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Methodology for Measuring the Demand Geo-information Transaction Costs: Based on Experiments in Berlin, Vienna and Zurich*

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Methodology for Measuring the Demand Geo-information Transaction Costs: Based on Experiments in Berlin, Vienna and Zurich*

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Abstract

Searching for geo-information and inquiring about the conditions of exchange involves transaction costs. Neoclassical economy neglects the existence of these costs and therefore lacks economic models which could be applied to geo-information. We are interested in establishing theoretical foundations of transaction costs related to geo-information and in methods which could help to quantify these costs. The importance of this article is that this is to date the first attempt to measure the transaction cost of geo-information and at the same time it presents the first quantitative results. The research is novel and therefore in development. The presented methodology reflects our experiences gained in the selected cities of Berlin, Vienna and Zurich. We conclude the article with open questions and further research directions.

Keywords: geo-information, transaction costs, demand geo-information transaction costs, experiments

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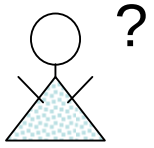
1. INTRODUCTION

Spatial data infrastructures (SDI) are designed to facilitate spatial data provision, accessibility, maintenance and use of geo-information. In this article we use geo-information (GI) in a broader sense, including spatial data, geo-information products and services providing geo-information, as the result of the service. A more detailed discussion on different definitions and meanings of geo-information can be found in Longhorn and Blakemore (2008). SDIs aim to provide efficient infrastructures for sharing and exchange of geo-information, enabling the users to effortlessly acquire and use geo-information in their decision-making processes. Experiences show that finding geo-information appropriate for the selected application or task is, in spite of all these technical developments, not an easy task. The surveys on the socio-economic impacts of the SDI in Lombardia, see more in Vanderhaegen and Muro (2005) and Craglia and Campagna (2009), show that companies experience problems in finding, accessing, and using the geographic and environmental information necessary to complete the environmental assessment studies. These authors report about 5-6% increase in cost due to the accounted problems in finding the data. “The total economic cost of poor data access and use was estimated in the order of € 100-200 million per annum” (Craglia and Campagna, 2009). The authors provide the estimation for the poor data access and user together and do not make any clear distinction among these two categories.

This article deals with the economic theory of the costs, called transaction cost, and presents a methodology for its quantification based on the empirical work done in the three selected European cities of Berlin, Vienna and Zurich. Transaction cost is basically the cost related to transactions. The trade of geo-information is a transaction. Consider a situation in which a potential user of geo-information searches for the appropriate dataset that can be used in her application. The questions that he will most likely ask are summarised in figure 1.

Figure 1: The geo-information user’s questions



Who has the appropriate dataset?

Is the available dataset useful for me?

How can I acquire it?

How much does it cost?

Finding the answers to these questions requires additional activities such as searching for the organisation which has the required data, finding the person responsible for the trade, and finding a knowledgeable person appropriate for a discussion about the technical characteristics of the data which are the subject of exchange. Due to the characteristics of the data being an experiential product (Niehans, 1987)**,** the potential user is able to estimate the fitness for use of the data for the application after testing it. This means that data acquisition and testing often need to be accomplished prior to purchasing the selected dataset. All these activities undertaken by the potential user require investment into the process of search and acquisition of the information about the spatial data and trade conditions. These efforts represent cost, which is in economic literature referred to as transaction cost (TC).

We are interested in geo-information transaction cost. Some ideas related to this cost come from our previous research (Krek, 2003; Krek, 2003a; Krek, 2003b; Krek, 2004; Krek, 2009a; Krek, 2009b). We believe that a SDI can be potentially more often used and successfully accessed by the users if it is able to reduce the transaction cost for the potential users and providers of geo-information. In this article we present the results of our experiments in which we measured geo-information transaction cost. The empirical work with the cases of Berlin, Vienna and Zurich resulted in an improved methodology for quantifying the geo-information transaction cost (GTC). The improved methodology is presented in the article together with our quantitative results. We are aware of the nascent stage of this research. The main value of this article is in its contribution to a better understanding of the transaction cost of geo-information and in presenting an attempt towards a methodology for measuring the geo-information transaction cost incurred on the potential user's side. Additional research needs to be done in order to better understand the geo-information transaction cost and its impact on the success of spatial data infrastructures. Our suggestions for further work are summarised in the concluding section.

2. TRANSACTION COST IN ECONOMY

Every trade is a transaction. In modern economy it is an exchange of a good for money or another good, depending on the agreement between the trading parties. Every exchange of the product entails costs that result from both parties attempting to determine the valued characteristics of the good (North 1990). It takes resources, including time, to measure these characteristics and additional resources to define and to measure the rights that are transferred to the user with the exchange of the goods. The cost associated with these efforts is considered to be the transaction cost (Williamson, 1985; North, 1990; Williamson and Masten, 1995; Sholtz, 2001).

2.1. Transaction cost and institutional economy

Coase (1937) was one of the first among economists who recognized the importance of transaction costs. In his research he focused upon the issue of the organisational structure of companies. He explored why some businesses are organised in the form of small companies and some others as large corporations. He focused on the relation of the organizational structure and the cost, claiming that certain organizational forms reduce transaction cost and are therefore potentially more prosperous in the competitive market economy. Coase (1960) established the crucial connection between institutions, transaction costs, and neoclassical theory. This field of economics concentrates on institutions, their organization and their impact on the competitive markets and is nowadays known as institutional economics.

