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FACULTY OF ECONOMICS

ÁGNES HORVÁTH KÁDÁR

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PH.D. THESES

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1. REVIEW OF THE RESEARCH TOPIC

The public view on district heating is highly contradictory in Hungary. It influences the everyday life of a wide layer of the society, approximately 2 million inhabitants, 650 thousand flats (approximately 16 percent of the flats) numerous public bodies, community services and industrial consumers. Due to its benefits for the environment and energy saving district heating is a method of heating internationally appreciated and preferred, the European Union encourages its development and spread. In Hungary though, due to the increasing price level since the changing of the regime, the social appreciation of district heating has been falling back, in spite of its benefits for environment and safety. Media tends to deal with the high price level of district heating more and more often, and district heat suppliers face increasing criticism because of the significant differences in price levels of different suppliers.

Even district heating suppliers themselves are not in easy situation. The majority of the system shows unfavourable determinations for energetic considerations. An unusual, specific economic and policy point of view was applied when forming the techniques for both the district heating of flats and heat transfer. Despite the numerous modernisations of the technical systems in the time passed since the changing of the Regime, district heating systems still wear some of the wasting characteristics of the original constructs which leads to the debated competitiveness of district heating among the transform environment today.

My attention was turned to the subject of the research in 2005, when I participated in a consultancy project of our Institute at the District Heating Supplier Ltd. in Miskolc. In the course of this work I gained entire insight into the specific operation and management of a district heating supplier company.

The research topic fits the profile of the Institute of Business Sciences too. During the last years I joined the lectures of the subjects “economics of public good suppliers” and “public supplier economics”. These experiences lead me to develop my pragmatic experiences and professional expertise to a more scientific direction.

Several studies were published on district heating. The majority of these deals with either technical or legal, regulatory aspects of the subject. There is a research gap in terms of publications focused at the management and economics aspects of district heating supplier companies, or synthesises the economic and management implications of legal and technical questions. I aim to represent this direction of research with my Dissertation, endeavouring to map the comprehensive picture of district heating suppliers.

I would like to say thank You to my supervisor, Professor Mária Illés for directing my work and for her supportive comments. In the course of my research I also received valuable professional help from Professor László Garbai, the professor of BMGE who used to be the secretary general of the Professional Association of Hungarian District Heat Suppliers for one and a half decades.

In the framework of a cooperation with the Hungarian Energy Office I gain access to the database of the Office (as it was filled by then) in the summer of 2009. I would like to thank Pál Lángfy, the head of the Permission and Controlling department of the Hungarian Energy Office for a lot of valuable conversations and comments. Finally, but not least I would like to thank the helpfulness of those managers and colleagues of district heating companies who agreed to contribute to my work by filling out my questionnaire and who helped my professional development by sharing their expertise at consultations with me.

2. THE OBJECTIVE AND THE STRUCTURE OF THE DISSERTATION

The basic objective of the research is: *the analysis of the factors influencing the price level of district heating, and gaining insight into the underlying reasons for drastic differences in the price level among Hungarian District Heating Supplier companies.*

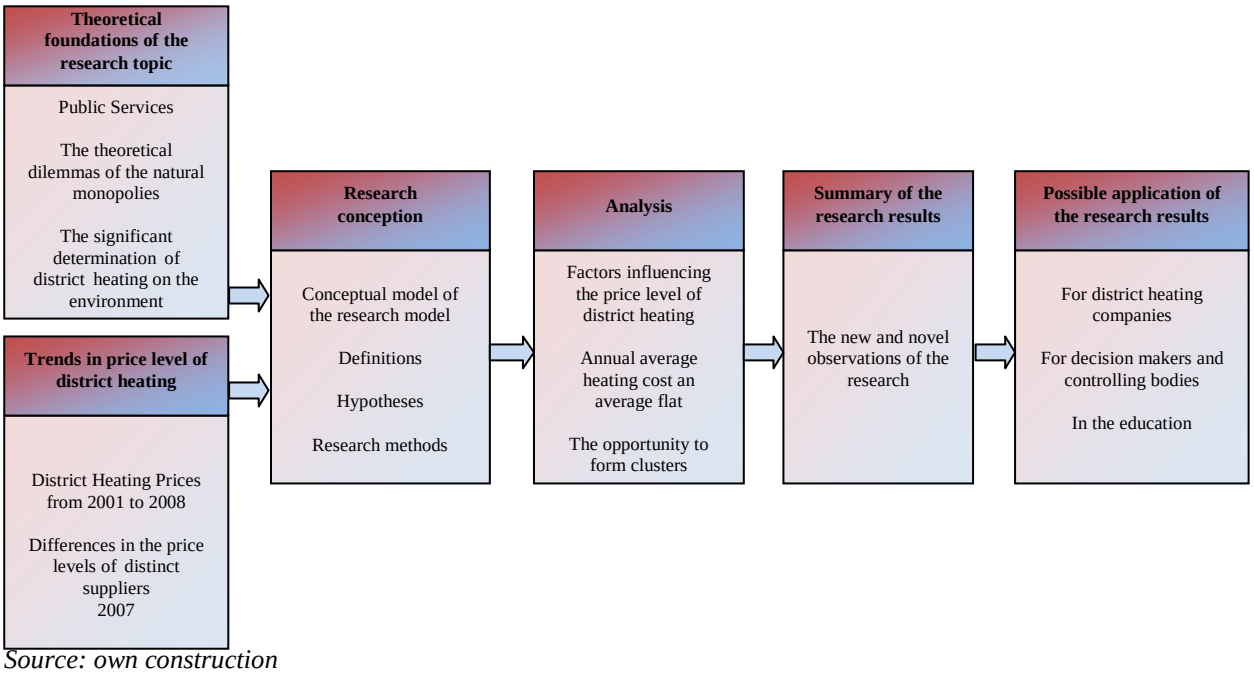
The structure of the Dissertation

The research was started by the mapping and evaluation of the technical literature. I made an overview of the theoretical dilemmas of typologies of public services and natural monopolies *(chapter 1)*, and continued by the review of the pragmatic literature on district heating *(chapter 2)*. My starting point for this writing this chapter was the significant determination of district heating on the environment. I introduced the major momentums of the international and national evolution, development and present situation of district heating, followed by an analysis of the strong energy-market dependence and policy- and legal determination of district heating.

District heating has been standing in the focus of media attention all along due to the high and significantly different price levels of the service. In order to see whether the critics are right, I analyzed the trends in price level of district heating, the major factors influencing it, and evaluated the differences in the price levels of distinct suppliers. *(Due to limited space this analysis can be found in appendix 5)*

After my analysis supported the tendency of increasing price level of district heating and significant differences were found in prices to be paid by consumers, I focused the objectives of the research and formulated the conceptual model of the research. Based on the logic of the conceptual model and my knowledge of the literature I formulated the hypotheses of my research. In order to make sure of the right understandability of my research results I defined the distinct content of the factors included in my model *(chapter 3)*.

