Governance variety in the energy service contracting market

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Abstract

There is a surprisingly high variety of actors involved in the supply of energy service contracting arrangements. Based on an empirical record of approximately 2,500 contracting projects in the domain of space heating in Germany, the paper analyses specialisation patterns of contractors. An econometric model is used to test hypotheses derived from transaction cost economics, which contractor type should be expected for which kind of contracting project. According to our results, if physical, site and human asset specificity are high, governance modes are preferred, for which contracting represents a downward integration of business activities along the value-added chain. This includes the supply of contracting by municipal utilities. More specifically, municipal utilities occur as superior suppliers of contracting if combined heat and power is implemented, if the building served is connected to their gas grid and if it is a public building. This pattern could orient the development of contracting activities for utilities reconsidering their strategic position following the liberalisation of the electricity market.

1 Introduction

Energy service contracting is an organisational innovation for the supply of useful energy, e. g. of heat instead of gas. There is a high variety of actors involved in the supply of contracting arrangements, including e. g. specialised contracting firms as well as equipment manufacturers. This variety is surprising, because we would expect that seemingly homogeneous transactions are supplied under similar governance structures (Ménard 1996; Ménard, Saussier, 2000). Instead, we find a rather segmented market with characteristic specialisation patterns between different contractors. This paper investigates possible explanations of the variety of actors and the specialisation patterns with a particular focus on the role of municipal utilities. Transaction cost economics is used as the theoretical framework for the analysis as presented in section 2. It is the basis for formulating propositions to be tested in an econometric analysis. The empirical part of the paper starts in section 3 with a descriptive analysis of the specialisation patterns observed and some more information about the data used. Subsequently, section 4 explains the specification of our econometric estimation model for the choice of the appropriate contractor and presents the estimation results. In the conclusions, we discuss implications for the further development of the energy service contracting market.

2 Theoretical background and propositions

Following Williamson, transaction cost economics focuses on the identification of a governance structure (or set of institutions and contracts) with incentive and adaptive characteristics, which minimises total costs (Saussier 2000b; Williamson 1985). In our research context, the different contractor types can be considered as specific governance structures for delivering the diffusion of contracting and of combined heat and power (CHP) plants. Transaction cost economics provides hypotheses, why one of the contractor types, e. g. municipal utilities, might be a superior or inferior governance structure in the contracting market. Which governance structure will be optimal depends on the prevailing determinants of the transaction costs. Three determinants of transaction costs are commonly distinguished: asset specificity, frequency and uncertainty. We expect these determinants – and consequently the optimal governance structure – to differ between the contracting projects.

Asset specificity represents the most intensely studied determinant and applies to "…durable investments that are undertaken in support of particular transactions, the opportunity cost of which investments is much lower in best alternative uses or by alternative users should the original transaction be prematurely terminated" (Williamson 1985: 55). It gives rise to appropriable quasi rents, i.e. the difference between the value of the asset in the transaction-specific use and the second-best use (Perry 1989). If asset specificity and quasi rents are high, transaction cost economics expects the exchange of goods to be governed by integrated governance modes designed to limit the hold-up risk and to avoid renegotiations (Saussier 2000a).

Different types of asset specificity are distinguished in the literature (Shelanski, Klein 1995; Williamson 1983). Site specificity concerns investments that allow the exploitation of a "cheek-by-jowl" relation. Physical asset specificity refers to relationship-specific equipment. It is large e.g. if an energy production plant is specifically tailored to the energy demand profile of a customer and immobile once installed and lower if the plant is mobile and suits the needs of other customers as well. Human asset specificity concerns transaction-specific knowledge created mostly by learning-by-doing. With respect to this determinant, municipal utilities may derive a competitive advantage relative to other contractors, because they have the data about the detailed energy consumption profile of their clients. Finally, dedicated assets refer to capacity expansions which are realised with a view to serving one specific client and which result in significant excess capacity if the transaction is terminated prematurely. They are an issue e.g. when it comes to the planning of electricity generation capacity.