North (1990) made a substantial contribution to the understanding of institutions and transaction cost and received a Nobel Prize in economics in 1993. He claimed that when it is costly to transact, institutions play an important role. According to North (1990) institutions are the humanly devised constraints that structure human interaction. They are made up of formal constraints (rules, laws, constitutions), informal constraints (norms of behaviour, conventions, and self imposed codes of conduct), and their enforcement characteristics. Together they define the incentive structure of societies and specifically economies. Institutions and the technology employed determine the transaction and transformation costs that add up to the costs of production. Only under the conditions of costless bargaining will the actors reach the solution that maximizes aggregate income regardless of the institutional arrangements (North 1990). North (1990) distinguishes between measurement and enforcement transaction costs. Measurement is the cost of measuring the valuable attributes and characteristics of the product, which is the subject of the trade. Enforcement cost is the cost of protecting rights, as well as policing and enforcing agreements. Transaction cost is generally independent of the price of the contracted good or service. Institutional economics provides diverse theoretical understandings of transaction costs (Williamson 1985, North 1990, Williamson and Masten 1999).

The empirical work in this research area shows that it is costly to transact. Wallis and North (1986) demonstrated in an empirical study that 45 percent of U.S. gross national product (GNP) was devoted to this transaction sector in 1970. This sector includes insurance companies, wholesale, retail trade, and banking as well as cost in occupations such as law and accounting. This percentage increased from approximately 25% of the GNP a century earlier. Twelve years later, Dollery and Leong (1998) studied the transaction cost in Australia. They observed a growth of transaction costs from 32% in 1911 up to 60% in 1991.

2.2. Information economy and transaction cost

Information researchers have debated for decades whether the so called “new economy”, the economy of information (Tapscott, 1996), can apply the economic models provided by classical economic theory. With classical economic theory we mean the neoclassical economy. Shapiro and Varian (1999), for example, claim that these models can be used to model the economy of information. In their research they basically apply the known neoclassical economic models and try to explain the characteristics of the economy of information. The user is, according to this theory, perfectly informed about the goods which are the subject of trade. This perfect information about the product and the conditions of trade results in zero transaction cost of acquiring the needed product (Mansfield 1993; Frank 2000).

This theory is not directly applicable to the digital information in general. Bates (2002) in her study reports how costly it is for companies to find information on the Web. She claims that American companies spend $ 107 billion a year paying their employees to search for external information. In her article she concentrates on the ways employees of business companies search for information and how much time and money do the companies invest into such activities. In this article, we focus on a particular kind of information, namely, geo-information and its specifics, which can be summarised as follows:

- First, finding the needed and appropriate geo-information is not an easy task. It requires time and knowledge. Time is invested into searching for the right provider, the responsible contact person, and the needed geo-information. Knowledge of the geo-information market is needed in order to understand how to efficiently search for the needed geo-information.

- Second, in order to be able to acquire the appropriate geo-information, the potential user needs to understand the characteristics of the good which is the subject of exchange. Without this knowledge, he or she is not able to communicate with the geo-information provider.

- Third, in order to be able to use the appropriate geo-information, the potential user has to invest additional time in the assessment of the quality of this information for the purpose of use. Knowing the quality parameters helps the user to understand the quality of the decisions taken with the help of this information. Often the knowledge of special software, which helps to manipulate and use this information, is needed.

The neoclassical economy completely neglects the existence of transaction cost. This is one of the reasons that geo-information economy needs new economic models which would consider transaction cost of geo-information (Krek 2003, Krek 2009a, Krek 2009b). Our article is an attempt to contribute to a better understanding of the transaction cost of geo-information and its specifics. In this article we concentrate only on geo-information even though the existence of transaction cost could be potentially valid for other information. An example is Scientific-Technical-Medical (STM) information, where searching for patents and abstracts requires skilled professionals.

3. GEO-INFORMATION TRANSACTION COSTS

Geo-information transaction costs appear in different phases of the search and acquisition of geo-information. In one of the first phases, the potential user of geo-information has to find the appropriate organisation and the contact person responsible for the trade. In the following phases he has to understand, and sometimes negotiate, the conditions of use and trade. A difference exists between an experienced user who has certain knowledge about geo-information market and the organisation of spatial data infrastructure (SDI) offering geo-information, and a novice, who has no information and no pre-knowledge about this market.

3.1. Pre-knowledge of the potential user

The knowledge of the potential user influences the transaction cost related to the search of the product, the provider and the contact person. We assume that a potential user who has certain knowledge about the geo-information market and the organisation of spatial data infrastructure (SDI) is able to find the potential providers more efficiently than the novice. He is informed about the basic characteristics of the national and local SDI and either knows the geo-information provider or is aware of where to find this information. In this case, the potential user can contact the provider without an extended search for the providing organisation and/or the responsible contact person. The geo-information transaction cost related to the search for the provider can be reduced due to the potential user's pre-knowledge of the geo-information market. A novice user, someone who has no knowledge about neither geo-information nor the organisation of a spatial data infrastructure, needs to invest time and effort to find the right provider of the needed geo-information, the providing organisation and the right contact person. The process of a search for the appropriate geo-information provider can be costly and sometimes very frustrating.

As soon as the potential user contacts the potential provider of geo-information, the transaction cost appears on both sides. In the process of agreeing on the geo-information exchange, the rights of use and trade and the characteristics of

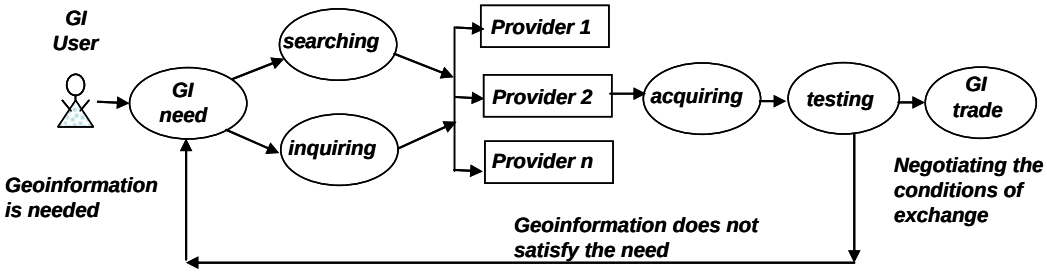
the exchanged geo-information, both parties invest resources. The transaction is costly, mostly due to the complex process of communication between the involved parties. The process of communication includes agreeing what has been exchanged, defining the properties of the exchanged geo-information and the conditions of its use. The costs appear on the user's and the geo-information provider's side. We distinguish between the demand and the supply geo-information transaction cost.

