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Designing energy efficiency subsidy programmes: The factors of transaction costs

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ABSTRACT

Transaction costs are perceived as one of the main barriers in achieving energy efficiency. Hence, the omission of transaction costs in the evaluation (and preparation) of energy efficiency policies leads to suboptimal decision-making. However, empirical evidence on the main factors influencing transaction costs of energy efficiency programmes remains insufficient. By investigating two cases of major energy efficiency subsidy programmes in the Czech Republic, we analyse the role of two factors influencing the transaction costs: size of the projects and type of actors. The results show that while the dependence between the size of the projects and the size of transaction costs is rather straightforward, the role of actors is more complex. On one hand, no significant difference has been found between total transaction costs of the two types of actors entering the analysed programmes (private companies and public entities). Our results imply the potential for optimization of transaction costs in energy efficiency subsidy programmes lies in streamlining the internal processes (especially in the preparatory phase and in public tenders) and a clear legal environment. On the other hand, differences between the two entities were found in the costs of external services, indicating a room for optimization for public bodies.

1. Introduction

In 2010 the European Commission launched the Europe 2020 initiative, which sets ambitious targets to be reached by 2020. Among others, a 20% increase in energy efficiency should be attained (European Commission, 2010). The Energy Efficiency Directive (European Parliament and Council, 2012), adopted in 2012, sets out a further set of binding measures that should help the EU Members States reach the energy efficiency target. It requires that energy distributors or retail energy sales companies (or the Member States, if they opt for so-called alternative policy measures) achieve 1.5% energy savings per year through the implementation of energy efficiency measures. Furthermore, 3% of the total floor area of heated and/or cooled buildings owned and occupied by the EU Member State central governments has to be renovated each year.

The European Union supports its Member States in achieving the goals by providing a substantial level of funding through its Cohesion Policy programmes. In the programming period 2007 – 2013 a total of EUR 6.1 billion was allocated to the priority theme “Energy efficiency, co-generation and energy management”, representing 2% of the total allocation (Ramboll and Institute for European Environmental Policy, 2016). Furthermore, the theme “Enterprise” (under which energy efficiency improvements have also been co-funded) was supported with EUR 51.9 billion, i.e. about 20% of total ERDF and Cohesion Fund support in the EU during the 2007 – 2013 period (Applica and Ismeri Europa, 2016).

Given the ambitiousness of the goals and the significant levels of expenditures allocated to reach them, it is crucial that careful evaluation (ex-ante and ex-post) is carried out in order to ensure that the public money is spent effectively. Transaction costs of the programmes are one of the main aspects of such assessment. The negative impact of transaction costs on the implementation of energy efficiency measures has been acknowledged and supported by a number of studies (Ostertag, 1999; Reddy, 1991; Sanstad and Howarth, 1994). Transaction costs can impede the implementation of energy efficiency policy measures or even prevent them from being implemented at all (Mundaca et al., 2013). Even though transaction costs cannot be zero (from the mere reason of existence of economic activity (Cheung, 1998)), it is believed that lower transaction costs are”almost always beneficial” (Gu and Hitt, 2001).

When designing energy efficiency policies, transaction costs are often not systematically taken into account and are not systematically evaluated ex-post (McCann et al., 2005). North (1990) categorises transaction costs to market costs (such as legal fees) and costs of time that the actors spend to gain the necessary information. Importantly, the transaction costs always consist of a variable part (dependent on the

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size of the project) and fixed part (independent of the size of the project) (Musole, 2009). The specific categorisation then tends to be case specific. Michaelowa and Jotzo (2005) for instance identified costs of monitoring as fixed costs and costs of negotiation as variable costs. The typical phases during which the transaction costs of energy efficiency programmes arise would be planning, implementation and monitoring and verification (Mundaca et al., 2013; Rao, 2003).

The empirical evidence on the transaction costs of energy efficiency programmes is still inadequate, and in particular, the number of quantitative estimates is limited (McCann et al., 2005; Mundaca et al., 2013).[1] In the available studies, transaction costs are of non-negligible levels. For instance, Jaraité et al. (2010) estimated the transaction costs of three programmes aimed at efficient transport. They found that the transaction costs ranged from 3% (of total costs of a fuel efficiency programme) to over 18% (of compliance costs of the Fuel Label Program). Björkqvist and Wene (1993) analysed the transaction costs of energy efficiency measures in households. They estimated the level of transaction costs at 28% of the level of energy efficiency investment (using gross labour to express the transaction costs). Mundaca (2007a) analysed the white certificates scheme in the United Kingdom, estimating the transaction costs at 8–12% of the investment in lighting and 24 – 36% of the investment costs for insulation. Falconer and Whitby (2000) analysed the administrative costs of agro-environmental schemes in 8 European countries. The administrative costs varied from 6% to 87% of the compensation costs. Nevertheless the studies are usually not directly comparable as they differ by their focus (different policy programmes), by the method used to study the transaction costs (the choice of at which stage and on which actors the transaction costs are measured), and by the choice of indicator that the transaction costs are compared to.

It seems that transaction costs can to some extent be lowered thanks to the effect of a “learning curve” (Lee and Han, 2016; Michaelowa and Jotzo, 2005). However, the extent to which this is possible may depend on the character of transaction costs (Kiss, 2016). Various studies (Jaraité et al., 2010; Michaelowa and Jotzo, 2005; Sathaye and Murtishaw, 2004) have concluded that transaction costs depend on the size of the project (or energy efficiency measure), i.e. the bigger the project, the lower the burden of transaction costs.

The key drivers that influence the size and structure of transaction costs have been summarised by, e.g. (Coggan et al., 2010; Mundaca et al., 2013; Musole, 2009). Among others, the actors of the transactions (projects) are one of the main drivers. Ahonen and Hämekoski (2005) found dependence between the transaction costs and the “competence and capacity of project developer”. Coggan et al. (2013) identify the characteristics of the transactors (their experience, capacity to assess information, etc.) as one of the core factors influencing the structure and level of transaction costs. Relatedly, the institutional environment and internal rules, in which the actors carry out the transactions, adds to the defining factors of transaction costs (McCann, 2013; Shahab et al., 2018).