The determinant of frequency originally draws on the notion of decreasing average costs but can also be linked to the development of competences through repetition and learning. Higher levels of transaction frequency provide incentives for internal organisation, because this mode makes it easier to implement specialised (transaction cost saving) governance structures (Williamson 1985). Concerning uncertainty, the theory's proposition is that, in the presence of high asset specificity, uncertainty will increase the probability for vertical integration. However, our data do not allow a further analysis of the latter two determinants.

We further need to specify the features of the competing governance structures. Two principal approaches have been followed in transaction cost economics, focusing on the degree of integration (Ménard, Saussier 2000) and on the completeness of the underlying contracts (Saussier 2000a) respectively. We follow the first approach. The analysis of the transaction cost determinants on the one hand and of the features of the competing governance structures on the other hand should allow us to identify competitive advantages of certain governance structures.

To conclude, we put up the propositions below. These which will be put into more concrete terms after having specified our variables (see section 4.3).

Proposition 1: If physical asset specificity (and site specificity) is high, an integrated form of governance is preferred.

Proposition 2: If human asset specificity is high an integrated form of governance is preferred.

3 Description of data and specialisation patterns

The econometric analysis is based on a representative sample of 2475 contracting projects in Germany, i. e. projects of supplying heat, taken from a database that is entertained by a professional association of contractors (the "Verband für Wärmelieferung"). In the year 2000 there were 480 contractors active in the contracting market, mainly in heat supply (E&M 2000). The database used in this study covers 149 contractors, i. e. around a third of all contractors in Germany. The projects were mainly initiated in a period from the 1990s, when the association was founded, until 2005. It provides data about the installed capacity in terms of thermal and electric power, the type of building served, the technology (boiler of combined heat and power), the fuel type and the number of completed projects by the contractor.

A client who is interested in contracting is confronted with a highly diversified market of suppliers. The alternatives comprise four types of contractors that are "specialized contractors", "municipal utilities", "real estate enterprises" and "other contracting actors" with a smaller market share including equipment manufacturers, consulting engineers, producers of measurement and control technology, as well as plumbers and engineers specialised in heating, ventilation and air conditioning systems. Figure 1 shows the share of each contractor type in the total number of contracts. Specialised contracting firms are the most important group, followed by municipal utilities and other contracting actors. This may be surprising, as other contracting actors are much more numerous than the other contractor types (almost 50 % of all contractors in our data base). However, they realise a considerably smaller number of contracts each when compared e. g. to specialised contractors (5 vs. 28 contracts per contractor on average). The real estate enterprises are mostly daughter firms of housing companies, of whom many belong to the public domain.

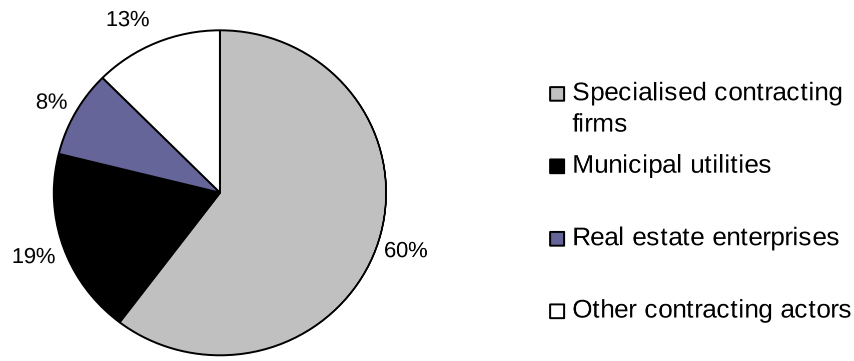

Figure 1. Share of each type of contractor in the total number of projects

Figure 2 depicts the different building types served. These can be divided into public buildings, including public housing, schools, hospitals, and other public buildings, on the one side, and private buildings. i. e. private housing, commerce and industry, on the other side. “Office buildings may be private or public.

Table 1 shows a cross tabulation between contractors and the type of building, which allows for a first overview of the specialization patterns in the contracting market. The results of a simple test for independence, the Pearson's chi-square test[1], suggest that contractors and building type are not independent. This is reflected by the chi-square probability of 0.000 which supports dependence between contractors and project types. In particular, the share of public building projects in the portfolio of municipal utilities (58 %) is significantly above the total share of public buildings (28 %). By contrast, specialised contracting firms are considerably less engaged in public building projects than average.