3.2. Demand geo-information transaction cost

The demand geo-information transaction cost (DGTC) is the cost borne by the potential user related to the exchange of the geo-information. It is the cost of the time spent on searching for the data provider, contacting the organisation and inquiring about the characteristics of the geo-information. Figure 2 shows the main steps he has to go through prior to buying the needed geo-information. Once he decides about the data provider and the product he wants to buy, he has to test it in order to check the quality of the geo-information and fitness of use for her specific needs. North (1990) defines these costs as the measurement costs. According to him, this is the cost of measuring the valuable attributes and characteristics of the product, which is the subject of the trade.

In the example of geo-information, the measurement cost (North 1990) includes inquiries about the geo-information and its characteristics, acquiring the data samples, the sources of geo-information, and spending the time needed to test their fitness for use within the application. Testing the acquired data samples enables the potential user to make an informed decision about the dataset acquisition. It is often a very time consuming activity, especially in cases of the acquisition of data from different data formats that cannot be easily imported into the existing software packages used by the potential user. This cost appears also for geo-information which is available for free, such as with OpenStreet Map. Figure 2 shows the process of geo-information acquisition and the basic activities related to this process, in detail listed in table 1, subsection 4.4.

Figure 2. Demand geo-information transaction cost



After the phase of testing, the potential user can decide whether he wants to buy the geo-informaton or not. A process of price negotiation, agreeing about the rights to use, and a more precise definition of the data content require additional investment by the potential user. Often, the user needs support of a commercial or legal expert or department who helps her to understand often used complex wording. This phase often requires different resources of the potential user. The cost related to negotiating for the conditions of trade are, according to (North 1990), called enforcement cost.

The enforcement cost of geo-information (figure 3) is the cost related to negotiating for the conditions of trade such as price of the geo-information, enforcing agreements, protecting copyright, and defining the right to use and distribute the acquired geo-information product or service. The negotiation process involves both, the potential user and the provider who are responsible for clarifying the suggested conditions of exchange and use. The cost include also the steps needed to be accomplished in order to legally posses the selected geo-information or to have it delivered. This cost incur on the potential user's and the provider's side and is differently distributed among them; the user has to understand the trade conditions and the rights to use the geo-information, and the provider needs additional resources dedicated to this process involved in explaining these conditions whenever they are not clear to the user.

Figure 3: Enforcement geo-information transaction cost (Krek, 2003)

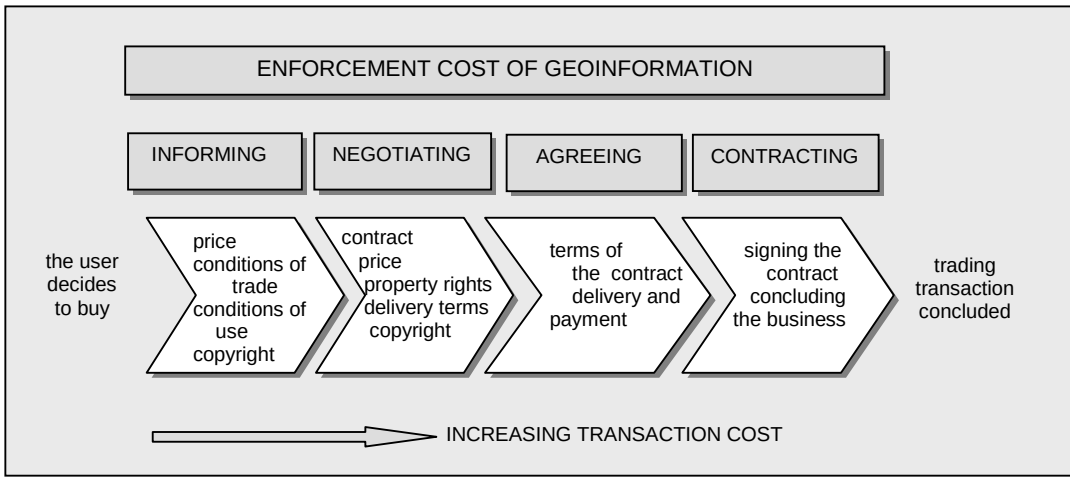


Figure 3 shows the categories of the enforcement cost for geo-information including informing, negotiating, agreeing and contracting. These phases may typically incur for other types of information, but in our research we focus on geo-information. The phase of informing includes the time spent gaining information

about the price of the product, conditions of trade and use, and copyrights. In the negotiation phase the parties negotiate the conditions of the exchange. In the phase of agreeing they come to agreements about the terms of the contract, payment and delivery. The phase of contracting includes the time spent on the contract, signing the contract and concluding the business. Some of these phases can be streamlined and automated, for example with online forms and licenses available for download, `click use` licensing policies or built-in digital rights management (DRM) for copyright control. These new forms, or documents, and services available online may have an impact on the distribution of the transaction cost between the potential user and provider.