Chapter 4 of the Dissertation contains the empirical analysis if factors influencing the price level of district heating, and the analytic introduction of the follow-up to my research. The analysis is deeper than a simple testing of the hypotheses. The summary of the new and novel finding of the research – in this case with a more goal-oriented summary of the results used to test my hypotheses – can be read in *chapter 5*. Finally I introduced the possible ways of follow-up research and the practical, pragmatic applications of the results of my research *(chapter 6)*. The process of the research is summarized in figure 1 bellow.



Source: own construction

Figure 1. The process of the research

3. THEORETICAL FOUNDATIONS OF THE RESEARCH TOPIC

District heating is a network system local public good, which is supplied in the form of quasi-company organizations. Due to the network system, district heating suppliers are natural monopolies. Due to these circumstances the forming of price levels and the quality of the service are strictly controlled by authorities. Based on these facts I summarized the theoretical background of the research by **three main subjects**: first, I made an overview of the literature on public goods (services); second, I endeavored to introduce natural monopolies and the theoretical dilemmas of this situation; third, an independent chapter deals with the summary of the pragmatic literature of district heating.

3.1. Overview of the literature on public services

I divided the relevant publications on public services to four approaches: according to the ***Economics approach,*** several authors use such a typology of commodities to systemize public services, which is based on the private and public characteristics of consumption. The first Hungarian literature dealing with the pragmatic questions of public goods suppliers' operation and regulation in the ***Entrepreneurship literature*** is *Illés* 2000. I have not found any other Hungarian literature focusing on the specialties of public good supplier companies. Several Hungarian authors in the ***organization and management literature*** deal with the major management aspects of public services along with the marketing considerations. The ***legal approach:*** there is no comprehensive, exact definition of public services in the Hungarian regulation. This view is confirmed by the definition of public services applied in the EU regulations too. A group of publications on public services deals with the regulation aspects of the field.

3.2. Natural monopolies and the theoretical dilemmas arising from this situation

Economics literature mentions six situations in case of which market mechanisms are not capable of efficient operation; these are defined as *market failures*. In my Dissertation I focused on ***natural monopolies*** of the six market failures. As network based systems, district heating supply among them, are subjects of the evolution of natural monopolies. As a result of the natural monopolistic situation, competition is limited or impossible, so strict legal regulation and strong control by authorities is necessary. To know more about the matter I studied the literature of ***regulation economics***. This is a kind of applied economics; its aim is the elimination and improvement of market failures. I also considered possible ways of interpreting information asymmetries and the theory of agents in the regulator-regulated relationship.

The traditional methods of the (neoclassical) regulation economics were not successful in giving explanations for the new tendencies at the end of the 20th century (liberalizations). The moment for a change in Paradigm arose, which lead to the application of the game theory instead of the neoclassical approach. ***Market theory*** (industrial organization) evolved, one of the most dynamically developing branches of modern economics, which analyses the market situations different from perfect competition or perfect monopolies.

There is no uniform view in the literature on the necessity of the strict government control on public services. According to the ***theories which deny the necessity for regulation***, a market failure, for example natural monopolies do not make government intervention necessary. The claim to liberalize public services, emphasizing the beneficial effects of the evolving competition gained momentum (see *Bolkestein directive, GATS-agreement).* The thought of privatization is often strongly attached to liberalization; privatization is considered a prerequisite for liberalization and competition. On the other hand, the view that public services, based on their characteristics still should be supplied by the state is still strong. This line of thought represents the idea that taking these services to the free market has serious consequences, endangering the sustainability of public services. I myself agree with the latter view.

3.3. District heating and its strong dependence on environment – an overview of the literature

Different countries formed different district heating systems, based on different principles, using different technologies. The literature background for the description of the ***international situation*** was based on the publications of the professional association *Euroheat&Power* and on the serial studies of the *DHCAN Project supported by the* EU funded SAVE[1] program. I compared the energy base, applied system of prices and price regulations of district heating, moreover the international agreements on district heating and national policies and ownership background of district heating.

During the introduction of the ***energy market situation*** I gave an overview of natural gas market's evolution, the increasing tendency in the global market price of natural gas, on the specialties (distortions) of the Hungarian natural gas system and on the expected advantages of the liberalization of the natural gas market, and their limited realization. I made an overview of the advantages and disadvantages, limits to the spread of the relevant *alternative sources of primary energy* as well. I put significant emphasis on the literature of the joint power- and heat general (co-generation). In my Dissertation I concentrated on the approach focusing on the economic aspects of operation of district heat suppliers in the first place. So the focus of my analysis is on the different points of view on subsidizing co-generation, the division of costs between heat- and power generation and the determination of the price for bought heat. Relating to this I introduced the methods of sharing costs between main product and supplementary product and between twin products based on the literature of Cost Accounting.

When introducing the ***legal, regulatory environment*** I wished to emphasize the role of the factors influencing the price of district heating, and the regulations influencing these factors. The overview was based on the following typology: price regulation, district heating law, types of subsidies for district heating, the effects of the regulation of energy industry and public procurement regulation.

[1] (SAVE: Special Actions for Vigorous Energy Efficiency)