1 A chi-square probability of .05 or less is commonly interpreted by social scientists as justification for rejecting the null hypothesis that the row variable is unrelated - that is, only randomly related - to the column variable (http://www2.chass.ncsu.edu/garson/pa765/chisq.htm, 19.02.2007)

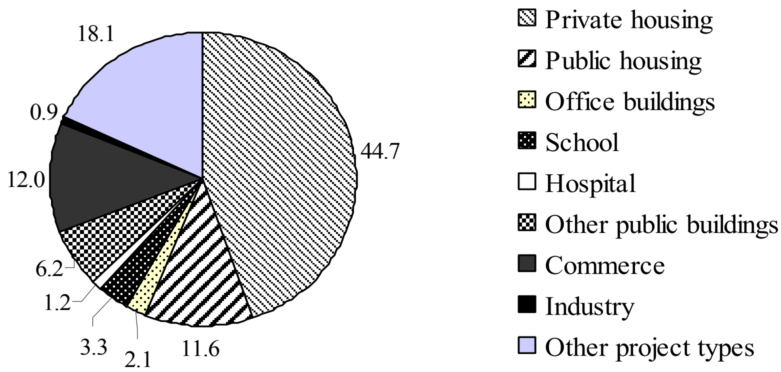

Figure 2. Building types

	Building types		
Contracting actors	**Public buildings (%)**	**Private buildings (%)**	**Total (%)**
Specialised contracting firms	21.16	78.84	100.00
Municipal utilities	57.94	42.06	100.00
Real estate enterprises	29.95	70.05	100.00
Other contracting actors	29.29	70.71	100.00
Total	28.14	71.86	100.00

Pearson chi2(3) = 139.3676 Pr = 0.000

Table 1: Specialisation patterns among contractors

4 Econometric model of specialisation patterns

In order to test the propositions deduced in the theoretical part of the analysis, a multinomial logistic model[2] is applied to assess the determinants relevant for the choice of the governance structures in the contracting market. For the regression analysis, contracts are taken as observations. The number of observations of the original database that contain enough information for the estimation process is 1048. For example, contracts that are classified by "Others" and “industry” with respect to building type served are not included into the regression analysis because the database doesn't provide detailed information about them.

4.1 Contractor choice as the dependent variable

As mentioned above, in this study, a contracting project can be carried out by four different types of actors. For municipal utilities, real estate enterprises and other contracting actors, such as equipment manufacturers, contracting represents a downward integrated business segment in the value-added chain. With respect to our propositions we, therefore, consider the choice of those contractors as a choice of a more integrated governance structure. By contrast, specialized contractors are exclusively engaged in contracting projects. We interpret them as a governance structure close to the market. In the multinomial logistic regression, specialised contractors are used as the comparison group. They are selected as the “base outcome” in

2 This model is generally suitable for analysing the relationship between a categorical outcome and the independent variables.

order to be able to compare the logistic coefficients and relative risk ratios of the regression.

4.2 Independent variables determining the choice of governance structure

In our model, the choice of contract with municipal utilities, specialized contracting firms, real estate enterprises or other contracting actors depends on physical and human asset specificity of the underlying investment. In order to test which one of the four categories of contractors are preferred as determinants vary, these exogenous variables are operationalised by dummies and continuous variables as follows:

4.2.1 Physical asset specificity and site specificity of investment

Physical asset specificity is measured in two ways using a dummy as well as a continuous variable. The data distinguish between different types of plants implemented in a heat service contracts – i. e. boilers or combined heat and power (CHP) plants, or a combination of both[3]. When installing a CHP plant, a certain knowledge about the site is necessary, for example the amount of energy used, the profile of heat demand throughout the year and the ratio of electricity and heat demand. This information is the basis for a client-specific technical concept, which is highly tailor-made to match those conditions. As a result, its value is very low for transactions with other clients (Ostertag 2003). We, therefore, argue that CHP plants represent a higher degree of physical asset specificity than boilers. In addition, site specificity of CHP plants is higher than for boilers. As heat and power are a result of co-production and efficiency is largest in the case of on-site consumption, the implementation of CHP is most successful, when a cheek-by-jowl" situation can be exploited. According to transaction cost theory this asset specificity of CHP favours integrated forms of governance to ensure the investment rents for the contracting parties. The data provides a dummy variable on CHP which takes the value one if CHP is established in the contracting project and zero otherwise.