3.3. Supply geo-information transaction costs

The supply geo-information transaction cost (SGTC) is the transaction cost related to the geo-information exchange that occurs on the geo-information provider's side. It is the cost that it is borne by the geo-information provider. It includes the cost related to explaining the complex rules about the use of geo-information and its copyright issues, non-transparent licensing, complex pricing policies and rules of sale. This cost is mostly the cost of the personnel working with the potential users of geo-information. The communication is done either via email or phone and can be very costly for the providing institution or business.

Some providers of geo-information try to reduce this cost with so called `click-use` licences and other sources of information and forms available online. In this case, the majority of the geo-information transaction cost is transferred to the potential user, who has to invest the time in reading the descriptions and documents available online. It takes time and additional effort to find the appropriate licensing policy and to fill in the forms available on the website. The transaction cost of the provider is potentially reduced, except in the cases of the potential user terminating the process of search for the right information, which could potentially result in the lost business for the geo-information provider.

In the imperfect market, institutions are composed of those that lower the transaction cost and those that raise it (North 1990). Institutions that raise it are the institutions that provide barriers to enter the market, encourage monopolistic restrictions, and impede the low cost flow of information. These policies represent another aspect of the transaction cost, which can potentially function as a barrier for other companies to enter the market. The national mapping agencies have often been seen as the institutions that raise the transaction costs and prevent further development of the geo-information market due to their data policies. Many of them are now facing liberalisation and reorganisation efforts. A more extreme example of this process is the reorganisation of the Ordnance Survey in Great Britain (OS, 2009), which now offers some of its geo-information for free.

In the case of intermediaries such as a central metadata system, a geo-information centre, a clearinghouse or a spatial data infrastructure, through which the geo-information can be assessed without a human communication, the majority of the transaction cost is potentially transferred to the user. The possibility to find the information available online may increase the geo-information transaction cost imposed on the potential user. The increased transaction cost may appear due to the extended search and investigations that need to be done by the potential user. It costs time and effort to search for the appropriate document online, to register in order to be able to get the needed documents, select, read and understand the appropriate licensing conditions, apply for the license agreement online, etc. Additional research is needed to understand the role of such intermediaries in respect to the geo-information transaction cost.

3.4. Total geo-information transaction costs

The total geo-information transaction cost (TGTC) is the sum of demand and supply geo-information transaction costs. It represents the total geo-information transaction cost incurred by the trade with geo-information and includes tangible (t) and intangible (i) geo-information transaction costs.

$$TGTC = DGTC\ (t, i) + SGTC\ (t, i)$$

Additional research has to be done in order to better understand the distribution of the geo-information transaction cost. The potential user might experience that the majority of the total geo-information transaction cost occurs on the potential user's side. This prevents many potential users to go through the process and to actually acquire geo-information. On the other hand, some of the geo-information providers (mapping and cadastral agencies, hydrographical services, etc.) employ personnel involved in their customer and sales services in spite of the considerable cost of the personnel involved in these activities.

3.5. Geo-information transaction cost is a sunk cost

Geo-information transaction cost is a sunk cost, which is a common expression in today's economics, which basically means a lost or irrecoverable investment. A sunk cost is the cost already incurred which cannot be recovered regardless of future events. In cases in which the user does not decide to buy the needed geo-information, the time invested in searching for the appropriate product, its provider, and inquiring about the conditions of the trade represent an economic loss for the potential user. It is furthermore the time spent on these activities that cannot be invested into other activities and it did not bring the needed result.

The same is valid for the geo-information provider. The time and energy invested into explaining the conditions of trade and the characteristics of the product

cannot be recovered in case the potential user does not decide to buy the geo-information product. It is a sunk cost for the geo-information provider, which adds to the cost of maintaining their sales and marketing departments.

4. MEASUREMENT METHODOLOGY BASED ON EXPERIMENTS

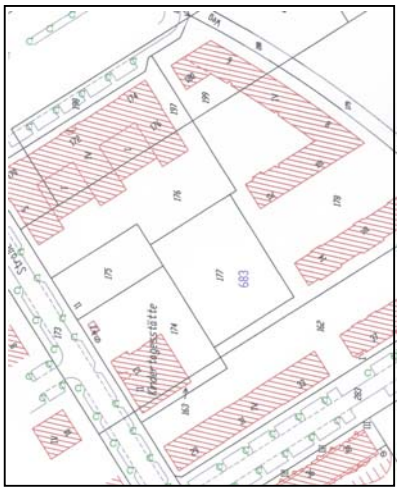
Our measurement methodology, as presented in this section, is a result of our ongoing research (Krek, 2003, Krek, 2004, Krek, 2009a, Krek, 2009b). The first experiments were limited student exercises which we soon extended and included in a more founded work. The results presented here are the results of our empirical work in which we, for the first time, went through the whole process starting with inquiring about the geo-information provider and the contact person, agreeing on the product which is a subject of the trade, and acquiring the test samples, and the conditions of trade and price. It included the whole cycle, from gathering the information to deciding about the purchase of the product.

The empirical work on measuring the geo-information transaction cost was done in three selected cities: Berlin, Vienna and Zurich. All three cities are European cities where the official language is German. The German speaking countries were selected in order to reduce the impact of the language knowledge or lack of knowledge on the estimation of the geo-information transaction cost. We attempted to acquire information about the layout of the public university buildings in the selected cities. This section describes our methodology for measuring the demand geo-information transaction cost and our first quantitative results.

4.1. Case study: searching for a dataset of the university buildings

The main task of the potential user was to find geo-information about the university buildings in the selected cities. The information required was initially the following: the layout of all university buildings located in the city; the number of floors in every building and the number of students in every university. After a complex search for this information, we decided to reduce the dataset required and re-focused on finding merely the layout of the university buildings, which includes basic dimensions, relative spatial placement, and the grounds. See the example of a dataset from Berlin (figure 4), which is a graphical representation of all buildings marked by hachure or diagonal lines.

