ESTONIAN RESIDENTS' WILLINGNESS TO PAY FOR STOPPING QUARRY EXPANSION: A CONTINGENT VALUATION STUDY

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Abstract

The article discusses the indirect external costs of limestone mining. Limestone is an important construction material in Estonia, with 5-6 million tons mined annually. Rubble is used extensively in road construction, for which there is no domestic alternative. Maintaining the volume of limestone production and ensuring security of supply requires the exploitation of new limestone deposits and opening of new quarries. Limestone mining is accompanied by extensive changes in the natural environment and disturbances to residents. However, local governments are often against the opening of new mines, and litigations can last for decades. This endangers the security of limestone supply. Municipal governments' opposition to mines is due to the decrease in residents' welfare associated with mines, which is not adequately compensated. A contingent valuations study was conducted to identify and quantify the indirect external costs of mined limestone, which revealed that the aggregate willingness to pay of the Estonian adult population to stop the expansion of limestone quarries is 36.6 million euros per year. This can be interpreted as an indirect external cost of limestone. By relating to the willingness to pay to the limestone produced, the indirect external cost of one ton of limestone is approximately 6 euros. Quantifying the indirect external cost allows it to be included in the price of production as an environmental tax.

Keywords: Environmental economics, economics of non-market values, contingent valuation, external costs of mining,

JEL classification number: Q5; Q51; Q56; Q57

Introduction

Limestone is an important local construction material used in Estonia, with an average annual mining volume of 5-6 million tons. (Ehitusmaavarad | Eesti Geoloogiateenistus (egt.ee). Limestone rubble is the most widely used material in road pavement construction. In road construction alone, the annual demand for rubble produced from limestone is approximately 2 million tons.

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It is possible to extract 250 thousand tons of limestone from one hectare. Considering
that an average of 5.7 million tons of construction limestone and construction dolostone are extracted annually, the area of quarries has increased by approximately 23 hectares per year.

The security of supply of high-grade building limestone is in a critical state in some areas of Harju County. Considering that transporting minerals over 50 kilometers is economically unreasonable and has a very large environmental footprint. According to the current mining permits, limestone will be available in Harju County for less than ten years. The solution to the threatening building mineral crisis would be close. Jõelähtme rural municipality near Tallinn has large and good-quality limestone reserves in a deserted swampy area. With this reserve, Harju County and Tallinn would have rubble for construction for the next 30 years. Limestone factories of Estonia have been applying for permission to start mining limestone there for years. But the local government will not let this happen at this time.

In fact, there are many large quantities of limestone reserves in North Estonia with very good quality and mining conditions. Unfortunately, a large reserve has been made inaccessible by construction activities. For example, the largest Tallinn city district Lasnamäe has been built on a very good-quality limestone reserve. However, mining cannot be carried out even in places where construction has not been allowed due to the location of the deposits and where there are no nature conservation objects, because inhabitants and local municipality are against it.

There is no doubt that the expansion of quarries has extensive negative impact both for the environment and people. The population disturbing (and therefore welfare losses) are not only related to the mining period, but the landscape loses its original function and is forever changed. The opposition of local governments and residents to the construction of new mines and the expansion of existing mines allows us to hypothesize that the mines have a real and measurable impact on the welfare of residents. Considering the good visual exposure of limestone quarries and the (sometimes heated) discussion in the media, it can be assumed that the expansion of quarries does not only affect local residents, but also the welfare of the Estonian people in general. Moreover, the decline in welfare is caused not only by the immediate physical (visual) impact, but also by the psycho-social impact, one of the causes of which is the knowledge of the existence of the area of limestone quarries.

To test the hypothesis, a contingent valuation study was conducted, which determined the willingness of the Estonian population to pay for the delay in the expansion of limestone quarries. In addition to presenting the results of the study, the article provides an overview of the legal framework related to the establishment of new limestone mines and the externalities of mining.

1. Legislative framework for opening new quarries

The legislative framework for opening new mines is provided for in the Earth's Crust Act (Maapõueseadus). The general principles of ownership of mineral resources are set out in Section 11 of the Earth's Crust Act, "Extent of Ownership of Mineral Resources and the Earth's Crust". According to this, the state owns mineral resources in the bedrock and mineral resources in public water bodies. The natural deposit of bedrock belongs to the state and the immovable property does not extend to this.