4. THE CONCEPTUAL MODEL OF THE RESEARCH

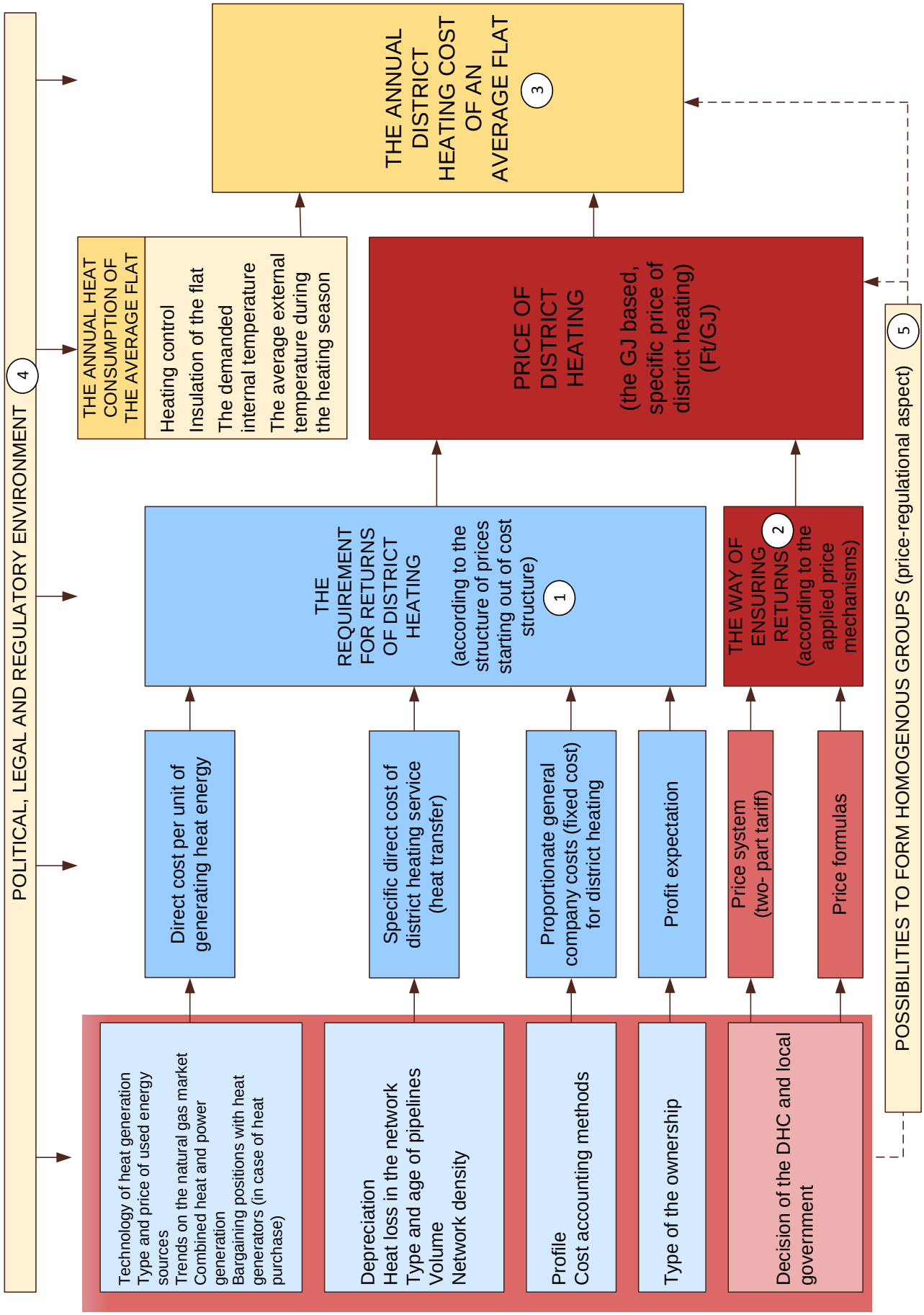
Based on the review of the literature and the determined objectives I formulated a conceptual model on the factors influencing the price level of district heating. The factors influencing the price level were distributed to two main categories:

1. **The requirement for returns on district heating activities (according to the structure of prices).** The major factor influencing the price level of district heating is the returns on the activity. This means that we have to analyse which costs must be covered by the price of district heating. When determining the factors influencing the price I used the well known assumption as a starting point, according to which district heating is made up of two, easily separable sub-activities, heat generation and heat transfer. The unit price of the heat transferred to the consumers is mainly determined by the direct cost of district heating, but the price structure also features the proportionate general company costs for district heat supply and some profit expectation as well.
2. **The way of ensuring returns (according to the applied price mechanisms).** District heat suppliers apply a price system with two factors (two-part tariff). Price is influenced by the match between these elements, so which part of the price should cover which return requirement. Important consequences can be attached to context of price system and cost structure and applied price formulas.

Further parts of the research

3. Besides the analysis of factors influencing the price, I also researched the **annual average heating cost an average flat, and the factors influencing this.** When doing the analysis assumed that the district heating cost of a flat is influenced not only by the price of the service, but also by the annual heat consumption of the average flat. The latter can be influenced by other factors, for example, can the heating be controlled, insulation of the flat, the demanded internal temperature and the average external temperature during the heating season.
4. Because of the high district heating price the **social implications** of district heating are significant. Due to the multifunctional nature of the local government significant political influence can be realised in district heating services, as the local governments own the district heating suppliers, decides on the authorised price and represents the interest of the voters. Both the price of district heating and the annual district heating cost of an average flat are significantly influenced by the **political- and regulatory environment.**
5. Finally, the research also covered the analysis whether **it would be possible to form homogenous groups of district heat suppliers.** I considered this analysis necessary because policymakers often propose to apply a unified price formula. In my opinion such a unified price formula, a model of factors influencing the price can not be formulated due to the large number of district heat suppliers, and their specific characteristics. Moreover, the opportunities to formulate homogenous groups are limited. In case of a successful cluster formation it would be worth considering the building of a unified price model for each cluster. But if we do not manage to form significantly different clusters, building a price mechanism can not be a realistic goal even for clusters.

The above described conceptual model of the research is visualised on the Figure 2.



Source: own construction

Figure 2 Conceptual model of the research

5. DEFINING THE CONTENT OF THE FACTORS FEATURED IN THE MODEL

In order to make sure that there will be a unified understanding of the research results I consider the clarification of the most definitions used and the introduction of the derived information's specific content necessary.

Based on the Law XVIII. year 2005 I accept the following ***definitions:***

- *District heat generation:* is the generation of district heat (heat energy) in a facility for heat generation.
- *District heating service:* is the transfer of heat to customers, following heat generation (I will use it as synonym for the expression *heat transfer*).
- *District heating:* is district heat generation and district heat service together. The expression district heating will be used in another meaning too, for naming the type of heating as such.

The content of the analysed (calculated) elements for return requirement

1. *Direct cost per unit of generating heat energy.*
   - In case of own production: *The (extended) direct first cost of heat generation* (traditional direct cots and the proportionate part of general plant cost (fixed cost) for a unit of generated heat energy)[2]
   - In case of heat purchase: *the specific cost of heat purchase (per unit)*[3]
   - In case of a combination of heat generation and heat purchase: *weighted average of the direct first cost of heat generation and the specific cost of heat purchase.*
     Weights: the share of heat quantity from own heat generation and purchase.

2. *Specific direct cost of district heating service (heat transfer):* the specific direct cost of transferring the heat to the customers[4]

3. *=(1+2) the (extended) direct cost of district heating:* the sum of direct first cost of supplying heat energy and the specific direct cost of heat transfer.

Information derived from customer prices:

- *The GJ based, specific price of district heating:* Due to the wide variety of pricing mechanisms and measurement units applied it was necessary to introduce a standard measure for the price of district heating, a specific, GJ based price (Ft/GJ). This shows the price of district heating paid by the customers.
- *The annual district heating cost of an average flat:* is the sum of the base price for an average flat and the annual heat price and the price for warming the water.

