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Deregulation of Finnish Electricity Markets:

Market Structure, Regional and Distribution Network Sharing Effects on District Heating Prices in Finland 1996-2002

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Deregulation of Finnish Electricity Markets: Market Structure, Regional and Distribution Network Sharing Effects on District Heating Prices in Finland 1996-2002 [1)]

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Abstract

We propose an empirical econometric panel data model to test deregulation and regional market structure effects on district heating prices in Finland 1996-2002. The data consists of 76 district heating firms in Finland. Special emphasis is put on the modeling of policy induced competition started in year 1999, regional based fuel selection, market structure, and distribution network sharing effects on district heating prices. The results imply that the local structures of energy production and selling have an important role on market prices and the price lowering effects of energy market deregulation have been permanent.

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I. Introduction

After decades of state ownership and heavy government regulation heat and power sectors worldwide are being deregulated. Finland is not exception in this global wave. However in Finland, a sparse inhabited country, the implementation of policy change is demanding task. The national energy markets are still typically dominated by a small number of producers. Even large geographic areas are dominated by one firm. When analysis is focused on the district heating markets, the restructuring can even be impossible. The reason for this meager result hinges on the general and specific features of Finnish electricity and district heating markets.

Generally market power is a prominent issue in the current debate about electricity and heat industry restructuring. Increasing the number of sellers in a market does not necessarily reduce market power as the standard theory suggest. Location advantages, contracts and vertical integration allow some firms to maintain profits and prices near to monopoly levels even the seller concentration is at levels generally considered competitive. In electricity markets independent national transmission system with enough capacity allows for local competition from companies outside. In contrary to this presence of transmission bottlenecks and peak load periods may induce temporal local market power even for a firm with small market share. However in district heating markets the heat transmission network is highly localized and no interconnections are technically or economically feasible over larger areas. Only in some big towns and in highly urbanized regions many producers may share the same network. Notice also that in some cases energy input substitution is possible for the small house owners. However the change of the form of energy input for warming in the highly horizontally and vertically integrated markets is not necessarily a competitive increasing act. Also the restructuring gain of firms to producer, distribution and retail seller markets is low if the number of firms is already low in the local markets.

In following we analyze in details the Finnish district heating markets in years 1996-2002 with a firm level data. Our theoretical background is in the industrial organization literature (IO) that stresses the importance of firm’s market share on its pricing policy. We build an empirical econometric model that focuses on three specific pricing effects in connection to the firm’s market share in energy production and retail markets: the effects competition induced policy reform, the effects of sharing distribution network, and the effects of regional based fuel dependency.

The household electricity markets in Finland were opened to competition in the 1st of November 1998. Regulation was only extended to limit the unreasonable pricing and to separate the different business units (production, distribution and sales). However the district heating industry is still simply regulated by the general Competition Laws. The policy induced competition in the electricity industry in late 1998 is expected to affect the district heating industry since both industries compete in the same heating goods markets. The industry is also constantly monitored and faces a threat of intensive regulation by the state authorities. The price effects of induced competition are modelled in regression model framework with different trend break and dummy variable specifications.

Geographically household heating product markets are limited to the area which is covered by the local district heating (warm water) pipe network. In Finland, most district heat companies are isolated from each other. Typically they have a local monopoly both in heat distribution and production. Many companies also produce both heat and electricity (CHP). A distribution company may also have no own production at all. These companies have the monopoly in heat distribution and they usually buy the district heat from separate producer. Still there exist some regions where the district heating network is shared by different production or distribution companies. All these market structures are expected to have effects on competition and prices in the wholesale and retail heat markets. These prices effects are analyzed by adding to estimated models firm’s market share (both in production and heat sale markets) in local markets. An interaction model alternative is estimated also where network sharing dummy variable interacts with other model variables. The estimates test the extension of network sharing firms’ different response to control variables. The network effects are also connected to regional analysis.

The regional pricing structure is also affected by the fuel type used by the local district heating company. In the Northern and Eastern Finland where winters are colder than in the other parts of Finland the heat production differs from the rest of country. The price of fuels is important in regional context. Natural gas is supplied (from Russia) only to the Southern Finland, peat and wood are used mainly in the Eastern and Northern Finland, and coal is the main fuel input on the coastal area (western Finland). We build a ($3x2$) -cross-classifying dummy variable reflecting the regional location and network sharing in these regions. This solution enables us to test at same time the network and regional specific price effects.

The structure of paper is as follows. Section 2 gives shot review non-competitive aspects of energy pricing related to economy theory. Section 3 gives a closer look at Finnish district heating markets. Section 4 introduces our econometric methods, specifications with relevant pricing variables, and hypotheses tests. Section 5 focuses on the obtained results, and Section 6 concludes the paper. Appendices I-II provide a more detailed picture of econometric model specification used in the study. Appendices III-IV report the analyzed data and some supplementary regression results.

2. Economic theory

Earlier energy and heat production and distribution were considered to be public utilities that provided their services equally to all members of society, both to industry and to private consumers. The target was delivery security, smoothed prices and tariffs, and equal access. This "public goods" framework was understandable in political climate of era 1950-1970. Also the huge grounding costs of energy plants and distribution networks supported the public solution to the development of energy sector. Since 1980's the political climate has changed toward private market solutions emphasizing the importance of market based pricing rules, competition and efficiency in production and distribution. Privatization and deregulation were seen as policy alternatives for these targets. The case of natural monopolies with price regulation and subsidies were buried as the huge grounding costs were paid after decades of operation. The case of small and declining fixed costs was the new paradigm leading to the marginal cost price rule supported by competitive markets. However the privatization is not a necessary - not even sufficient condition - for market based solution to energy pricing. The real question is the market structure, i.e. number of operating firms in the markets, not the ownership form of the firms. Monopoly or what ever other non-competitive price conduct can be formulated without reference to the ownership of firms. In theory all of many companies in the competitive market can be public owned or in the other end we have only one private owned monopoly. However in reality, especially in energy markets with their background in public (natural) monopolies, things are more complicated with localized markets, weak product substitution of energy products, and with horizontal and vertical integration of markets.

The case of pure monopoly is well-formulated in economic theory. The monopoly sets its product price above the competitive efficient market price and naturally sells less. The monopoly facing the whole local market demand curve can conduct price discrimination leading to increased output. This social gain is however small compared to the total monopoly loss due the monopoly pricing. When the number of firms in the market increases, the number of firms matter, but also their relative market shares play a crucial role. The oligopoly is an interesting case with dynamic rivalry. In pure theory co-operative solution boils down to cartel solution having price conduct of multi-plant monopolist. The non co-operative case leads us to many solutions and concepts of game theory. Typically in this literature conditions for the equilibrium with stability are demanding and refer to few cases found in real markets. Because of complexity of the issue there is no reason why price should fall to the level where it equals marginal cost. The Bertrand-Nash equilibrium, where price is decision variable in homogenous product oligopoly, is the exception. When number of players increases the role of relative magnitude of players (i.e. market shares) is important for market pricing. With high entry costs and with some product differentiation the dominant firm can still behave close to monopoly (Waterson 1984, Tirole 1989).

