly and oligopsony market power in the German food retail industry by evaluating a set of monthly retail beef and pork marketing data of the federal state of Hesse. Applying the revenue function approach, Hockmann and Vöneki (2009) found considerable oligopsony market power in the Hungarian milk market. The econometric results obtained by Bakucs et al. (2010) have revealed the existence of oligopsony market power in the Hungarian slaughter hog market.

At this point, it is necessary to underline that all of these studies relied on the New Empirical Industrial Organization theory (NEIO) and used market-level data, which were available only to a limited extent, to estimate the degree of market power at a national level. At a regional level, as far as we know, the degree of market power has been estimated only by Wann and Sexton (1992), Weliwita and Azzam (1996), Koontz and Garcia (1997), Anders (2008) as well as Perekhozhuk, Grings, and Glauben (2009); and in so doing have found evidence of market power.

There are a lot of empirical studies that have estimated and tested for oligopoly and/or oligopsony power on the basis of industry-level data, while there is only little literature on such studies analyzing plant-level data. Morrison Paul (2001), using plant-level data of U.S.

beef packing plants, identified the presence of market power based on estimating input demand equations derived from a Generalized-Leontief-Quadratic cost function. Moreover, the parameter of market power was specified as a function of the number of cattle buyers, the expenditures for cattle procurement, the overtime payments to workers, and others variables.

The objective of this paper is to provide an analysis of market power at plant-level and to identify plant-specific effects that may affect both market structure and pricing in the Hungarian dairy industry. Using a unique plant-level data set in this paper, we will, therefore, focus on specifying a parameter for oligopsony power that takes into account policy changes in Hungary, the ownership form of enterprises as well as plant-specific issues.

Our paper is organized as follows. The next section describes, in depth, the restructuring process in the Hungarian dairy sector that is, currently changing the market structure in the Hungarian dairy sector. Section 3 provides a theoretical model which may be used to test the plant's conjectural elasticities. The model's estimates are applied to develop an econometric test for market behavior based on plant-level data in Section 4. Descriptions of data sources and variables used in the econometric analysis are presented in Section 5. Estimation results and specification tests of the parameter of oligopsony market power are discussed in Section 6. The final section summarizes our results and draws conclusions.

2 Structural change in the Hungarian dairy sector

After the fall of the planned economic system and the beginning of the transition period, a restructuring process in the Hungarian economy – and with it, the dairy sector, set in. And indeed, the Hungarian dairy industry as part of this economy had to undergo severe changes leading to an unexpected dramatic decrease in both the milk production and milk processing sector. Table 1 presents available figures of the milk production sector for selected years. Between 2000 and 2007, the number of dairy cows decreased by 25.1% or 89 thousand, from 355 to 266 thousand head. Despite this sharp decline, milk production declined by 15.8% or 95 thousand metric tons, from 2,137 to 1,448 thousand metric tons as the annual milk yield per cow increased by 905 kg, from 6,020 to 6,925 kg. Surprisingly, however, milk deliveries to the processing plants declined by 382 thousand metric tons (from 1,830 to 1,448 thousand metric tons) leading the share of milk deliveries in milk production to fall by 7%. According to Hockmann and Vöneki (2009), the reduction in milk deliveries to the processing plants largely results from increasing raw milk exports to Italy, while imports of raw milk, mainly from Slovakia, only constitute a marginal share in milk processing.

Between 2000 and 2007, the number of dairy farms plummeted by 23,020 dairy farms, almost to a third of the original number, and amounted only to 34.6%. Given the number of dairy farms by size of dairy herd in Table 1, it is obvious that the Hungarian milk production sector is dominated by one of the two following forms of agricultural farms: (1) individual dairy farms (small-scale dairy farms) and (2) industrial dairy farms (large-scale dairy farms). In the literature on transition economics, one distinguishes between two forms of agricultural production in transition economies which develop with large-scale and small-scale agriculture. On the one hand, there are individual farms (one-man farm), so-called personal subsidiary plots (private family plots or private subsidiary plots), that have from one, but not more than ten heads of milk cows. On the other hand, there are industrial dairy farms that generally own ten or more head of milk cows. This dual structure of agricultural production is characteristic for Central and Eastern European Countries (CEEC), New Independent States (NIS), China, and India (OECD 1999, 68–9).

From Table 1 it can be seen that the number of individual farms that own between 1 and 9 cows was significantly reduced by 23,110 dairy farms, from 32,890 to 9,780 dairy farms, and thus in 2007, amounted to only 29.7% of the original number. Despite this significant drop in the number of individual dairy farms, their share remained high, accounting for 80.4% of all dairy farms. Surprisingly, the number of dairy farms with more than 50 cows also decreased, by 210, from 750 to 540 dairy farms whereas the number of dairy farms with between 10 and 49 dairy cows slightly increased by 270 dairy farms, and thus amounted to 17.2% of all dairy farms.

The Statistical Office of the European Union (EUROSTAT) released statistical data on the number of dairies by size (milk processing enterprises by volume of annual milk collection), which are presented in Table 2. From this table it is apparent that, in 2003 and 2006, there were 49 and 37 dairies that annually collected and processed 100 thousand metric tons of raw milk or less in Hungary, compared to Germany where there were 138 and 128 dairies, respectively. Although the number of

Table 1 Development of the milk production sector in Hungary for selected years.

Item	2000	2003	2005	2007
Number of dairy cows, 1,000 head	355	310	285	266
Annual milk yield, kg per cow*	6,020	6,552	6,768	6,925
Milk production, 1,000 t	2,137	2,031	1,929	1,842
Milk collection, 1,000 t	1,830	1,717	1,518	1,448
Milk collection share in/of milk production, %*	86	85	79	79
Number of dairy farms	35,190	22,000	16,250	12,170
Number of dairy farms by size of dairy herd:				
Between 1 and 2	21,850	13,050	7,090	4,610
Between 3 and 9	11,040	6,840	6,760	5,170
Between 10 and 19	1,130	980	1,160	1,210
Between 20 and 29	270	280	390	290
Between 30 and 49	170	190	190	340
Between 50 and 99	140	170	210	120
100 or more	610	490	460	420

Notes: The superscript * denotes authors' calculation based on data from EUROSTAT and FAOSTAT.
Source: EUROSTAT and FAOSTAT.