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[2] *Direct cost of heat generation:* the cost of primary energy sources used, repair and maintenance cost and depreciation of heat generation facilities (own property power plants, furnaces, boiler rooms, gas engines, buildings for heat generation, etc), wages, social security contributions and other personal cost of those employed in heat generation and other cost related to heat generation.

[3] *Cost of heat purchase:* performance price, energy price and supplementary water price of the purchased heat.

[4] *Direct cost of district heating service (heat transfer)*: electrical power needs of network operation (for circulation) depreciation, repair and maintenance cost of heat transferring facilities (network of pipelines, heat centres, heat pumps and other heat transferring devices), wages, social security contributions and other personal cost of those employed in heat generation and other cost related to heat transfer, the cost of loss in heat and supplementary water in the system and the other cost related to heat transfer.

6. HYPOTHESES OF THE RESEARCH

I formulated the following hypotheses on the logic of the conceptual model, applying my knowledge on the theoretical and pragmatic literature:

Elements of the return requirement and the factors influencing these	Direct first cost of supplying heat energy	*H1a The price of district heating and the significant differences in it are determined by the type and price of primary energy resources used. The cost heat generation can be decreased by the application of alternative primary energy sources, despite this we can not except fast spread in their use.*
		H1b The liberalisation of natural gas market has not brought about fully the expected competition and decreased price of natural gas, hoped for as its consequence. The purchase price of natural gas depends primarily on the bargaining position of the district heat suppliers.
		H2a Combined heat- and power generation has beneficial effect on the price of district heating but the extent of the advantages can differ with the ownership of the facilities.
		H2b The reform subsidy system of combined heat- and power generation in process now can be expected to have a negative influence on the price of district heating, but the present subsidy system can not be maintained without changes either.
	Specific direct cost of heat transfer	*H3 Depreciation makes up a significant share of the specific direct cost of heat transfer because of the large network needed for it. The type and age of pipelines, the loss in heat in the network and network density are decisive factors of the direct cost of heat transfer.*
	Price structure of district heating	*H4 The price pf district heating is primarily determined by the direct first cost of district heating. The share of supplying the heat energy constitutes a larger of the direct first cost then the specific direct cost of heat transfer.*
The way of securing return	The context of price system and cost structure	*H5a District heat suppliers generally aim to apply a price system which represents a realistic cost structure, but the share basic price for the inhabitants is smaller.*
	Applied price mechanism	*H5b The applied price formulas of the district heating companies correspond to the requirements of the price cap regulation method.*
Further parts of the research	Factors influencing the annual heating cost of an average flat	*H6 Hungarian district heating systems have several, inherited technical- construction problems, and the insulation of flats is usually very poor. This increases the heat consumption of flats and due to this the annual heating cost of an average flat will be higher. Higher district heating prices work as an incentive for saving heat.*
	The opportunity to form clusters	*H7 Due to the specific nature of district heating companies the possibilities to form homogenous groups of them is very limited. Based on the characteristics of heat transfer it impossible, while based on the methods of obtaining heat and the combined- or not combined nature of heat generation it is possible to cluster them to homogenous groups.*

7. RESEARCH METHODS

I have done the analysis by using *simple descriptive statistical methods* (*frequency distribution, average, deviation, minimum - maximum values, median) and multivariable statistical methods (correlation analysis, regression analysis, cluster analysis and factor analysis).* In the course of the analysis I considered the significance level of 5 percent as relevant. I used SPSS 16.0 statistical software and Microsoft Excel for processing and analysing the data.

Data bases

Besides mapping the relevant literature I pursued primary research. The following data bases stood at my disposal for conducting my research:

- The data bases of the Hungarian Energy Office and the Trade Association of Hungarian District Heat Suppliers, which consist mostly of technological and natural unit based data. Besides the technological information, the Financial Reports of the years 2007-2008 and the consumer prices between 2001 and 2008 stood at my disposal.
- I have also conducted a questionnaire-based survey in terms of district heating suppliers because I needed information on the management for achieving the aim of my research.

The attributes of questionnaire-based survey conducted

I have conducted a questionnaire-based survey of Hungarian district heating suppliers in order to analyse the factors influencing the price of the service. District heat supply is available in 92 settlements of Hungary. 85 district heating suppliers got the questionnaire covering 99 percent of the flats having district heating.

Some questions of the survey concerned the technological and management (mostly cost) data of firms while others aimed to map the management's opinion. For the latter the application of Likert-scale seemed to be the best.

Due to the limited length of the questionnaire to be sent out we had to eliminate several questions which could have contributed to gaining deeper insight into factors influencing the price of district heating.

The questionnaire was sent out in January, 2009. The requested data applied to the last enclosed year, 2007. The questionnaire was returned by 27 companies. This gives a 31.76 percent return rate. The number of flats supplied by the answering firms is 418 016 (650170 flats in 2007[5]) which takes 64.3 percent of all flats supplied with district heating. The analysis of direct cost structure could have been carried out properly only in case of 15 companies due to the deficiencies of the district heating suppliers' registration systems. This means 17.65 percent of the surveyed district heating suppliers. It also means 55.1 percent coverage of the flats supplied with district heating.

[5] According to the Hungarian Energy Office

8. NEW AND NOVEL OBSERVATIONS OF THE RESEARCH

The new and novel observations of the research will be introduced by the logical of the conceptual model.

8.1. Major observations on the elements of the return requirement and the factors influencing them

According to the previously described theory, the primarily determinant of the price of district heating is the return requirement on the activity. The return requirement was analysed based on the price structure. The major observations on the elements of the return requirement and the factors influencing them are the following.

8.1.1. The effect of the type and price of used primary sources of energy on the price of district heating

District heat supply is a very energy-intensive activity. I analysed the Hungarian district heat suppliers' structure of primary energy sources used and the direct cost structure of heat generation.[6].

Mainly natural gas is used as energy source for generating heat in Hungary. According to the data of the Hungarian Energy Office the structure of energy sources used for heat generation has been transforming through the years. The use of natural gas had been dominant even at the changing of the regime (58.9 percent), and the rate of this amounted to 82.8 percent by 2005. In 2007 the rate of natural gas decreased somewhat though compared to 2005, but it still represented a significant 78.27 percent share among the used energy sources.

According to the Hungarian Energy Office's data of 2007, 64 district heating supplier companies of those which operate on Hungary's 92 settlements being connected to district heating, generate (or purchase) heat based solely on natural gas. The share of natural gas as a primary source of energy is above 92 percent (in case of their majority even above 96 percent) in case of another 10 companies. 82.4 percent of flats that are supplied with district heating are covered by these two groups. The share of natural gas used in district heating is outstandingly high. This indicates that the price of this source of energy is one of the most decisive factors influencing the price of district heating supply.