In the context of energy markets the product differentiation is not so important issues as the vertical integration. Typically the same company owns the production, distribution and selling of the energy to end users. In some cases the company may also be a multi-product company, i.e. producing, distributing and selling electricity and heat. However from the viewpoint end users the substitution possibilities are very limited as they are constrained by prevailing distribution network in supply only to one alternative. Although the substitution possibilities existed the vertically integrated multi-product monopoly controls the price setting in the every dimension of markets with cumulative price markups. The opposite ideal position is obtained when all vertical stages of energy product markets are independent and competitive. The case stands up as theoretical curiosity, and practical restructuring of energy markets have only stressed the importance of separating the energy production (generation) and distribution (transmission). Oligopoly markets with multi-product industries lead to interesting market solutions depending on the complementarities in inputs and outputs (Iossa 1999, Laffont & Martimont 1997 and 2000, Jansen et al. 2006).

The base level restructuring is typically augmented with by breaking up large dominant production plants to smaller independent units by privatization and building up auction markets for energy demand and selling units (mostly for electricity) that reflect almost the real time demand and supply conditions. These both solutions can been seen as methods to improve the market mechanism to operate efficiently. However the end users' demand price elasticity is typically very low although wholesale prices may fluctuate greatly by hour to hour in wholesale markets. This means that market power in retail markets can have little effect on short-run consumption quantity and allocative efficiency. The optimal market design, at least for electricity markets, is a complex and multidimensional challenge. The pros and cons of different designs are still under heat debate (see e.g. Harris 2006, Wilson 2002, Cavanagh & Sonstelie 1998, Borenstein et al. 2002).

3. Finnish district heat markets

Although the aspects of location independency of production and distribution network are more important in the district heating markets than in the electricity markets, the above market complexity is not redundant, at least in Finland, for district heating markets. First, the heat producing companies are in multiple ways integrated to other power markets. Many firms produce also other forms of energy and are connected to national electricity network. Second, ownership structure is strongly vertically and horizontally integrated. Small suburban areas and towns have typically only one heat producer with its own distribution network. The retail selling company is operated by same local private or public owned firm. In some cases the companies are independent and owned by large national level companies. Also the contractual forms, deliberately suppressing market mechanisms, between the firms in vertical, horizontal, and spatial dimensions can be many. Third, the geographical location of heat producing unit determines what raw material inputs it uses. In the Southern Finland firms typically use natural gas as input, but in the coastal regions coal and oil is still used, and in northern parts of country peat and wood (woodchips) are the main inputs. Still the heat company and market heterogeneity can be extended by production scale and product differentiation aspects. Typically big plants are more efficient (economies of scale) and they have combined energy production (CHP, combined heat and power production). Different prices are exercised on the different end users, i.e. the prices of heat (and electricity) are different for small private houses, apartment block and industrial buildings. The price differences are mostly based on different tax rules, but quantity discounts are also used.

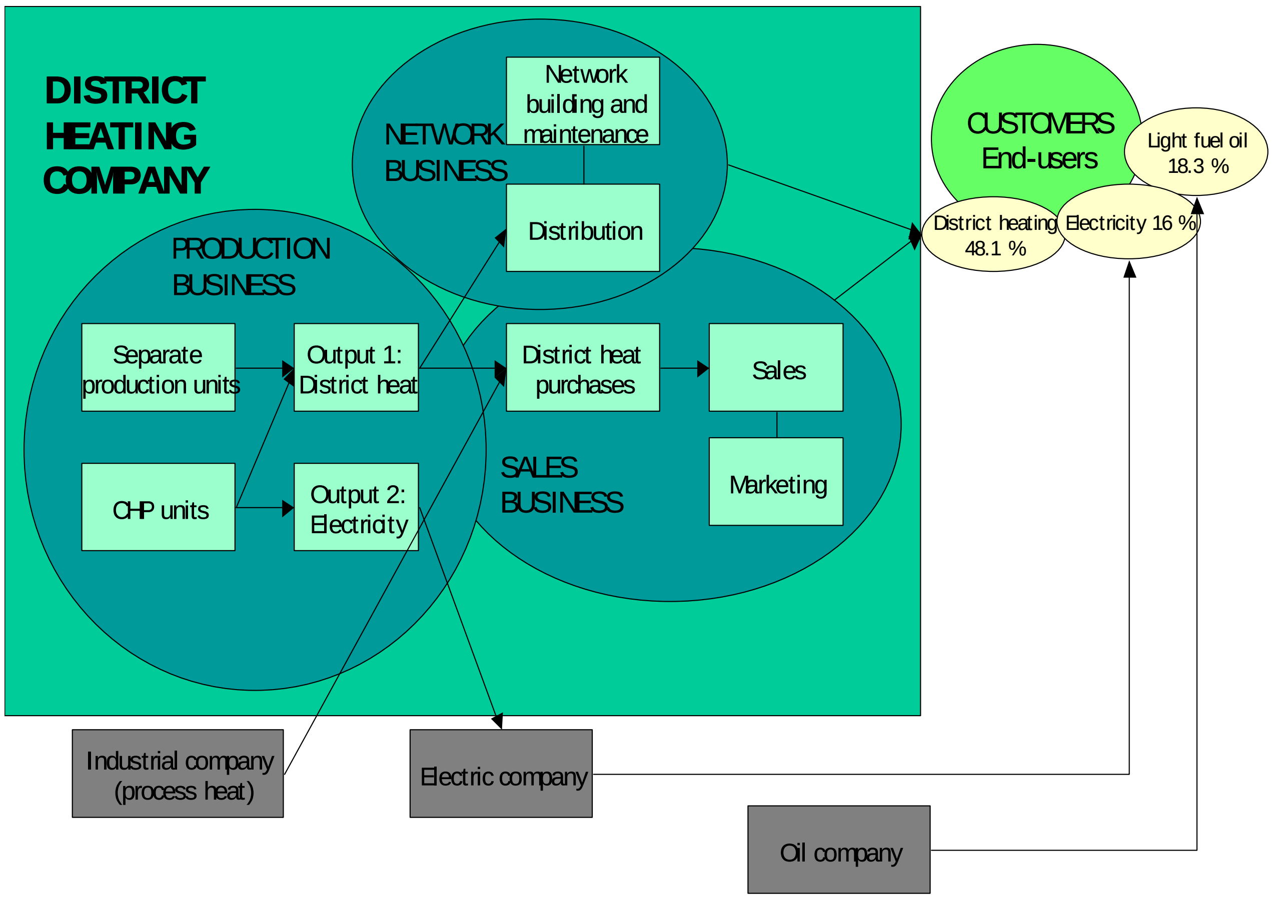
District heating is the most important heating good in Finland. It is the primary heating system in 48 % of the Finnish buildings. Both electricity and light fuel oil has a 17 % market share in the heating goods markets. Due to the Northern European weather conditions there is a demand for heating for 7 – 10 months in a year. District heating industry can be defined as production and distribution of hot water for central heating purposes in a heating network. In 2005, the total district heating production was 32.2 TWh[1]. The share of CHP production was 74 % and separate production 26 % of district heating. However the number of CHP companies was about 20 % of total district heating companies. The district heating industry is quite heterogeneous. There are only few large energy companies participating both in electricity and district heating markets. Thus the energy market deregulation of act started in year 1999 must have some effects on the heat prices also. Figure 1. illustrates operating of the average district heating company in Finland.