The volume of investment is another indicator for physical asset specificity of investments. It is measured as a continuous variable and can be interpreted as the scale of the project. For larger investments an integrated form of governance should be preferred in the contracting market. As there is no data available on investment in contracting projects in monetary terms, installed capacity in terms of thermal and electric power serves as a starting point. This is weighted to reflect plant specific average investment costs per kilowatt. The resulting variable SIZE is a proxy without dimension, which reflects the absolute monetary investment volume.

4.2.2 Human asset specificity

There are two variables that measure human asset specificity. Firstly, the variable 'TYPE OF BUILDING' draws a link between contractors and clients or buildings respectively who are close to or belong to the public domain. This proximity hints to established relations between contractor and client which can serve as a "human asset" of particular value for exchanges between the two parties concerned. For example, municipal utilities are expected to be primarily specialized on contracting projects in public buildings as there exists an acquaintanceship between the trading partners if they are both in the public domain. There may be an overlap between the owners of the municipal utility and of the public building, for example a school. As there is data on several types of buildings including private housing, social housing, commerce, industry, schools, hospitals and other public buildings, the effects of an established relation on specialization patterns concerning the trading partner can be deduced. The information mentioned above is included into the regression equation as separate dummy

[3] A common technical solution is that the CHP plant provides heat at a low temperature level that can be used all the year through, e. g. for supplying warm water. An additional central heating boiler is installed to provide additional energy during cold days.

variables for each type of building[4]. In order to improve the estimation results, schools and hospital are combined as a dummy because they depict a small number of observations and are mostly public buildings.

Secondly, human asset specificity can be depicted by an information advantage of municipal utilities concerning their customers if they do not only own the electricity but also the gas grid. In this survey, they mostly do. In order to control for this advance of knowledge about gas consumption and hence heat demand, the dummy variable GAS as a type of fuel is integrated into the regression equation. It takes the value one if the project is supplied with gas and zero otherwise. According to proposition 2 integrated governance modes like municipal utilities are the preferred choice if gas is used for supplying heat.

4.3 Summary of model specifications

A summery of all exogenous variables and their characteristics is given in Table 2.

Variables	*Description*	*Min*	*Mean*	*Median*	*Max*
CHP	type of plant: 1= combined heat and power(CHP); 0= otherwise	0	0.023	0	1
SIZE	investment volume index	0.057	0.533	0.16	72
TYPE OF BUILDING					
PRIVHOUSE	1=private housing; 0= otherwise	0	0.552	1	1
PUBHOUSE	1: public housing; 0=otherwise	0	0.143	0	1
SCH/HOSP	1=school or hospital; 0=otherwise	0	0.055	0	1
OTHERPUB	1=other public facilities/buildings; 0=otherwise	0	0.077	0	1
OFFBUILD	1=office building; 0=otherwise	0	0.0264	0	1
COMMERCE	1=commercial building; 0=otherwise	0	0.148	0	1
GAS	type of fuel: 1= gas; 0= otherwise	0	0.668	1	1
FREQ	frequency - number of signed contracts of a contractor	1	65.686	27	377

Table 2. Descriptive statistics for the influencing variables

On the basis of the variable specifications, we can now also formulate our propositions more concretely. With the information above in mind they now become:

Proposition 1: If physical asset specificity is high an integrated form of governance is preferred. This means that municipal utilities, real estate enterprises and other contractors are more likely to be chosen than specialised contractors

- if CHP is implemented in the contract **(Proposition 1a)**.

4 Office buildings are omitted to avoid multicollinearity.

- If project investments as measured by the variable SIZE increase **(Proposition 1b)**.

Proposition 2: If human asset specificity is high an integrated form of governance is preferred. I. e.

- if there are previously established relations reflected in the building being connected to the gas grid, municipal utilities should be more likely to be chosen than specialised contractors **(Proposition 2a)**.
- In addition, municipal utilities and real estate enterprises should be more likely to be chosen for projects in public buildings than specialised contractors, because they are close to or belong to the public domain themselves **(Proposition 2b)**.