Figure 4: Example of the dataset from Berlin



Our goal was to find a dataset, and a dataset provider, which could deliver this geo-information to us in a digital format. It should be possible to use the delivered dataset in the well known AutoCAD or ArcGIS software programmes. This means that we would need the data either in a DXF, DWG or Shape data formats, which can easily be imported either in the AutoCAD or ArcGIS software. Our further goal was to use this data for our analysis of the university buildings and their locations, and with this also the organisation of the universities studied in all three cities. The analysis should be done with the help of the geo-information system software ArcGIS. The study case was the result of a real world need by a group of urban planning students who wanted to analyse the locations of the universities in the selected cities for a university project.

4.2. Characteristics of the potential user and the basic tasks

The experiments were executed by potential users who had no pre-knowledge about the existing spatial data infrastructures in the selected countries and cities. He or he had absolutely no knowledge about possible providers of the digital data in general nor about the information related to the layout of the university buildings. All potential users involved in the experiments had no previous knowledge about geo-information markets which made the experiments comparable. They were young people, experienced in internet searches and in the middle of their university studies. They present the generation which is used to the internet and computers and have the energy to go through the complex process of data search, acquisition, and negotiations. The potential user's task was to find a digital dataset containing the layouts of all public universities in the selected cities. The potential user had access to a phone or E-Mail for the

exchange of information and the Internet or a phone book for information about the universities. They all used the same office at the university and the same computer, but their experiments were executed at different times. The same instructions about the geo-information required were given to all potential users of geo-information. They received the table 1 (section 4.4.) with measurement categories and their explanations. A short introduction into the experiments and an additional explanation of the measurement categories was given by the conducting researcher. He was available during the experiment for all further questions of the potential users. A good command of the German language aided these potential geo-information users in the executed experiments.

4.3. Demand geo-information transaction cost

In our experiments, we concentrated on the cost imposed on the potential user of geo-information and we neglected the cost incurred on the geo-information provider's side. For the purpose of our study we defined the transaction cost as suggested by the study of Wallis and North (1986) and Niehans (1987) in his publication. According to them, the transaction costs are "all costs borne by the consumer that are not transferred to the seller of the good". Particularly, we focused on the demand geo-information transaction cost (see section 3.2). This cost includes the cost related to searching for the geo-information provider and the contact people, inquiring about the geo-information and its technical characteristics, getting information about the price and trade conditions, acquiring it, and testing it within the application. The measurement categories are, in detail, explained in the following sub-section.

4.4. Measurement categories

The measurement categories are the core of our measurement methodology. Our goal is to identify and describe them in such a way that they are understandable to everybody using our methodology for measuring demand geo-information transaction cost.

One of the main issues was to define the measurement categories in such a way that everybody using this methodology would allocate the incurred cost in the same way. In table 1 they are presented according to the activities of the geo-information product acquisition process. The activities, noted with the numbers 1 – 6, are chronologically organised, but can also overlap and repeat in different phases of the geo-information product acquisition process.

Table 1: Phases of the process and measurement categories

Phases of the process	***Measurement categories***
Activity 1 *Searching for the geo-information provider*	Searching for the providing organisation Searching for the responsible contact person
Activity 2 *Inquiring about the general conditions of the exchange*	Inquiring via E-Mail Inquiring via phone
Activity 3 *Inquiring about the specific conditions of the exchange; phone or E-Mail*	Inquiring about the pricing policy Inquiring about the availability of the dataset
Activity 4 *Defining the exact characteristics of the geo-information*	Defining the features of the dataset, understanding the offer and explaining the need
Activity 5 *Acquiring and testing the geo-information*	Free sample data acquisition and storage Testing the "fitness of use"
Activity 6 *Understanding the documentation about the trade and use conditions*	Reading and understanding the conditions of use, trade and pricing policies

An important category, not included in the table, is a category of "waiting time". This category includes the time of waiting for the response on e-mails and phone calls, sometimes caused by the responsible person being sick or on holiday leave. Sometimes the contact person does not have all the necessary knowledge about the needed geo-information. This might cause additional frustration for the potential user trying to reach the responsible person, waiting for the response, checking emails often while waiting on the response, and not being able to continue with the search for the needed geo-information until he gets a response. Long waiting times can possibly lead to late deliveries of the user's projects or services due to the underestimated time of delivery and search for geo-information. This is a rather complex category which needs additional research. It is not included in the investigation within the experiments presented in this article and therefore also not included in table 1.

Table 2 provides a detailed description of the measurement categories, which are grouped according to the activities presented in table 1. The right column is a more detailed description of the categories listed. It is necessary for the people who execute the experiments in order for all of them to understand them properly and to use the table in the same way. We aimed to get comparable results executed in different cities and countries by different simulated potential users.

