ORIGINAL SCIENTIFIC PAPER

OBTAINING LOANS FOR ENERGY EFFICIENCY DEPENDING ON THE INFLUENCE OF ANALYZED FACTORS ON THE DECISION-MAKING OF CITIZENS AND SMALL BUSINESSES IN THE REPUBLIC OF SERBIA

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ABSTRACT

The focus of the authors of the study was aimed at determining the importance of factors that can influence the decision of citizens and small businesses in the Republic of Serbia to enter into a credit relationship regarding the energy efficiency of the buildings in which they live and work. The aim of the study was to determine the possible impact of the following factors: installation of new PVC doors and windows, installation of roof insulation, installation of solar panels, installation of heating systems, installation of biomass boilers, installation of cooling systems, installation of solar water heaters, and installation of heat pumps, as well as their overall contribution to obtaining loans for energy efficiency among citizens and small businesses. Based on the performed t-test, we determined that there is a strong influence of all the mentioned factors on obtaining a loan. In addition, it was found that these factors strongly influence the prediction of the installation of new PVC doors and windows as the most frequently used form of improving energy efficiency among citizens ($F = 180.21$, $p < 0.0005$), as well as among small businesses ($F = 105.49$, $p < 0.0005$).

Keywords: *bank credit, energy efficiency, citizens, small businesses*

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INTRODUCTION

The improvement of living and working conditions is a permanent category for a large number of legal entities, but also for a large number of citizens who strive in various ways to improve their living conditions. One of the ways in the struggle to achieve a real improvement in life is to emphasise the practical application of preferences related to climate change, as well as the achievement of benefits in that regard, as pointed out by numerous authors [1].

The improvement of living conditions for a large number of the population, but also for the economy, is largely related to achieving optimal energy efficiency, which is particularly characteristic of large urban areas where many inhabitants live and work, as emphasised by the authors [2] using the example of the metropolis of New York, noting the importance of implications for energy demand. Assessment of energy goals and efficiency measures in multi-family residential facilities can largely be predicted based on the application of various simulations that are useful for future decision-making regarding the essential optimisation of energy use [3].

The above should be considered in the context of a comprehensive analysis of heterogeneous energy sources, as well as the optimisation of energy efficiency, primarily concerning the construction of numerous residential facilities and the performance of economic activities, because the consequences of greenhouse gas emissions—especially in specific segments, such as the negative effects of greenhouse gases in the production of agricultural products—are increasingly being revealed [4].

Living and working conditions can be improved by applying a number of instruments that fundamentally establish digital economy systems in relation to increasing energy efficiency in the emerging economy, using the example of business in China [5].

To this can be added issues such as so-called green bonds, which can be used to finance numerous forms of renewable energy and energy efficiency under real-life and work conditions [6], as well as the introduction of new technologies that enable carbon trading and energy efficiency [7].

THEORETICAL BACKGROUND

The banking system in the Republic of Serbia, within which the frameworks for the development of credit relations are defined, is legally regulated through the adopted Law on Banks ("Official Gazette of RS", No. 107/2005, 91/2010, and 14/2015) [8].

In this paper, the authors provide a fundamental observation of the issue of obtaining loans to finance energy-efficient projects, aimed at improving the living and working conditions of residents and businesses in the facilities where people perform their daily work tasks.

The authors observed both citizens and the operations of small businesses operating in the Republic of Serbia, based on the basic legal classification of activities ("Official Gazette of RS", No. 104/2009) [9].

The legislative framework governing energy efficiency is closely related to the presence of numerous heterogeneous risks that can fundamentally affect the operations of many companies operating in this area [10], [11].

Additionally, it is important to consider the realistic evaluation of each business, including the analysed (small) companies [12], which should take into account the application of various international standards—primarily those relating to corporate reporting by responsible entities [13]—which indirectly also applies to citizens, especially when they intend to enter into credit relations with commercial banks.

Business operations that involve compliance with monetary conditions in lending processes [14] must also ensure that control mechanisms are applied by all participants in the process of obtaining loans from commercial banks [15].

This is governed by the circulation of documentation at all levels [16], particularly in terms of achieving desired outcomes [17], including the use of loans from commercial banks for the purchase of energy-efficient devices and for improvements in living and working conditions within upgraded and modernised facilities.

MATERIALS AND METHODS

For the purposes of this study, the authors conducted research by surveying a total of 226 subjects. The survey included 150 citizens of the Republic of Serbia and 76 small businesses operating within the territory of the Republic of Serbia.

The research was conducted over a three-year period, from January 15 to February 15 in each of the observed years, specifically during the research period from 2022 to 2024.