The district heating company can be theoretically divided to production, distribution, and sales business. Still most of the district heating companies are vertically integrated. In many small companies the maintenance services of the distribution network are outsourced. In some municipalities also the production business is separated to an own company so that the district heating water is produced in different industrial company, which production process produces hot water as side product, or production units are divided to an independent production companies. These independent production companies do not usually own any distribution network. The distribution network business includes network building, maintenance, and the distribution of district heating. The sales business includes purchases of district heating, sales, and marketing of district heating services to the customer (small private houses and apartment block). Note that the sales business contracts only with the end-

[1] TWh = terawatt hour i.e. 1 TWh = 1 000 GWh = 1 000 000 MWh

user customer. However the sales business is typically not separated from distribution business.

Figure 1. District heating company



4. Modeling price setting in district heating firms

Our data consist of 76 district firms (90% of all firms) in Finland during time period 1996-2002. Thus our sample consists of 532 observations. Appendix III gives more detailed description of data. Target is to model price setting behaviour of firms in the end-user markets with industrial organization features reviewed above. We build a panel data regression model for observed market retail prices explained with variables describing the firm's level of vertical and horizontal integration, geographical location, raw material costs, network sharing, joint production (CHP), production scale, and ownership structure of the firms. The model specification is derived from the principles of empirical IO-literature (see, e.g. Bresnahan1989, Cubbin 1988, Reiss & Wolak 2005).

The variables are defined as

Price variables:

$P_{i,t}^{SMA}$ = price of district heating for small (single) family houses (€/kWt)

$P_{i,t}^{APA}$ = price of district heating for apartment houses (€/kWt)

Vertical and horizontal integration variables:

$PROD_{i,t}^{MS}$ = firm's market share in district heat production (0-100%)

$SMALL_{i,t}^{MS}$ = firm's market share in energy retail markets of small family houses (0-100%)

$APART_{i,t}^{MS}$ = firm's market share in energy retail markets of apartment houses (0-100%)

$CHP_{i,t}$ = dummy variable for joint production of electricity and heat (1 = joint production, 0 = heat production)

$JOINT_{i,t}$ = dummy variable for joint retail selling of electricity and heat (1 = joint retail selling, 0 = only heat selling)

$SUPPLY_{i,j}$ = number of wholesale suppliers that the retail seller has (0,1,..,N)

$NETWORK_{i,t}$ = dummy variable of distribution network sharing (1 = firm shares network other firms, 0 = no sharing) *)

Geographical location:

$LOCATION_{i,t}$ = dummy variable for firm's geographical location reflecting the local raw material dependency (0=south, 1=coast, 2= east and north) *)

Ownership:

$PUBLIC_{i,t}$ = dummy variable for firm's ownership (1 = public, 0 = private)

$COMPANY_{i,t}$ = dummy variable for firm's ownership structure (1 = part of larger company, 0 = not part of larger company)

Firm's scale:

$SCALE_{i,t}$ = the scale of production or retail selling of district heat (GWt)

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*) These variables were connected together as two-dimensional dummy variable, D_{km}, describing dependency between firm's location and network sharing (see Appendix I for more details)

Input costs:

$FUELCOST_{i,t}$ = the unit cost of fuel input of producer company (if the company is sole retail seller or distribution company variable gets the value of this company's major heat supplier)

Competition:

$$TRL_{1999} = \begin{cases} 0, & \text{when } t < 1999 \\ 1, & \text{when } t \geq 1999 \end{cases}$$

= a trend level shift variable that describes the price effect of deregulation of Finnish energy markets starting in year 1999.

Our base line model has the from of (expect that $APART^{MS}_{i,t-1}$ is used instead of $SMALL^{MS}_{i,t-1}$ for apartment house specification)

$$\begin{aligned} P^{j}_{i,t} = {} & \alpha_i + \beta_0 P^{j}_{i,t-1} + \sum\nolimits_{k=0}^{2} \sum\nolimits_{m=0}^{1} a_{km} D_{km} + \delta_0 TR_t + \delta_* TRL_{1999} \\ & + \beta_1 PROD^{MS}_{i,t-1} + \beta_2 SMALL^{MS}_{i,t-1} \\ & + \beta_3 CHP_{i,t} + \beta_4 JOINT_{i,t} + \beta_5 SUPPLY_{i,t} + \beta_6 PUBLIC_{i,t} + \beta_7 COMPANY_{i,t} \\ & + \beta_8 SCALE_{i,t} + \beta_9 FUELCOST_{i,t} + u^{j}_{i,t}, \end{aligned}$$

where $t = 1, 2, ..., 6$, $i = 1, 2, .., 76$, and $j =$ small or apartment house.

TR_t in a common time trend variable for all firms describing the common time depended price effects. One period lagged endogeneous variable is also included in the model as price dynamics are quite slow in district heating retail markets. Typically the firms change their prices only on yearly basis. Notice also that market share variables are lagged with one period. The price setting is one strategic variable in rivalry for market shares. Now the lagged share variables exclude the effects from prices to market shares. Thus the used specification is not sensitive to endogeneity specification bias. Note that we use also GMM –estimation method in panel setting (Arellano 2003). In this case market share variables are not lagged with one period but we use instrumental variable estimation method (i.e. GMM) to solve the endogeneity problem. α_i is the firm specific (fixed or random) component that models the unobserved firm heterogeneity. Finally u_{it} is normally and independently distributed error term with common variance, $u_{it} \sim N(0, \sigma_u^2)$.

We estimate different specifications of above model in pooled and panel data settings emphasizing the time dependent policy changes in the sample period, and regional network sharing classifying price effects D_{km} (see Appendix II for different specifications). In order to study more closely the network-sharing effects the model was augmented with interaction terms between $NETWORK_{i,t}$ and other right hand side variables (excluding D_{km}'s and $P_{i,t-1}^{j}$). This specification enables us to test if the possible network-sharing effects are only location specific or they have more general pricing effects, i.e. the network-sharing firms' pricing policy with respect to their market and production structure imply different energy prices compared to non network-sharing firms.