4.4 Results

For the interpretation of the regression results we refer to relative risk ratios instead of the logistic coefficients[5]. The advantage of these ratios is that they not only indicate the direction but also the level of the different effects.[6] A relative risk equal to 1 implies that the event is equally probable in both the base group and the group considered. A relative risk greater than 1 implies that the event is less likely in the base group. A relative risk less than 1 implies that the event is more likely in the base group. The regression results in terms of relative risk ratios are summarised in Table 3[7].

Regarding the effect of physical asset specificity on governance structures as measured by CHP, municipal utilities and real estate enterprises show significant relative risk ratios above unity. This confirms Proposition (1a) that integrated forms of governance are preferred to market oriented structures if physical asset specificity is high. For CHP- relative to non-CHP-projects, the chance for municipal utilities to win a contract against a competing specialized contractor would be expected to increase by a factor of 4 given the other variables in the model are held constant. For real estate enterprises compared to specialized contractors this factor is even higher, whereas the probability of being engaged in such a contracting project is lower for other contracting actors such as equipment manufacturers and consulting engineers compared to specialized contractors.

Another variable that implies physical asset specificity is SIZE. It shows a significant negative effect (i. e. relative risk rations below unity) for other contracting actors and real estate enterprises relative to specialized contractors as the dimension of the project increases. Thus, given a one unit increase in SIZE, the relative risk of real estate enterprises being engaged in a contracting project would decrease. If the size of the project increases contracting is expected to be done by specialized contractors rather than real estate enterprises or other contracting actors. For municipal utilities relative to specialized contractors no statement can be made because the relative risk ratio is not significant. However, the results suggest that Proposition (1b) is not supported because specialized contractors as suppliers of a market oriented service seem to be more likely as investments increase. A reason for the undetermined effect of SIZE for municipalities, that is expected to be significantly positive according to theory, might be partially due to tighter budget restrictions for municipal utilities compared to private actors. Ménard and Saussier (2000) argue, that such constraints can lead to the choice of a governance mode less well suited to the transaction.

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5 The logistic coefficients of the regression results depicting directions, positive or negative, of the different effects on contract choice are presented in Appendix 2, Table A.

6 For their mathematical definition see Appendix 1.

7 Base outcome: specialised contractors; Reference group for type of building (that is not included because of collinearity): commerce For more statistical details see Appendix 2, Table B.

	Relative risk ratios		
Independent variables	**Municipal utilities**	**Real estate enterprises**	**Other contracting actors**
CHP	3.998896***	14.39358***	.275928*
SIZE	.9491102	.0114238***	.5882531***
GAS	1.775419 (**)	.2311688***	.8712537
TYPE OF BUILDING			
PRIVHOUSE	.5350042(*)	1.750376	.2775838***
PUBHOUSE	3.397786**	9.599283***	.3447437***
OFFBUILD	2.313218	1.439309	1.353613
SCH/HOSP	3.495117**	.9288619	.651995
OTHERPUB	5.252138***	2.233624	1.812104(*)

Log likelihood = -961.55457 Pseudo R2 = 0.1190

Number of obs = 1048 LR chi2(24) = 259.72 Prob > chi2 = 0.0000

*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level, (**) Significant at a 15% level, (*) Significant at a 20% level

Table 3: Relative risk ratios of the multinomial logistic regression

Regarding Proposition (2a) on human asset specificity and the effect of an information advantage for municipal utilities reflected by the dummy variable GAS, a strong conclusion cannot be drawn because the estimated effect for municipal utilities is only significant at the 15% level. But the logistic coefficients exhibit the expected positive sign.[8] Therefore, the relative risk ratio of choosing a municipal utility against a specialized contractor, if the fuel is gas, indicates an advantage of municipal utilities because they mostly own the gas distribution system.