The survey regarding the structure of district heating's direct cost price[7] has also affirmed the cost- and hereby price formative function of natural gas energy source. Looking at its degree and its tendency, the heat generation's direct cost has been determined in the highest degree by the natural gas cost needed for generating one GJ heat quantum.

Positive strong correlation[8] has been shown between the heat generation's direct cost price and the natural gas cost needed for generating one GJ heat by correlation analysis between certain components of the heat generation's direct cost structure and the heat generation's direct cost price.

According to the single elements of cost's percentile distribution (pursuant to aggregated average), natural gas cost runs to the biggest share, covering on the average 69 percent of the heat generation's direct cost structure. Positive correlation has been shown between the heat generation's specific direct cost, heat price and the specific GJ-based price of district heating.

The use of natural gas as fuel had been spread more and more widely because of its fire technological advantage. Russian natural gas being given to the country for a remarkably low price

[6] The analysis of the structure of primary energy sources used was done for the entire population of Hungarian district heat suppliers. The analysis of the cost structure of heat generation was possible only in case of 12 district heat suppliers, but this sample still covers 55.3 percent of the Hungarian district heated flats.

[7] Data were available only for 2007 and for a narrower sphere of district heating suppliers (but the analysis still covers 53.3 percent of flats supplied with district heating).

[8] (Pearson corr: 0.897, sig.: 0.000)

and in unrestricted quantity before the changing of the Regime also contributed the escalation of this process. In addition to this, the prices of natural gas had been kept at an artificially low level due to social reasons by domestic policy. High world market-prices are more and more dominant in Hungary as well as a result of the persistent and drastic growing tendency of the natural gas's world market-price, the changing of curb market formula of natural gas price, and also the gradual alteration of the domestic natural gas-policy. District heating suppliers are also stricken by the distortions of the domestic gas price-system. Based on these it has become obvious by this time that one of the most expensive energy sources is natural gas and those district heating supplies that are running merely or dominantly on a natural gas basis can generate or purchase heat for an exceedingly high price.

The remarkable dominance of natural gas-based heat generation and the disadvantages arising from it have brought on the analysis of alternative energy sources' possible uses in district heating. I have been analysing the impact of alternative energy sources on heat generation cost and charges.

The use of alternative energy sources takes favourable effect on the cost of heat generation and hereby on the price of district heating. Heat generation's direct cost was lower than average in case of those companies which use other energy source beside natural gas.[9] The service of those district heating suppliers which apply alternative energy sources is usually cheaper.

I have tried to approach the problem from a different perspective considering that this statement does not rest on significant coherence. I have analysed the annual average district heating cost that is typical of the settlements according to the Hungarian Energy Office's holistic database of 2008. I have illustrated the data by the help of *Box-plot diagram* which marked five outstanding rates. All but one of the five companies which have salient annual district heating cost marked out from the other suppliers with the fact that their annual district heating cost are substantially lower. The four companies which have salient low annual district heating cost differed in numerous parameters; however, one very important similarity was obtrusive. The share of natural gas's use was infinitesimal in all four settlements.

Most likely this causes the fact that the mentioned companies can work on much lower fares, and the specific price of district heating is also much lower in their case.

In connection with alternative energy sources, beside the advantages I have also analysed the emerging disadvantages and the limits of their spread. Empirical data did not stand at my disposal so I have summarised my relating observations based on the literature.

The advantage of district heating being able to generate heat by using any types of energy sources and transferring it to the consumers can not be utilised in Hungary today.

The analysis supported Hypothesis *H1a*.

T1a The fact that 81 percent of district heating supplier companies (covering 82 percent of the supplied flats) generate heat solely or dominantly (over 90 percent) by using one of the most expensive energy sources, natural gas, or they buy heat generated on natural gas base (according to data of 2007) plays a decisive role in the high price of Hungarian district heating. Due to the not adequately over thought economics- and energy policy conception, prevailing (mainly natural gas based) technologies in heat generation determine the structure of energy sources used in district heating for a longer period. The use of alternative energy sources has a positive effect on the cost of heat generation and on the price of district heating; however, their quick inland spread can not be prognosticated. Their gradual spread can be expected through the depreciation of conventional technologies and their modernizing change.

[9] Covering 53.3 percent of flats applied with/having district heating (according to data of 12 companies, but the sample still covers 55.3 percent of the Hungarian district heated flats)

8.1.2. The effect of the liberalisation of natural gas market on the price of district heating

The dominant role of natural gas in the primary energy source structure of district heating made it necessary to evaluate the effects of the liberalisation of natural gas market on the price of district heating. In the questionnaire the respondent were asked to evaluate their experiences on the free market compared to the public service on a five steps Likert-scale for the years 2007-2008[10]. The average of the points given was positive for all aspects, which means that respondents generally evaluated the opportunities supplied by the free market as positive, but based on the responses the advantages decreased from 2007 to 2008. The same tendency was supported by the following examination too. The question on the differences in purchase price between free market and public market was given different answers in the different years. The average price difference in 2007 was -5.8 percent, which means a cheaper purchase, but in 2008 the difference decreased to -0.03 percent, and in 2009 it was +1.06 percent.

The survey supported the hypothesis that the bargaining power of companies is a major determinant for obtaining beneficial prices. Different companies reported different price differences. The companies with better bargaining power were able to realise significant benefits even among worse circumstances, while companies with worse bargaining positions were only able to realise smaller advantages at the beginning. The significance of bargaining positions was confirmed by the fact that different customers of the same gas supplier had different contract conditions based on the data supplied by the respondents. The analysis supported hypothesis *H1b.*.

T1b Competition in the natural gas sector which was expected from the conversion of the structure, materialized only to a limited extent. Vertically integrated transnational actors have emerged. The market dominancy of these is ordinary today. The interest vindication ability of district heating sector is slight in this situation. The extent to which companies are able to make use of the possible advantages of the free market primarily depends on the bargaining positions of the companies. Obtainable advantages decreased from 2007 to 2008.

8.1.3. The effect of the combined heat- and power generation on the price of district heating

Combined heat and power (CHP) generation (or cogeneration) was granted high importance in district heating and electricity-production due to the primary- energy saving opportunities which can be gained based on them. The benefit of combined heat and power generation appears in different ways in the pricing of district heating though, depending on whether the production is based on own capacities or on a third party.