Table 2 Number of dairies by volume of annual milk collection in metric tons.

Item	Germany		Hungary	
	2003	2006	2003	2006
Number of dairy plants	201	190	53	39*
Number of dairy plants by classes of volume of milk collection (t/year):				
5,000 or less	39	37	26	16
Between 5,001 and 20,000	25	21	11	12
Between 20,001 and 50,000	33	33	8	4
Between 50,001 and 100,000	41	37	4	5
Between 100,001 and 300,000	43	40	3	*(c)*
More than 300,000	20	22	1	*(c)*

Notes: The superscript * denotes rough estimates calculated by the authors based on data from EUROSTAT. *(c)* denotes that data are not published for confidentiality reasons.
Source: EUROSTAT.

dairies in both countries decreased by about 10 milk processing enterprises within 3 years, the development within the size classes differed significantly (between the two countries). In Germany, there were more than 63 dairies that processed more than 100 thousand metric tons as compared to only four dairies in the same class in Hungary in 2003. The Hungarian figures for 2006 of the two highest classes (more than 100 metric tons per annum) are not available since data provided by EUROSTAT are confidential for this year. Their number is, therefore, open to conjecture; we suppose that there could have been three dairies at a maximum (cf. Table 2).

Despite the fact that the number of dairy plants in the lowest class (≤ 5,000 t/year) decreased, their number still remains high and amounts to more than 40% of all dairy plants in the industry. In Germany, on the other hand, these dairy plants make up less than 20%. Moreover, the share of dairies with an annual collection volume of equal or less than 20,000 metric tons account for more than 75% in Hungary and around 29% in Germany. Compared to Germany, the Hungarian dairy industry is comprised of a few large and many small milk processing plants (dairies).

At this point it is helpful to look at measures suitable for making further statements on concentration processes of the Hungarian dairy sector. We, therefore, calculated the concentration of plants in the industry. The calculation had to be based on firm-level rather than plant-level data because of confidentiality reasons that would not have disclosed either name or owners of dairy plants. Thus, using individual plant data would have led to ambiguous results as a single firm may have multiple plants. However, most Hungarian dairy firms are single-plant firms. Only two multi-plant firms operate five dairy plants. Data sources came from the Institute of Economics of the Hungarian Academy of Science (IEHAS) and were collected by the Hungarian Tax Authority.

Table 3 contains the number of dairy plants (N), the Herfindahl–Hirschman Index (HHI), and the three selected concentration ratios (CR_1), (CR_4), and (CR_{10}), denoting the largest, the four, and the ten largest dairy plants, respectively. Looking at the whole period from a 1993 to 2006, the number of dairy plants decreased from 35 to 21, though not steadily as the lowest number of 19 was reported for the years 2003 and 2004. Again, for confidentiality reasons, we cannot accurately specify whether the decline in the number of milk processing plants was associated with the exit of plants from the industry, mergers or acquisitions.

However, a straightforward comparison between the number of dairy plants from Table 3 and the number of dairy farms (agricultural and individual farms) from Table 1 yields marked differences: In 2005, there were only 20 dairy plants compared to 16,250 dairy farms. From this, we conclude that the market structure of the

Table 3 Concentration Ratio and Herfindahl–Hirschman Index.

Year	*N*	CR_1	CR_4	CR_{10}	HHI	1/*N*
1993	35	10.65	33.67	66.47	549.9	285.7
1994	36	11.35	34.01	66.07	546.5	277.8
1995	40	9.95	31.26	63.06	496.6	250.0
1996	40	9.99	33.71	63.26	507.1	250.0
1997	36	11.53	38.18	66.23	575.4	277.8
1998	40	13.10	38.50	70.00	616.1	250.0
1999	35	21.76	51.69	82.75	965.1	285.7
2000	35	23.00	56.89	84.63	1,079.4	285.7
2001	32	20.02	55.92	83.78	1,048.6	312.5
2002	24	21.43	61.30	90.11	1,241.7	416.7
2003	19	31.60	70.77	92.63	1,670.5	526.3
2004	19	27.28	68.50	92.63	1,451.4	526.3
2005	20	24.32	65.59	90.65	1,306.1	500.0
2006	21	36.16	65.64	87.52	1,721.4	476.2

Source: Own calculations based on plant-level data provided by the Institute of Economics of the Hungarian Academy of Science.

Hungarian market for raw milk is oligopsonistic,[1] all the more so because the calculated average of milk suppliers (i.e., dairy farm) per milk processor (i.e., dairy plant) amounts to 813. Similar conclusions with respect to the market structure of Hungarian diary industry have been reached by many other authors.

Juhász and Stauder (2006) analyzed the concentration of Hungarian food retailing and supplier–retailer relationships by calculating the concentration ratios of the top five firms and their sum of market shares. From the single concentration ratios of 18%, 17%, 9%, 8%, and 6% (in descending order) and their joint market share of net sales in the industry 58%, they concluded that the market structure of the Hungarian dairy industry may be best described as duopolistic, i.e. the dairy industry is dominated by two large milk processors.

In our analysis, we calculated the concentration ratios for the largest individual dairy plants in terms of revenue from sale of products for the period from 1993 to 2006. In doing so, we found that the market share of the four largest dairy plants nearly doubled from 33.67% to 65.64% (Table 3).

In 2006, the concentration ratio of the ten largest plants (CR_{10}) made up almost 90% of the total output of the dairy industry. At the same time, the market share of the largest dairy plant tripled, increasing from 10.7% to 36.1%.[2] Mellen and Evans (2010, 151) point out that “a company with a 20% market share may be able to dominate an industry when no other company possesses more than 5% of the market. However, a 20% market share where two competitors each control 40% leaves the company in a much weaker position.” So as not to rely solely on concentration ratios but also on a more complete measure of industry concentration we calculated the Herfindahl–Hirschman Index for the Hungarian dairy industry. Since we measured percentage of market share held by dairy plants in an industry, the concentration ratio ranges from 0 to 100 and the HHI from 0 to 10,000. For the period from 1993 to 2006 we obtained HHIs ranging from 496.6 to 1,721.4. Thus, according to the Classification of the U.S. Department of Justice and the Federal Trade Commission,[3] the Hungarian dairy industry is moderately concentrated.