This article, therefore, aims at partially filling this gap and focuses on the role of the actors on the size and structure of the transaction costs of energy efficiency programmes. Using qualitative and quantitative analysis it studies the transaction costs of two major energy efficiency subsidy programmes in the Czech Republic. In the Czech Republic, the allocation to energy efficiency policy measures amounted to roughly EUR 1.03 billion in 2007–2013 (Ministry of the Environment, 2007; SEVEn, 2010). Besides having distributed substantial amounts of financing to energy efficiency, the two analysed operational programmes are optimal for the research as they coincide in their main characteristics (type of subsidised projects, size of the projects, administration processes). Therefore, the only major factor in which the two programmes differ are the actors – the eligible applicants (public bodies and private entities). Furthermore, given their size (and the number of subsidised projects), the two programmes provide a solid base for research, and as they are part of the EU Cohesion Policy, there is potential for replicability of the research and findings in other countries and the current and future programming periods.

Based on the current state of knowledge on the factors influencing the transaction costs, the research question has been translated into two main research hypotheses. The **first hypothesis** is that the size of transaction costs is not fixed and depends on the size of the subsidised project. The **second hypothesis** states that the level and structure of transaction costs differ according to the type of actor carrying out the project.

The structure of the article is as follows. Section 2 describes the analytical background of the research, embedding the research within the conceptual framework of transaction costs theory and providing a detailed description of the methodological approach. In Section 3, the results of the analysis are presented, with a focus on testing the two main hypotheses on the relation between transaction costs and the size of the project and the actors. Section 4 assesses and discusses the main findings and embeds them in a broader context. Section 5 concludes and conveys policy implications.

2. Theoretical framework

2.1. Concept of transaction costs

Transaction costs are perceived as one of the main barriers to efficiency. As to e.g. (Schleich and Gruber, 2008), such statement can be extended to energy efficiency measures, too. The transaction costs theory is imbedded in the New Institutional Economics theory which stipulates that all actors in an economy make their decisions with bounded rationality (Musole, 2009). That means that all transactions (and contracts) induce transaction costs. Not including transaction costs in the decision-making leads to suboptimal decisions from the systemic point of view as a non-negligible part of the reality is neglected.

However, there is not an academic consensus on a standard definition of transaction costs (Musole, 2009; Ostertag, 1999). Also, the methods used to measure transaction costs differ in different studies and are tailored to the specificities of the studied policies and measures (McCann et al., 2005; Mundaca et al., 2013; Musole, 2009).

A definition that is suitable for this article is the one adopted by Mundaca (2007) and derived from Matthews (1986), which identifies transaction costs as the costs of preparation of a contract (ex-ante costs) and its implementation, monitoring and enforcement. Such a definition fits the studied energy efficiency subsidy programmes. In line with McCann et al. (2005), transaction costs also comprise administrative costs.

Björkqvist and Wene (1993) further highlight the need to consider the time of the ones who rejected or were unable to participate in the innovation (energy efficiency measure) in order to assess the effectiveness of the given demand side management programme. In the analysis presented in this article, such an assumption is extended to rejected, unsuccessful applicants.

2.2. Model of transaction costs

Transaction costs were examined in two particular subsidy programmes financed from the European Cohesion policy in the period 2007 – 2013: Operational Programme Environment (OP E, specifically Priority axis 3 focused on energy efficiency) and Operational Programme Enterprise and Innovation (specifically the ECO-ENERGY programme). Running under the same framework umbrella (the Cohesion funds), the two programmes had similar administrative procedures. They both focused on subsidising a broad range of energy

[1] In the Czech Republic, Lízal et al. (2001) analysed adjustment costs of investments in the Czech Republic, their general specification can be viewed as another approach evaluating the transaction costs.

efficiency measures in buildings, including thermal properties of buildings, technological measures, and other. The only substantial difference between the two programmes were the eligible subsidy recipients: public organisations (OP E) and private enterprises (ECO-ENERGY). The two programmes are described in detail in (Valentová, 2013).

The data were collected based on mixed method research. The reason is that this method combines the advantages of both quantitative and qualitative research methods (Creswell and Plano Clark, 2011). In line with this method, firstly qualitative research provides initial ("exploratory") information on the given topic. Based on this knowledge, quantitative research is carried out, that should test, generalise, and support the initial findings.

The research was conducted in three stages: desk research, structured interviews and a questionnaire survey. A similar approach has been already used by, e.g. Ofei-Mensah and Bennett (2013). Firstly, the desk research allowed the study of the primary documents of the subsidy programmes, such as the programming documents, that contain information on the administrative structure of the programmes and therefore provide a solid initial picture of the functioning of the programmes and the main steps in the whole administration process.

Secondly, semi-standardised in-depth interviews with subsidy recipients were carried out (as the qualitative part of the research). In total, eight subsidy recipients were interviewed (four for each programme) and two representatives of the administrative bodies. All the interviews were carried out in July – October 2011. The interviewees were selected from the whole population of applicants in a way to represent the structure of the population of the subsidy recipients in the given programme. The structure and sources of transaction costs were identified based on the desk research and confirmed and specified during the semi-structured interviews. In turn, the interviews helped to explain the findings from the questionnaire.

A question arises whether more qualitative interviews may have brought further themes (i.e. stages of the administration process, external costs of administration) to be then tested in the quantitative survey. In other words, the question is whether some topics may have been omitted. Galvin (2015) provides guidance for this reflection. He calculates the probability of a theme being present in a given sample of interviewees with respect to the percentage of the target population in whom the theme exists. For eight interviewees, there is an 83% probability of finding a topic that is represented in 20% of the population and 73% probability of finding a theme that is represented only in 15% of the population (see Annex B in (Galvin, 2015)). For themes represented in higher percentages of the population, the probability reaches above 90%. Apart from subsidy recipients, the project administrators (representatives of the administrative bodies) were interviewed. Even though the main aim of these interviews was to get information on the processes of the administrative body itself, being in daily contact with the subsidy recipients, the project officers also helped to identify and assess the processes of subsidy recipients. In line with (Galvin, 2015) this further helps to ensure that all relevant topics have been rightly and fully covered.

Thirdly, based on the interviews, a questionnaire was distributed among subsidy recipients (the quantitative part of the research). The questions were categorised in four main parts: 1) type of subsidised measures and general experience with the administration process, 2) time dedicated by the recipients to respective phases of the subsidised project's administration, 3) recipients' expenditures on external services connected with the subsidy administration and 4) their own experience, comments and opinion on the subsidy programme. The example of the questionnaire for ECO-ENERGY is in Annex A. In total, 463 subsidy recipients were contacted and 125 of them fully completed the questionnaire – 84 for OP E and 41 for ECO-ENERGY (a total response rate of 27%).

From those, only the respondents with one project were selected for further analysis. Even though respondents were asked to estimate the costs and time for all the projects together, given the character of the costs (and the fact that some of the respondents managed more than ten projects within the subsidy scheme), this step was taken to ensure comparability. As a result, a total of 55 responses for OP E and 35 responses for ECO-ENERGY were used in the further analysis.

