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Article

Reversal of the Project-Size Gradient in Bank Financing of Regional Industrial Investment: Evidence from Navoi Region (Uzbekistan) and a Transferable Diagnostic for Programme-Based Financing

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Abstract: Using records of 1,904 industrial projects of the Regional Investment Programme of Navoi region (2017-2025), the paper estimates how the probability of attracting a bank loan varies with project cost across periods, sectors and districts. Period-specific logit models and a cross-validated gradient boosting classifier show that in 2017-2018 the probability of bank participation increased with project size, whereas in 2022-2025 the relationship reversed. The author proposes a four-step size-gradient diagnostic that can be applied to programme registries in other sectors.

Keywords: investment project, bank credit, project size, logit model, gradient boosting, regional investment programme, Navoi region

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1. Introduction

Regional investment programmes have become one of the main channels through which industrial projects in Uzbekistan are selected, financed and monitored. The Development Strategy of New Uzbekistan for 2022-2026 and the 2030 reform priorities set targets for attracting investment and for increasing the role of commercial banks in financing the real sector [1], [2]. Navoi region holds a special place in this policy because of its free economic zone regime and its role as a mining and metallurgical centre [3], [4]. Programme registries kept by regional administrations contain project-level information on cost and on the planned structure of financing. In the author's view, these registries are an under-used source of evidence on which projects banks actually finance.

The question addressed here is simple but has direct policy content: does the probability that a bank participates in an industrial project rise or fall with the size of the project, and has this relationship been stable over time? Classical finance-and-growth research shows that access to external finance is uneven across firms and projects and is tighter for smaller borrowers [5], [6]. Studies of state-led credit allocation show that the size gradient may also depend on policy priorities [7], [8]. A gradient that changes sign within a few years would indicate that the allocation rule of banks has shifted. Such a shift would not be visible in aggregate statistics on sources of finance.

The paper has three aims. The first is to estimate the size gradient of bank participation separately for 2017-2018, 2019-2021 and 2022-2025 using the Navoi programme registry. The second is to check whether the result depends on the functional

form of the logit model by comparing it with a gradient boosting classifier [9]. The third is to formulate the procedure as a diagnostic that can be applied to other programme-based financing schemes, such as agricultural, tourism, renewable energy or social infrastructure programmes. All estimates are associational. They describe how financing outcomes are distributed across projects; they do not identify a causal effect of project size on bank decisions.

1.1 Literature review

The literature relevant to this study falls into three strands. The first concerns financing constraints and the size of the borrower. Rajan and Zingales showed that industries more dependent on external finance grow faster where financial systems are deeper [5]. Beck and Demirgüç-Kunt documented that small and medium-sized firms face tighter access to finance than large firms [6]. Fazzari, Hubbard and Petersen interpreted the sensitivity of investment to internal cash flow as a sign of financing constraints [10]. The pecking-order view links the order of financing sources to information asymmetry [11], [12]. In this framework, larger projects with more collateral and better documentation should find bank finance easier. In the author's opinion, this prediction holds only when banks are free to choose among projects; programme-based allocation may change it.

The second strand concerns state influence on credit allocation. La Porta, Lopez-de-Silanes and Shleifer and Sapienza showed that government-owned banks allocate credit differently from private banks [13], [14]. Evidence from China shows that stimulus credit was directed to particular types of firms and that the China Development Bank served as a long-term lender to large projects [7], [8]. Lazzarini et al. found that the Brazilian development bank BNDES mainly lent to large firms that could obtain finance elsewhere [15]. Research on credit guarantees shows that public schemes can shift bank lending towards smaller borrowers [16], [17]. For Uzbekistan, Ruziev and Midmore showed that access of SMEs to formal finance depends on connectedness [18]. Bae and Mah described the role of industrial policy in the country's development [19]. The author believes that these studies explain why the size gradient can change sign when the policy mix changes: when large projects gain access to foreign credit lines and direct investment, domestic banks may move to smaller projects.