Such state-owned mineral resources are not in civil circulation in their natural form. If a permit is required to remove state-owned mineral resources from their natural state, the quarry obtained from mining under the permit belongs to the permit holder. The quarry obtained from mining without a permit belongs to the state. A permit from the Ministry of Climate or a state agency authorized by the Minister of Climate is required for activities affecting the condition and use of the earth's crust.

The application for a mining permit is provided for in Section 49 of the Earth's Crust Act. According to the Act, in order to obtain a mining permit, the applicant shall submit an application to the issuer of the mining permit. The issuer of the mining permit shall immediately send the application for a mining permit to the state authority responsible for ensuring the geological competence of the state for an opinion, which shall submit its opinion in writing within ten days of receipt of the application.
The issuer of the mining permit shall send the application for a mining permit to the local municipality unit of the proposed mining site for an opinion, which shall submit its opinion in writing within two months of receipt of the application.

The Earth's Crust Act also provides for the protection of residential buildings in the immediate vicinity of a mine. If a mining concession or its service area is located closer than 100 meters to a residential building, the application must be accompanied by the consent of the owner of the property.

Section 55 of the Earth's Crust Act, "Refusal to issue a mining permit", also provides for cases and circumstances in which a mining permit will not be issued.
In addition to many technical criteria, local governments are protected by the provision that a mining permit will not be issued if the local government unit does not agree to issue a mining permit. Households in the immediate vicinity of a planned mining operation are protected by the provision that a permit for mining will not be issued if the mining reserve or its service area is located closer than 100 meters to a residence.

Issues related to sustainable environmental use play an important role in the Act. Thus, Section 13 of the Act establishes the principle of reducing environmental disturbances. In their activities guiding the use of the earth's crust, administrative bodies are guided by the principle that environmental disturbances caused by the use of the earth's crust must be reduced to the greatest extent possible, paying particular attention to such environmental disturbances that affect water, air, soil, protected natural objects and the right of individuals to an environment that meets their health and well-being needs. If various solution options exist, a solution that entails less environmental disturbances should be preferred, if possible.

2. Problems related to limestone mining: externalities and opposition to mine expansion

One of the most complete mappings of the externalities associated with quarries has been done by the Environmental Law Center. Estonian Environmental Law Center (EELC) is an independent expert organization. The aim of EELC is to shape environmental law rules and their application in a manner that takes due account of public interests (Legal experts in environmental matters).

EELC advises people on legal issues related to the environment, including legal analysis and finding solutions to disturbances and conflicts associated with mineral extraction. By advising people whose welfare is threatened by mining, EELC outlines advice for people to submit their views on mining permits (Keskkonnaõiguse Keskus).

The EELC identifies the following impacts for all quarries:
• noise generated by machinery in the quarry (buckets, excavators, loaders, trucks, screening and crushing units);
• noise generated by machinery moving within the quarry (e.g. when transporting material);
• dust generated by both mining activities and transport,
• irreversible changes in landscape and land use during and after mining,
• increased traffic, which in turn affects road safety and road conditions.

The use of blasting (especially in the mining of limestone and dolomite) additionally entails:
• short-term, but very loud noise,
• vibration, which can damage buildings,
• in the immediate vicinity of the quarry, there may be a danger from rocks being thrown into the air during blasting operations.

After considering the significant impacts, people are advised to ensure that mitigation measures are proposed in the draft permit for all impacts associated with mining.
Different mitigation measures can be taken for different impacts. The most common measures, based on the impact to be mitigated, are as follows:
• Surrounding the quarry with earth embankments or other noise barriers,
• Placing larger noise sources (e.g. sorting and crushing equipment) further away from residential buildings and other sensitive objects, at the bottom of the quarry,

• Planning mining operations so that they start as far away from residential buildings and other sensitive objects as possible and movement towards them takes place in the quarry pit, which blocks the noise,
• Limiting working hours, including the time of transportation,
• Transporting material along alternative routes,
• Reducing the speed of trucks transporting minerals,
• Using smaller charges in the case of blasting noise,
• Preserving the forest between the quarry and residential buildings and other sensitive objects (or preserving it for as long as possible).
In addition, other measures related to the water regime are recommended, such as: mining below groundwater without pumping it out and settling water pumped out of the quarry before discharging it into rivers and lakes.

Landscape-related measures are also very important, such as:
• starting remediation as early as possible,
• setting conditions for remediation that allow the area to be used again later.