5. Results

5.1. Small house pricing

We first pay attention to regional differences in pricing. Table 1a. reports the standard OLS model estimates and interaction OLS-model estimates for pooled data. Results indicate that there exist regional price differences for small houses. The estimates for *D00,...,D21* show tendency that firms located in the Eastern or Northern Finland (*D20,D21*), using mainly wood and peat based material input in heat production, have the lowest retail energy prices. However if the firm is a distribution network-sharing firm (*Di1, i=01,2)* this does not lower the price. Notice that this result does not mean that price differences between network-sharing and non-network-sharing firms are non-existing. The parameter equality tests for estimates of *D00,...,D21* in Tables 1b-1c. indicate clearly that relevant pricing differences are found among the firms depending on their geographical location and network-sharing possibilities. However there are no systematic differences over the regions for network-sharing. Note that the "long run" level estimates of *D00,...,D21* are obtained by adjusting the estimates with the price dynamics estimate, e.g. $D00_{LR}=9.34/(1-0.77) = 40.6$. Appendix IV

Table 1a. Pooled OLS-estimates of small house energy price setting

Variable	estimate	t-value[1)]	estimate	t-value[1)]
$P_{i,t-1}^{SMALL}$	0.77	(17.31*)	0.76	(16.53*)
D00	9.34	(4.03*)	9.90	(4.02*)
D01	8.35	(3.27*)	13.44	(4.81*)
D10	9.33	(3.95*)	9.96	(3.91*)
D11	12.66	(4.37*)	5.94	(0.78)
D20	8.43	(4.02*)	9.00	(3.98*)
D21	8.75	(4.01*)	4.25	(1.54)
TR	0.44	(2.74*)	0.34	(1.91*)
TRL_{1999}	-0.82	(-1.71*)	-0.48	(-0.89)
$PROD_{i,t-1}^{MS}$	1.21	(1.72*)	1.34	(1.77*)
$SMALL_{i,t-1}^{MS}$	-6.06	(-2.41*)	-8.75	(-2.85*)
$CHP_{i,t}$	0.49	(1.10)	0.33	(0.63)
$JOINT_{i,t}$	0.55	(1.09)	0.38	(0.62)
$SUPPLY_{i,j}$	-0.04	(-0.01)	0.01	(0.00)
$PUBLIC_{i,t}$	-0.01	(-0.03)	0.10	(0.19)
$COMPANY_{i,t}$	0.67	(0.71)	1.13	(1.06)
$SCALE_{i,t}$	-0.01	(-0.22)	0.08	(1.57)
$FUELCOST_{i,t}$	0.13	(3.04*)	0.14	(2.70*)
$NETWORK_{i,t} * TR$			1.19	(4.10*)
$NETWORK_{i,t} * TRL_{1999}$			-2.73	(-2.90*)
$NETWORK_{i,t} * PROD_{i,t-1}^{MS}$			4.06	(1.39)
$NETWORK_{i,t} * SMALL_{i,t-1}^{MS}$			38.57	(1.57)
$NETWORK_{i,t} * CHP_{i,t}$			-7.85	(-2.08*)
$NETWORK_{i,t} * JOINT_{i,t}$			-2.44	(-1.48)
$NETWORK_{i,t} * SUPPLY_{i,j}^{F}$			5.94	(1.80*)
$NETWORK_{i,t} * PUBLIC_{i,t}$			1.85	(1.12)
$NETWORK_{i,t} * COMPANY_{i,t}$			-7.00	(-4.05*)
$NETWORK_{i,t} * SCALE_{i,t}$			-0.15	(-2.40*)
$NETWORK_{i,t} * FUELCOST_{i,t}$			-0.17	(-2.80*)
R^2		0.793		0.799
Breusch-Pagan heterog. test		$\chi^2(17)$: 226.2*		$\chi^2(27)$: 260.9*
BJ normality test		$\chi^2(2)$: 415.1*		$\chi^2(2)$: 487.2*
Durbin Watson test		2.43		2.36

1) t-values corrected for heteroskedasticity
*) significant at 10% level

Table 1b. Tests for equality of distribution network-sharing and regional specific effects (p-values in parenthesis)

Overall equality: D00=D10=D20= D01=D11=D21	Regional equality: D00=D10=D20, D01=D11=D21	Network sharing / non sharing equality: D00=D01,D10=D11,D20=D21
$\chi^2(5) = 16.92$ (0.005)	$\chi^2(4) = 14.26$ (0.006)	$\chi^2(3) = 13.16$ (0.004)

Table 1c. Tests for equality of distribution network sharing and regional specific effects in interaction model (p-values in parenthesis)

Overall equality: D00=D10=D20= D01=D11=D21	Regional equality: D00=D10=D20, D01=D11=D21	Network sharing / non sharing equality: D00=D01,D10=D11,D20=D21
$\chi^2(5) = 19.32$ (0.001)	$\chi^2(4) = 8.73$ (0.009)	$\chi^2(3) = 13.31$ (0.004)

reports the unbalanced panel estimation results where variables *D00,...,D21* build up six regional-network specific cross sections in the panel setting. The estimation results are in line with Table 1a. results but some positive price effects mount from the firm being part of larger company.

Before analyzing in details the remaining results we notice that our estimation results are greatly harmed by residual heteroskedasticity and non-normality. The firm level heterogeneity of our sample is not controlled in the OLS-model estimation for pooled data. To secure consistent t-values we used heteroskedasticity consistent standard errors (White's diagonal moment matrix correction).

The second part of Table 1. reports the results from interaction model where we let network-sharing dummy to interact with explanatory variables. The specification reveals the differences between network-sharing and non network-sharing firms' energy pricing explained by the "structural" variables. The results indicate that network-sharing firms react differently to these variables compared to non-sharing firms. Generally the pricing effects among the network-sharing firms are amplified but some network-sharing firm specific effects are also found, e.g. joint production of electricity and heat among the network-sharing firms ($NETWORK_{i,t} * CHP_{i,t}$ - variable) decreases energy prices. Likewise if the firms is part of larger company ($NETWORK_{i,t} * COMPANY_{i,t}$), and if the production scale of firm is large ($NETWORK_{i,t} * SCALE_{i,t}$) the energy prices are lower. However contrary to theoretical arguments, the number of wholesale suppliers ($NETWORK_{i,t} * SUPPLY_{i,j}$) increases, and the unit cost of fuel input of network-sharing producer company ($NETWORK_{i,t} * FUELCOST_{i,t}$) depresses prices.