The third strand is methodological. Fractional and binary response models remain the standard tools for financing shares and participation decisions [20]. Machine-learning classifiers such as gradient boosting can capture non-linear relationships and interactions without specifying them in advance [9]. In this paper, the machine-learning model is used as a robustness check on the parametric results, not as a replacement for them. To the author's knowledge, size gradients of bank participation have not previously been estimated by period on project-level registries of Uzbek regional programmes.

2. Materials and Methods

The source is the address list of the Regional Investment Programme of Navoi region for 2017-2025 and the summary of commissioned projects [21]. After removing six duplicate records, the cleaned registry contains 2,000 project records. Of these, 1,904 projects have a full breakdown of financing by source (own funds, bank loans, foreign credit lines, foreign investment) and are used in the analysis. The 2019-2025 subsample, which coincides with the main specification of the author's dissertation research, contains 1,294 projects. Project cost is measured in million soums at current prices. Sectors are grouped into eight categories, and districts follow the administrative division of the region.

The dependent variable equals 1 if the financing plan of the project includes a bank loan and 0 otherwise. The main regressor is the natural logarithm of project cost. The control variable for foreign funding equals 1 if the project includes foreign credit lines or foreign investment. Sector, district and year fixed effects absorb level differences. For heterogeneity analysis, mining and metallurgy, chemicals and pharmaceuticals, construction materials, and machinery and electrical engineering are classified as heavy industries.

The baseline is a logit model with heteroskedasticity-robust (HC1) standard errors, estimated separately for 2017-2018 (n = 610), 2019-2021 (n = 552) and 2022-2025 (n = 742). Average marginal effects of log cost and average predicted probabilities at fixed costs of 0.5, 5 and 20 billion soums are reported. An interaction of log cost with the heavy-industry dummy tests whether the gradient differs between sector groups. As a robustness check, a gradient boosting classifier (300 trees, depth 3, learning rate 0.05, subsampling 0.8) is trained on the same features [9]. Its out-of-sample discrimination is compared with a logistic regression by stratified five-fold cross-validation (area under the ROC curve, AUC). The partial dependence of the predicted probability on project cost is computed by setting the cost of all projects to fixed values and averaging the predictions. All calculations are reproducible with Python (statsmodels, scikit-learn).

3. Result

Descriptive pattern. The share of projects with bank participation was 47.7% in 2017-2018, 56.9% in 2019-2021 and 47.7% in 2022-2025. The share of projects with foreign funding rose from 1.5% in 2017-2018 to 16.1% and 12.5% in the following periods. In 2019-2025, banks participated in 67.0% of projects costing up to 1 billion soums (n = 585), in 50.1% of projects of 1-5 billion (n = 383), in 33.3% of projects of 5-20 billion (n = 207) and in 12.6% of projects above 20 billion (n = 119). Among projects that did use a bank loan, the median loan-to-cost ratio was 40.0%, 45.9%, 49.3% and 14.9% in the same size classes. In the author's view, this means that the largest projects are less likely to use bank credit and, when they do, the loan covers a much smaller part of the cost.

Table 1 shows the central result. In 2017-2018, an increase in log project cost by one unit was associated with a 12.9 percentage-point higher probability of bank participation. The average predicted probability rose from 54.3% for a project costing 0.5 billion soums to 90.6% for a project costing 20 billion. In 2019-2021 the slope was still positive but much flatter (marginal effect +3.7 p.p., p = 0.015). In 2022-2025 the sign reversed: the marginal effect was −10.3 p.p. (p < 0.001), and the predicted probability fell from 64.9% at 0.5 billion to 23.6% at 20 billion soums. The pooled 2019-2025 model reported in the dissertation (coefficient −0.234, marginal effect −4.4 p.p., AUC 0.795) averages the last two regimes and therefore understates the change. In the author's opinion, the reversal is the key fact that an aggregate analysis of financing sources cannot reveal.

