IMPROVING THE MECHANISMS FOR SHARING INNOVATION PROJECT RISKS AMONG INDUSTRIAL CLUSTER ENTITIES

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Annotatsiya

Maqolada O‘zbekiston sanoat klasterlarida innovatsion loyihalar tavakkalchiliklarini yetakchi korxona, qayta ishlovchi, xomashyo yetkazib beruvchi, ilmiy-tadqiqot instituti va bank o‘rtasida taqsimlash mexanizmi o‘rganildi. Ilmiy-tadqiqot, tajriba, ishlab chiqarishni kengaytirish va bozorga chiqish bosqichlari bo‘yicha tavakkalchiliklar reyestri tuzildi, har bir tavakkalchilik uni eng kam xarajat bilan nazorat qila oladigan tomonga biriktirildi. Xarajat va daromad ulushlari hamda bosqichli to‘lovlardan iborat shartnoma aniq ekvivalent orqali ifodalandi, ulushlarni tavakkalchilikka bardoshlilikka bog‘lovchi Pareto-optimal qoida qo‘llanildi. Faraziy to‘qimachilik loyihasi bo‘yicha 100 000 marta takrorlangan Monte-Karlo hisob-kitobida har bir tomon o‘z bosqichini o‘zi moliyalashtirganda qayta ishlovchi va ilmiy institut loyihaga qo‘shilmasligi aniqlandi. Bardoshlilikka mos ulushlar va kafolat fondi barcha tomonlarni loyihaga jalb qildi, bankning 5 foizli CVaR ko‘rsatkichini ikki baravar, ilmiy institutnikini 69 foizga kamaytirdi.

Kalit so‘zlar: sanoat klasterlari, innovatsion loyihalar, tavakkalchilikni taqsimlash, aniq ekvivalent, CVaR, Monte-Karlo usuli, O‘zbekiston.

Аннотация

В статье был изучен механизм распределения рисков инновационных проектов между участниками промышленных кластеров Узбекистана: якорным предприятием, переработчиком, поставщиком сырья, научно-исследовательским институтом и банком. Был составлен реестр рисков по стадиям НИОКР, пилотирования, масштабирования и выхода на рынок, и каждый риск был закреплён за стороной, способной контролировать его с наименьшими затратами. Контракт с долями затрат и доходов и этапными платежами был описан через детерминированный эквивалент, применено Парето-оптимальное правило, связывающее доли с толерантностью к риску. Иллюстративное моделирование Монте-Карло (100 000 прогонов) гипотетического текстильного проекта показало, что при поэтапном самофинансировании переработчик и институт в проект не вошли бы. Доли по толерантности к риску вместе с гарантийным фондом привлекли всех участников, вдвое снизили 5%-ный CVaR банка и на 69% снизили CVaR института.

Ключевые слова: промышленные кластеры, инновационные проекты, распределение рисков, детерминированный эквивалент, CVaR, метод Монте-Карло, Узбекистан.

Abstract

The article examined how innovation project risks can be shared among industrial cluster entities in Uzbekistan: the anchor firm, processor, supplier, research institute and bank. A risk register was built for the R&D, pilot, scale-up and market stages, and each risk was assigned to the party able to control it at least cost. A contract with cost shares, revenue shares and milestone payments was valued through certainty equivalents, and a Pareto-optimal rule linking shares to risk tolerance was applied. An illustrative Monte Carlo simulation of a hypothetical textile project showed that under stage-by-stage self-financing the processor and the institute would stay out. Risk-tolerance shares combined with a

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guarantee fund brought every party in, halved the bank's 5% CVaR and cut the institute's CVaR by 69%.

Keywords: industrial clusters, innovation projects, risk sharing, certainty equivalent, conditional value at risk, Monte Carlo simulation, Uzbekistan.

INTRODUCTION

Uzbekistan rebuilt its cotton and textile sector around the cluster model in only a few seasons. According to a World Bank review, 15 clusters worked 16% of the cotton area in 2018, 75 clusters worked 63% of the area and produced 73% of raw cotton in 2019, and 92 clusters were planned to cover 88% of the area in 2020 [1]. By 2024, 142 cotton-textile clusters were reported, alongside more than 7,000 textile enterprises, about 600,000 workers and textile exports of nearly USD 4 billion in 2023 [2]. The legal base grew with the model: Resolution PQ-4186 of 12 February 2019 deepened the reform of the textile and garment industry [3], Cabinet of Ministers Resolution No. 747 of 10 December 2021 widened the activity of cotton and textile clusters [4], and Resolution PQ-4549 of 11 December 2019 gave fruit and vegetable clusters a contract framework built on tripartite agreements and priced supply contracts [5].