Proposition (2b) on human asset specificity which emphasizes an advantage of contractors with previously established relations is again supported by the data. The relative risk (or chance) of obtaining a contracting project is higher for municipal utilities than for specialized contractors if the type of building is a public rather than a private building. This is indicated by their relative risk ratios above unity for public housing (PUBHOUSE) and other public buildings (OTHERPUB). Looking at real estate enterprises, the high and highly significant relative risk ratio for public housing buildings catches the eye. This indicates a strong advantage for (public) real estate companies or their daughter companies in obtaining contracting projects for public housing compared to specialised contractors. The overall picture for this proposition with respect to the real estate industry, however, is mixed. The core business of the real estate industry suggests that rather than proximity in terms of public versus private domain actors the sectoral proximity of public and private housing may create an advantage for real estate enterprises in public and probably private housing as well. In conclusion, Proposition (2b) is only confirmed for municipal utilities, whereas the picture is mixed for real estate enterprises.

8 See Appendix 2, Table A

5 Conclusions

Our estimations results provide evidence that governance modes vary in their suitability to govern the range of different contracting projects considered. Some modes are superior to others largely following our propositions based on transaction cost economics. The main propositions that concern asset specificity of investment (Propositions 1a, 2a and 2b) are supported by the data. If physical, site and human asset specificity are high, governance modes are preferred, for which contracting represents a downward integration of business activities along the value-added chain. This includes the supply of contracting by municipal utilities, real estate enterprises and our group of "other contracting actors", for example equipment manufacturers. More specifically, as theory would suggest municipal utilities indeed turn out to be superior suppliers of contracting if CHP is implemented, if the building is connected to their gas grid and if it is a public building. This pattern could orient the development of this business activity for utilities reconsidering their strategic position following the liberalisation of the electricity market.

With regard to the size of investment, the empirical results show specialised contractors to be the preferred suppliers as project size increases. This is opposed to our proposition according to which size as a measure of physical asset specificity should foster more integrated governance structures. Further empirical research should examine, whether this result reflects a mismatch in governance structures that should be amended and what causes this mismatch to occur. Financial constraints could be a possible explanation.

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References

E&M (Energie&Management) (2000): Contracting bleibt ein Wachstumsmarkt. In: Energie & Management, No. 7/2000 dated 01.04.2000

Ménard, C and Saussier, S. (2000): Contractual choice and performance: The case of water supply in France. In: Revue d'Économie Industrielle, Vol. 92 (2000), No. 2/3, pp. 385 - 404

Ostertag, K. (2003): No-regret Potentials in Energy Conservation: An Analysis of Their Relevance, Size and Determinants. Heidelberg (Physica-Verlag), Technology, Innovation and Policy, Series of the Fraunhofer ISI Vol. 15

Perry, M.K. (1989): Vertical integration: determinants and effects. In Schmalensee R., Willig, R.D. (eds.): Handbook of Industrial Organization Volume I, Amsterdam: Elsevier Science Publisher, pp. 183-260.

Saussier, S. (2000a): Transaction costs and contractual incompleteness: - the case of Électricité de France. In: Journal of Economic Behavior & Organization, 42 (2), pp. 189-206.

Saussier, S. (2000b): When incomplete contract theory meets transaction cost economics: a test In: Ménard, C. (Hrsg.): Institutions, contracts and organisations. Perspectives from New Institutional Economics. Cheltenham, Northampton: Edward Elgar, pp. 376-398.

Shelanski, H. A. and Klein, P. G. (1995): Empirical research in transaction cost economics: A review and assessment. In: Journal of Law, Economics, and Organisation, Vol. 11, No. 2, pp. 335 - 361

Stata Base Reference Manual (2005), -Release 9, Stata Press, Vol.2: K-Q

Williamson, O.E. (1983): Credible Commitments: - Using Hostages to Support Exchange. In: American Economic Review, 73 (4), pp. 519-540.

Williamson, O.E. (1985): The economic institutions of capitalism, New York: Free Press.

Williamson,O.E. (1990): Transaction cost economics. In Schmalensee R., Willig, R.D. (eds.): Handbook of Industrial Organization. Volume I and II. Amsterdam (Elsevier Science Publisher). pp. 135 – 182

Appendix

A1. Applying a multinomial logistic model

For each outcome (y) a set of coefficients, β^1(specialized contractors), β^2(municipal utilities), β^3(real estate enterprises) and β^4(equipment manufactures and consulting engineers) is estimated.