Table 1. Period-specific logit estimates of bank participation (dependent variable: bank loan in the financing plan)

Indicator	2017-2018	2019-2021	2022-2025
Number of projects	610	552	742
Coefficient on ln(project cost)	0.665***	0.207**	−0.616***
Average marginal effect of ln(cost), p.p.	+12.9	+3.7	−10.3
Predicted probability at 0.5 bn soums, %	54.3	54.7	64.9
Predicted probability at 5 bn soums, %	81.8	62.9	38.0
Predicted probability at 20 bn soums, %	90.6	67.4	23.6
Share of projects with bank loan, %	47.7	56.9	47.7

Note: all models include the foreign-funding dummy and sector, district and year fixed effects; HC1 standard errors; * **p < 0.01,** p < 0.05. Source: author's calculations based on [21].

In all specifications the foreign-funding dummy has a large negative coefficient (−2.34 in the interaction model, p < 0.001). Projects that include foreign credit lines or foreign investment are much less likely to include a domestic bank loan. Because foreign funding is concentrated in large projects, this pattern is consistent with large projects replacing domestic bank credit with foreign sources after 2019. This interpretation is associational:

the data do not show whether banks withdrew from large projects or whether sponsors chose foreign funds first.

In the 2019-2025 sample the slope of log cost is −0.395 (s.e. 0.079) for light and food industries and other non-heavy sectors. The interaction with the heavy-industry dummy is +0.219 (s.e. 0.097, p = 0.024), so the slope for heavy industries is about −0.18. The negative gradient is thus steeper in light manufacturing, where large projects are rarer and collateral is weaker. In heavy industries, large projects of established enterprises keep somewhat better access to bank credit.

In five-fold cross-validation, the gradient boosting classifier reached an AUC of 0.818 (standard deviation 0.015), compared with 0.771 (0.010) for a logistic regression with the same features. The non-linear model therefore discriminates somewhat better between projects with and without bank finance. Its partial dependence curve (Figure 1) confirms the negative gradient in 2019-2025: the average predicted probability is 62.6% at 0.5 billion soums, 49.9% at 2 billion, 35.0% at 10 billion and 19.5% at 50 billion soums. The curve is almost flat below 0.5 billion soums and declines steadily above 1 billion soums. In terms of impurity-based importance, project cost accounts for 38.8% of the model's splits, district for 22.7%, foreign funding for 14.5%, sector for 12.4% and year for 11.6%. The author concludes that the negative gradient is not an artefact of the logit functional form.

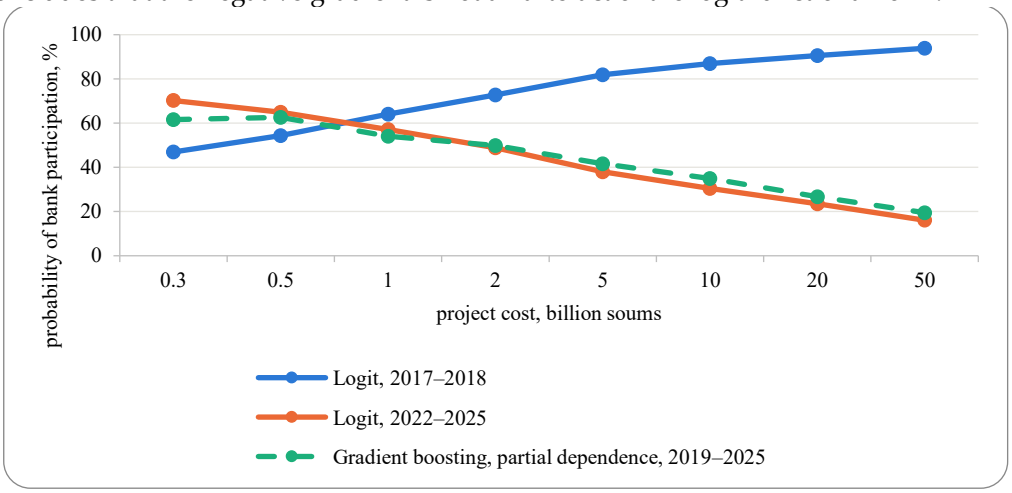


Figure 1. Predicted probability of bank participation by project cost: period-specific logit models (2017-2018, 2022-2025) and gradient boosting partial dependence (2019-2025), %

Source: author's calculations based on [21].