Having secured raw material and primary processing, clusters now move to new fabrics, finishing technologies, deep processing of agricultural output and import-substituting chemical and automotive components. Such projects cross firm boundaries. A research institute develops the technology, a processor tests it, suppliers adapt their inputs, the anchor firm invests in capacity and a bank lends. Cluster strength supports regional growth [6], yet a joint project can stall when one party is asked to carry a risk it can neither control nor absorb. The World Bank review named the farm-gate price as one of the biggest risks of the cluster model [1]; for innovation projects technical and scale-up risks come on top of it.

The thesis asks three questions. Which participant should carry which risk at each stage of a cluster innovation project (RQ1)? What sharing rule balances costs, revenues and risk among unequal partners (RQ2)? How much does such a rule change each party's downside and its willingness to join (RQ3)? The contribution is a compact tool that joins the risk allocation principle known from project finance with the classical theory of Pareto-optimal risk sharing and a tail-risk measure, and adapts it to the anchor-led cluster model of Uzbekistan.

LITERATURE REVIEW

J. Hagedoorn, A. N. Link and N. S. Vonortas showed that firms enter research partnerships largely to share the cost and the uncertainty of R&D [7]. B. H. Hall and J. Lerner explained why R&D is hard to fund from outside: its assets are intangible, its outcomes uncertain and its information unevenly held, so small partners face a financing gap [8]. For a cluster this means the weakest balance sheet can block a project that is worth doing for the group as a whole.

The rule that a risk should go to the party best able to manage it was set out for public-private partnerships by L. Bing and co-authors [9]. J. Hallikas and co-authors carried the idea into supplier networks, where risks are identified and assessed jointly before responsibilities are fixed [10]. The economic logic behind sharing comes from K. Borch, who derived Pareto-optimal risk exchange in a reinsurance market [11], and from R. Wilson, whose theory of syndicates showed that members with exponential utility share a common outcome linearly, in proportion to their risk tolerance [12]. B. Holmström and P. Milgrom proved that linear sharing rules also remain optimal when incentives matter over time [13].

Contract design studies add the instruments. G. P. Cachon and M. A. Lariviere showed that revenue-sharing contracts can coordinate a supply chain and spread demand risk [14]. P. Crama, B. De Reyck and Z. Degraeve found that the choice between milestone payments and royalties in R&D licensing depends on who holds information about the project and whose effort must be motivated [15]. To judge the downside, R. T. Rockafellar and S. Uryasev proposed conditional value at risk (CVaR),

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the expected loss in the worst tail [16]. These strands have rarely been combined for anchor-led clusters in transition economies, where the anchor holds most of the capital and research institutes and suppliers hold little.

METHODOLOGY

Risk allocation by stage

A project passes four stages: R&D, pilot, scale-up and market. For every risk source k in the register, the controller is chosen as:

$$j^*(k)=\arg\min_j[m_{jk}+\frac{r_j}{2}(1-e_{jk})^2\sigma_k^2] \quad (1)$$

where m_{jk} is the cost to party j of monitoring and mitigating risk k, e_{jk} is the share of the risk's spread that party j can remove, σ_k^2 is the variance of the risk and r_j is the party's risk aversion. Put simply, a risk goes to the partner who can reduce it most cheaply and who is calm enough to carry what is left.

Sharing contract and valuation

The payoff of participant i in present value is:

$$\pi_i=\theta_i PV(R)-c_i PV(I)+T_i \quad (2)$$

where θ_i is the revenue share, c_i the cost share, PV(R) the present value of net cash flows after debt service, PV(I) the present value of equity outlays and T_i the milestone transfers, which sum to zero across participants. In everyday terms, each partner pays part of the bills, receives part of the income and may get fixed payments when a stage succeeds. For parties with constant absolute risk aversion the Pareto-optimal linear share is [11]; [12]:

$$b_i^*=\frac{1/r_i}{\sum_{j=1}^{n}1/r_j} \quad (3)$$

where n is the number of equity participants. The partner able to bear more risk takes a larger slice of both costs and revenues. Each party judges the contract by its certainty equivalent:

$$CE_i=-\frac{1}{r_i}\ln E[\exp(-r_i\pi_i)]\approx E(\pi_i)-\frac{r_i}{2}Var(\pi_i) \quad (4)$$

where E is the expectation and Var the variance. The certainty equivalent is the sure sum a partner would accept instead of the risky payoff; a negative value means the partner stays out. The downside is measured by:

$$CVaR_\alpha(\pi_i)=E[\pi_i \mid \pi_i\le VaR_\alpha(\pi_i)] \quad (5)$$

where $\alpha=0.05$, so CVaR is the average result in the worst 5% of outcomes [16]. A guarantee fund pays half of the bank's loss and is financed by a levy on cash flows:

$$\lambda=\frac{E(G)}{E(PV(R))};\ G=0.5\cdot\max(0,-B) \quad (6)$$

where G is the fund's payout and B the bank's present-value result on the loan. The levy is set so that the fund breaks even on average; it moves part of the bank's loss to the whole group at a small, predictable price.

Illustrative simulation design

The simulation is an illustrative (hypothetical) example, not an estimate for a real cluster. A cotton-textile cluster plans a new functional fabric line. R&D costs USD 0.6 million and succeeds with probability 0.65; the pilot costs USD 1.2 million a year later and succeeds with probability 0.75; scale-up costs USD 6.0 million in year two and succeeds with probability 0.90. The bank lends USD 3.6 million of the scale-up cost at 14% for six years and recovers 40% if scale-up fails; the rate is close to the commercial cluster loan rates of 22–25% net of the 6–9% subsidy reported for 2020 [1]. Annual net cash flows in years 3–8 are lognormal with a mean of USD 3.3 million, a coefficient of variation of 45% and 15% year-to-year noise, discounted at 12%. Risk aversion per USD million is 0.05 for the anchor firm, 0.15 for the processor, 0.30 for the supplier and 0.60 for the research institute. The model ran 100,000 times in Python with a fixed seed.

Three mechanisms were compared. Under M1 (stage owner) the institute pays for R&D, the processor for the pilot, the supplier USD 0.8 million and the anchor USD 1.6 million of scale-up equity,

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and residual cash flows are split 70/15/10/5 among the anchor, processor, supplier and institute. Under M2 (pro rata) costs and revenues are shared 55/20/15/10. Under M3 shares follow formula (3), which gives 63.2/21.1/10.5/5.3, the guarantee fund of formula (6) is added and milestone transfers are used only if a party's certainty equivalent falls below USD 0.02 million. The levy that balanced the fund was 1.29% of cash flows.

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ANALYSIS AND RESULTS

Stage-based risk register

Table 1

Risk register of a cluster innovation project by stage[1]

Stage	Main risk sources	Least-cost controller	Sharing instrument
R&D	technical failure, wrong specification, leakage of know-how	research institute (technology), processor (specification)	milestone payments, joint ownership of results
Pilot	process yield, fit of raw material, cost overrun	processor, supplier	cost sharing by formula (3), trial-batch purchase commitment
Scale-up	capital overrun, delay, loan default	anchor firm, bank	anchor equity, bank loan backed by the guarantee fund
Market	price, demand, quality claims, supply volume	anchor firm (price, demand), supplier (volume, grade)	revenue sharing, volume contract with indicative price

Table 1 shows that the controller changes from stage to stage. Technical risk sits with the research institute at the start, process risk moves to the processor and supplier in the pilot, capital risk is concentrated on the anchor firm and the bank at scale-up, and in the market the anchor firm carries price and demand risk while the supplier answers for volume and grade. A single owner for the whole project therefore cannot be the least-cost controller of every risk, and the contract has to move responsibility as the project advances.