In line with, e.g. Björkqvist and Wene (1993) the estimated time that the respondents devoted to the subsidy administration was converted into monetary terms through total labour costs. It is assumed that all the costs are incurred within one year. This simplifying assumption is based on the interviews with respondents (Eq. (1)).

$$C_t = h \times L \tag{1}$$

where C_t are the costs of time induced by subsidy administration, h is the estimated time spent on subsidy administration, L are the total costs of labour.

In the next step, the costs for external services connected with subsidy administration are added to the costs of time, which gives the total costs of subsidy administration in the given organisation (Eq. (2)).

$$TC_R = C_t + C_e \tag{2}$$

where TC_R are total transaction costs for individual subsidy recipients, C_e are costs of external services connected with the subsidy administration.

Total costs are then related to the total amount of the given subsidy, giving a percentage formula of the recipients' transaction costs so that projects of different sizes can be compared (Eq. (3)).

$$c_R = \frac{TC_R}{S} \times 100\% \tag{3}$$

where c_R is the percentage share of transaction costs on subsidy for individual recipients, S is the allocated subsidy for individual recipients.

The respondents were selected only from the successful recipients, as the list of unsuccessful subsidy applicants is not available.

Two main research hypotheses were formulated. The **first hypothesis** is rather straightforward (following, e.g. (Jaraité et al., 2010; Michaelowa et al., 2003; Mundaca et al., 2013; Musole, 2009)) and states that the level of transaction costs depends on the size of the subsidised project. The **second hypothesis** (following, e.g. (Coggan et al., 2013)) states that level of transaction costs depends on the type of actor carrying out the project.

A simple model was established to test the two hypotheses. The size of the subsidy of the project and the type of the programme are the independent variables and the transaction costs related to the project are the dependent variable.

$$TC_R = f(S; P) \tag{4}$$

where TC_R are the total transaction costs for individual subsidy recipients, S is the allocated subsidy for individual recipients, P is binary variable defining the type of programme being analysed for the individual subsidy recipients (i.e. the type of actor: private company in ECO-ENERGY and public body for OP E).

Regression analysis was used to establish the relationship between the variables TC_R, S and P. Firstly, regression analysis was run for the two samples separately, splitting the data by the type of the programme. This shows the relation between the two variables: the size of the subsidy and transaction costs. The dataset has a lognormal distribution.[2] Therefore, the regression was operationalized as:

$$\text{for ECO-ENERGY:} \quad lnTC_{R1} = \alpha_1 + \beta_1 lnS_1 + \varepsilon_1 \tag{5}$$

$$\text{for OP E:} \quad lnTC_{R2} = \alpha_2 + \beta_2 lnS_2 + \varepsilon_2 \tag{6}$$

where ε_i are the standard i.i.d. error terms, i = 1,2. The same regression

[2] We provide the evidence for treating the distribution as log normal in the next section.

equation can also be established for the relation between the total subsidy (S) and costs of time (C_t) and costs of external services (C_e) of the subsidy recipients.

To answer the second hypothesis of the paper – whether the transaction costs differ due to different actors, two null hypotheses have to be tested to assess the elasticity:

1) H_0: $\boldsymbol{\beta_1 = \beta_2}$, and
2) H_0: $\boldsymbol{\alpha_1 = \alpha_2}$,

A dummy variable D (where ECO-ENERGY was coded 1 and OP E 0) was introduced, to test these hypotheses:

$$ln(TC_R) = \alpha_2 + (\alpha_1 - \alpha_2)D + \beta_2 \ln(S) + (\beta_1 - \beta_2)D\ln(S) + \varepsilon \quad (7)$$

A regression function is developed and the coefficients ($\boldsymbol{\alpha_1 - \alpha_2}$) and ($\boldsymbol{\beta_1 - \beta_2}$) tested to be equal to zero. If the differences of coefficients are statistically significant, it means that these are different from zero and therefore there are statistically significant differences between α_1 and α_2, and between β_1 and β_2. The test of equality of variances of standard errors on standard confidence levels was also conducted.[3]

On the side of the administration body, the administrative costs associated with the administration of the subsidy programme were approximated through so-called technical assistance. Each operational programme is divided into so-called "priority axes", which further specify the supported themes. Technical assistance is a subpart of all operational programmes and is represented as one specific priority axis in each programme. It is allocated to ensure implementation of the programmes. Administrative intensity was therefore estimated as the share of costs allocated to technical assistance for the given programme divided by the total allocation of the programme within the rest of the (substantive) priority axes in the programme, which define the supported types of projects (i.e. all priority axes except priority axis technical assistance). It is assumed that the technical assistance is distributed proportionally across the specific subsidised themes (priority axes) within each programme (Eq. (8)).

$$AI = \frac{TA}{S_{PA}} \times 100\% \quad (8)$$

where AI is the administrative intensity of the programme, TA are the costs allocated to technical assistance for the programme, S_{PA} is the total amount of financing allocated to subsidised themes (priority axes) of the programme, except technical assistance.

2.3. Limitations

The method employed has several limitations that need to be taken into account when discussing the results. The method does not include overheads (such as rental costs, electricity costs, administrative staff costs, etc.) attributable to the management of the subsidy. The in-depth interviews revealed that the accounting practice for overheads differed across companies and public bodies and therefore the obtained data would not be comparable. Therefore, only the direct staff working on the subsidy administration on the side of the recipient was included.[4] Furthermore, the subsidy recipients do not keep track of the hours allocated to subsidy administration and therefore the hours spent on different stages of the subsidy administration had to be estimated. The method used was similar to that used by, e.g. Hein and Block (1995), and Ofei-Mensah and Bennett (2013).

It is also assumed that the whole administration of the subsidy takes place within one year. The interviews revealed that in the studied subsidy programmes, all of the subsidy administration and implementation does take place within one year, except the monitoring reports that are to be submitted several years after finalisation of the project. However, the portion of the transaction costs related to the monitoring reports is so small that such a simplification could be made in this case. Relatedly, it is assumed that the administration costs (of the administration body) are evenly distributed across the priority axes and also across individual projects.

While the respondents estimated the time spent on the activity, they were reluctant to provide data on actual labour costs. Therefore, similarly to, e.g. Björkqvist and Wene (1993) the labour costs had to be approximated through general statistical data on wages and labour (and other costs directly related with the wages such as social and health insurance) in the given economic sector.