4. Discussion

The results add a time dimension to the familiar finding that access to finance differs by borrower size [6], [5]. In Navoi, the gradient did not simply weaken; it changed sign within about five years. A plausible explanation combines three factors. First, the share of projects with foreign funds rose from 1.5% to more than 12%, and these funds went mainly to large projects. Second, the State Fund for Support of Entrepreneurial Activity, created in 2017, offers guarantees and interest compensation on bank loans to small businesses [22]. This support may have made small projects more attractive to banks, which would be consistent with international evidence that guarantees move bank lending towards smaller borrowers [16], [17], [23]. Third, the high cost of domestic credit makes long-term bank loans less attractive for capital-intensive projects than foreign credit lines. Each of these explanations is consistent with the data, but none is tested causally here.

The finding also has a measurement implication. A region can report a stable share of projects with bank loans (47.7% in both 2017-2018 and 2022-2025) while the composition of these projects changes completely. In the author's view, an indicator such as "share of bank credit in financing" should therefore be monitored together with its size gradient. Otherwise, the withdrawal of banks from medium and large projects may remain hidden.

Transfer to other fields. The procedure does not depend on industry-specific information. It needs only a registry with project cost, a binary or fractional financing

indicator and basic classifiers. The author proposes to formalise it as a four-step size-gradient diagnostic (Table 2). Its use is particularly appropriate where public programmes are kept as project registries: agricultural and agro-processing programmes, tourism infrastructure, renewable energy, public-private partnership projects in health and education, and SME support schemes. In each case, the same question is relevant: which project sizes does the financing instrument actually reach, and is this changing?

Table 2. Size-gradient diagnostic for programme-based financing proposed by the author

Step	Content	Output for decision-makers
1. Registry harmonisation	Unify cost units, remove duplicates, code financing sources, sector and district	Analysable project panel
2. Period-specific estimation	Logit (or fractional logit) of the financing indicator on ln(cost) by period, with fixed effects	Sign and size of the gradient in each period
3. Non-parametric check	Gradient boosting with cross-validated AUC and partial dependence on cost	Confirmation of the shape; thresholds where access drops
4. Policy trigger	If the gradient is negative and significant in the mid-size segment, review guarantee, syndication or co-financing instruments for that segment	Targeted adjustment of instruments

Source: developed by the author.

The diagnostic has limitations. The registry records planned rather than disbursed financing, so the results describe programme design. Projects that never entered the programme are not observed, so selection into the programme cannot be modelled. The machine-learning model improves prediction but does not by itself explain why the gradient changed. These limitations point to the next step of the research: linking registry data with bank-level lending data [24] to separate supply from demand.

5. Conclusion

The study estimated the relationship between project size and bank participation on 1,904 projects of the Navoi regional investment programme. The main result is a reversal of the size gradient: in 2017-2018, larger projects were much more likely to include a bank loan, while in 2022-2025 they were much less likely to do so. The average predicted probability at 20 billion soums fell from 90.6% to 23.6%, while at 0.5 billion soums it rose from 54.3% to 64.9%. A cross-validated gradient boosting classifier confirms the negative gradient in 2019-2025 with an AUC of 0.818. The pattern is associated with the growth of foreign funding in large projects and is steeper in light industries than in heavy industries.

In the author's opinion, the practical value of the study lies less in the Navoi numbers themselves than in the procedure. Monitoring the size gradient by period makes visible changes in the allocation of bank credit that aggregate shares conceal. The proposed four-step diagnostic can be applied without modification to agricultural, tourism, renewable energy, social infrastructure and SME programmes. Its regular use would help regional authorities and banks to identify the project-size segments where co-financing, guarantee or syndication instruments are most needed.

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