The implementation of landscape-related measures will determine how the area will look after mining is completed. In addition to measures to reduce impacts, the mining permit may include monitoring conditions, i.e. an obligation to measure/assess impacts after mining has started.

Local governments and residents, represented by non-profit organizations, often challenge both environmental impact assessments for the opening of mines and mining permits that have already been issued. A good example of a local government's fight against mining expansion is the Jõelähtme rural municipality's attempt to block the expansion of limestone mines, which lasted almost 20 years (Riigikohus, 2023).

OÜ Väo Paas submitted an application for mining construction limestone in Jõelähtme rural municipality back in 2005. The rural municipality did not agree to this, but in 2010 the government nevertheless approved the establishment of the mine, and the Environmental Board issued the company a mining permit a year later. The creation of the new mine was justified primarily by the shortage of limestone rubble needed for road construction in Harju County.

Since then, legal disputes have been running in parallel over the granting of the mining permit and the creation of a protected area in the same location. Namely, in 2017, the rural municipality took the area around Ruu village under local protection, which excluded limestone mining there. The rural municipality referred to the need to protect the valuable dune landscape and preserve and improve people's recreational and recreation opportunities.

The Administrative Court annulled the creation of the protected area based on a complaint by OÜ Väo Paas, but in 2020 the rural municipality took the area under protection again. A year later, the Administrative Court annulled the establishment of the protected area for the second time, and today the Supreme Court also agreed with this.

3. The Contingent valuation study (CVM)

Each person's assessment of the quality of their life includes an assessment of their standard of living and the non-market goods they perceive, value, and consider necessary. Theoretically, each person can assess what (how much) part of their income they are willing to sacrifice (how much they want to spend) to achieve the desired non-economic good - with the aim of increasing their well-being. Each non-market good has a different and even time-changing monetary equivalent for each person.

Many natural values are non-market. Individuals' economic assessment of these values is shown by their willingness to pay for the preservation or restoration of a natural object as a carrier of value. Methodologically correctly determined willingness to pay provides information about the monetary equivalents of preserved natural values and prevented damage (Garrod, G.; Willis, K.G., 2001).

In the case of contingent valuation, the aim is to explain the willingness to pay of respondents for goods, projects or programs that are hypothetical in nature. The value attributed by respondents to the object being evaluated in the form of willingness to pay is conditional with respect to the market (or market scenario) constructed or simulated in the survey (Portney, R., 1990). If there is no real market for a certain good (i.e. the good is non-market), it must be created hypothetically. People are asked how much they are willing to pay for an increase in the quality or quantity of a non-market good (preventing a decrease), which is considered willingness to pay. Most applications of the contingent valuation method are related to environmental objects and other non-market goods that have the characteristics of a public good.

In the last decades of the 20th century, the contingent valuation method has become increasingly popular and is widespread in all developed democratic countries, serving as a good quantitative input in social cost-effectiveness analysis when comparing competing or mutually exclusive development and resource use scenarios that contain non-market components.

The contingent valuation method is considered to be very reliable in determining the monetary equivalent of the value of non-market goods and services of nature. The method is also universal, practically suitable for determining the monetary equivalent of very different types of non-market environmental goods. Despite its wide distribution, especially in academic research, a major drawback of the method is the need for expensive special studies each time the method is applied. The contingent valuation methodology has been exhaustively discussed by Carson (Carson, R.T., 2011).

The implementation of the contingent valuation method in Estonia began at the beginning of the 21st century (Ehrlich, Ü ja Habicht, K., 2001). In recent years, the monetary equivalent of non-market ecosystem services obtained with the contingent valuation method has become an important input into ecosystem services statistics (Ehrlich, 2021; Ehrlich, 2021).

3.1 Methodology and results

To fulfill the research task, a contingent valuation study was conducted, during which a representative sample of approximately 1,000 Estonian adult population was interviewed. The analysis conducted in the study is based on 906 questionnaires completed in accordance with the requirements. All meetings with sample members were conducted as a physical meeting between the interviewer and the interviewee in the form of an interview, and the questionnaires were completed on paper. In addition to the questions on willingness to pay typical of a contingent valuation study, the questionnaire also included questions on the respondents' information about limestone quarries and their attitude towards the increase in quarries area (see Table 1).

Table 1 Distribution of answers to questions about limestone quarries.