The results from first difference and panel data model estimates are found in Tables 2 and 3. At this moment we not analyze results in different tables in details. Instead we focus on the

Table 2. First difference OLS model estimates of small house energy price setting

Variable	estimate	t-value[1)]	estimate	t-value[1)]
	1997-2002		*1998-1999*	
Constant	1.68	(6.88*)	-0.82	(-1.96*)
$\Delta P^{SMALL}_{i,t-1}$	-0.37	(-3.91*)	0.07	(0.50)
D_{1999}	-1.85	(-4.99*)		
$\Delta PROD^{MS}_{i,t-1}$	3.13	(2.17*)	0.01	(0.21)
$\Delta SMALL^{MS}_{i,t-1}$	15.72	(2.07*)	-58.01	(-0.44)
$\Delta CHP_{i,t}$	-0.36	(-0.34)	0.53	(0.46)
$\Delta PUBLIC_{i,t}$	1.05	(3.82)		
$\Delta COMPANY_{i,t}$	1.88	(0.81)	-0.71	(-2.05*)
$\Delta SCALE_{i,t}$	0.43	(3.21*)	-3.42	(-2.07*)
$\Delta FUELCOST_{i,t}$	-0.05	(-0.83)	0.05	(0.35)
R^2	0.138		0.086	
Breusch-Pagan heterog. test	$\chi^2(9)$: 44.46*		$\chi^2(7)$: 7.87*	
BJ normality test	$\chi^2(2)$: 201.11*		$\chi^2(2)$: 116.21*	
Durbin Watson test	2.15		-	

1) t-values corrected for heteroskedasticity
*) significant at 10% level

sum-up of parameter estimates from different model specifications (see Table 4). Table reports + symbol if positive estimate of parameter value at 10% significance level is obtained, - symbol when negative pricing effects is found, and the cell is empty when the estimate is insignificant. Note that some 0/1 dummy variables are not included in all estimations because of their lack of variability. The last column of Table 4. reports the summary over different estimation. Parentheses are used if less or equal to three significant estimates are found. We consider these cases non-significant in terms of economic arguments with low level of robustness. The major concern in Table 4. is the energy price effects of induced competition started in year 1999 measured by the trend level shift variable TRL_{1999} .

Table 3. Panel model estimates of small house energy price setting

Variable	estimate	t-value[1)]	estimate	t-value[1)]	estimate	t-value[1)]
	fixed effects model		*random effects model*		GMM_{RE}[2)]	
Constant	34.45	(8.37*)	5.93	(3.40*)	16.51	(2.50*)
$P^{SMALL}_{i,t-1}$	0.23	(3.31*)	0.83	(21.26*)	0.55	(3.38*)
TR	1.10	(5.87*)	0.36	(2.18*)	0.67	(2.76*)
TRL_{1999}	-1.86	(-3.83*)	-0.69	(-1.45)	-1.25	(-1.80*)
$PROD^{MS}_{i,t-1}$	2.54	(1.89*)	0.58	(1.00)	2.09	(1.85*)
$SMALL^{MS}_{i,t-1}$	17.23	(2.31*)	-6.83	(-2.50*)	-17.89	(-2.17*)
$CHP_{i,t}$	0.93	(1.33)	0.96	(2.35*)	1.55	(1.93*)
$PUBLIC_{i,t}$	-4.78	(-2.78*)	0.42	(1.06)	0.98	(2.05*)
$COMPANY_{i,t}$	0.75	(0.67)	0.59	(0.73)	0.71	(0.77)
$SCALE_{i,t}$	0.66	(3.83*)	0.01	(0.98)	0.01	(0.62)
$FUELCOST_{i,t}$	0.14	(2.72*)	0.14	(3.19*)	0.23	(2.59*)
R^2	0.866		0.785		0.727	
Durbin Watson test	2.15		2.37		1.66	
BJ normality test	$\chi^2(2)$: 432.4*		$\chi^2(2)$: 416.21*		$\chi^2(2)$: 516.21*	

1) t-values corrected for heteroskedasticity

2) J-statistics for instrumental adequacy: $\chi^2(17) = 8.09$

Instrument list: All trend, 0/1 variables and lags 1-2 of right hand side variables

*) significant at 10% level

Also the price effects of firm's district heat production share and energy retail market share variables $PROD_{i,t}^{MS}$ and $SMALL_{i,t}^{MS}$ are important. Results in Table 4 confirm that the deregulation act in the Finnish electricity markets started in 1999 had a price decreasing effect on district heating prices. The effect was a permanent downward level shift in general positive price trend. The incidence of change was on the network-sharing firms (see Table 1a). The estimated average magnitude of energy price decrease in year 1999 was close to 2.00 euros/kWt. The firm's share of production of district heat in the localized markets has a positive effect on the energy price. Thus the production market power increases the energy price level. The estimated average long run price effect is close to 3 euros/kWt. However the firm's market share in district heat retail markets has opposite price effects depending in the model/estimation used. The outcome is disturbing reflecting the fact that estimation results are partly model specification dependent. Similar effects are also found for the scale variable. However the price effects of primary fuel cost are positive. Note that if the firm is distribution network-sharing firm the fuel cost effects are hampered. The results may reflect the fact that network-sharing companies must be more cost-effective than non-network-sharing ones.

Table 4. Sum-up of small house energy pricing estimation results

method/ variable	*OLS*	*OLS / interac.*	*1st diff 97-02*	*1st diff 98-99*	*Panel FE*	*Panel RE*	*Panel GMM*	***Total***
TR	+	+/+	+	n.i	+	+	+	+
TRL_{1999}	-	/-	-	-	-		-	-
$PROD^{MS}$	+	+/	+		+		+	+
$SMALL^{MS}$	-	-/	+		+	-	-	±
CHP		/-				+	+	(±)
JOINT			n.i	n.i	n.i	n.i	n.i	
SUPPLY		/+	n.i	n.i	n.i	n.i	n.i	(+)
PUBLIC			+	n.i	-		+	(±)
COMPANY		/-		-				(-)
SCALE		/-	+	-	+			±
FUELCOST	+	+/-			+	+	+	+

(n.i. = not included in the model)

The rest of results in Table 4. lack stability and robustness. However if we overvalue the results we notice that firm being part of larger company has a price depressing effect. Also if the firm production structure allows for CHP-production it is expected to have negative price effects. This result is confirmed by OLS-estimation and D_{km} -stratification panel estimation results found in Appendix IV. However a firm selling both electricity and heat has no retail price effects.

5.2. Apartment house pricing

On general level results for apartment houses are close to small house results (see Tables 5-8). However some differences are found. First, no regional or network-sharing price difference effects are found (see Tables 6b-c). The result may be an outcome of less competition found in the apartment house energy retail product markets compared to small house markets where energy input substitution possibilities also exist. Apartment house markets are more concentrated that the small house markets (see Appendix III). The argument is supported by the weak evidence that market share of firm in energy retail markets has price increasing effect (see Table 5). Second, the firm's market share in heat production has larger retail price effects than in small house pricing. The long run average price effect is close to 4 euros/kWt. Lastly, the scale of production price effect is pronounced but lack robustness. Unstable public ownership effects were also found.