Probability of y=1 (specialized contractor):

$$\Pr(y = 1) = \frac{e^{X\beta^1}}{e^{X\beta^1} + e^{X\beta^2} + e^{X\beta^3} + e^{X\beta^4}}$$

Probability of y=2 (municipal utility):

$$\Pr(y = 2) = \frac{e^{X\beta^2}}{e^{X\beta^1} + e^{X\beta^2} + e^{X\beta^3} + e^{X\beta^4}}$$

Probability of y=3 (real estate enterprises):

$$\Pr(y = 3) = \frac{e^{X\beta^3}}{e^{X\beta^1} + e^{X\beta^2} + e^{X\beta^3} + e^{X\beta^4}}$$

Probability of y=4 (others):

$$\Pr(y = 4) = \frac{e^{X\beta^4}}{e^{X\beta^1} + e^{X\beta^2} + e^{X\beta^3} + e^{X\beta^4}}$$

In order to identify the model β^1 is set to zero. Therefore, the other coefficients will measure the change relative to the base outcome, specialized contractor.

$$\Pr(y = 1) = \frac{1}{1 + e^{X\beta^{(2)}} + e^{X\beta^{(3)}} + e^{X\beta^{(4)}}}$$

$$\Pr(y = 2) = \frac{e^{X\beta^{(2)}}}{1 + e^{X\beta^{(2)}} + e^{X\beta^{(3)}} + e^{X\beta^{(4)}}}$$

$$\Pr(y = 3) = \frac{e^{X\beta^{(3)}}}{1 + e^{X\beta^{(2)}} + e^{X\beta^{(3)}} + e^{X\beta^{(4)}}}$$

$$\Pr(y = 4) = \frac{e^{X\beta^{(4)}}}{1 + e^{X\beta^{(2)}} + e^{X\beta^{(3)}} + e^{X\beta^{(4)}}}$$

In order to detect the strength of the coefficient's effect, relative risk ratios can be applied. The risk of choosing a municipal utility relative to choosing a specialized contractor is the relative probability of $y = 2$ to the base outcome:

$$\frac{\Pr(y=2)}{\Pr(y=1)} = e^{X\beta^2}$$

The ratio of the relative risk for a one-unit change in x_i, e.g. in size, is then

$$\frac{e^{\beta_1^2 x_1 + \ldots + \beta_i^2 (x_i+1) + \ldots + \beta_k^2 x_k}}{e^{\beta_1^2 x_1 + \ldots + \beta_i^2 x_i + \ldots + \beta_k^2 x_k}} = e^{\beta_1^2} \quad .$$

Thus the exponential value of a coefficient is the relative-risk ratio for a one-unit change in the corresponding variable.[9] Relative risk ratios represent the risk of choosing a municipal utility as a contractor relative to choosing a specialized contractor for each one-unit change in, for example, the SIZE or FREQ measure, holding all other variables constant.