Additional limitation lies in the very research instrument, the questionnaire. It is not possible to influence who responds to the questionnaire. Therefore, the analysed sample can be best characterised as the sample of successful applicants that replied to the questionnaire. To partially make up for this limitation, a comparison between the survey population of successful applicants and the sample based on the main characteristics, such as the level of subsidy, type of applicant, type of facility and type of measure, was made.[5]

3. Results

Transaction costs were analysed for the two main energy efficiency subsidy programmes in the Czech Republic: Operational Programme Environment (specifically Priority axis 3 focused on energy efficiency, hereafter referred to as OP E) and Operational Programme Enterprise and Innovation (OPEI, specifically the ECO-ENERGY programme, hereafter referred to as ECO-ENERGY). The programmes were running in the years 2007 – 2013.

3.1. Transaction costs of the applicants

The following main phases of the subsidy administration process were identified in which transaction costs arise. Where differences between the two programmes occur, this is highlighted in the description.

3.1.1. Initial information and decision about the project

At this stage, the prospective applicant finds initial information on the subsidy programme and the conditions of the subsidy allocation. The decision on applying has to be made. The process depends on the type of the applicant. For private companies, this step mainly entails presenting the proposal to the company's management, for public entities it means preparing and presenting the background documents to the municipal council or similar body and its approval.

3.1.2. Submission of the subsidy application

After the decision has been made, the applicant prepares and submits the subsidy application. Some of the applicants hire an external company to help them with the subsidy administration. In some cases, *public tenders* for such external services are organised. The subsidy application consists of an online application form and paper documents. In the case of ECO-ENERGY, the application is a two-stage process. Firstly, the so-called *registration application* is submitted (serving as a preliminary filter for the projects). Upon approval of the registration application, the *full application* is submitted.

3.1.3. Project implementation (including public tenders for suppliers)

Once approved, the subsidised project is prepared and implemented. Following the conditions of the programme and the applicable laws, public tenders need to be organised for suppliers of the technology and other measures. The transaction costs connected with

[3] The tests show that in the logistic specification the error terms have equal variance on any convention level of significance; yet another fact supporting our specification.

[4] For instance, Pružvic (2006) identified the costs of the "overhead" employees to be 20 – 25% of the costs of "direct" staff.

[5] More details on the comparison are provided in (Valentová, 2013).

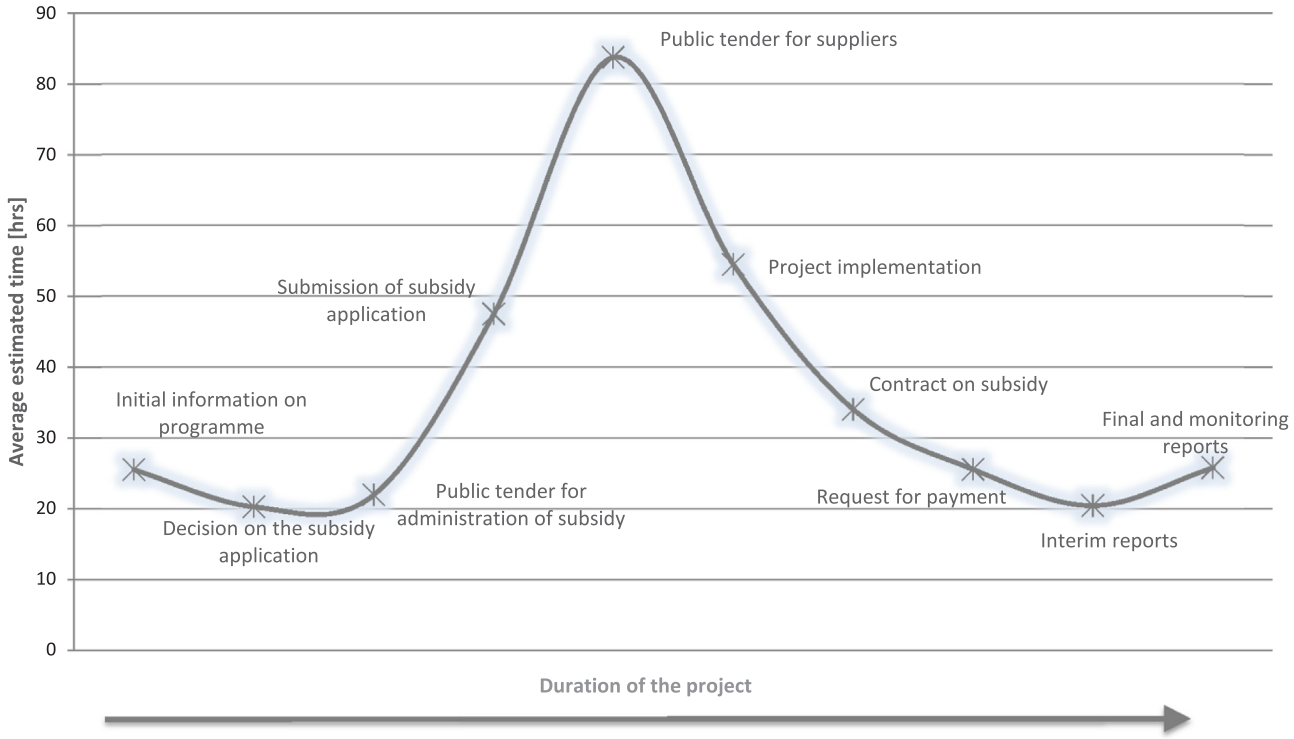

Fig. 1. Amount of time of individual phases of the administration process of the subsidy recipient – OP E.

the realisation of the project are the ones related to the fact that the project is subsidised. They mainly consist of the need to consult changes in the project or eligibility of expenditures with the administration body (i.e. whether these are eligible costs under the subsidy programme).

3.1.4. Contract on subsidy and request for payment

When the subsidy is approved, the contract between the administration body and the subsidy recipient is prepared and signed. Only after that is the subsidy recipient allowed to submit the request(s) for payment of the eligible expenditures connected with the project.

3.1.5. Interim, final and monitoring reports

The subsidy recipients have to regularly submit reports to the administration body. Those include interim reports throughout the realisation of the project, a final report at the end of the project and yearly monitoring reports for four years after the end of the project.

The following figures (Figs. 1 and 2) illustrate the whole administration process and the average amount of time of each stage of the process as estimated by respondents of the questionnaire survey.

The analysis has shown that the most time intensive phases are the processes connected with the preparation of the subsidy application and then the public tender for suppliers of the subsidised energy efficiency measures. Altogether from the initial information on the programme to submission of the application, the respondents spent on average 115 (OP E) and 195 h (ECO-ENERGY). Furthermore, they spent on average 84 and 120 h respectively on preparation and organisation of the public tenders. In total, the respondents estimated the time spent on administration of the subsidy to average 324 (OP E) and 494 h (ECO-ENERGY).