The main research goal was to determine the existence of the influence of the analysed factors, namely: installation of new PVC doors and windows, installation of roof insulation, installation of solar panels, installation of heating systems, installation of biomass boilers, installation of cooling systems, installation of solar water heaters, and installation of heat pumps, as well as their total score in relation to obtaining loans for citizens and small businesses, which could contribute to increasing energy efficiency among the research subjects.

The survey was completed by citizens of the Republic of Serbia and by owners of small businesses operating in the country, with a guarantee of anonymity and the assurance that the collected data would be used exclusively for the preparation of this study. The aim was to support the credibility of the scientific community regarding the importance of enhancing energy efficiency in the Republic of Serbia.

Survey participants evaluated the listed items using a scale ranging from 1 to 10. A score of 1 indicated a weak level of credibility, while a score of 10 reflected the highest level of certainty related to improving energy efficiency for citizens and small businesses in the Republic of Serbia—particularly in connection with loans obtained from commercial banks during the observed period.

Subsequent activities included classical statistical processing of the survey data and comparison of the evaluations provided by the participants. The level of certainty was further examined using a t-test.

Finally, the authors predicted the procurement of new PVC doors and windows as the most commonly used individual method of improving energy efficiency, based on the analysis of other factors that could influence such procurement by both citizens and small businesses.

HYPOTHESES

For the purposes of this study, the authors proposed the following hypotheses:

H1: There are no differences in the evaluation of the factors influencing loan acquisition by citizens and small businesses in the Republic of Serbia in relation to improving the energy efficiency of buildings in the first year of observation.

H2: There are no differences in the evaluation of the factors influencing loan acquisition by citizens and small businesses in the Republic of Serbia in relation to improving the energy efficiency of buildings in the second year of observation.

H3: There are no differences in the evaluation of the factors influencing loan acquisition by citizens and small businesses in the Republic of Serbia in relation to improving the energy efficiency of buildings in the third year of observation.

H4: The procurement of new PVC doors and windows by citizens, for the purpose of improving the energy efficiency of buildings, cannot be predicted based on the other analysed factors.

H5: The procurement of new PVC doors and windows by small businesses, for the purpose of improving the energy efficiency of buildings, cannot be predicted based on the other analysed factors.

DATA PROCESSING

After the survey was completed, the authors performed classical statistical processing using the Statistical Package for the Social Sciences (SPSS). To increase the credibility of the research, they applied a t-test for independent samples to determine the existence of potential differences in the evaluation of energy efficiency between citizens and small businesses based on the analysed factors. In addition, the authors applied multiple regression analysis to explore the influence of these evaluations on the most widespread method of improving energy efficiency—namely, the procurement of new PVC doors and windows through loans—both in citizens' residences and in business facilities. For these purposes, a significance threshold of 0.05 was applied.

RESULTS

The obtained results are grouped into two major sections.

In the first part

The authors presented the impact of eight analysed factors, as well as their total score, in relation to the acquisition of more energy-efficient equipment and devices by citizens and small businesses through loans from commercial banks over three years of observation, i.e., in 2022, 2023, and 2024.

Table 1. Differences in the analysed factors in the first year of research

The influence of factors on decision-making regarding loan acquisition	Citizens (N=150)	Small business (N=76)	t	p
	Mean value			
Installation of new PVC doors and windows	8.49 ± 0.42	5.55 ± 0.42	43.058	<0.0005*
Installation of roof insulation	8.58 ± 0.47	6.56 ± 0.45	29.240	<0.0005*
Installation of solar panels	8.78 ± 1.01	7.34 ± 0.78	11.058	<0.0005*
Installation of heating systems	8.68 ± 0.40	4.74 ± 0.39	66.318	<0.0005*
Installation of biomass boilers	3.52 ± 0.44	7.70 ± 0.37	-69.499	<0.0005*
Installation of cooling systems	8.80 ± 0.95	6.18 ± 0.42	28.620	<0.0005*
Installation of solar water heaters	6.22± 0.68	8.74 ± 0.39	-34.550	<0.0005*
Installation of heat pumps	6.58 ± 0.45	9.33 ± 0.44	-40.569	<0.0005*
Total score	59.88 ± 1.60	56.40 ± 1.19	16.111	<0.0005

** Statistical significance at the level of 0.05*

Source: by the Authors

The results presented in Table 1 indicate that in the first year of observation, all eight analysed factors, as well as the total score, show statistically significant differences in the level of interest between citizens and small businesses in the Republic of Serbia in terms of using credit to improve energy efficiency in residential and business facilities.