Considering the structural change in the Hungarian dairy sector and reasons for oligopsony power, we can hypothesize that milk processors (dairy plants) may exercise market power in the input market for raw milk. Moreover, Hockmann and Vöneki (2009) estimated industry-wide indexes of market power and found evidence of oligopsony power. In addition to many NEIO studies, the purpose of this paper is to provide an alternative model that may be used to test for oligopsony market power based on plant-level data without additional assumptions about the aggregation of plant’s marginal product, and consequently of plant’s conjectural elasticities which must be taken into account when applying industry-level data (cf. Azzam and Pagoulatos 1990; Schroeter and Azzam 1990; Muth and Wohlgenant 1999).

1 Many studies carried out on milk markets in industrialized countries, point out reasons for the existence of oligopsony power such as the perishable nature of raw milk, high storage and transport costs, and limited access to alternative milk buyers. Alvarez et al. (2000) examined processor oligopsony power in the procurement of milk in one Spanish region and found that Spanish dairy processors exercise spatial oligopsony power over dairy farmers. Graubner et al. (2011) investigated spatial competition in the German raw milk market and found evidence that price transmission between producers and processors is in line with cooperative or non-cooperative behavior.

2 The results on concentration ratios for the largest dairy plants are similar to the calculations performed by König and Major (2006) who considered the market share of the largest dairy firms in Hungarian dairy industry in 2004 and 2005.

3 The Merger Guidelines of the U.S. Department of Justice and the Federal Trade Commission that classify the spectrum of market concentration as measured by the HHI into three regions: (1) unconcentrated (HHI below 1,000), (2) moderately concentrated (HHI between 1,000 and 1,800), and (3) highly concentrated (HHI above 1,800).

3 Theoretical framework

Assuming that there are N dairy plants (milk processors) in the milk processing, the industry is producing a homogeneous product (y) by employing the two factors, raw milk (m) and other non-agricultural inputs (z). The production function of the ith dairy plant is given by:

$$y_i = f(m_i, z_i), \quad [1]$$

where y_i is the output quantity of milk and milk products produced by the ith dairy plant, m_i is the input quantity of raw milk bought by the ith dairy plant, and z_i is the quantity of non-agricultural inputs used by this dairy plant.

It is assumed that each dairy plant faces two different market situations: for one thing, it may exercise some buyers' market power when purchasing raw milk inputs m_i, but, for another, all dairy plants act as price takers in both the market for other non-agricultural inputs z_i, and in the selling market of their outputs y_i. The dairy industry's market supply curve in its input market for raw milk can be expressed as inverse function:

$$W_{\mathrm{M}} = g(M, \mathbf{S}), \quad [2]$$

where W_{M} denotes the market price of raw milk, M the total of raw milk purchased by all dairy plants in the dairy industry such that $M = \sum_{i=1}^{N} m_i$, and $\mathbf{S}$ is a vector of supply shifters.

Given the objective of each dairy plant to maximize its profit π_i, and given both the production function [1] and the supply function of raw milk [2], the profit equation for the ith dairy plant may be defined as:

$$\pi_i = Pf(m_i, z_i) - W_{\mathrm{M}} m_i - W_{\mathrm{Z}} z_i, \quad [3]$$

where π_i is the profit earned by the ith dairy plant, P is the output price of the milk processing industry, W_{M} and W_{Z} are market prices of raw milk and other non-agricultural inputs, respectively.

The first order condition for profit maximization with respect to raw milk input, which allows for imperfect competition in this market, is given by:

$$\frac{\partial \pi_i}{\partial m_i} = P\frac{\partial f(m_i, z_i)}{\partial m_i} - W_{\mathrm{M}}\left(1 + \frac{\varphi_i}{\varepsilon}\right) = 0, \quad [4]$$

or

$$W_{\mathrm{M}} = \frac{Pf_{m_i}}{\left(1 + \frac{\varphi_i}{\varepsilon}\right)}, \quad [5]$$

where $\varphi_i = (\partial M/\partial m_i)(m_i/M)$ is the ith dairy plant's conjectural elasticity in the input market for raw milk, $\varepsilon = (\partial M/\partial W_{\mathrm{M}})(W_{\mathrm{M}}/M)$ is the market price elasticity of raw milk supply and f_{m_i} is the marginal product of raw milk input used by the ith dairy plant.

According to Appelbaum (1982), and Azzam and Pagoulatos (1990), the dairy plants' conjectural elasticities provide useful benchmarks for the econometric test for market behavior. If $\varphi_i = 0$, then the input market for raw milk is perfectly competitive, i. e. the marginal product of raw milk of each dairy plant equals the market price W_{M}. If $\varphi_i = 1$, then the market for raw milk is monopsonistic or the dairy plants act like a monopsony (cartel) and consequently the marginal factor cost should be equal to the value marginal product. Intermediate values of φ_i imply the presence of oligopsonistic market behavior in varying degrees. An implication that leaves the first-order condition open to the interpretation that the "perceived" marginal factor cost equals the aggregate value of the marginal products of raw milk.

4 Econometric specification of the model

Due to missing firm-level data, many empirical NEIO studies alternatively estimated industry's average conjectural elasticities applying industry-level data to a modified framework including additional assumptions about conjectural elasticities and marginal products, respectively. In contrast to these studies, we used dairy plant data to estimate plant's conjectural elasticities. For econometric implementation, however, we needed to select a specific form of production function [1]. In NEIO studies, the production technology is usually represented by a flexible function form, e.g. the translog production function which was introduced by Christensen, Jorgenson, and Lau (1971, 1973).

The translog production function, in the context of plant-level data, can be written as follows:

$$\ln y_i = \alpha_0 + \sum_{j=1}^{J} \alpha_j \ln x_{ji} + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{K} \alpha_{jk} \ln x_{ji} \ln x_{ki} + \gamma_t t + \frac{1}{2}\gamma_{tt} t^2 + \sum_{j=1}^{J} \gamma_{jt} \ln x_{ji} t, \quad [6]$$

where subscript i is the index of plants in the dairy industry $(i = 1, 2, \ldots, N)$ and $j = 1, 2 \ldots, J$; $k = 1, 2 \ldots, K$ are the indexes of the inputs; $\ln y_i$ denotes the logarithm of the output quantity of the ith dairy plant, and $\ln x_{ji}$ the logarithm of the jth input quantity used by the ith milk processing plant. The variable t captures the time-trend to account for technical change in the dairy industry.