In case of those companies which applied a technology allowing for combined heat- and power generation, the benefits of cogeneration can clearly be shown[11]. The own capacity combined heat- and power generation was shown to be in significant negative relationship with the rates, the GJ-based specific price and also with the specific direct cost of heat generation. This means that those district heating suppliers which pursue own capacity based combined heat- and power generation had lower specific direct cost and rates. As a 2008 survey covering all the district heating suppliers also confirmed, those district heating suppliers which are involved in combined heat- and power generation in any form have slightly lower GJ-based specific prices on average. The specific price of district heating is the lowest in the group the members of which pursue exclusively own capacity based combined heat- and power generation. This context seems to justify the hypothesis that the presence of combined heat- and power generation in district heating supply

[10] Respondents gave their opinions on a scale ranging from -2 to +2. Choosing the answer option -2 meant that company regards the opportunities on the free market significantly worse than the public market, 0 meant that there is no significant difference between the two options while +2 meant that free market is significantly better than public market.

[11] 27 companies, approximately 32 percent answering rate, 64.3 percent coverage relative to the number of flats being supplied by district heating

has a favourable impact on the prices of district heating. This is especially true if the benefits arising from cogeneration are realised by the district heat supplier.

In the open question of the questionnaire I was looking for the answer to two major problems of purchasing heat from external source. First, the pricing mechanism of purchased heat in the context of the heat producer and the district heating supplier was addressed. Second, the problems of distributing the profit of third-party (accomplished with private equity involvement) combined heat- and power generation. In the aspect of the open questions, companies almost without exemption reacted to the second question.

The variety of answers given by the companies to the open questions lets us deduce that in the opinions of the district heat supplier companies the price of purchased heat and so from the aspect of district heat supply prices too, the distribution of the combined heat- and power generation's profit between the heat generator and the heat supplier is a cardinal question.

In case of purchased heat, combined heat- and power generation can also have benefits – similarly to own cogeneration –, but the extent to which this benefit can be exploited is much smaller. This hints at the fact, that heat generators do not or not justly share the benefits of cogeneration with district heating companies.

District heating suppliers are concerned with the opportunities to solve this problem. The analysis proved that hypothesis *T2a is true.*

T2a Combined heat and power generation has a beneficial effect on the direct cost of heat energy supply, and on the price of district heating. in case of the own property combined heat and power generation these beneficial effects are more significant, the (direct) cost of heat generation and price level of the service is lower in case of these companies, than the average. In case of heat purchase heat generators use their (characteristically) monopolistic situation do not, or not properly share the benefits of cogeneration.

The advantages of cogeneration can primarily be attributed to the subsidy system in force today. A problem of the present subsidy system is that the about ten billion forint subsidy is paid by the consumers of electric power consumers in the end, while the benefits of it can not reach the final consumers of district heat consumers. The external heat generators can just keep the profit and give very few of it to the district heat suppliers. It is a debated question whether and to what extent it is reasonable to subsidy cogeneration. Theoretically, in the period after the investment was returned it should be able to stand on its own based on its efficiency. The question emerges if gas engine technology is not able to survive without subsidies, was it reasonable to give incentive to its spread via a not well-considered subsidy system. Because of the unfavourable circumstances which evolved on electric power market, a deeper analysis of this question would be necessary.

Regarding t*he present reform of the subsidy system* the basic problem is that after the subsidy will be withdrawn, a free market price will be applied to electric power on the electric power market instead of a guaranteed purchase price. So while electric power will be sold on free market price on the electric power market, heat will still be sold on a regulated market. The free market price of electric power in the present (2010) economic situation is rather low, due to the fall back in industrial consumption and the resulted decrease in the demand for electric power. In case of those companies which have own property cogeneration, the unfavourable situation on the electric power market can result in a loss in the operation of gas engines and the necessity to return to furnace based technologies can emerge. In case of those companies which purchase heat from external heat generators several problems can emerge. If the net benefit of energy generation was subtracted from the billed basic price in the fixed price formula according to the conditions settled by the heat generator and district heat supplier, the price of heat, and via that the price of district heating will increase, as after the changes in the regulation come into force, this cross-financing will not work anymore. Another factor increasing the price of district heating can be that power plants (heat generators) – if they are not directly involved in district heating - will want to increase their

competitiveness on the free market for electric power vie higher district heating prices, or try to compensate for their lost profits on selling electric power. This will be a major pressure on district heat suppliers as the regulated price for inhabitants will be maintained.

T2b The subsidy system for cogeneration being used until December 2010 has not reached its goal. In some cases it even subsidized the spread of not properly efficient construction which individually are unable to survive, while the benefits of the subsidy have not reached the consumer of district heating. The present reform of the subsidy system will have a negative effect on the price of district heating (both in case of own-property cogeneration and in case of heat purchase). It is necessary to reconsider the subsidy system but it can only be efficient when accompanied by an objective regulatory- and control system. Strict regulation would be needed for the price of purchased heat, based on the theory on sharing the cost of twin products. (Hiding the profit by using transfer prices could still not be avoided in this case.)

8.1.4. The factors determining the specific direct cost of heat transfer

The second phase of district heat supply is heat transfer, which means the transfer of generated/purchased heat to the customers. The cost structure of heat transfer is different from the previous. According to the expectation depreciation takes a large share of the specific direct cost structure of heat transfer due to the large extent of the pipeline network. Besides, the type and age, the loss of heat in the network and network density can be regarded as decisive factors for the direct cost of heat transfer.

I analysed the structure of specific directs cost of heat transfer for the year 2007[12]. Depreciation accounted for approximately 29 percent of the direct cost of heat transfer. This share is smaller than expected. The specific direct cost of heat transfer is in a significant positive relationship with the loss of heat in the network[13]. In order to map further relationships I distributed the respondents to two groups, the first group consisted of the district heat suppliers with a lower than average specific heat transfer cost, while the other group consisted of those with above average values. Averages were calculated for the two groups for each factor. In case of the companies with lower than average heat transfer cost the share of newer, more modern pipelines were higher, the average age of pipelines and the loss of heat the network were lower. In case of distinct heat transfer facilities we meet lower depreciation rates where the cost of heat transfer is lower (on average). The specific heat supply cost of companies with a higher network density is lower on average than in case of towns with smaller network density. The first part of hypothesis H3 (on the high share of depreciation) was not supported by the analysis, the second part of it on the determinants of heat transfer cost were proved during the analysis.

T3 Despite the large extent of the pipeline network, the share of depreciation is smaller than anticipated in the specific direct cost structure of district heat transfer (approximately 29 percent in 2007). This can be explained by the low depreciation keys used for pipelines and the large share of already depreciated heat transfer facilities. In case of companies with a higher share of new, modern pipelines depreciation is higher but the loss of heat in the network is lower. This has a beneficial effect on the specific cost of heat transfer. In case of towns with a larger network density the specific heat transfer cost is lower.