9 Stata Base Reference Manual (2005), p. 211

A2. Regression results for a Multinomial Logistic Model of contract choice

	Coeff	**Std. Err.**	**z**	**P>│z│**	**[95%Conf. Intervall]**	
Municipal utilities						
SIZE	-.0522304	.1129242	-0.46	0.644	-.2735578	.169097
CHP	1.386018	.4279406	3.24	0.001	.5472703	2.224767
GAS	.5740362	.3579361	1.60	0.109	-.1275057	1.275578
PRIVHOUSE	-.6254806	.4672805	-1.34	0.181	-1.541334	.2903724
PUBHOUSE	1.223124	.4948239	2.47	0.013	.253287	2.192961
OFFBUILD	.8386398	.7218282	1.16	0.245	-.5761175	2.253397
SCH/HOSP	1.251367	.5552807	2.25	0.024	.1630367	2.339697
OTHERPUB	1.658635	.5797968	2.86	0.004	.5222544	2.795016
CONSTANT	-2.656903	.5272346	-5.04	0.000	-3.690264	-1.623542
Other contracting actors						
SIZE	-.5305979	.1682704	-3.15	0.002	-.8604019	-.2007939
CHP	-1.287615	.7747396	-1.66	0.097	-2.806077	.2308462
GAS	-.137822	.2170717	-0.63	0.525	-.5632748	.2876308
PRIVHOUSE	-1.281632	.2592133	-4.94	0.000	-1.789681	-.7735837
PUBHOUSE	-1.064954	.3726769	-2.86	0.004	-1.795387	-.3345206
OFFBUILD	.3027772	.4783676	0.63	0.527	-.634806	1.24036
SCH/HOSP	-.4277184	.4425889	-0.97	0.334	-1.295177	.43974
OTHERPUB	.5944884	.4502139	1.32	0.187	-.2879146	1.476891
CONSTANT	.0133551	.2886512	0.05	0.963	-.5523907	.579101
Real estate enterprises						
SIZE	-4.472059	.9768152	-4.58	0.000	-6.386582	-2.557537
CHP	2.666782	.481597	5.54	0.000	1.72287	3.610695
GAS	-1.464607	.2607276	-5.62	0.000	-1.975624	-.9535905
PRIVHOUSE	.5598305	.5858574	0.96	0.339	-.5884288	1.70809
PUBHOUSE	2.261688	.612068	3.70	0.000	1.062057	3.46132
OFFBUILD	.3641632	1.002267	0.36	0.716	-1.600244	2.32857
SCH/HOSP	-.0737952	1.192777	-0.06	0.951	-2.411596	2.264006
OTHERPUB	.8036254	.9972948	0.81	0.420	-1.151037	2.758287
CONSTANT	-.8981582	.614146	-1.46	0.144	-2.101862	.3055458

Number of obs = 1048
LR chi2(24) = 259.72 Prob > chi2 = 0.0000
Log likelihood = -961.55457 Pseudo R2 = 0.1190

Table A. Logistic Coefficients

	RRR	Std. Err.	z	P>│z│	[95%Conf. Intervall]	
Municipal utilities						
SIZE	.9491102	.1071775	-0.46	0.644	.7606684	1.184235
CHP	3.998896	1.71129	3.24	0.001	1.728528	9.251323
GAS	1.775419	.6354864	1.60	0.109	.8802884	3.580771
PRIVHOUSE	.5350042	.2499971	-1.34	0.181	.2140954	1.336925
PUBHOUSE	3.397786	1.681306	2.47	0.013	1.288253	8.961711
OFFBUILD	2.313218	1.669746	1.16	0.245	.5620764	9.520021
SCH/HOSP	3.495117	1.940771	2.25	0.024	1.17708	10.37809
OTHERPUB	5.252138	3.045173	2.86	0.004	1.685824	16.36289
Real estate enterprises						
SIZE	.0114238	.0111589	-4.58	0.000	.001684	.0774954
CHP	14.39358	6.931905	5.54	0.000	5.600577	36.99176
GAS	.2311688	.0602721	-5.62	0.000	.1386748	.3853549
PRIVHOUSE	1.750376	1.025471	0.96	0.339	.5551989	5.518411
PUBHOUSE	9.599283	5.875414	3.70	0.000	2.892315	31.85899
OFFBUILD	1.439309	1.442572	0.36	0.716	.2018473	10.26326
SCH/HOSP	.9288619	1.107926	-0.06	0.951	.0896721	9.621553
OTHERPUB	2.233624	2.227582	0.81	0.420	.3163087	15.77281
Other contracting actors						
SIZE	.5882531	.0989856	-3.15	0.002	.422992	.818081
CHP	.275928	.2137723	-1.66	0.097	.0604416	1.259666
GAS	.8712537	.1891246	-0.63	0.525	.5693415	1.333265
PRIVHOUSE	.2775838	.0719534	-4.94	0.000	.1670134	.4613568
PUBHOUSE	.3447437	.128478	-2.86	0.004	.1660631	.7156811
OFFBUILD	1.353613	.6475245	0.63	0.527	.5300383	3.456859
SCH/HOSP	.651995	.2885658	-0.97	0.334	.2738494	1.552304
OTHERPUB	1.812104	.8158342	1.32	0.187	.7498256	4.379311

Number of obs = 1048
LR chi2(24) = 259.72 Prob > chi2 = 0.0000
Log likelihood = -961.55457 Pseudo R2 = 0.1190

Table B. Relative Risk Ratios