Table 5. Sum-up of apartment house energy pricing estimation results

method/ variable	*OLS*	*OLS / interac.*	*1st diff 97-02*	*1st diff 98-99*	*Panel FE*	*Panel RE*	*Panel GMM*	*Sum*
TR	+	+/+	+	n.i	+	+	+	+
TRL_{1999}	-	-/-	-		-	-	-	-
$PROD^{MS}$	+	+/	+		+	+	+	+
$APART^{MS}$		/+						(+)
CHP						+		(+)
JOINT			n.i	n.i	n.i	n.i	n.i	
SUPPLY			n.i	n.i	n.i	n.i	n.i	
PUBLIC			+	n.i	-			(±)
COMPANY		/-		-				(-)
SCALE	-	- /+	+	-	+	-	-	±
FUELCOST	+	+/-			+	+	+	+

(n.i. = not included in the model)

Table 6a. Pooled OLS-estimates for apartment house energy price setting

Variable	estimate	t-value[1)]	estimate	t-value[1)]
$P_{i,t-1}^{APART}$	0.72	(14.96*)	0.69	(13.99*)
$D00$	9.86	(4.42*)	9.46	(4.38*)
$D01$	8.03	(3.61*)	5.89	(1.67*)
$D10$	9.32	(4.25*)	8.84	(4.13*)
$D11$	11.23	(4.33*)	6.21	(1.09)
$D20$	8.88	(4.36*)	8.46	(4.25*)
$D21$	9.77	(4.21*)	6.02	(0.87)
TR	0.57	(3.81*)	0.49	(3.19*)
TRL_{1999}	-1.35	(-2.72*)	-0.96	(-2.00*)
$PROD_{i,t-1}^{MS}$	2.06	(3.18*)	2.37	(3.44*)
$APART_{i,t-1}^{MS}$	0.06	(0.06)	0.89	(0.82)
$CHP_{i,t}$	-0.40	(-0.89)	0.03	(0.05)
$JOINT_{i,t}$	-0.06	(-0.12)	-0.15	(-0.25)
$SUPPLY_{i,j}^{F}$	-0.03	(-0.14)	-0.04	(-0.18)
$PUBLIC_{i,t}$	0.14	(0.34)	0.46	(0.92)
$COMPANY_{i,t}$	0.53	(0.52)	0.82	(0.84)
$SCALE_{i,t}$	-0.04	(-2.98*)	-0.17	(-3.76*)
$FUELCOST_{i,t}$	0.12	(3.15)*	0.15	(3.33*)
$NETWORK_{i,t} * TR$			1.28	(2.94*)
$NETWORK_{i,t} * TRL_{1999}$			-3.92	(-2.12*)
$NETWORK_{i,t} * PROD_{i,t-1}^{MS}$			-2.28	(-0.53)
$NETWORK_{i,t} * APART_{i,t-1}^{MS}$			13.00	(2.09*)
$NETWORK_{i,t} * CHP_{i,t}$			-3.20	(-0.93)
$NETWORK_{i,t} * JOINT_{i,t}$			-4.51	(-0.69)
$NETWORK_{i,t} * SUPPLY_{i,j}^{F}$			2.94	(0.76)
$NETWORK_{i,t} * PUBLIC_{i,t}$			-0.68	(-0.72)
$NETWORK_{i,t} * COMPANY_{i,t}$			-5.28	(-3.29*)
$NETWORK_{i,t} * SCALE_{i,t}$			0.13	(2.54*)
$NETWORK_{i,t} * FUELCOST_{i,t}$			-0.29	(-2.08*)
R^2	0.699		0.713	
Breusch-Pagan heterog. test	$\chi^2(17): 207.9$*		$\chi^2(27):$ 177.3*	
BJ normality test	$\chi^2(2): 557.1$*		$\chi^2(2):$ 540.4*	
Durbin Watson test	2.45		2.46	

1) t-values corrected for heteroskedasticity
*) significant at 10% level

Table 6b. Tests for equality of distribution network sharing and regional specific effects (p-values in parenthesis)

Overall equality: D00=D10=D20= D01=D11=D21	Regional equality: D00=D10=D20, D01=D11=D21	Network sharing / non sharing equality: D00=D01,D10=D11,D20=D21
$\chi^2(5) = 7.09$ (0.214)	$\chi^2(4) = 6.19$ (0.184)	$\chi^2(3) = 5.34$ (0.147)

Table 6c. Tests for equality of distribution network sharing and regional specific effects in interaction model (p-values in parenthesis)

Overall equality: D00=D10=D20= D01=D11=D21	Regional equality: D00=D10=D20, D01=D11=D21	Network sharing / non sharing equality: D00=D01,D10=D11,D20=D21
$\chi^2(5) = 6.21$ (0.285)	$\chi^2(4) = 4.47$ (0.351)	$\chi^2(3) = 2.36$ (0.501)

Table 6. First difference OLS model estimates for apartment house energy price setting

Variable	estimate	t-value[1)]	estimate	t-value[1)]
	1997-2002		*1998-1999*	
Constant	1.75	(7.62*)	-0.51	(-1.36)
$\Delta P_{i,t-1}^{APART}$	-0.40	(-4.62*)	-0.44	(-2.64*)
D_{1999}	-1.99	(-5.78*)		
$\Delta PROD_{i,t-1}^{MS}$	3.03	(2.16*)	3.54	(0.70)
$\Delta APART_{i,t-1}^{MS}$	3.83	(0.44)	-50.31	(-1.16)
$\Delta CHP_{i,t}$	-0.64	(-0.75)	0.02	(0.02)
$\Delta PUBLIC_{i,t}$	1.04	(4.04*)		
$\Delta COMPANY_{i,t}$	1.47	(0.76)	-0.88	(-2.21*)
$\Delta SCALE_{i,t}$	0.30	(2.52*)	-3.82	(-2.72*)
$\Delta FUELCOST_{i,t}$	-0.08	(-1.51)	-0.07	(-0.46)
R^2	0.180		0.305	
Breusch-Pagan heterog. test	$\chi^2(9)$: 40.46*		$\chi^2(7)$: 6.75*	
BJ normality test	$\chi^2(2)$: 265.65*		$\chi^2(2)$: 89.88*	
Durbin Watson test	2.15		-	

1) t-values corrected for heteroskedasticity
*) significant at 10% level

Table 7. Panel model estimates for apartment house energy price setting

Variable	estimate	t-value[1)]	estimate	t-value[1)]	estimate	t-value[1)]
	FE: fixed effects model		*RE: random effects model*		GMM_{RE}[2)]	
Constant	28.01	(6.00*)	8.18	(4.47*)	21.22	(3.73*)
$P_{i,t-1}^{APART}$	0.16	(2.39*)	0.74	(16.41*)	0.97	(3.97*)
TR	1.24	(7.15*)	0.54	(3.64*)	0.97	(3.97*)
TRL_{1999}	-2.19	(-4.29*)	-1.34	(-2.75*)	-1.98	(-3.13*)
$PROD_{i,t-1}^{MS}$	2.31	(1.94*)	1.75	(3.04*)	3.99	(3.34*)
$APART_{i,t-1}^{MS}$	3.31	(0.46)	-0.41	(-0.36)	-1.75	(-1.10)
$CHP_{i,t}$	0.25	(0.42)	0.02	(0.01)	-0.44	(-0.72)
$PUBLIC_{i,t}$	-2.61	(-2.01*)	0.22	(0.63)	0.36	(0.40)
$COMPANY_{i,t}$	0.03	(0.06)	0.21	(0.30)	0.21	(0.26)
$SCALE_{i,t}$	0.36	(2.47*)	-0.03	(-2.23*)	-0.07	(-3.22*)
$FUELCOST_{i,t}$	0.10	(1.99*)	0.13	(3.64*)	0.20	(3.62*)
R^2	0.809		0.691		0.727	
Durbin Watson test	2.31		2.44		1.66	
BJ normality test	$\chi^2(2)$: 316.10*		$\chi^2(2)$: 208.98*		$\chi^2(2)$: 501.11*	