[12] Data on 15 companies, covering 55.1 percent of the flats with district heating
[13] (Pearson corr.: 0,803, sig.: 0,000)

9. PRICE STRUCTURE OF DISTRICT HEATING

Correlation analysis showed a significant positive relationship between the GJ based price of district heating and the overall specific direct cost of district heating[14]. If we analyse the specific cost of district heating without details this relationship can be found in case of 27 companies. To filter the effects of other factors and demonstrate the relationship between the two variables I performed a *regression* analysis. The proportion explained by the regression function is 0.918 (Adjusted R Square), which suggests that 91.8 percent of the variance in the price of district heating can be explained by the direct first cost of district heating. Based on this we can see that general operation cost and profit content influence the price of district heating only to a smaller extent.

Pursuing a separate analysis of the direct cost, significant positive relationship can be found between the direct first cost of securing the heat and the heat prices. Those district heating suppliers in case of which the direct first cost is higher, heat price will be higher[15]. The specific direct cost of heat transfer was not in a significant relationship with any elements of the prices. Approximately three quarter of direct cost of district heating supply is the cost of securing heat energy, and only 25 percent is the specific direct cost heat transfer (based on the data of the year 2007). So the direct first of cost securing heat energy plays a decisive role in the price structure of district heating.

In case of district heat suppliers we must view the profit rates with some considerations. The majority of district heat suppliers seem to apply cost-based pricing methods, maybe a smaller loss can be realized, or smaller profit can be calculated in the price.

T4 The dominant factor influencing the price of district heating is the direct cost of the activity, more specifically the direct first cost of securing heat energy which covers 75 percent of the direct cost structure. Compared to this, the share of the specific direct cost of heat transfer is only 25 percent. The differences in the price of district heating can be explained to a significant extent (based on the data of the year 2007 in 91.8 percent) by the differences in the direct cost of district heating. General operation cost and expected profit do not play a significant role in the price structure of district heat supply.

9.1. The methods of securing returns – the relationship between the price system and the cost structure

I analysed *the place of realizing different elements of the returns requirement* in the distinct price elements[16]. Based on these we can assume that some of the elements to be paid for do not have a standardised place in among the elements of the price structure. Almost half of the companies' accounts for these cost elements in the basic price while the rest among the heat price elements.

I also analysed the ratio of base- and heat price for inhabitants and for the whole population of customers. In 2007 30 percent of the price billed for inhabitants was base price while 70 percent was heat price. Calculating the same for the whole population of customers the ration was 39-61 percent. It can be seen that this case shows a higher share of base price than the inhabitants'. So, for inhabitants district heat suppliers opt for a lower share of base- and a higher share of heat price.

I compared the ratio of base- to heat price to the ratio of fixed- to variable cost. In case of the 15 analysed companies the ratio of price elements is harmonised with the ratio of fixed to variable cost. Billed base price covered fixed cost while billed heat price covered variables cost. The analysis supported hypothesis H5a.

[14] (Pearson Correlation=0.542, p=0.037) Data of 15 companies, covering 55.1 percent of the flats with district heating

[15] (Pearson corr. 0.653; sig: 0.008) Data of 15 companies, covering 55.1 percent of the flats with district heating

[16] I made an overview of this in case of 36 district heat suppliers, partially based on the answers of 27 companies and partially on the answers of the 36 local governments' regulations on " district heating service and setting the maximal regulated prices for inhabitants" (in 2007 data for this number of companies was available)

T5a We can see differences among district heat suppliers in which elements of the price covers which return requirement elements. Companies, on the level of the population of their customers try to fit the ratio of base- to heat price top the ration fixed to variable cost. Due to the negative feedback of the customers they can not maintain this ratio for the inhabitants so in their case a lower base and higher heat price is realized.

I analysed the pricing mechanism of 36 companies based on the regulations of the local governments. By this analysis I tried to answer the question whether price cap regulation is widespread for determining the price of district heating.

The majority of the district heating supplier companies applies method of calculating base prices annually. In case of applying price formula the praxis of district heating suppliers differ, but we can find similarities in base price formulas. Applying consumer and producer (mostly industrial) price indices appears in case of almost each formula as a correction element. Consumer price index plays a larger role in each case; many times the difference is significant. Using the consumer price index pops up several problems though, among others the prices of the special resources used by the district heat suppliers do not vary together with the consumer prices. In case of district heating service industrial or maybe construction industry domestic price indices would be an appropriate factor for determining the increase in the price level.

The changes in the wage and social security contribution, changes in depreciation can be regarded as simple shifts in the company's cost structure and not the application of a real price index. We can suspect that the ratio of these cost elements within the formula is larger than the actual (and reasoned) share of this cost in the price structure.

Mainly two types of formulas are applied for determining heat price as well. First, a formula on the content of the heat prices itself; second, a summary of the opportunities to realize the changes in the heat price. This latter type is more widespread. Very different mechanisms are used to determine the new heat prices at different district heat suppliers; it is rather difficult to find common elements in the formulas. A common characteristic is that settling the new heat price happens via a correction of the base heat price. The change in the heat price basically follows the change in the energy prices but several others factors can be found among the correction factors, varying from company to company. A basic problem of the formulas is that instead of the basic price normally only the price of the base period is featured, which can mean an accumulation of distortions from year to year. Base price should be determined in a way which secures its applicability as a fixed formula for the whole period. Hypothesis *H5b* can only partially be proved.

T5b District heating companies usually use the method of calculating base prices annually. In case of applying price formulas they use structured price indices to control for inflation-related needs to adjust prices. The increase of heat prices is basically driven by the changes in energy prices, but other correction factors appearing in the formulas applied by different companies differ to a large extent. The opportunities to increase prices determined in the formulas are often based on incorrect mechanisms, and conserve, or even accumulate the distortions of the base period's prices. The majority of the price formulas applied in the district heating service do not meat the requirements of the price cap regulation.

9.2. Factors influencing the aggregate annual heating cost of an average flat

Besides analysing the factors influencing the price my research also focused on the factors influencing the aggregate annual heating cost of an average flat. Besides the GJ-based specific price of district heating this is determined by the flat's annual average heat consumption.

In order to visualise the relationship among the aggregate annual heating cost of an average flat, the GJ-based specific price of district heating and the annual average consumption of an average flat – to enable the visualisation of the three variables on two dimensions – I performed a cluster analysis and made up four clusters of the factors influencing the annual average district

heating cost of an average flat. I show the answers of the companies in coordinate system of annual district heating cost and GJ-based price of district heating, indicating the affiliation to clusters by different colours on the figure. Taking a look at the schedule it can be concluded that the higher price of district heating works an incentive to decrease consumption. As a result of this, even with higher unit prices of district heating, the annual district heating cost can be lower for an average flat.

The type of the heating system determines whether the temperature – and so the heat consumption can or cannot be controlled in a flat. Generally spoken, in case of about 82 percent of all flats, there seems to be some solution to control the temperature.