Table 2: Description of the measurement categories

Measurement categories	***Description of the measurement categories***
Searching for the geo-information provider	
Searching for the providing organisation	Searching for the providing organisation and for the contact information of the provider. This category includes also searching for the seller of the data in case the main provider and the responsible seller are not in the same organisation. Searching can be done via Internet, in a phone book or by phone.
Searching for the responsible contact person	Searching for the responsible contact person, his or her phone number and email address. Searching via Internet, contacting people who might be responsible for the geo-information exchange. This category includes Internet search, phone conversations, waiting for the responsible person (especially on the phone), and getting information about the availability of the responsible person.
Inquiring about the general conditions of the exchange	
Inquiring via E-Mail	Includes writing emails and reading the provider's responses. Included are all inquiries which occur rather at the beginning of the process and include inquiring if this organisation has the right dataset and what are the conditions of its possible acquisition.
Inquiring via phone	Includes phoning and comprehending the geo-information provider's offer. Included are all inquiries which occur rather at the beginning of the process and include inquiring if this organisation has the right dataset and what are the conditions of its possible acquisition.
Inquiring about the specific conditions of the exchange; phone or E-Mail	
Inquiring about the pricing policy	Searching for information about the price, talking to the responsible person about the price of the selected geo-information product.
Inquiring about the availability and conditions of use	Searching for information about the availability of the geo-information product, copyright, and the conditions of use
Defining the exact characteristics of the geo-information product	
Defining the features of the geo-information	Defining the features of the geo-information; the potential user explains the need for geo-information to the provider. Understanding the offer; understanding the characteristics of the product as communicated to the user by the provider. Communication done via E-Mail, phone and Internet search.
Acquiring and testing the geo-information product	
Free sample data acquisition and storage	Downloading the free samples from the website and/or talking to the responsible person about sending the free sample data. Acquisition is a minor cost in this category and therefore is combined with testing the geo-information product.

Testing the "fitness of use"	Testing the data quality, format and other characteristics within the application or software.
Understanding the documentation about the trade conditions and pricing	
Understanding the conditions of use	Reading and understanding the licensing conditions, copyrights, terms of use. It includes also the steps necessary to understand the conditions of use. In case of complex licensing, this might include involving an expert or contacting the geo-information provider and inquiring about the details.
Understanding the pricing conditions	Reading and understanding the pricing conditions.

5. EXPERIMENTS: QUANTITATIVE RESULTS AND DISCUSSION

Table 2 served as the list of possible measurement categories. In this paper we present the latest version of the methodology, which has been revised during and after the execution of these experiments. In this section we present the quantitative results of the executed experiments and discuss them critically in relation to the proposed methodology for measuring tangible demand geo-information transaction cost. We conclude the section with a list of intangible demand transaction costs not measured within this study.

5.1. Quantitative results: Tangible demand GTC

The quantitative results in this section are presented for the three selected cities; Berlin, Vienna and Zurich. They serve as an illustration of the relations among the categories and cannot yet be generalised. We measured the time spent for the presented categories. The executed experiments helped us to improve the measurement categories as presented in table 2, a revised methodology and the quantitative results gained are presented in table 3.

The quantitative results show that there is a substantial investment needed in the process of geo-information acquisition. In our case (table 3) the search for all three datasets lasted approximately 12.5 hours. In case the potential user's cost per hour would be valued at € 60, this would result in a cost of € 750. This is only the cost of transacting with one selected dataset in three different cities. It is a high cost and still does not include the price of the data, neither the cost of waiting time and delays in the student's project due to difficulties in acquisition of data nor any of the intangible demand geo-information transaction costs listed in section 5.3.

The most time consuming activities, calculated in minutes, were the following: defining the characteristics of the geo-information, acquiring it and testing (together 262 min.), inquiring about the general conditions of exchange (210

min.) and searching for the data provider and the responsible contact person (181 min.). These activities are listed in table 1 as Activity 1, 2 and 4.

Table 3: Quantitative results of the executed experiments

Measurement categories	***Time spent in minutes for the selected cities***		
	Berlin	***Vienna***	***Zurich***
Searching for the geo-information provider Total 181 min.	***13***	***95***	***73***
Searching for the providing organisation	10	78	58
Searching for the responsible contact person	3	17	15
Inquiring about the general conditions of the exchange Total 210 min.	***35***	***67***	***108***
Inquiring via E-Mail	20	45	42
Inquiring via phone	15	22	66
Inquiring about the specific conditions of the exchange Total 47 min.	***7***	***15***	***25***
Inquiring about the pricing policy; phone or E-Mail	5	8	15
Inquiring about the availability and conditions of use; phone or E-Mail	2	7	10
Defining the exact characteristics of the geo-information product Total 101 min.	***42***	***55***	***4***
Defining the features of the geo-information product	42	55	4
Acquiring and testing the geo-information product Total 161 min.	***69***	***49***	***43***
Free sample data acquisition and storage includes opening the data and storing the data in the right format	34	14	3
Testing the “fitness of use”	35	35	40
Understanding the documentation about the trade conditions and pricing Total 45 min.	***15***	***23***	***22***
Understanding the conditions of use	15	10	10
Understanding the pricing conditions	5	13	12
Total demand GTC Total approximately 12.5 hours	***186***	***304***	***275***

The total demand GTC for Berlin was 186 minutes, which is approximately 3 hours. This translates into € 180. The data was available only in .edbs format. A converter into a format readable in AutoCAD or ArcGIS environment would cost additionally € 900.-. The data itself cost € 0.32 for one object (with 60% discount possible for universities and research institutions). There are 361 objects representing university buildings in Berlin, which results in the price of € 115.52. The whole price for this dataset consists of € 180 for the demand geo-information transaction cost, € 115.52 for the data, and € 900 for the data converter. Together this dataset for Berlin costs € 1,195.52. The demand GTC (€ 180) is, in this case, higher than the price of the dataset (€ 115.52).

The total demand geo-information transaction cost in these experiments was the highest for Vienna. It required approx. 5 hours of work to get the dataset. The dataset is just a graphical representation of the buildings without attribute data showing different categories of the buildings. The search of 5 hours resulted in the recognition that there is only a geometric representation of the buildings in the dataset. This search of 5 hours translates into € 300 for this dataset, considering that one hour of the user's time costs € 60. The transaction cost of this dataset is almost as high as the price. The price of this dataset is € 353.97; a 90% discount is given for universities and research institutions. Acquiring this particular dataset would cost the potential user € 300 (transaction cost) + € 353.97 (price discounted for the universities), which means altogether € 653.97.