Apart from their own time, the respondents all stated that they outsourced some of the tasks connected with subsidy administration. All but one respondent said they hired an external company to prepare an energy audit (one of the compulsory parts of the application) and also more than 80% had the project documentation prepared by external companies. More than 60% had an external company helping to prepare the application as such. Two-thirds of the respondents in OP E (i.e. public bodies) hired an external company to prepare the tender dossier for the public tender for suppliers of energy efficiency measures, whereas the same applies only to 39% of ECO-ENERGY respondents (i.e. private companies).

The relative transaction costs of the subsidy recipients in the sample average 5.9% of the subsidy for OP E (with the maximum reaching 31% and median 6.7%) and 7.4% for ECO-ENERGY (with the maximum of 53% and median 11.5%). It means that for each EUR 100 of a subsidy, the recipients spent on average EUR 5.9 for OP E and EUR 7.4 for ECO-ENERGY on transaction costs connected with the subsidy. The main results are summarised in the following Table 1.

For unsuccessful applicants, the data are not available. If we approximated the transaction costs of unsuccessful applicants by the share of the transaction costs devoted to the preparatory phase of the application of the successful applicants, the percentage share of transaction costs of unsuccessful applicants would be 2.7% (OP E) and 3.5% (ECO ENERGY) of the average subsidy.

3.2. Administrative costs

Administrative costs are associated with the costs assigned for technical assistance in the programmes. It is assumed that the administrative costs are the same across all subsidised projects (all project get equal “attention” from the administrators of the subsidy). The levels of technical assistance for OP E and OPEI (ECO-ENERGY) are summed up in Table 2.

The numbers above are likely to represent the lower boundary of the administrative burden, as the technical assistance does not cover some of the stages of the administrative process, mostly the ones related to tasks that are carried out by other bodies than the main administrative body. For instance, for OP E, the main administrative body was the State Environmental Fund. However, the strategic issues were covered by the Ministry of the Environment and the financial flows between the European Commission and the administration body are channelled by the Ministry of Finance. The costs of these bodies are not covered in the technical assistance (but can be estimated to be an order of magnitude

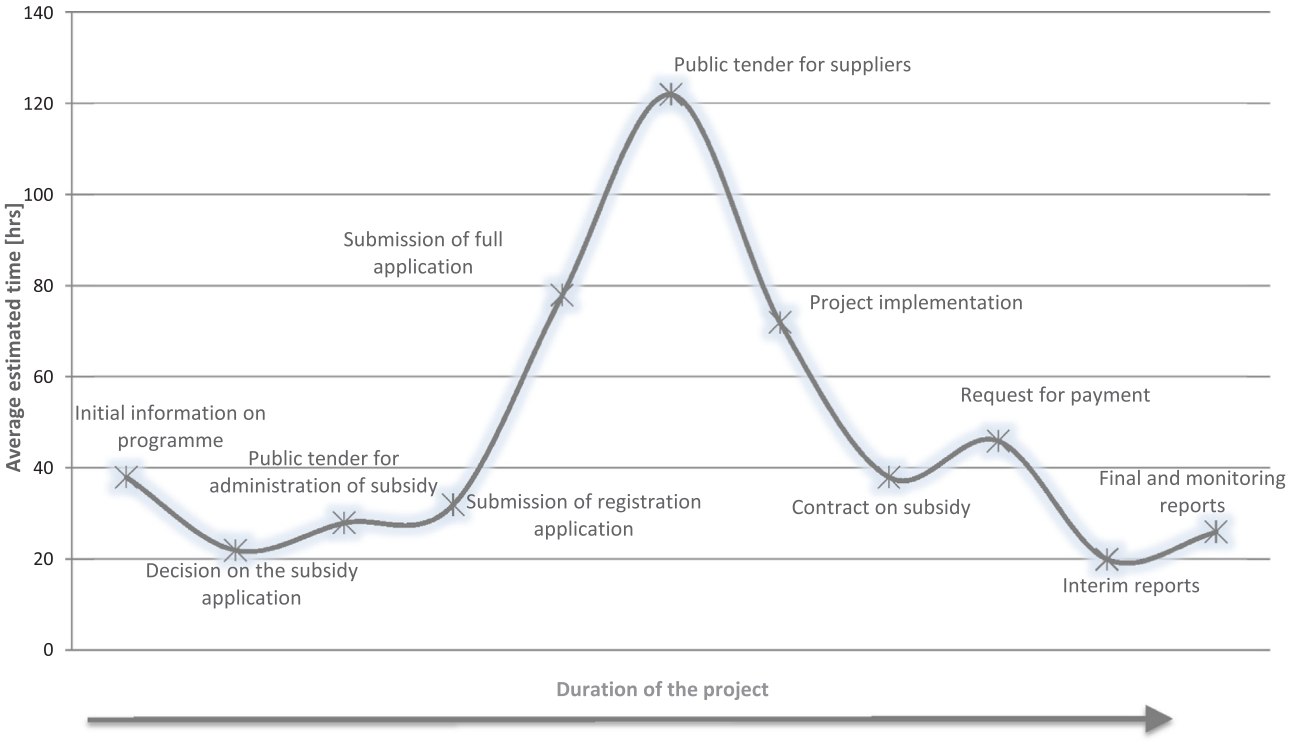

Fig. 2. Amount of time of individual phases of the administration process of the subsidy recipient – ECO-ENERGY.

Table 1
Transaction costs of subsidy recipients of OP E and ECO-ENERGY.

	Time (labour) costs [EUR]	External costs [EUR]	Average subsidy [EUR]	Relative transaction costs [%]
OP E	3,520	13,710	293,696	5.9
ECO-ENERGY	4,583	19,077	320,041	7.4

Note: The total labour costs in the respective economic activities were used to translate the estimated time into monetary terms (EUR 10.6 in the public sector and EUR 9.3 in industry in 2011 (Czech Statistical Office, 2012) The exchange rate of EUR/CZK 24.6 was used.

Table 2
Technical assistance.
Source: (Ministry of Industry and Trade, 2015; Ministry of the Environment, 2009), own calculations

Programme	Total allocation [EUR]	Technical assistance [% of total allocation]	Technical assistance [% of allocation on individual projects][a]
OP E	168,000,000	2.91%	2.99%
OPEI	105,000,000	2.93%	3.02%

[a] In case of OP E that means share of technical assistance on allocation for priority axis 1–7, in case of OPEI, share of technical assistance on allocation for priority axis 1–6.

smaller).