Considering the cost structure of the dairy industry, we assume that milk processing plants use only three factors of production, namely, raw milk m_i, capital c_i, and labor l_i. Given the specific production function [6], the first-order condition for profit maximization with respect to raw milk [5] can be rewritten as follows:

$$W_M = P\frac{y_i}{m_i}\frac{(\alpha_m + \alpha_{mm}\ \ln\ m_i + \alpha_{mc}\ \ln\ c_i + \alpha_{ml}\ \ln\ l_i + \gamma_{mt}t)}{\left(1 + \frac{\varphi_i}{\varepsilon}\right)}, \qquad [7]$$

Interpreting the price elasticity of raw milk supply ε as exogenous constant point,[4] the parameter of plant's conjectural elasticities φ_i can be econometrically tested based on the estimation of production function [6] together with the first order condition for profit maximization that allows for imperfect competition [7]. For econometric reasons, homoscedastic disturbance terms were added.

Since eq. [7] is intrinsically nonlinear in its parameters, the translog production function [6] and the first-order condition for profit maximization [7] can be simultaneously estimated using the nonlinear least-squares (NLS) estimation technique.[5] Additionally, the exogenous variable price elasticity of raw milk supply was set $\varepsilon = 0.1$. The value was taken as previously estimated in other empirical studies, for example, by Suzuki, Lenz, and Forker (1993), Lopez, Altobello, and Shah (1994), and Perekhozhuk (2007, 172–87). The estimation itself was carried out using the statistical software Stata (cf. Stata 2009, 459–80).

5 Description of statistical data source

In order to test for the existence of oligopsony power in the Hungarian dairy industry, we used plant-level data collected, as mentioned earlier, by the Hungarian Tax Authority. The records included an almost universal sample of dairy plants since they were provided by double-entry bookkeeping.[6] Besides a common balance sheet, the dairy plant data include income statement information such as output, labor, capital, material input, and information on the form of ownership of the dairy plants (private, wholly foreign owned and government or state owned enterprises). But again, as mentioned before, we did not receive any information on either the names or owners of the dairy plants. But in order to test for market power, we created a panel data set comprising individual information about dairy plants' net revenue, material cost, capital, and labor inputs. The data set includes, in total, 432 plant-level observations made in the investigation period of 1993–2006. The data set is an unbalanced panel as dairy plants with contiguous and non-contiguous time series are included.

The original data set included 455 observations. 23 observations were omitted because the three dairy plants had zero production output (net revenue) and material inputs. The final number of plants in our unbalanced panel data set is 88 plants. The number of dairy plants changes from year to year, varying between 19 and 40 dairies. The different number of plants over time is due to entry and exit of dairy plants in the sample, with more plants exiting than entering. The observed periods for sample plants range from 1 to 14 years. Table 4 counts the number of observations and the life duration of dairy plants over the observed period. In the year-by-year analysis, we find that in the first 2 years of our sample period, 18 of the 88 samples containing dairy plants were liquidated, notably 13 plants in 1993 and 5 plants in 1994 (cf. Table 4).

There are two main reasons for the mass exit of plants from the dairy industry in the first year. The first reason associated with the new bankruptcy law in Hungary, which came into force in January 1992. According to this new law, the plants with arrears of 90 days or more were required to file for reorganization referred as bankruptcy or liquidation.[7] Disaggregation of the data reveals a considerable variation in industry entry and exit patterns over time. Almost one half of the dairy plants in our sample (48.9%) have been in business for not more than 3 years and hereby 24 plants in the sample have been operating only for 1 year. Economic theory suggest that entry to industry increase competition in industry, and put pressure on existing plants to operate as efficiently as possible. However, looking more closely at our sample, we found that the dairy plants exiting in the first year produce only 5.6% of the industry output over the entire period. The new entering dairy plants were considerably, in terms of production output, smaller than existing dairy plants. They have high rates of failure. Moreover, during the observed period more plants have exited than entered the industry.

4 Similar assumptions may be found in the works of Schroeter (1988), Azzam and Pagoulatos (1990) and Morrison Paul (2001).

5 Details on estimation methods are given in Greene (2003, 339–77) and Cameron and Trivedi (2005, 214–22).

6 For a more detailed description of the data collection see Békés, Harasztosi, and Muraközy (2009).

7 According to the data on reorganization and liquidation of firms represented by Gray, Schlorke, and Szanyi (1995) most of firms in Hungary were liquidated rather than reorganized.

Table 4 Number of observation and life duration of dairy plants.

Year	Life duration of dairy plants (years)														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1993	13	5	4	0	3	2	2	2	0	1	2	0	0	1	35
1994	0	5	6	2	3	2	4	3	1	1	3	2	3	1	36
1995	5	0	5	2	4	2	5	2	1	3	3	4	3	1	40
1996	0	1	2	3	7	2	5	3	1	4	4	4	3	1	40
1997	0	2	0	3	7	2	4	3	1	2	4	4	3	1	36
1998	1	1	2	2	5	5	4	2	2	4	4	4	3	1	40
1999	0	0	1	1	3	4	5	4	2	4	3	4	3	1	35
2000	1	1	2	1	3	3	3	4	2	4	3	4	3	1	35
2001	1	2	1	1	2	3	2	2	2	4	4	4	3	1	32
2002	1	0	0	1	2	2	0	2	2	2	4	4	3	1	24
2003	1	0	0	0	1	2	0	1	1	3	4	2	3	1	19
2004	0	1	1	0	1	0	0	1	1	4	2	4	3	1	19
2005	0	1	1	0	2	0	0	2	1	3	2	4	3	1	20
2006	1	1	2	0	2	1	1	1	1	1	2	4	3	1	21
Total	24	20	27	16	45	30	35	32	18	40	44	48	39	14	432

Source: Own calculations based on the data from the Hungarian Tax Authority and the Institute of Economics of the Hungarian Academy of Science, respectively.