Table 2. Differences in the analysed factors in the second year of research

The influence of factors on decision-making regarding loan acquisition	Citizens (N=150)	Small business (N=76)	t	p
	Mean value			
Installation of new PVC doors and windows	7.08 ± 0.60	4.19 ± 0.72	29.001	<0.0005*
Installation of roof insulation	6.17 ± 1.60	4.78 ± 0.42	9.850	<0.0005*
Installation of solar panels	6.98 ± 0.40	6.00 ± 0.88	7.418	<0.0005*
Installation of heating systems	7.53 ± 0.69	3.37 ± 0.42	51.298	<0.0005*
Installation of biomass boilers	2.52 ± 0.70	6.18 ± 0.76	-34.870	<0.0005*
Installation of cooling systems	7.04 ± 0.70	4.59 ± 0.46	26.351	<0.0005*
Installation of solar water heaters	4.88± 0.68	6.00 ± 1.22	-7.730	<0.0005*
Installation of heat pumps	5.10 ± 0.64	7.55 ± 1.00	-18.317	<0.0005*
Total score	47.39 ± 3.45	42.82 ± 2.77	10.215	<0.0005

** Statistical significance at the level of 0.05*

Source: by the Authors

The results presented in Table 2 show that in the second year of research, i.e., for 2023, there are statistically significant differences in the evaluations provided by citizens and small businesses for all eight analysed factors, as well as in their total score, concerning the allocation of loans for energy efficiency improvements.

Table 3. Differences in the analysed factors in the third year of research

The influence of factors on decision-making regarding loan acquisition	Citizens (N=150)	Small business (N=76)	t	p
	Mean value			
Installation of new PVC doors and windows	8.98 ± 0.53	6.39 ± 0.47	36.370	<0.0005*
Installation of roof insulation	6.19 ± 4.01	7.60 ± 0.46	-4.213	<0.0005*
Installation of solar panels	9.42 ± 0.47	8.60 ± 0.78	8.180	<0.0005*
Installation of heating systems	9.39 ± 0.51	5.40 ± 0.35	61.870	<0.0005*
Installation of biomass boilers	4.71 ± 0.69	9.00 ± 0.59	-48.095	<0.0005*
Installation of cooling systems	9.58 ± 0.48	7.21 ± 1.13	17.040	<0.0005*
Installation of solar water heaters	7.15 ± 0.75	9.39 ± 0.45	-22.458	<0.0005*
Installation of heat pumps	7.60 ± 0.69	9.76 ± 0.39	-24.360	<0.0005*
Total score	63.20 ± 4.90	64.58 ± 2.50	-1.269	0.121

** Statistical significance at the level of 0.05*

Source: by the Authors

The results presented in Table 3 show that in the third year of observation, there are statistically significant differences in the evaluations provided by citizens and small businesses for all eight analysed factors, as well as in their total score, concerning the acquisition of loans for energy efficiency improvements.

In the second part

The authors applied multiple linear regression with the aim of predicting the adoption of the most widely used form of energy efficiency improvement—namely, the installation of new PVC doors and windows—in both residential and business facilities, based on other influencing factors.

This was carried out with respect to the following analysed factors: installation of roof insulation, installation of solar panels, installation of heating systems, installation of biomass boilers, installation of cooling systems, installation of solar water heaters, and installation of heat pumps, for both citizens and small businesses in the Republic of Serbia.

The obtained results are presented in Tables 4 and 5.

Table 4. Prediction of the impact of the installation of new PVC doors and windows based on citizens' evaluations of other analysed factors

	Beta	t	p
A constant	-	11.899	<0.0005*
Installation of roof insulation	-0.026	-1.064	0.280
Installation of solar panels	0.162	4.395	<0.0005*
Installation of heating systems	0.065	1.805	0.069
Installation of biomass boilers	0.269	6.204	<0.0005*
Installation of cooling systems	0.102	2.629	0.009*
Installation of solar water heaters	0.276	6.784	<0.0005*
Installation of heat pumps	0.105	2.430	0.015*

** Statistical significance at the level of 0.05*

Source: by the Authors

Table 5. Prediction of the impact of the installation of new PVC doors and windows based on evaluations by small businesses through analysis of other energy

	Beta	t	p
A constant	-	3.248	<0.001*
Installation of roof insulation	1.090	10.122	<0.0005*
Installation of solar panels	-0.460	-6.699	<0.0005*
Installation of heating systems	-0.054	-0.570	0.559
Installation of biomass boilers	-0.070	-0.995	0.315
Installation of cooling systems	0.166	2.905	0.039*
Installation of solar water heaters	0.103	1.578	0.113
Installation of heat pumps	0.053	0.975	0.325

** Statistical significance at the level of 0.05*

Source: by the Authors

DISCUSSION

The results presented in Table 1, referring to the first year of observation, indicate that there is a statistically significant difference regarding the potential acquisition of more energy-efficient equipment through loans for installation in facilities used by citizens and small businesses in the Republic of Serbia.

Eight factors were analysed, and their total score shows a statistically significant difference in the interest levels of citizens and small businesses in the Republic of Serbia, in terms of obtaining loans aimed at improving energy efficiency in residential and business facilities.