The interviews with the representatives of the administration bodies revealed that similarly to the experience of the applicants, the most time intensive is the evaluation of the project applications. Secondly, the administrators of the subsidy programmes identified the checking of public tenders carried out by the subsidy recipients as particularly demanding. The demanding character of the public tenders can be attributed to the legal framework. However, the time intensity is mainly attributed to the fact that administrators check the public tender dossiers before the launch of the public tender.

3.3. Factors influencing transaction costs

Firstly, Figs. 3 and 4 endorse the lognormal distribution of the sample. While the non-transformed distribution for subsidy has a declining character of a distribution of an exponential type, the logarithms of subsidy exhibits shape typical for a normal distribution.

Following the regression analysis, the regression equations can be therefore formulated as[6]:

$$\textbf{ECO–ENERGY}: \quad \ln(\boldsymbol{TC}) = \boldsymbol{2.95} + \underset{(1.03)***}{} \quad \underset{(0.09)***}{\boldsymbol{0.56}\ \ln(\boldsymbol{S})}$$
$$Adj.\ R^2 = 0.55$$

$$\textbf{OP}\boldsymbol{E}: \quad \ln(\boldsymbol{TC}) = \boldsymbol{5.17} + \underset{(1.13)***}{} \quad \underset{(0.09)***}{\boldsymbol{0.36}\ \ln(\boldsymbol{S})}$$
$$Adj.\ R^2 = 0.20$$

The F-test for both regression equations is significant; therefore the model has explanatory power. The results suggest that there is a positive dependence of transaction costs on the size of the subsidy for both programmes. Both coefficients, $\boldsymbol{\alpha_1}$ and $\boldsymbol{\alpha_2}$, are significant. The coefficients α_1 and α_2 can be interpreted as elasticity, i.e. for ECO-ENERGY if subsidy changes by 10%, we could expect the transaction costs to change by 5,6%. The results further imply that the size of the subsidy could be a stronger predictor of transaction costs for OP E (0,56) than for ECO-ENERGY (0,36).

A regression equation was developed to test the two coefficients β_1 and β_2, and $\alpha_1$and α_2. This in turn gives an answer to the hypothesis that the transaction costs differ depending on the type of actor. The regression function is formulated as follows:

$$\ln(\boldsymbol{TC}) = \underset{(1.24)***}{\boldsymbol{7.23}} - \underset{(1.87)}{\boldsymbol{2.87}\ \boldsymbol{D}} + \underset{(0.08)***}{\boldsymbol{0.36}\ \ln(\boldsymbol{S})} + \underset{(0.13)}{\boldsymbol{0.20}\ \boldsymbol{D}\ \ln(\boldsymbol{S})}$$

Both coefficients of model difference (intercept and slope) are insignificant. The p-values both for coefficient (α_1 - α_2) and for coefficient (β_1 - β_2) are greater than 0.05 (and even greater than 0.1). That

[6] (Standard error) ***p = 0.01, **p = 0.05, *:p = 0.1. No * means that the coefficients are not statistically significant at conventional levels.

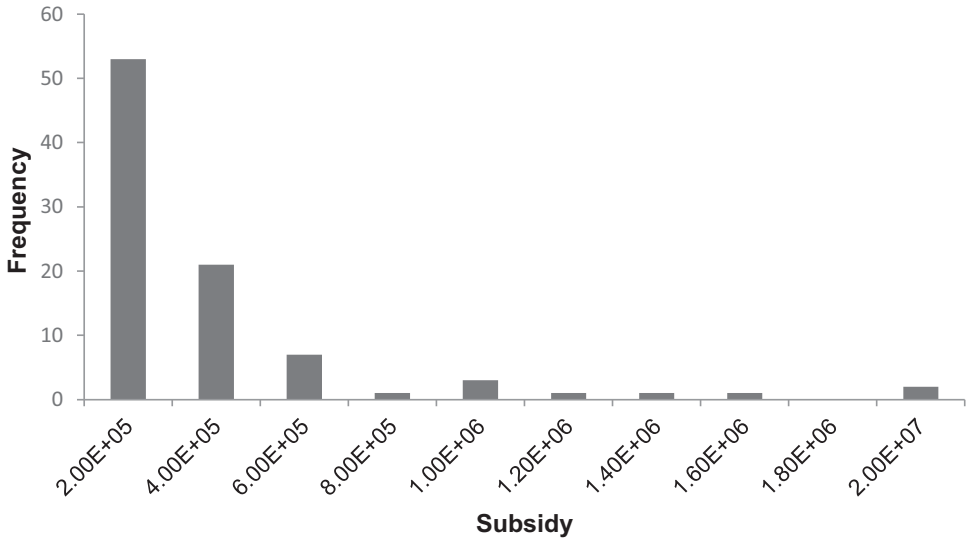

Fig. 3. Histogram of the size of the subsidy.

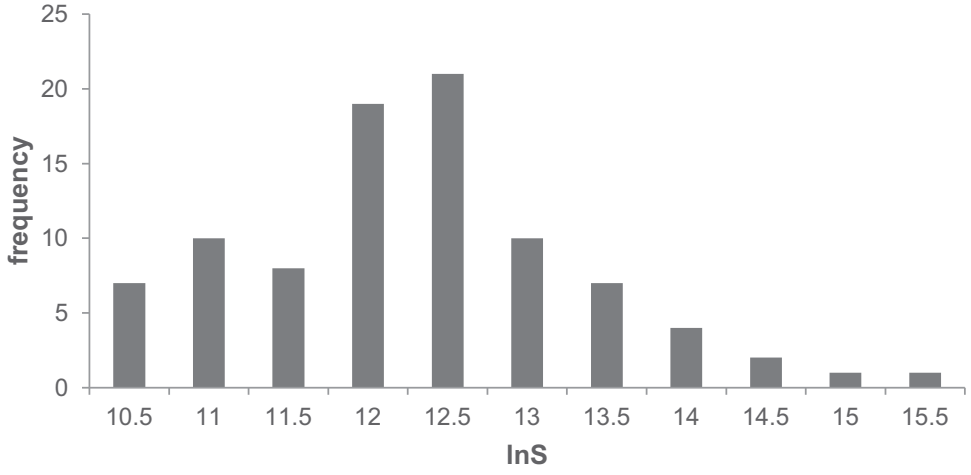

Fig. 4. Histogram of the natural logarithm of the size of the subsidy.

indicates that we cannot reject the null hypothesis and therefore cannot state that on the 95% (90%) confidence level the regression coefficient β_1 is significantly different from and β_2, or that $\alpha_1$is different from α_2. However, the joint F-test rejects equality of both slopes and intercepts. Based on additional test, we can say that the slope coefficients β are the same and the programmes differ in the intercept term. Therefore, based on the data sample, we cannot say that the slope of total transaction costs would be different depending on the type of the actor – i.e. that there would be a statistically significant difference between the "behaviour" of private companies and public entities, when it comes to transaction costs in energy efficiency programmes.