There are two additional problems with the acquired datasets. First, the potential user would have to identify all the university buildings by himself, which would require additional investment in time. Several hours would be necessary to complete this process by the user, and perhaps field work would be needed in order to identify the university buildings. Second, the data is in a format which cannot be directly imported neither into AutoCAD nor into ArcGIS, which represents additional problems. The true demand geo-information transaction cost is in this case much higher than the measured € 300 and it is again higher than the cost of data acquisition with the special price for the universities.

The result for the city of Zurich is similar to the one in Vienna; it required 4.6 hours to acquire the dataset, which translates into € 276 of the tangible demand geo-information transaction cost. In this case the data provider required a list of all universities from the potential user. This information was not available on the geo-information provider's side. Our investment into searching for the universities of University Zurich is not included in the time estimation. We found a list of the universities and concluded that this university has more than 200 buildings, which results in at least 200 objects in the database; and this is not the only university in the city. Our rather quick and imprecise estimation did not result in a complete evidence of all university buildings in this city. The price of vector data in .dwg or .dxf format is CHF 223.25 per object (without the tax; the tax is additionally

7.6%). 200 objects cost CHF 44.650,00 which is, according to the rate of exchange at the time of this writing, € 29.556,31. To acquire a simple dataset of 200 buildings as objects in Zurich, knowing that these are not all the buildings and they are not related to any attribute data, would cost € 276 tangible demand GTC and € 29.556,31 for the data, which altogether is € 29.832,31.

5.2. Critical discussion of the experiments

The executed experiments helped to improve the methodology for the measurement of geo-information transaction cost. The quantitative results have to be critically considered. In this section we share what we have learned during the execution of the experiments.

Each potential user executed the search in all three cities. At the beginning, the potential user was completely un-knowledgeable about the geo-information market. This is reflected in the numbers of the search for the providing organisation and the contact person. In the case of starting with the research in a particular city, for example, in Vienna, it took him or her some time to figure out the characteristics of the geo-information market and its organisation in this city. And not only this, one of the user's first ideas was to call and email universities and ask them about the layout plans of their university, which seems reasonable and efficient. This activity did not bring any results and resulted in an exhausting search for the appropriate contact person. The potential users were not aware of the existence of a geo-information market. The consequence of this was that in the city which was the starting city, he or he went through the whole procedure of searching without having any idea where such geo-information could be found. Searching for the providing organisation and the contact person in the following two cities appeared to be easier because of the experiences and the knowledge gained in the first city.

An improvement of the experiments would be to assign a novice potential user only for one experiment in one city and another person for the experiment in another city. In this case the measured results in every city would be comparable to the numbers in other cities. In our presented case, additional, independent experiments are necessary in order to provide more reliable quantitative results for the selected cities. A set of experiments with knowledgeable geo-information users would enable one to analyse the impact of pre-knowledge of geo-information market on the demand geo-information transaction cost.

The potential users were all from Germany. This might be the reason that the least time was needed for the search in Berlin, a German city. The reasons for this might be of an objective nature (the potential users had slightly more knowledge about the situation, even if unconsciously) or subjective nature (the

feeling of talking with someone from another country might result in less patience or a different style of communication).

In the categories of “reading and understanding the conditions of use and pricing policies” we limited the experiments to the reading the documentation. The potential users had to understand how much the needed geo-information would cost, but were not required to understand the legal conditions or more complex pricing policies. The experiments were limited to the use of geo-information for research at the universities. A more complex process of understanding licensing, terms of use conditions, which often requires at least minimal legal training or an equivalent comprehension, has not been included in this investigation. The commercial use was not considered in our experiments. Taking the commercial use into account and a study of the complex conditions would result in an even higher demand geo-information transaction cost.

Additional experiments would have to be executed in order to be able to make conclusions about the spatial geo-information infrastructures in the selected cities and the role of clearinghouses, data portals and metadata systems. A profound knowledge of the national geo-information infrastructure would help to understand the presented quantitative results in every city. Additional research is needed to relate the organisational structures of SDI and the geo-information transaction cost.

5.3. Intangible demand geo-information transaction cost

Table 3 presents the quantitative results measured by the time spent for the listed tasks and includes only the measured categories. Besides these categories, the demand geo-information transaction cost includes also intangible transaction costs. The execution of our experiments demonstrated a need for estimating this cost as well. The intangible demand transaction cost includes the costs that are difficult to quantify. It is the cost of frustration for the potential user, so often observed in our experiments, while dealing with the potential geo-information provider, searching for a possible provider, or trying to define the characteristics of the geo-information. A great amount of patience is needed in such cases. The amount of patience and possible frustrations are difficult to measure, but we should be aware of their existence. The level of frustration is difficult to estimate, but it is an important parameter that needs to be mentioned in this analysis.

In this section we provide a description of the reasons for some frustrations experienced during our empirical work. Some of them almost prevented the simulated potential user from further activities within the experiment. These are additional transaction costs which have to be borne by the potential user, but may also result in the cost for the seller in the form of a lost sale. They are not included in the measured categories within our methodology. Additional research

is needed to understand this cost and to find the best method for its estimation and measurement.

- **Intangible costs related to finding the right contact person**

Finding the responsible provider and the contact person is not always easy. Sometimes it is easy to find the responsible people, who later in the process may start claiming not to be responsible anymore. This change in the situation causes frustration and effort in searching for a new responsible person. The frustration is quite high in cases when they start sending the potential user from one address to another one, everyone claiming that he or she is not the right contact. This happened in one of our experiments. The frustration was so high that the potential user wanted to stop the experiment.