Only 16 of the 88 dairy plants in Hungarian dairy industry have been in business for 10 and more years, and operate approximately 50% of the industry output over the investigation period. Moreover, these facts suggest that the existing dairy plants tended to be large relative to all plants in dairy industry.

The second main reason is that privatization of state owned enterprises (SOEs) in Hungary was significantly undertaken in the 1990s. Table 5 gives the evolution over time of the number of dairy plants (observations) in the ownership categories. The number of dairy plants registered as state enterprises declined from 21 in 1993 to 1 in 2003.

The number of privately owned dairy plants rose from 9 in 1993 to 26 in 1996 and then receded to 10 in 2004 and again rose to 16 in 2006. In the first half of the sample period, the number of foreign owned dairy plants in Hungary increased from 2 in 1993 to 10 in 1999. Since then the number of foreign owned dairy plants has decreased and composed only 4 dairies in 2006.

However, as shown in Figure 1, the foreign owned plants play an important role in the Hungarian dairy industry. They expanded their market share from 9.8% in 1993 to 81.4% in 2004. Moreover, the market share of the 4 foreign owned dairy plants was close to 55% in 2006. At the same time, the market share of the 16 private dairy plants was just 44%. It is obvious that foreign plants are more concentrated, simply because are fewer. Furthermore, due to the privatization of the state owned dairy plants their market share has continually decreased from 79.8% in 1993 to 0.5% in 2006.

Table 6 provides the descriptive summary statistics (mean, standard deviation, minimum and maximum of each variable) of the plant-level data used in the estimation. In connection with the output and input variables of the production function, we used the net revenue figures as output quantities of dairy plants.

The difference in net revenue between the largest and smallest dairy plants is extremely large and lies between

Table 5 Number of dairy plants (observations) by ownership categories.

Ownership	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
State	21	12	12	5	4	6	3	2	5	2	1	1	1	1	76
Private	9	17	17	26	23	24	23	24	18	16	13	10	12	16	248
Foreign	2	4	8	9	9	10	9	9	9	6	5	8	7	4	99
Other	3	3	3	0	0	0	0	0	0	0	0	0	0	0	9
Total	35	36	40	40	36	40	35	35	32	24	19	19	20	21	432

Source: Own calculations based on the data from the Hungarian Tax Authority and the Institute of Economics of the Hungarian Academy of Science, respectively.

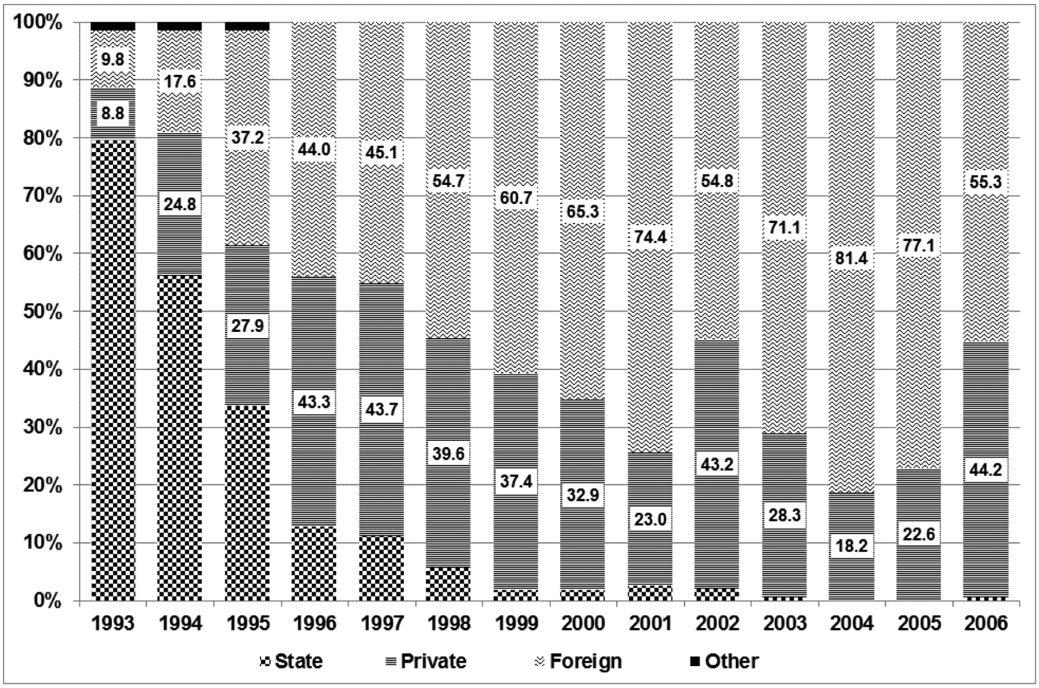

Figure 1 Market share (sales revenue) by ownership categories.
Source: Own calculations based on the data from the Hungarian Tax Authority and the Institute of Economics of the Hungarian Academy of Science, respectively.

Table 6 Summary statistics of the plant-level data.

Variable	Description	Mean	Std. Dev.	Minimum	Maximum
y	Production output (net revenue, mio HUF)	1,466.7	1,981.7	3.717	12,234.7
m	Material input (material cost, mio HUF)	1,258.7	1,713.5	1.859	11,024.2
c	Capital input (tangible assets, mio HUF)	232.6	320.6	0.536	1,778.4
l	Labor input (number of employees)	298.7	333.4	10	1,874
W_M	Farm price of raw milk (100 HUF per kg)	18.3	1.7	13.9	20.4
P	Retail price of milk (100 HUF per kg)	35.1	2.7	31.5	41.0
t	Time ($t = 1993, \ldots, 2006$)	1,998.6	3.8	1993	2006
PC	Policy change	0.1388	0.3462	0	1
SE	Scale of enterprise	0.2893	0.4540	0	1
PE	Private enterprises	0.5740	0.4950	0	1
FE	Foreign enterprises	0.2291	0.4208	0	1
GE	Government enterprises	0.1759	0.3812	0	1

Notes: The Hungarian forint, denoted by the ISO code HUF, is the official currency of Hungary. For the dummy variables, policy changes (PC), scale of enterprise (SE), private (PE), foreign owned (FE), and government enterprises (GE), the figure is the percentage of plants that take value 1, for example, 57.40% of dairy plants are privately owned or 17.59% of dairy plants are government owned.
Source: Own calculations based on the data from the Hungarian Tax Authority and the Institute of Economics of the Hungarian Academy of Science, respectively.