1) t-values corrected for heteroskedasticity

2) J-statistics for instrumental adequacy: $\chi^2(17) = 8.19$

Instrument list: All trend, 0/1 variables and lags 1-2 of right hand side variables

*) significant at 10% level

6. Conclusions

We proposed an empirical econometric panel data model to test deregulation and regional market structure effects on district heating prices in Finland 1996-2002. On the general level results imply that the local structures of energy production and selling have an important role on retail market prices. The price lowering effects of energy market deregulation, started in 1999, have been permanent. However many firm specific features like firm ownership, CHP, heat and electricity joint selling, firm being part of larger company, and scale of production did not have unambiguous retail price effects. Although the main empirical results obtained preserve robustness and theory corroboration the large unobserved firm heterogeneity needs in future research more attention.

The results showed also the housing type dependency. For small house district heat markets regional and distribution network sharing aspects are important but for apartment houses they are not. However for both house types, the market shares of local district heat production firms correlate positively with retail prices. The price effects of retail market shares of energy selling firms were not confirmed. A firm sharing a distribution network with other companies has stronger pricing effects with firm specific control variables than a non-sharing firm. Some network sharing firm specific effects were also found.

From the policy perspective of market deregulation and industry restructuring the results are encouraging. The electricity market restructuring started in 1999, affecting district heating markets only indirectly, has lowered district heat housing prices. At the same time firm market shares – especially in wholesale markets - have still non-competitive price effects. As the district heating markets are highly localized with extended dependency, the market deregulation and industry restructuring may be impossible. Stronger regulation and market monitoring by the authorities may also in future be the only policy alternative.

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Appendix I

Distribution network-sharing and regional specific effects

Following firm and region classifying variables are specified

(A1')
$$D_{iNET} = \begin{cases} 0, \text{ if firm has own network} \\ 1, \text{ if firm shares the network} \end{cases}$$

and

(A1'')
$$D_{iREG} = \begin{cases} 0, \text{ firm is located in Southern Finland} \\ 1, \text{ firm is located on coastal side of Finland} \\ 2, \text{ firm is located in Eastern or Nothern Finland.} \end{cases}$$

We can connect these variables in following way

(A2)
$$\begin{array}{cc} & D_{iNET} \\ D_{iREG} & \begin{array}{|cc|} 0,0 & 0,1 \\ 1,0 & 1,1 \\ 2,0 & 2,1 \end{array} \end{array}$$

giving parametric presentation $\sum_{k=0}^{2}\sum_{m=0}^{1} a_{km}D_{km} = a_{00}D_{00} + a_{01}D_{01} + .. + a_{21}D_{21}$.

Appendix II

Time dependent policy analysis in panel data

2 period model

Assume that we have observations from two time periods $t = 1$ and $t = 2$. A policy change takes place at the beginning of period 2. Letting *i* denote the cross section unit and *t* the time period. A one way panel data model with a single observed explanatory variable is

(A1)
$$y_{it} = \beta_0 + \delta_* d2_t + \beta_1 x_{it} + a_i + u_{it}, \quad t = 1,2 \text{ and } i = 1,2,..,N,$$

where

$$d2_t = \begin{cases} 0, & \text{when } t = 1 \\ 1, & \text{when } t = 2 \end{cases}, \quad \text{and}$$

a_i measures cross section (unobserved) heterogeneity effects, and
u_{it} captures all other idiosyncratic and time-variyng unobserved effects.

Thus at time period $t = 2$ the intercept is $\beta_0 + \delta_*$ measuring the impact of policy change on the level of y_{it}. Next if subtract the second period equation from the first, we obtain

$$\text{(A2)} \qquad y_{i2} - y_{i1} = \Delta y_i = \delta_* + \beta_1 \Delta x_i + \Delta u_i \,,$$

and read the policy effects form cross section OLS estimate of δ_0. This first-difference estimator has some advantages over the panel data model estimate (A1) since it has less parameters and consistency preserving condition for OLS, $Corr(a_i, x_{it}) = 0$, disappears. If the cross section effects are of less importance the **first difference model** (A2) is a natural alternative for policy analysis (Wooldridge 2000).

Multi-period model

Typically we have a panel data with many time periods $t = 1, 2, .., t^*, .., T$, where a policy change takes place at the beginning of period t^*. Now a one way panel data model with *p* observed explanatory variables and year specific effects is

$$\text{(A3)} \qquad \begin{aligned} y_{it} &= \beta_0 + \delta_2 d2_t + ... + \delta_* dt^* + ... + \delta_{T-1} d(T-1)_t + \delta_T dT_t \\ &\quad + \sum_{v=1}^{p} \beta_v x_{vit} + a_i + u_{it}, \text{ where } \ t = 1, 2, ..., t^*, ...T \ \text{ and } \ i = 1, 2, .., N, \ \text{ and} \end{aligned}$$

$$dv_t = \begin{cases} 0, & \text{when } t = 1, t \neq v \\ 1, & \text{when } t = v, \end{cases} \qquad v = 2, 3, ..., t^*, ...T.$$

Difference model takes now from of

$$\text{(A4)} \qquad \begin{aligned} \Delta y_{it} &= \delta_2 \Delta d2_t + ... + \delta_* \Delta dt^* + ... + \delta_{T-1} \Delta d(T-1)_t + \delta_T \Delta dT_t \\ &\quad + \sum_{v=1}^{p} \beta_v \Delta x_{vit} + \Delta u_{it}, \quad t = 2, 3, ..., t^*, ...T \ \text{ and } \ i = 1, 2, .., N. \end{aligned}$$

Model (A4) is problematic since it does not include a constant term and different yearly dummy variable takes different values in three year sequences. Likewise policy change year

$t*$ is treated similarly like other years. One solution to these problems is the following difference model

(A5)
$$\Delta y_{it} = \beta_0 + \delta_3 d3_t + ... + \delta_* dt * + ... + \delta_{T-1} d(T-1)_t + \delta_T dT_t$$
$$+ \sum_{v=1}^{p} \beta_v \Delta x_{vit} + \Delta u_{it}, \quad t = 2,3,...,t*,...T \text{ and } i = 1,2,..,N.$$

A more efficient way to handle the policy issue is to use trend model like

(A6)
$$y_{it} = \beta_0 + \delta_0 TR_t + \delta_* TRL_{t*} + \sum_{v=1}^{p} \beta_v x_{vit} + a_i + u_{it},$$
$$TR_t = 1,2,...,t*,...T \text{ and } i = 1,2,..,N, \quad \text{and}$$
$$TRL_{t*} = \begin{cases} 0, & \text{when } t < t* \\ 1, & \text{when } t \geq t*. \end{cases}$$

The specification in (A6) means that all time depended effects in y_{it} are buried in a common time trend variable TR_t and a trend level shift takes place at policy change year $t*$. Thus a trend break occurs at year $t*$ without affecting the slope of trend.