If the same analysis is performed for the two components of the transaction costs: the costs of time and costs of external services, the regression equations are:[7]

ECO−ENERGY

$$\ln(\boldsymbol{C_E}) = \boldsymbol{0.74}\ \ln(\boldsymbol{S})$$
$$(0.12)^{***}$$
$$Adj.\ R^2 = 0.52$$

OP E

$$\ln(\boldsymbol{C_E}) = \boldsymbol{4.52} + \boldsymbol{0.38}\ \ln(\boldsymbol{S})$$
$$(1.68)^{***}(0.14)^{***}$$
$$Adj.\ R^2 = 0.13$$

$$\ln(\boldsymbol{C_T}) = \boldsymbol{5.45} + \boldsymbol{0.24}\ \ln(S)$$
$$(0.98)^{***}(0.08)^{***}$$
$$Adj.\ R^2 = 0.20$$

$$\ln(\boldsymbol{C_T}) = \boldsymbol{5.34} + \boldsymbol{0.22}\ \ln(S)$$
$$(0.89)^{***}(0.07)^{***}$$
$$Adj.\ R^2 = 0.15$$

Analogically to the analysis with total transaction costs, a regression equation was formulated to test the two coefficients β_1 and β_2, and $\alpha_1$and α_2 in case of independent variable external costs and time costs. The regression function for the external services has been estimated with results as follows:

$$\ln(\boldsymbol{C_E}) = \boldsymbol{4.52} - \boldsymbol{4.18}\ \boldsymbol{D} + \boldsymbol{0.38}\ \ln(\boldsymbol{S}) + \boldsymbol{0.36}\ \ln(\boldsymbol{S})\ \boldsymbol{D}$$
$$(1.63)^{***}(2.24)^{*} \quad (0.13)^{***} \quad (0.19)^{*}$$

$$\ln(\boldsymbol{C_T}) = \boldsymbol{5.34} + \boldsymbol{0.11}\ \boldsymbol{D} + \boldsymbol{0.22}\ \ln(\boldsymbol{S}) + \boldsymbol{0.01}\ \ln(\boldsymbol{S})\ \boldsymbol{D}$$
$$(0.95)^{***}(1.31) \quad (0.08)^{***} \quad (0.01)$$

For the variable of costs for external services, there is a statistically significant difference (on 90% confidence level) between the two programmes, suggesting that there is a difference in how the two actors handle tendering for external services for administration of the subsidies. Conversely, the results suggest that the costs of time for the two programmes are not statistically different from each other – as can also be inferred directly from the regression equation.

[7] The constant is not statistically significant on any conventional level, therefore has been excluded in this case.

Table 3
Transaction costs of OP E and ECO-ENERGY.

Programme	Transaction costs of successful applicants [%]	(Estimated) transaction costs of unsuccessful applicants [%]	Administrative costs [%]
OP E	5.9%	2.7%	3%
ECO-ENERGY	7.4%	3.5%	3%

4. Discussion

4.1. The level of transaction costs

The percentage share of transaction costs of the analysed energy efficiency subsidy programmes is summarised in Table 3. The results are indicative given the size of the sample (90 respondents).

The time lag between the implementation of the subsidy and the research may have influenced the results. The transaction costs were estimated through a combination of interviews and a questionnaire survey. The respondents estimated the time spent on individual stages of the subsidy administration process and also the external costs. They were selected from the applicants who went through the whole administration process. This, however, meant that the time lag between the actual project and the survey was quite significant (usually 1–3 years). Clearly, the higher the time lag, the more difficult to correctly estimate the transaction costs (see also McCann et al., 2005).

Transaction costs rise for third-party actors in the given programme, too. These can be for instance the suppliers of the subsidised energy efficiency measures, which may need to acquire specific certification to be eligible as suppliers in the programme, or banks that cooperate with the programme. In the analysed programmes, the third parties were included only as the external companies supporting the applicants in the administration process. In this case, it can be assumed that all costs connected with the programme are reflected in the price of the service.

To correctly estimate the structure and level of transaction costs, the unsuccessful applicants should be covered in the analysis (Björkqvist and Wene, 1993). For OP E the success rate of the applications is 53%, and in ECO-ENERGY it is 69%. However, for both programmes, only data on successful applicants are publicly available. Therefore, the transaction costs of unsuccessful applicants could not be properly analysed. That means that a significant part of the transaction costs cannot be thoroughly analysed. The important message is not to omit this significant segment of actors, both in ex-ante and ex-post evaluation of the policy instruments. Relatedly, ex-ante and ex-post evaluation of the programme should aim at covering the actors/entities that decided to implement the measures without the subsidy programme.

To properly analyse administrative costs, it is crucial to detect the institutions or bodies that are responsible for the operation of the programme and set the boundary of the whole system. For the programmes analysed in this article, the boundary is the Czech Republic. However, given the fact that the programmes are financed from European funds, the national-European negotiations, administrative procedures and financial flows should be taken into account as well.

In this study the effect of the learning curve appears weaker than in other research studies (e.g. Falconer and Whitby, 2000; Kiss, 2016; Lee and Han, 2016; Michaelowa et al., 2003; Michaelowa and Jotzo, 2005). Even though the statistical analysis was carried out for applicants with one project only, there were a high number of respondents with more than one project (i.e. they applied with various projects at once or applied subsequently within different calls). The in-depth interviews revealed that, especially in the case of towns and cities, this does not necessarily mean that the transaction costs for these applicants would be lower. In the case of the public administration, if the respondents applied for more projects in the same programme, the various projects tend to fall under different departments (e.g. renovation of a school under the Department of Education, healthcare centre renovation under the Department of Public Health). The different parts of the administration hardly communicate and therefore do not make use of the potential for the transfer of knowledge and advantages of a learning curve. The second reason is the below further mentioned fluctuation of political employees.