Correlation analysis showed a significant negative relationship between the share of flats renovated in the panel programme and the annual district heating cost of an average flat.[17] This allows us to conclude that the companies serving a higher share of the renovated blocks of flats supplies at a lower average annual district heating cost. The annual average heating cost a renovated flat is approximately 33 percent lower than that of a not renovated flat. Data was available for the share of renovated flats (either in panel- or programmes) in case of 20 settlements. Based on this database out of the 370 424 flats supplied by district heating only 64 824 was renovated in the panel program which is a share of about 17.5 percent. (It is probable that the share of renovated flats would be similar in case of the other settlements too). Hypothesis *H6 was proved in the analysis.*

T6 The aggregate annual heat consumption of an average flat is lower in those settlements where the price of district heating is higher because of the need for saving. Despite the higher unit cost for district heating the annual average heating cost of an average flat can be lower. The average annual heating cost is lower in those settlements where the share of renovated flats is higher. In case of a renovated flat the cost of district heating is significantly lower due to the better insulation and the ability to control the temperature. Despite these benefits only a small fragment of flats (until 2007 only 17.5 percent) used the opportunities offered by panel programme for renovation. The reason for this can be the own capital need and the requirement for the dominant majority of the flats in the block to agree to participate in the programme.

9.3. Major observations on the opportunities for clustering out of price-regulatory point of view

I wished to analyse whether cluster-based price models can be accomplished or not by analysing the opportunities of clustering the district heating companies (primarily to deny this option)[18]. Clustering district heating companies out of price-regulatory point of view has limited opportunities because of their numerous specific characteristics according to my assumption. Besides the different characteristics of district heating companies settlements also show several specific characteristics, for example network density, soil (but local government's policy, income situation of the inhabitants could be mentioned as well) and all these differences create significantly different conditions for the operation of the companies. Starting with these assumptions clustering district heating companies based on their methods of heat transfer is not possible. Based on technical parameters, primarily on the number of supplied flats, the method of securing heat energy and the combined (or not combined) nature of heat generation we are more likely to be able to cluster them.

As a first step I tried to formulate homogenous groups with *cluster analysis*. After several unsuccessful attempts I chose an *artificial way of formulating clusters*. Each district heating company received a code with three digits, where the first digit stood for the size, the second for the share of own heat generation while the third for the combined or not combined nature for heat

[17] Pearson Correlation: -0.460, p=0.047.

[18] Because of the numerous specific characteristics of district heating companies I did not consider the opportunity of creating a unique price model for all of the companies.

generation. District heating companies were dispersed to 32 code-variations based on these three characteristics. In order to limit the variation further I introduced a new limit. Based on this 10 groups of district heat suppliers were formulated. With this method I managed to put 56 companies to one cluster. The other 28 companies can be regarded as rather unique cases based on three relevant characteristics; they can not be clustered into one group with regards to these three characteristics.

I pursued an analysis to investigate whether there are any similarities within these groups and significant differences between these groups with regards to the prices (based on the data of the year 2008). The context is visualised by *Box-plot diagrams*. In case of half of the groups it was proved that there were no significant differences within the groups in the annual average district heating cost of the average flat. According to my assumption the companies belonging to these groups are similar to each other in their other characteristics too. But in case of the other half of the groups I found major differences in the specific heating price and in the annual heating cost too. In case of these groups it is probable that their companies differ in some of their other characteristics as well. When making a more detailed analysis, with the elimination of those companies which differed to a large extent from the mean in the group, the differences within the groups became smaller. I could only pursue this comparison for the prices and the data derived from them. it would have been important to analyse how the direct cost of district heating varies within the groups as the variables based on which clusters were formulated mainly influence the direct cost of district heating. Unfortunately this data was available only for 27 companies. The analysis supported *hypothesis H7*.

T7 Due to the differences in the characteristics of the settlements no homogenous groups can be formulated based on the heat transfer characteristics of district heat suppliers. The clusters based on the size, the way of securing heat energy and the combined nature of heat generation can not be regarded as entirely homogenous either. The groups only show significant differences in the parameters based on which the clusters were formulated, and the members of the groups differ in several other characteristics. Based on these findings it can not be a realistic goal to make a standardised price formula for clusters of district heating companies either.

I formulated all the hypotheses, tests and the theses of my research according to the logic of the conceptual model.

1. táblázat

		H	Evaluation	T
Elements of the return requirement	Direct cost per unit of supplying heat energy	H1a	*Proved→*	T1a
		H1b	*Proved →*	T1b
		H2a	*Proved →*	T2a
		H2b	*Proved →*	T2b
	Specific direct cost of heat transfer	H3	*Only partially proved →*	T3
	Price structure of district heating	H4	*Proved→*	T4
The way of securing return	The context of price system and cost structure	H5a	*Proved→*	T5a
	Applied price mechanism	H5b	*Only partially proved →*	T5b
Further parts of the research	Factors influencing the annual heating cost of an average flat	H6	*Proved→*	T6
	The opportunity to form clusters for price regulation	H7	*Only partially proved →*	T7

10. POSSIBLE APPLICATIONS OF THE RESEARCH RESULTS

The primary result of the research is the comprehensive picture it gives on the factors influencing the price of district heating, the causes behind the price differences among district heat suppliers and shows that there are several other factors influencing the heating cost of an average flat. The analysis on the opportunities to form homogenous clusters showed that district heat suppliers can not be clustered because of their specific characteristics so formulating a standardised price formula can not be a realistic goal either.

In my Dissertation I endeavoured to map the questions and issues influencing the price of district heating entirely and give an analysis of the problematic questions from an economic aspect. I introduced the technical issues, the energy market and the regulatory environment with a focus on their economic effects. I also tried to accomplish a study on district heating aggregating and synthesising theoretical, methodological and pragmatic aspects.

My analysis contains valuable information for decision makers, controlling bodies and district heating companies as well.

The results of my research can be used as a basis for working out such a "price-control" analysis tool which could be used by control bodies to investigate whether the prices of district heating companies meet the legal requirements, considering the specific operation conditions of the companies too. My proposal for this is detailed in the Dissertation.

In my Dissertation I detailed the problems of the database standing at the control bodies' disposal. I proposed to formulate a more comprehensive database which would contain not only technical but also economic details.

The results of my research can also be applied in the education. The major results can be built in the lesson exercises of the subjects "economics of public service companies" and "Public service economics", and so can be used to improve the teaching materials of my Institute,

The research is not over at this point. The questions and unsolved issues found during the process of the research show new directions of research which I was not able to follow with the database standing at my disposal in the time period when I wrote my dissertation. My objective is to pursue further research with a scientific and pragmatic orientation on these research gaps.

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