Now the difference model has a form

(A7)
$$\Delta y_{it} = \delta_0 + \delta_* \Delta TRL_{t*} + \sum_{v=1}^{p} \beta_v \Delta x_{vit} + \Delta u_{it},$$
$$t = 2,...,t*,...T \text{ and } i = 1,2,..,N, \quad \text{and}$$
$$\Delta TRL_{t*} = \begin{cases} 0, & \text{when } t \neq t* \\ 1, & \text{when } t = t*. \end{cases}$$

Thus the policy change year $t = t*$ has its own specific, non permanent impulse, effect on Δy_{it}, i.e. δ_*, at year $t*$.

Inserting the regional-network dummies in level model above leads to

$$y_{it} = \sum_{k=0}^{2} \sum_{m=0}^{1} a_{km} D_{km} + \delta_0 TR_t + \delta_* TRL_{t*} + \sum_{v=1}^{p} \beta_v x_{vit} + \alpha_i + u_{it}, \quad \text{(A8)}$$

$$\text{where} \quad t = 1, 2, 3, ..., t*, ..., T \quad \text{and} \quad i = 1, 2, .., N.$$

The corresponding difference model equals to Eq.A7) since regional-network dummies are constants in time. The cross-sections and time effects are measured by coefficients $\alpha_{km} + \delta_0 + \delta_* + \alpha_i$ with reference to $\alpha_{00} + \delta_0$.

Appendix III

Data

Our sample consists of 76 district heat producing firms in Finland (90% of all firms). Time dimension of data is 7 years (1996-2002) leading to panel data with number of observation of 532.

	Mean	Std.Dev.	Skewness	Kurtosis	Minimum	Maximum
$PRICE^{SMALL}$	53.72	7.32	0.74	4.11	38.76	83.22
$PRICE^{APART}$	41.00	5.77	0.61	3.78	26.56	61.99
$PROD^{MS}$	0.63	0.42	-0.41	1.31	0.00	1.00
$SMALL^{MS}$	0.05	0.06	1.49	4.39	0.00	0.27
$APART^{MS}$	0.52	0.18	-0.16	2.66	0.04	0.92
SCALE	357.79	873.09	5.82	42.61	6.83	7224.11
FUELCOST	15.24	6.87	1.63	5.89	7.04	45.07

D_{km} -stratification divides the number of firms to following cross regional and network sharing variable cell numbers

	own network	*joint network*	
south	***18***	***1***	19
coast	***14***	***6***	20
north	***35***	***2***	37
	67	9	76

Appendix IV

Results from OLS-estimation without D_{km} -dummies and from unbalanced panel estimation with D_{km} - cross section stratification

Table IVA. Pooled data OLS and panels data -estimates of small house energy price setting (D_{km} –stratification)

	OLS		*FE*		*RE*	
Constant	11.31	(2.33*)	18.98	(6.78*)	17.25	(7.86*)
$P_{i,t-1}^{SMALL}$	0.62	(12.41*)	0.53	(9.04*)	0.57	(16.49*)
TR	0.36	(1.82*)	1.05	(5.22*)	1.04	(5.00*)
TRL_{99}	-1.56	(-1.92*)	-1.88	(-3.16*)	-1.90	(-2.26*)
$PROD_{i,t-1}^{MS}$	3.52	(3.11*)	3.09	(3.34*)	3.11	(4.11*)
$SMALL_{i,t-1}^{MS}$	0.38	(0.69)	-1.15	(-0.23)	-1.13	(-0.27)
$CHP_{i,t}$	0.75	(1.40)	0.63	(1.06)	0.64	(0.36)
$JOINT_{i,t}$	-0.17	(-0.39)	0.25	(0.59)	0.19	(0.44)
$SUPPLY_{i,j}^{F}$	0.04	(4.82*)	-0.16	(-0.47)	-0.09	(-0.28)
$PUBLIC_{i,t}$	0.33	(0.64)	-0.06	(-0.12)	0.08	(0.23)
$COMPANY_{i,t}$	1.43	(1.74*)	1.79	(2.12*)	1.74	(2.09*)
$SCALE_{i,t}$	-0.04	(-2.91*)	-0.06	(-2.36*)	-0.05	(-1.75*)
$FUELCOST_{i,t}$	0.28	(5.43*)	0.24	(5.24*)	0.25	(6.14*)
R^2	0.639		0.655		0.669	
Breusch-Pagan heterog. test	$\chi^2(17): 240.4*$					
BJ normality test	$\chi^2(2): 456.7*$		$\chi^2(2):$ 287.2*		$\chi^2(2):$ 212.5*	
Durbin Watson test	1.79		1.82		1.92	

1) t-values corrected for heteroskedasticity
*) significant at 10% level

Table IVB. Pooled data OLS and panels data -estimates of apartment house energy price setting (D_{km} –stratification)

	OLS		*FE*		*RE*	
Constant	13.91	(6.53*)	10.12	(9.12*)	8.81	(8.79*)
$P_{i,t-1}^{APART}$	0.59	(12.75*)	0.70	(14.79*)	0.71	(19.21*)
TR	0.62	(3.63*)	0.50	(2.73*)	0.47	(2.76*)
TRL_{1999}	-1.53	(-2.78*)	-1.31	(-1.96*)	-1.30	(-2.02*)
$PROD_{i,t-1}^{MS}$	2.44	(3.96*)	2.13	(3.33*)	2.02	3.94*)
$APART_{i,t-1}^{MS}$	1.74	(1.44)	0.61	(0.23)	0.33	(0.12)
$CHP_{i,t}$	-0.55	(-0.65)	-0.35	(-0.63)	-0.11	(-0.22)
$JOINT_{i,t}$	-0.62	(-1.07)	-0.38	(-0.75)	-0.51	(-0.70)
$SUPPLY_{i,j}^{F}$	0.04	(4.07*)	-0.02	(-0.07)	0.05	(0.19)
$PUBLIC_{i,t}$	0.18	(0.45)	0.15	(0.38)	0.32	(0.77)
$COMPANY_{i,t}$	1.06	(0.18)	1.09	(1.67*)	1.07	(1.51)
$SCALE_{i,t}$	-0.07	(-4.11*)	-0.03	(-1.03)	-0.03	(-1.15)
$FUELCOST_{i,t}$	0.15	(4.47*)	0.13	(4.87*)	0.15	(5.21*)
R^2	0.573		0.683		0.678	
Breusch-Pagan heterog. test	$\chi^2(17): 127.0$*					
BJ normality test	$\chi^2(2): 211.2$*		$\chi^2(2): 187.6$*		$\chi^2(2): 204.2$*	
Durbin Watson test	1.93		1.94		1.92	

1) t-values corrected for heteroskedasticity
*) significant at 10% level