4.2. The factors of project size and actors

Various studies have identified the relationship between the size of the project (or the performance) and the level of transaction costs (Bakam et al., 2012; Michaelowa and Jotzo, 2005; Mundaca et al., 2013). The data from the two analysed programmes, OP E and ECO-ENERGY has confirmed this premise. The relation is logarithmic, i.e. it seems that for bigger projects, the burden of transaction costs will be lower than for smaller projects. Following the regression function (for ECO-ENERGY), if the subsidy is EUR 10,000, the burden of transaction costs would be over 30%, for the subsidy of EUR 100,000, it would be 12%, and for EUR 1,000,000, it would be only 4%. The same pattern can be observed for OP E with the burden of transaction costs of 48% for the subsidy of EUR 10,000 going down to 2% for a subsidy of EUR 1,000,000. Therefore, in line with, e.g. (Michaelowa and Jotzo, 2005) economies of scale apply in the case of the analysed energy efficiency programmes. That would also suggest that the fixed costs (unrelated to the size of the project) prevail over variable costs.

On the other hand, the hypothesis that the size of transaction costs differs according to the type of actor in the energy efficiency programmes could not be confirmed. The analysis has shown that there is not a statistically significant difference between the two subsets of data, which differ only by the type of applicant. Yet, the results are close to conventional 10% confidence levels ($p = 0.13$ for $(\alpha_1 - \alpha_2)$ and 0.11 for $(\beta_1 - \beta_2)$).[8]

However, taking a closer look at the data, it can be seen that while there is no statistical difference between the costs of time and the size of the project between the two types of applicants, there is an observable difference as to the size of costs of external services. While the difference is on the verge of statistical significance (being significant only at 90% confidence level), the results suggest that private companies may be able to negotiate the services more effectively, but only for projects up until a certain size. The intercept of the two regression equations is at roughly EUR 300,000 subsidy, which includes 75% of the sample projects. The results seem to imply that unlike public entities, private companies in these programmes tend to contract suppliers of external services specifically for the project and therefore the amount of external services is in a tighter relationship with the size of the project. One can further speculate that the public entities will have the procedures and contracts standardised and therefore less dependent on the actual size of the contract.

On the other hand, for both OP E and ECO-ENERGY subsidy recipients the internal (time) costs were much less correlated with the size of the project – both slopes are low – 0.2. That would suggest that the activities carried out internally are predominantly of a fixed nature (for example, disregarding the size of the project, the structure and complexity of project applications remain the same). The results, therefore, suggest that there is room for optimisation for both public and private entities.

As for the structure of transaction costs, the main source of transaction costs for both types of applicants and administration bodies in the analysed programmes lies in the preparation process (the search for information, internal approval procedure and application submission)

[8] If the same analysis were performed for normal distribution of the sample – i.e. without converting the two variables into logarithms, there would be a statistically significant difference between the two programmes. That means that such hypothetical difference would be primarily pulled by large projects in the sample, which, however, do not form the core of the sample, nor of the population.

and the processes connected with public tenders for implementation of the energy efficiency measures.

The transaction costs related to tender procedures were found to be largely dependent both on existing legislation and on internal conditions set by the programmes. A straightforward and simple legal environment could play a significant role in decreasing the transaction costs burden (McCann, 2013). However, the respective transaction costs cannot be attributed only to this external factor. For OP E the programme conditions were set in a way that the initiation of public tenders was dependent upon approval from the administration body. Therefore, long time delays often developed, making the realisation of the energy efficiency measures more difficult (e.g. building envelope reconstruction in schools needs to fall in the time of summer holidays not to interfere with the school year). For ECO-ENERGY, the requirement to call for a public tender for energy efficiency measures stems purely from the conditions of the programme. In both programmes, the administrators aimed to streamline the procedures by developing checklists and standard documents.

Also, the type of actors seems to play a role in the very research on transaction costs. Given the nature of the subsidy recipients in OP E (towns, municipalities), the political cycle is a limiting factor. Often, the people responsible for the administration process have been replaced in the meantime (typically the mayors of the small villages), that means that the data on the transaction costs is irreversibly lost. The situation could be partially solved if the applicants had a tracking system in place, in which they assigned their time directly to a particular project. This problem did not arise in the case of ECO-ENERGY; continuity in the private companies systems seemed to be therefore better secured.

5. Conclusions and policy implications

Operational programmes distribute a significant amount of financing; large part is devoted to energy efficiency. For instance in the Czech Republic, over 1 billion EUR was dedicated specifically to energy efficiency measures solely in the programming period 2007 – 2013, so about 5% of the total allocation. However, monitoring and evaluation of the programmes remain often inadequate. It has been shown that when designing energy efficiency (subsidy) programmes transaction costs should be included in the ex-ante evaluations. Furthermore, ex-post evaluation of the programmes needs to cover not only the effects of the programme (energy efficiency gains, and other), but also total costs of the programme, including transaction costs.

The data in this study suggests that the transaction costs in energy efficiency subsidy programmes are of non-negligible levels, altogether averaging at 11%–14% of the total subsidy allocation. The results are comparable in their order of magnitude to the conclusions of available international analyses (even though due to methodological differences the studies tend to be rather case specific). In line with other studies, the size of transaction costs is closely related to the size of the project. For smaller projects, there seems to be directly proportionate relation whereas for bigger projects economies of scale apply and the total burden of transaction costs decreases.

Other factors being the same, the type of actor did not show to play the major role in the size of transaction costs in the two studied programmes. However, some differences can be traced in how the two actors negotiate for external services for implementing the projects. For smaller projects, which form most of the sample and the whole population in the programme, private companies are more effective, while for bigger projects (over EUR 300,000) public entities seemed more efficient. For both types of actors, transaction costs mostly arise in the preparatory phase of the application and tender procedures.

In order to optimise transaction costs, policymakers should try to address both the internal and external factors in programme preparation. Regarding the internal factors, a clear setting of the conditions of the programmes, provision of templates and streamlining of processes seem to be the most powerful tools. Externally, the legal environment determines to a high extent the complexity of the tendering process.

The data further revealed that there is room for improvement in setting the administrative processes for public bodies as recipients in energy efficiency subsidy programmes. Specifically, the public bodies may reconsider setting up their public tendering procedures to reflect the actual size of the project better.

Even though it was not the primary goal of the paper, the research also demonstrated that unsuccessful applicants need to be taken into account both in the ex-ante and ex-post evaluation of the programmes. The transaction costs born by unsuccessful applicants represent a non-negligible share of the subsidy and should not be omitted. (In extreme cases, transaction costs may event prevent possible applicants from applying.) A two-stage submission process may be a good way to lower the transaction costs for the unsuccessful applicants.

The research has opened further questions that could be examined, such as whether the role of actors in transaction costs is country/region specific or to what extent transaction costs develop over time in similar programmes. Systemic evaluation of transaction costs in policy measures could give answers to those questions.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.enpol.2018.04.055.

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