		Number of respondents	%	Number of respondents	%	Number of respondents	%
1.	1- Yes, I have seen limestone quarries in nature.	508	56.1				
	2 - Yes, I have seen limestone quarries in photos.	303	33.4				
	3 - I haven't seen any limestone quarries.	95	10.5				
2.	1 - Yes, if it is economically justified			214	23.7		
	2 - Yes, if it is not near where I live			109	12.1		
	3 - Yes, as long as it doesn't harm nature			270	29.9		
	4 - No, because it is not possible to mine limestone without damaging			241	26.7		

		Number of respondents	%	Number of respondents	%	Number of respondents	%
	the environment.						
	5 - Can't say.			70	7.7		
3.	1 - Destroys the natural environment					610	67.3
	2 - Makes monotonous nature more varied					71	7.8
	3 - If limestone rubble is needed for construction, the environment is not important					95	10.5
	4 - Can't say.					130	14.3
TOTAL		906	100.00	904	100.0	906	100.0

The questions asked in addition to the question of willingness to pay, along with the distribution of answers, are presented in Table 3. 56% of respondents answered yes to the question "Have you seen any limestone quarries?". This is a surprisingly high proportion considering the total area of the quarries and shows that more than half of the people have had at least a visual contact with limestone quarries. Only 10.5% of respondents had not been to a limestone quarry either directly or in a photograph. Limestone quarries and their impact on the environment are well known to Estonian residents, as is also shown by the significant quantified demand to stop the further expansion of the quarries.

The second question, "Do you think the expansion of limestone quarries is right?" was not simply given a yes/no answer, but was formulated conditionally in order to clarify the residents' opinions in a more nuanced way (see Table 1). The largest number of respondents (29.9%) agreed with the expansion of limestone quarries if it does not harm nature. The proportion of those who thought that it was not possible to extract limestone without damaging the environment (26.7%) was approximately the same. Only 12.1% agreed with the extraction provided that the mine was not located near their home. Only 7.7% of respondents did not have an opinion on the issue of the expansion of quarries.

In summary, based on additional questions, it can be concluded that the majority of Estonian residents have seen limestone quarries, are convinced that they damage the natural environment. All of these positions are also supported by the significant quantified demand of Estonian residents to stop the expansion of limestone quarries.

The distribution of the respondents' willingness to pay according to sociometric indicators is presented in Table 2. In addition to the arithmetic mean, which is used to calculate the aggregated total willingness to pay of the Estonian adult population, the table also shows the median willingness to pay of groups with the corresponding sociometric indicators.

The arithmetic average willingness to pay of men and women differs little, with men having 93.9 percent and women having 105.8 percent of the total average. However, the median willingness to pay of men is 10 euros compared to 20 euros for women. This suggests that men's willingness to pay is more variable, and the proportion of men with a higher willingness to pay is probably higher.

Table 2. Distribution of willingness to pay (WTP) according to sociometric indicators.

	Arithmetical average WTP, EUR	Per cent of total average	Median WTP, EUR	Per cent of total average
Gender:				
Male	32.2	93.9	10	66.7
Female	36.3	105.8	20	133.3
Education:				
Basic	36.0	105.0	10	66.7
Secondary	30.7	89.5	10	66.7
High (University)	38.0	110.8	20	133.3
Age:				
18-23	25.2	73.6	12	80.0
24-29	35.0	102.2	15	100.0
30-39	41.3	120.3	20	133.3
40-49	48.1	140.1	25	166.7
50-59	36.4	106.1	20	133.3
60-69	32.1	93.7	15	100.0
70 and over	21.2	61.9	10	66.7
Average net monthly income (EUR):				
500 or less	27.6	80.3	10	66.7

501-800	22.8	66.4	10	66.7
801-1000	30.7	89.5	12	80.0
1001-1300	35.9	104.7	15	100.0
1301-2000	39.2	114.3	20	133.3
Over 2000	42.3	123.4	20	133.3
TOTAL AVERAGE	34.3	100	15.0	100

The distribution of the arithmetic average willingness to pay is also relatively even by education, with respondents with higher education having a willingness to pay of 110.8 percent, slightly higher than those with primary (105.0%) and secondary education (89.5%). However, the median willingness to pay of respondents with higher education is 20 euros compared to 10 euros for other groups.