12,234.7 and 3.717 million Hungarian forint (mio HUF). The net revenue of the dairy plants in the sample amounts to 1,466.7 mio HUF on average.[8]

The variable input quantity of raw milk bought by each dairy plant was approximated by material cost. Its minimal and maximal values varied between 1.859 and 11,024.2 mio HUF, which corresponded to the smallest and largest dairy plant, respectively. Capital input was obtained from the number of tangible assets held by dairy plants. Labor input was measured by the number

8 On January 1, 2006, the monetary values of 12,234.7, 1,466.7, and 3.717 million HUF equaled 57.4, 6.9, and 17.4 thousand US Dollar, respectively.

Table 7 Statistical inference of NLS estimation.

Equation	Model 1		Model 2		Model 3		Model 4	
	Parameters	R^2	Parameters	R^2	Parameters	R^2	Parameters	R^2
[6]	15	0.9944	15	0.9945	15	0.9952	15	0.9952
[7]*	5	0.9783	6	0.9785	9	0.9819	11	0.9822

Notes: * Uncentered R-square.
Source: Own estimation based on the data from the Hungarian Tax Authority and the Institute of Economics of the Hungarian Academy of Science, respectively.

of employees hired per year at the dairy plants. A number that showed significant differences: while the largest dairy plant employed 1,874 workers, the smallest employed only 10. Data for farm price of raw milk (W_M), and output price of milk and milk products (P) were provided by the Institute of Economics of the Hungarian Academy of Science. All price variables and monetary values were deflated by the consumer price index.

In order to test for the effects of policy changes and plant-specific effects on market power, we constructed a binary dummy variable that could take the values 1 and 0. In case of policy changes, the dummy variable served as proxy for the abolition of export subsidies in 2004 (Hockmann and Vöneki 2009). To create a dummy variable that takes into account scaling effects, we used the net revenue figures of the dairy plants in question. If the net revenue was higher than the mean value, which amounted to 1,466.7 mio HUF, then the dummy variable was set to 1. Using the information on the ownership form of the dairy plants, we created three dummy variables to separately capture the effects of being either a private, wholly foreign owned and government enterprise.

6 Estimation results and specification testing

Concerning the estimation and interpretation of the parameter of market power, a number of additional aspects can be found in other empirical studies. Based on plant-level data, Morrison Paul (2001) came to the conclusion that the parameter of market power has to be a function of, among others, specific variables for the number of cattle buyers, and the expenditures for both cattle procurement and working overtime. Schroeter (1988) modeled the parameter of market power as a general function of exogenous variables whose values vary with changing market conditions. Hockmann and Vöneki (2009) introduced a binary dummy variable to capture effects resulting from the removal of export subsidies at the beginning of 2004 and estimated the parameter of oligopsony power over time.

Based on conclusions of empirical NEIO studies together with developments in the Hungarian dairy industry, we extended the model of oligopsony market behavior introduced in the theoretical section (eqs. [6] and [7]) and estimated four market structure models. In the first model, the parameter of oligopsony market behavior was set to represent competitive market behavior, consequently φ_C was restricted to zero (Model 1). In the second model, the parameter φ_C was estimated to be a constant (Model 2). In Model 3, we used dummy variables to capture various effects from policy changes (PC) over time (T), exactly from 1993 to 2006, and the effects of changes in scale of enterprise (SE). Finally, instead of considering the scale effect, Model 4 covers effects induced by the ownership form of the plant,that is, private (PE), foreign owned (FE), and government enterprises (GE).

For a general comparison of the estimated models, Table 7 lists the summary of the statistical inference from the nonlinear least-squares (NLS) estimations of the nonlinear equation system introduced above.[9] Eqs. [6] (translog production function) and [7] (first-order condition for profit maximization) were simultaneously estimated. Hence, the output quantity of the ith dairy plant (y_i) and the market price of raw milk (W_M) are endogenous. The number of estimated parameters and the values of R-squares (R^2) for each model are given in the first and second column of Table 7. While the number of parameters in the translog production function (eq. [6]) is constant for all models, it increases from five to eleven in the first-order condition (eq. [7]), in ascending order from Model 1 to Model 4.

The fit of the estimated models is quite good. The lowest and largest R-square generated by the production function [6] are almost equal and range from 0.9944 for

9 The feasible generalized nonlinear least-squares (FGNLS) estimators were also applied, but reveal statistical inferences identical to those reported here.

Table 8 Estimated parameters of NLS estimation with robust standard errors

Parameter	Model 1		Model 2		Model 3		Model 4	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
α_0	−0.0651***	(0.0093)	−0.0602***	(0.0092)	−0.0617***	(0.0085)	−0.0616***	(0.0085)
α_{m}	0.9738***	(0.0059)	0.9359***	(0.0103)	0.9553***	(0.0102)	0.9519***	(0.0097)
α_{c}	0.0197**	(0.0079)	0.0262***	(0.0079)	0.0131*	(0.0075)	0.0124*	(0.0074)
α_{l}	0.0231*	(0.0122)	0.0600***	(0.0146)	0.0447***	(0.0138)	0.0488***	(0.0135)
γ_{t}	−0.0031**	(0.0016)	−0.0028*	(0.0015)	−0.0021	(0.0014)	−0.0020	(0.0014)
α_{mm}	0.1523***	(0.0054)	0.1460***	(0.0054)	0.1461***	(0.0050)	0.1484***	(0.0049)
α_{cc}	0.0203**	(0.0086)	0.0240***	(0.0084)	0.0126	(0.0079)	0.0084	(0.0079)
α_{ll}	0.0358	(0.0227)	0.0517**	(0.0223)	0.0343	(0.0218)	0.0505**	(0.0207)
γ_{tt}	0.0036***	(0.0008)	0.0031***	(0.0008)	0.0038***	(0.0007)	0.0038***	(0.0007)
α_{mc}	−0.0478***	(0.0060)	−0.0431***	(0.0058)	−0.0271***	(0.0057)	−0.0219***	(0.0058)
α_{ml}	−0.1197***	(0.0099)	−0.1242***	(0.0096)	−0.1204***	(0.0094)	−0.1319***	(0.0090)
α_{ml}	−0.0157***	(0.0015)	−0.0158***	(0.0014)	0.0028	(0.0024)	0.0027	(0.0024)
α_{cl}	0.0678***	(0.0109)	0.0601***	(0.0108)	0.0499***	(0.0102)	0.0498***	(0.0100)
γ_{ct}	−0.0006	(0.0020)	−0.0003	(0.0019)	−0.0035*	(0.0018)	−0.0032*	(0.0018)
γ_{lt}	0.0189***	(0.0029)	0.0199***	(0.0028)	0.0006	(0.0033)	0.0006	(0.0033)
φ_{C}			−0.0055***	(0.0012)	−0.0722***	(0.0118)	−0.0961**	(0.0392)
φ_{C}					0.0144***	(0.0031)	0.0136***	(0.0032)
φ_{PC}					0.2749***	(0.0348)	0.2822***	(0.0347)
φ_{SE}					0.0048**	(0.0019)		
φ_{PE}							0.0123	(0.0390)
φ_{FE}							0.0859**	(0.0418)
φ_{GE}							0.0037	(0.0040)