Citizens rated higher the following: installation of new PVC doors and windows, installation of roof insulation, installation of solar panels, installation of heating systems, and installation of cooling systems. On the other hand, small businesses rated higher the installation of biomass boilers, installation of solar water heaters, and installation of heat pumps.

Therefore, Hypothesis 1 can be rejected based on the obtained results, indicating that there are differences in the evaluation of the factors influencing loan acquisition by citizens and small businesses in the Republic of Serbia in relation to improving the energy efficiency of buildings in the first year of observation.

The results shown in Table 2 indicate that in the second year of the study, a similar pattern is observed with respect to the analysed factors that may influence loan allocation for energy efficiency.

There is a statistically significant difference in the evaluation of all eight factors, as well as in their total score, between citizens and small businesses.

Citizens gave higher ratings to the installation of new PVC doors and windows, installation of roof insulation, installation of solar panels, installation of heating systems, and installation of cooling systems. Small businesses, meanwhile, rated higher the installation of biomass boilers, installation of solar water heaters, and installation of heat pumps.

Accordingly, Hypothesis 2 can be rejected, confirming that there are differences in the evaluation of all eight analysed factors, as well as the total score, affecting loan acquisition by citizens and small businesses in the Republic of Serbia related to improving the energy efficiency of buildings during the second year of observation.

Based on the results shown in Table 3, it can be concluded that in the third year of observation there is a statistically significant difference in the evaluation of all eight analysed factors, as well as in the total score, that may influence loan acquisition for energy efficiency by both citizens and small businesses.

Citizens rated higher the installation of new PVC doors and windows, installation of solar panels, installation of heating systems, and installation of cooling systems. In contrast, small businesses rated higher the installation of roof insulation, installation of biomass boilers, installation of solar water heaters, and installation of heat pumps, as well as the total score.

Therefore, Hypothesis 3 can be rejected, confirming the existence of differences in the evaluation of all eight analysed factors, as well as in the total score, related to the acquisition of loans by both citizens and small businesses in the Republic of Serbia for the purpose of improving the energy efficiency of buildings in the third year of observation.

In the second part of the research, the authors conducted predictions through multiple linear regression analysis based on the potential procurement of new PVC doors and windows by citizens, using the analysed factors shown in Table 4.

The regression analysis yielded a coefficient of determination of 0.740, indicating that the model explains 74% of the total variance. The introduction of new PVC doors and windows, as the most individually used method for improving energy efficiency among citizens, can be predicted based on the analysed factors, confirming the statistical significance of the model ($F = 180.21$, $p < 0.0005$).

Therefore, Hypothesis 4 can be rejected, confirming that the procurement of new PVC doors and windows for the purpose of improving energy efficiency among citizens can be predicted based on the other analysed factors.

The use of multiple linear regression to predict the procurement of new PVC doors and windows by small businesses, based on the analysed factors, is presented in Table 5.

The regression analysis yielded a coefficient of determination of 0.760, indicating that the model explains 76% of the total variance. The valuation of new PVC doors and windows can be predicted based on the analysed independent variables, confirming that the model is statistically significant ($F = 105.49$, $p < 0.0005$).

Therefore, Hypothesis 5 can be rejected, confirming that the procurement of new PVC doors and windows for the purpose of improving energy efficiency among small businesses can be predicted based on the other analysed factors.

CONCLUSIONS

The results obtained in this study indicate both theoretical and practical significance regarding the impact of eight analysed factors and the total score on loan acquisition by citizens and small businesses for energy efficiency improvements in residential and business facilities in the Republic of Serbia.

The main conclusion is that all eight analysed factors and the total score have a strong influence on loan acquisition from commercial banks, both for citizens and small businesses, throughout the entire research period—from 2022 to 2024—for the purpose of financing energy-efficient improvements.

Another important conclusion is that, based on the application of multiple linear regression, the procurement of new PVC doors and windows—identified as the most widely used form of energy efficiency improvement—can be predicted in relation to the following analysed factors: installation of roof insulation, installation of solar panels, installation of heating systems, installation of biomass boilers, installation of cooling systems, installation of solar water heaters, and installation of heat pumps, as well as their total score, both in relation to loan acquisition by citizens and small businesses in the Republic of Serbia.

The conclusions presented in the study, in the authors' opinion, confirm both the relevance and importance of the research. Furthermore, they emphasise the need for deeper analysis of the mentioned factors that may influence decisions related to loan acquisition for energy efficiency, both among citizens and among small businesses.

The research essentially targeted the most dominant user group for banks, and for the broader functioning of the economy—thus contributing to social responsibility and the improvement of living comfort for citizens in the Republic of Serbia, as well as in the wider region.

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