The distribution of willingness to pay by age shows quite large differences between age groups. The lowest willingness to pay is in the youngest (18-23; 73.6% of the total average) and the oldest (70 and over; 61.9% of the total average) age groups. Willingness to pay increases evenly from both the youngest and oldest age groups towards the middle age group (40-49; 140.1% of the total average), where willingness to pay is highest. The median willingness to pay also follows the same pattern. Such a result can be considered as expected, because firstly, middle age groups are most likely to be better secured financially and probably also better informed, which is why issues related to the expansion of limestone quarries are relatively more important as a determinant of their welfare.

The last indicator asked, average monthly income (net), shows the dependence of willingness to pay on the amount of income. Although the lowest (66.4% of the total average) willingness to pay is not in the group with the lowest income (less than 500 euros per month), but in the next income range (501-800 euros per month). The highest willingness to pay is in the group with the highest income (over 2000 euros per month).

To determine the statistically reliable dependence of the amount of willingness to pay on the sociometric indicators of the respondents, a correlation analysis was conducted. For this purpose, a regression equation was prepared in the form:

$$\ln(WTP) = B_0 + B_1 GENDER + B_2 \ln(AGE) + B_3 \ln(INCOME) + B_4 \ln(EDUC) + u_i$$

The analysis was carried out using the econometric software E-Views 4. The results are presented in Table 3 (the analysis conducted using E-Views is presented in its original form).

As can be seen from the results of the analysis, the amount of willingness to pay is strongly and statistically reliably dependent on income (at the 99% level, P=0.0004). There is a weaker, but still statistically reliable (P=0.0730) dependence on the gender of those who declared it. The age and education of those who declared willingness to pay are not statistically correlated with the size of the willingness to pay.

The basic dataset for the work is a willingness-to-pay survey of a representative sample of the Estonian working-age population regarding the halt in the expansion of limestone quarries. Based on this, the aggregate demand function for the halt in the expansion of limestone quarries is determined and a demand curve is constructed.

Dependent Variable: WTP
Method: Least Squares
Date: 09/27/24 Time: 10:21
Sample (adjusted): 1 905
Included observations: 905 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.54918	9.596540	1.307678	0.1913
SUGU	6.615719	3.685663	1.794988	0.0730
VANUS	-0.858858	0.915116	-0.938523	0.3482
HARIDUS	-0.435362	3.439863	-0.126564	0.8993
SISSETULEK	4.200385	1.172833	3.581401	0.0004

R-squared	0.018352	Mean dependent var	34.32008
Adjusted R-squared	0.013989	S.D. dependent var	54.76743
S.E. of regression	54.38302	Akaike info criterion	10.83549
Sum squared resid	2661761.	Schwarz criterion	10.86205
Log likelihood	-4898.059	Hannan-Quinn criter.	10.84564
F-statistic	4.206290	Durbin-Watson stat	1.902781
Prob(F-statistic)	0.002222		

The curve describing the actual distribution of willingness to pay is best fitted by the function

$$WTP = \alpha e^{-\beta x}$$

Where WTP denotes willingness to pay in euros, x is the number of people in thousands who are willing to pay a specific amount; α and β are the parameters to be estimated. The Figure below shows the actual distribution of willingness to pay and the corresponding graph equation produced by the software

$$WTP=183{,}24e^{-0{,}005x}$$

Where the parameters to be estimated are α=183.24 and β=0.005 and a demand curve is constructed based on this.

The total demand of the Estonian population for the cessation of the increase in the area of limestone quarries is mathematically proportional to the area under the demand curve in the figure. Total demand (CS- consumer surplus) is found by integrating the demand curve in the figure according to the formula:

$$CS = \int_{x_1}^{x_2} WTP(x)dx = \int_{x_1}^{x_2} \alpha e^{-\beta x} dx = -\frac{\alpha}{\beta}(e^{-\beta x_2} - e^{-\beta x_1}) \cong \frac{\alpha}{\beta}$$

where x1 is 0 and x2 is the number of people with a positive willingness to pay.

The aggregate demand curve of the Estonian working-age population after the increase in the area of limestone quarries stops is presented in Figure 1.