Notes: The values in parentheses are asymptotic standard errors. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Own estimation based on the data from the Hungarian Tax Authority and the Institute of Economics of the Hungarian Academy of Science, respectively.

the competition model (Model 1) to 0.9952 for Model 3 and 4, respectively. It should be noted that the eq. [7] does not have a constant term. Therefore, an uncentered R-square is reported.[10] The lowest and the largest R-square values for the first-order condition [7] are 0.9783 in Model 1 and 0.9822 in Model 4. Thus, altogether, Model 4 performs slightly better.

The estimation results of the four estimated models are presented in Table 8.[11] The asymptotic standard errors (in parentheses) indicate that most parameters are significant, even at the 1% level. To simplify the interpretation of the estimated parameter values, all model variables were transformed into deviations from their geometric mean. In doing so, the estimated parameters of the translog function, namely α_{m}, α_{c}, and α_{l}, can be considered the production elasticity of raw milk, capital and labor inputs, respectively, and moreover, the parameter γ_{t} captures the rate of technical change in the dairy industry over time.

The production elasticity of raw milk was estimated to lie between 0.97 (Model 1) and 0.95 (Model 4). The estimated production elasticity of both capital and labor proves very robust since changes appear visible only in the second decimal place. However, not all of the estimated parameters of the capital and labor elasticities are statistically significant. In addition, the hypothesis of constant returns to scale was tested on the basis of the test for linear hypotheses on the parameters of the production function (eq. [6]), such that $\sum_j \alpha_j = 1$, where $j = \mathrm{m, c, l}$. The hypothesis of constant returns to scale could be rejected even at the 1% level. Thus, we estimated increasing returns to scale in the Hungarian dairy industry. The scale elasticity was

10 For details on uncentered R-square see Greene (2003, 414) and Cameron and Trivedi (2005, 241).

11 We employ different nonlinear estimation methods and procedures to avoid estimation problems as autocorrelation, heteroskedasticity and selection bias. First, we estimated the models using a nonlinear least-squares (NLS) estimator with robust and clustered standard errors. Second, the feasible generalized nonlinear least-squares (FGNLS) estimators were also applied to the models in order to check the robustness of our results. Appendix Table A presents the estimation results of the four estimated models using the FGNLS estimator. The estimated coefficients are nearly identical for both estimation methods.

almost equal in all four models, yielding 1.02 for the first and second model, and 1.01 for the third and fourth model. The estimated rate of technical change (γ_t) came out negative, but not statistically significant not even at the 10% level of statistical significance.

The estimated parameters of the first-order condition for profit maximization were of particular interest to us because, as stated before, they were used as a measure of the degree of oligopsony power of dairy plants. Model 2 – with a constant parameter specification – produced a parameter of oligopsony power φ_C that is, close to zero and statistically highly significant. With respect to Model 3 and Model 4, the results especially for the dummy variables accounting for policy changes and other plant-specific effects are of interest. More precisely, Model 3 considers effects of policy changes (PC) over time (T), as well as the effects of changes in scale of enterprise (SE). The asymptotic standard errors indicate that all of these effects are significant, even at the 1% level of statistical significance. In addition, Model 4 also allows for other plant-specific effects, that is, effects induced by the ownership form of enterprise. While the estimated parameter for the dummy variable of foreign enterprises φ_{FE} appeared to be statistically significant, at least at the 5% level, the parameters for the dummy variable of private enterprises and government enterprises, φ_{PE}, and φ_{GE}, respectively, failed to do so.

Furthermore, we tested the null hypothesis for three different subsets of parameters: the single parameter φ_C (Model 2), the subset $\varphi_C + \varphi_T + \varphi_{PC} + \varphi_{SE}$ (Model 3), and the following subset of plant-specific effects $\varphi_C + \varphi_T + \varphi_{PC} + \varphi_{PE} + \varphi_{FE} + \varphi_{GE}$ (Model 4). Table 9 presents the results of the Wald test and the estimates of the market power parameters; it also summarizes the impacts of various plant-specific effects.

The asymptotic standard errors indicate that the results are significant, even at the 1% level in all estimated models. For the investigation period from 1993 to 2006, the econometric results confirm the presence of oligopsonistic market behavior in the Hungarian dairy industry. The corresponding parameter was estimated to be 0.22 in Model 3 and 0.30 in Model 4; a result that is, consistent with the relatively high concentration ratios in the Hungarian dairy industry and the considerable increase of the HHI as its value tripled in the course of the last 7 years (cf. Table 3). Moreover, based on the set of accessible plant-level data, the econometric results corroborate the test characteristics of effects reported by Hockmann and Vöneki (2009).

Table 9 Wald test and estimates of the parameter of market power.

Model	Oligopsony power and plant-specific effects	Coef.	Std. Err.
Model 2	φ_C	−0.0055***	(0.0012)
Model 3	$\varphi_C + \varphi_T + \varphi_{PC} + \varphi_{SE}$	0.2219***	(0.0352)
Model 4	$\varphi_C + \varphi_T + \varphi_{PC} + \varphi_{PE} + \varphi_{FE} + \varphi_{GE}$	0.3015***	(0.0598)

Notes: The values in parentheses are asymptotic standard errors. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Own estimation based on the data from the Hungarian Tax Authority and the Institute of Economics of the Hungarian Academy of Science, respectively.