- **Intangible cost related to the geo-information**

Data format: Several frustrating experiences were related to the data format. The potential user experienced the following feelings; the feeling of being left alone in the situation, angry because of lack of help, helpless due to the missing software or clear instructions on how to solve the problem. In one of our study cases, the data was not available in a data format which could be easily imported into a geographical information system (GIS). It was not possible to get data neither in .dxf or .dwg formats, which are standard AutoCAD formats, nor in a Shape, a format of the software ArcGIS. The data was stored instead in an .edbs format and the sample of this dataset was sent to the potential user as a text file. A special converter, which could convert the data in the needed format, costs approximately 900 €. The potential user was not able to convert the data in a usable format, as the converter was too expensive. This is only one example. The tangible demand GTC can be objectively measured by the time needed for the conversion and for the search for the converter, but the potential user felt very frustrated due to the amount of additional work imposed on him because of the inappropriate data format.

Understanding the characteristics of the product: Understanding the characteristics of the geo-information, which is the subject of trade, is not easy. It is sometimes not clear what is included in the dataset and whether this dataset will serve the needs for geo-information the user has. An example of such a frustration happened at the beginning of one of our experiments in which it was difficult to find the right contact person responsible for the trade. The first contact person representing possible official providers explained that such data exists only in an analogue form. Later we realised that it was a misunderstanding; they were talking about the interior building plans, which was not our question. A discussion about the needed product over the phone can often be frustrating; it is difficult to describe the characteristics of the needed geo-information.

Acquisition of the geo-information: The next problem, and the frustrations related to it, represented the acquisition of the test samples. According to the potential provider, the test samples of the data were available on the Internet. It was not possible to find the suggested dataset and also not possible to acquire a dataset for testing. Both situations required some effort in explaining what we were trying to find and letting the provider know that the potential user still did not understand the geo-information offer.

- **Intangible cost related to the communication**

The possible frustration in the communication process is one of the most important intangible demand geo-information transaction costs. It appeared in almost all activities of the trade with geo-information in our experiments. It was often difficult to find the responsible persons and to get information from them. Even though all were speaking the German language, one of the potential users had substantial problems understanding the Swiss German language; communication via phone therefore represented a serious problem. Several E-Mails were not answered. An interesting issue is how to estimate the waiting time, frustration with unanswered emails, with responsible contact persons that do not have the needed information, and unpleasant and unkind personnel.

6. DISCUSSION AND FURTHER RESEARCH DIRECTIONS

This article presents the result of our ongoing research. It aims at contributing to a better understanding of the geo-information transaction costs. Understanding the transaction cost and its effect is crucial for the development of spatial data infrastructures and the prosperity of geo-information markets in general. The awareness of the existence of geo-information transaction costs and their implications on the geo-information market can potentially lead to new business models for both geo-information providers and users. This paper describes our first quantitative results in our ongoing research related to the measuring of geo-information transaction costs. In this article we described the experiments conducted in Berlin, Vienna and Zurich.

The highest demand geo-information transaction cost was found in the categories of searching for the providing organisation and the responsible person, acquiring information about the conditions of exchange, and testing the data samples. The demand GTC related to the providing organization depended very much on the characteristics of the geo-information product, the previous knowledge of the user and the characteristics of the spatial data infrastructure. We found out that the transaction cost is much higher for the specific datasets which are not in the standard selling program of the national mapping agencies, such as data needed for a real estate GIS-based application. In an earlier experiment, for instance, the search for a suitable provider of the real-estate data lasted 40 minutes in

comparison with the search for a base map in Sweden, which lasted an average of 15 minutes (Krek 2009a, Krek 2009b).

Another important factor in the estimation of the demand geo-information transaction cost is the potential user's pre-knowledge of the geo-information market and of the providers and their geo-information products and services. The pre-knowledge of the user substantially influences the level of the geo-information transaction costs imposed on the potential user. Knowing the name and the address of the main provider helps to substantially reduce the measurement transaction cost, and with this the total geo-information transaction cost. More attention should be paid to the cost of transacting and especially in finding ways to reduce transaction costs for the potential users. The newly developed national and local spatial data infrastructures should be designed in such a way as to reduce the geo-information transaction cost for the potential user and geo-information provider. Such systems would potentially be very beneficial to those who are still implementing various policy and business model aspects of their SDIs. Additional research is needed in order to find the best possible strategies that could lead to reduced geo-information transaction costs for all involved parties.

The metadata, and the form of informing the potential users about the offers, additionally influence the level of the transaction cost. They are part of the organisation of the spatial data infrastructure. What are the organisational forms and procedures and how do they influence the demand and supply of geo-information transaction cost? This is another research area that needs additional attention.

We assume that the organisational structure of the spatial information infrastructure, especially the national spatial data infrastructure profoundly impacts the geo-information transaction cost. By organisation we refer to the organisational structure such as: the number of providers for the same or similar datasets, the existence of clearinghouses, the availability of metadata systems, etc. In our future work we plan to explore the relation between the organisation of a SDI and the level of the geo-information transaction cost. Our hypothesis is that the centrally organized spatial data infrastructures reduce the transaction cost for the potential user. Additional studies are needed which could prove this hypothesis. They have to be complemented with the study of the supply geo-information transaction cost. It is not possible to know if the supply GTC is higher in centralized or decentralised organised spatial data infrastructures.

Our experiments confirmed the importance of transaction cost and the need for a new economic model in the geo-information market. These new economic models would have to consider the geo-information transaction cost as one of the important parameters in this market. In our empirical work we will continue

working on the measurement of the geo-information transaction costs. Our special interest is in the relation of the organisational structure of the spatial data infrastructure and the geo-information transaction cost.

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