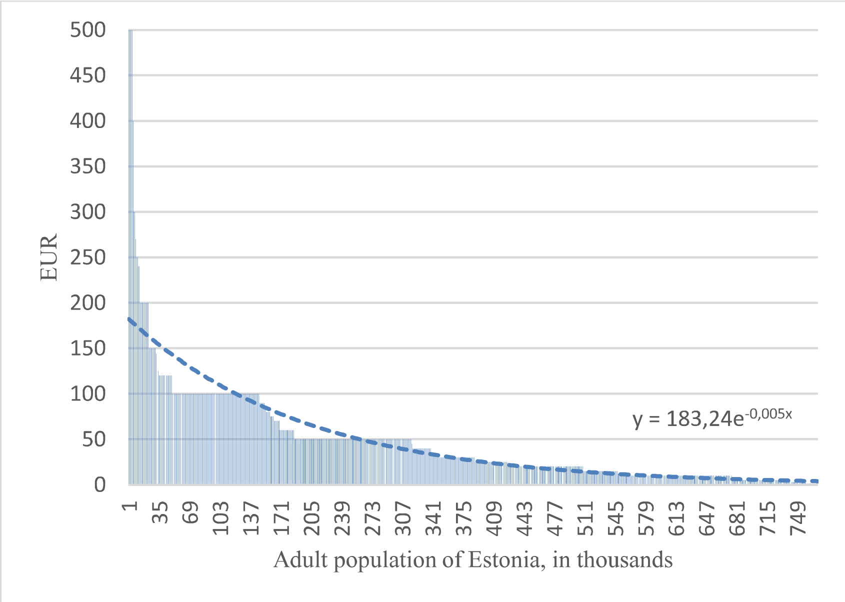

Figure 1. Willingness to pay to stop the expansion of limestone quarries

$WTP = \alpha e^{-\beta x}$; $WTP = 183{,}24e^{-0{,}005x}$;

$WTP_T = \alpha/\beta = 183{,}24/0{,}005 = 36\ 648\ 000$ EUR

As can be seen from the aggregate demand function, the total demand of the Estonian working-age population for the cessation of the expansion of limestone quarries is 36.648 million euros per year.

Conclusion

Limestone is a very important building material in Estonia, with an annual extraction volume of over 5 million tons. Limestone rubble is very important in road construction, for which there is currently no local alternative. The annual need for limestone
aggregate for road construction alone is approximately 2 million tons. The expansion of quarries and the establishment of new quarries significantly change the environment. The disruption to the population is not only related to the mining period, but the landscape changes forever.

Mining has significant external costs (externalities), such as noise generated by machinery in the quarry (buckets, excavators, loaders, trucks, screening and crushing units), noise generated by machinery moving within the quarry (e.g. when transporting material), dust generated by both mining activities and transport, irreversible changes in landscape and land use during and after mining, increased traffic, which in turn affects road safety and road conditions. The use of blasting (especially in the mining of limestone and dolomite) additionally entails short-term, but very loud noise, vibration, which can damage buildings, in the immediate vicinity of the quarry, there may be also danger from rocks being thrown into the air during blasting operations.

Local governments and residents, and the non-profit organizations representing them, often challenge both environmental impact assessments conducted to open mines and mining permits that have already been issued, and legal disputes can last for decades. Municipalities' opposition to the expansion of limestone mines and the construction of new mine entrances is at least partly because there are no mechanisms to compensate for the decline in human well-being associated with mining. The indirect external costs of limestone mining are not included in the price of production.

A contingency valuation study was conducted to identify and quantify the indirect external costs associated with the expansion of limestone mines and the establishment of new mines. A total of 906 questionnaires were analyzed. The sample was representative of the adult population of Estonia, which allows for extrapolation of the results obtained. In addition to willingness to pay, the sample members were also asked several other questions related to limestone mining. It was somewhat surprising that as many as 56% of the respondents had visually encountered limestone mines themselves. Over 67% of the respondents believed that limestone mines damage the environment. Only 24% of the respondents believed that limestone should be mined in any case if there were economic arguments.

The arithmetic average willingness to pay of the survey participants to stop the expansion of limestone quarries was 34 euros per year. Extrapolating this result to the adult population of Estonia, we obtain an annual willingness to pay of 36.6 million euros per year. This amount can be considered as an indirect external cost of the expansion of limestone mines. On average, 250 thousand tons of limestone can be extracted from one hectare. Thus, the extraction of 5.7 million tons of limestone leads to the expansion of quarries by an average of 23 hectares per year. The indirect external cost per 1 hectare of quarry expansion is 1.6 million euros. Thus, the indirect external cost of one ton of limestone is approximately 6 euros.

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