7 Summary and conclusions

Considering structural change in the Hungarian dairy sector, there is empirical evidence that milk processors may exercise market power in the input market for raw milk. Juhász and Stauder (2006) concluded that the Hungarian dairy industry is characterized by a duopolistic market structure, i.e. dominated by two large milk processors. As regards the number of market participants, including both dairy plants and dairy farms, we draw the conclusion that the structure of the Hungarian raw milk market is best to be characterized as oligopsonistic. The calculated values of the concentration ratios and the Herfindahl–Hirschman Index indicate a moderately concentrated Hungarian dairy industry. Moreover, our findings are supported by the empirical study of Hockmann and Vöneki (2009) who found evidence for the existence of market power estimating industry-wide indexes of oligopsony market power on the basis of industry-level data.

In the pursuit of providing an alternative approach to evaluating (oligopsony) market power on applying plant-level data, we evaluated previous empirical studies, together with taking into account specific developments in the Hungarian dairy industry, and specified a model that generates benchmarks so as to efficiently test for oligopsony market power. The empirical model consists of a production function and the first order condition for profit maximization which allows for imperfect competition in the input market for raw milk. The production technology in the Hungarian dairy industry is represented by a translog production function, which imposes considerably less a priori restrictions on the technology than neoclassical production functions. All of the estimated production elasticities were found to be positive at the sample mean. A result also true of the production elasticities of capital and labor, certainly; but they failed to be highly statistically significant. The hypothesis of constant returns to scale could not be confirmed. Instead, the econometric results revealed increasing returns to scale in the Hungarian dairy industry.

We estimated the parameter of oligopsony market power in the Hungarian dairy industry using plant-level data. The null hypothesis test for perfect competition in the Hungarian dairy industry was rejected. Furthermore, in order to test for the effects of policy changes and plant-specific effects on market power, subsets of relevant parameters were specified. For this reason, in addition to the basic model, three other models were estimated. The estimation yielded highly statistically significant coefficients as regards effects from policy changes over time and plant-specific effects triggered by changes in scale, and thus produced evidence of the exercise of market power by Hungarian dairy enterprises. The coefficient on policy change is significant and indicates that the abolition of export subsidies in 2004 has effects on oligopsony power in the Hungarian dairy industry. Using monthly time series observations from January 1998 to October 2006 for at the industry level Hockmann and Vöneki (2009) found similar results regarding the abolition of export subsidies in Hungary. At the same time, effects of the ownership form of dairy plants led to inconsistent results: while effects of foreign owned enterprises (plants) yielded significant, those of being either a private or government enterprise did not. The econometric results of models, together with the plant-specific effects, provide empirical evidence of oligopsony market power in the input market for raw milk. For the investigation period from 1993 to 2006, the estimated parameter of oligopsony market power amounted to 0.22 and 0.30, respectively. This econometric result is consistent with the oligopsonistic structure of the Hungarian dairy industry and confirms the findings of earlier analyses of the Hungarian market for raw milk.

Appendix

Table 10 Estimated parameters of FGNLS estimation with robust standard errors.

Parameter	Model 1		Model 2		Model 3		Model 4	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
α_0	−0.0092	(0.0085)	−0.0096	(0.0081)	−0.0199	(0.0083)	−0.0210	(0.0079)
α_m	0.9635***	(0.0051)	0.9072***	(0.0078)	0.9173***	(0.0091)	0.9176***	(0.0084)
α_c	0.0244	(0.0085)	0.0320*	(0.0085)	0.0195	(0.0080)	0.0205	(0.0082)
α_l	0.0277	(0.0130)	0.0908***	(0.0161)	0.0854***	(0.0162)	0.0841***	(0.0154)
α_l	−0.0042**	(0.0016)	−0.0033	(0.0016)	0.0000	(0.0013)	−0.0002	(0.0013)
α_{mm}	0.1354***	(0.0203)	0.1367***	(0.0178)	0.1349***	(0.0206)	0.1365***	(0.0202)
α_{cc}	0.0134	(0.0122)	0.0158	(0.0109)	0.0084	(0.0096)	0.0082	(0.0098)
α_{ll}	0.0206	(0.0220)	0.0539*	(0.0207)	0.0490	(0.0223)	0.0545*	(0.0214)
γ_{tt}	−0.0008	(0.0007)	−0.0020**	(0.0007)	−0.0002	(0.0007)	−0.0001	(0.0007)
α_{mc}	−0.0443***	(0.0132)	−0.0395***	(0.0125)	−0.0290**	(0.0108)	−0.0265*	(0.0115)
α_{ml}	−0.1008***	(0.0246)	−0.1194***	(0.0222)	−0.1180***	(0.0237)	−0.1226***	(0.0233)
γ_{mt}	−0.0147***	(0.0023)	−0.0150***	(0.0022)	−0.0009	(0.0030)	−0.0010	(0.0032)
α_{cl}	0.0613***	(0.0131)	0.0549***	(0.0117)	0.0482***	(0.0112)	0.0467***	(0.0112)
γ_{ct}	0.0005	(0.0022)	0.0014	(0.0019)	−0.0005	(0.0015)	−0.0005	(0.0016)
γ_{lt}	0.0155***	(0.0023)	0.0163***	(0.0022)	0.0018	(0.0028)	0.0022	(0.0030)
φ_C			−0.0087***	(0.0011)	−0.0950***	(0.0109)	−0.0966***	(0.0130)
φ_T					0.0134***	(0.0031)	0.0130***	(0.0032)
φ_{PC}					0.1822***	(0.0249)	0.1866***	(0.0243)
φ_{SE}					0.0016	(0.0017)		
φ_{PE}							−0.0046	(0.0128)
φ_{FE}							0.0301	(0.0186)
φ_{GE}							0.0007	(0.0015)

Notes: The values in parentheses are asymptotic standard errors. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Own estimation based on the data from the Hungarian Tax Authority and the Institute of Economics of the Hungarian Academy of Science, respectively.

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