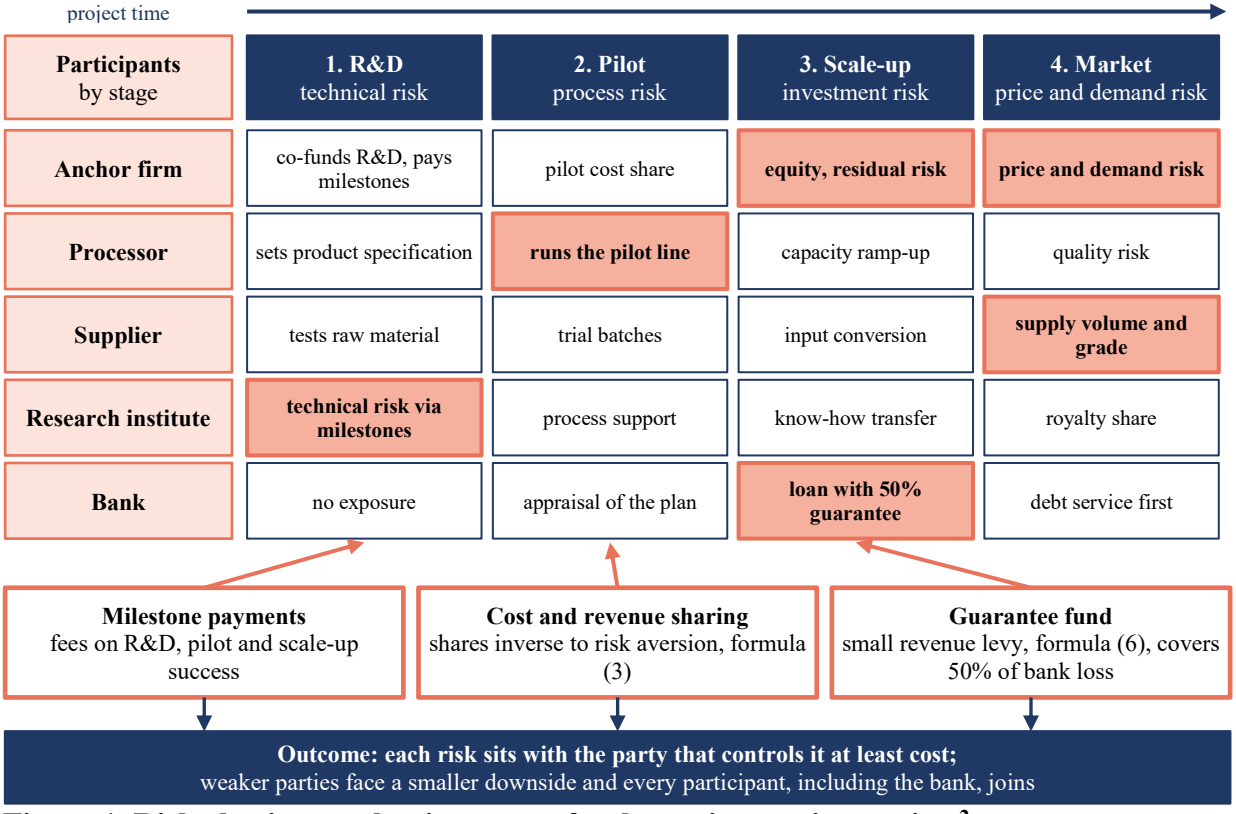


Figure 1. Risk-sharing mechanism map of a cluster innovation project[2]

[1] Source: Developed by the author on the basis of [9]; [10]; [1].
[2] Source: Developed by the author on the basis of [9]; [12]; [15].

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Figure 1 links the register to the instruments. Milestone payments act at the R&D stage, where the institute controls the risk but has little capital; cost and revenue sharing spreads pilot and later costs in line with risk tolerance; the guarantee fund protects the bank at scale-up, where the loan is largest. Shaded cells mark the least-cost controller in each stage.

Simulation results

The project reached the market in 43.9% of runs. Its expected net present value was USD 1.19 million with a standard deviation of USD 4.23 million; it lost money in 63.8% of runs and the average of the worst 5% of outcomes was a loss of USD 3.58 million. In plain words, the project pays on average but fails in nearly two runs out of three, which is typical of innovation and explains why no single small partner would fund it alone.

Table 2

Payoffs of cluster participants under three sharing mechanisms, USD million[3]

Participant	Risk aversion	M1: stage owner	M2: pro rata	M3: risk-tolerance shares and guarantee fund
Anchor firm	0.05	1.77 / −1.27 / 1.55	0.66 / −1.97 / 0.53	0.72 / −2.26 / 0.57
Processor	0.15	−0.18 / −1.07 / −0.22	0.24 / −0.72 / 0.19	0.24 / −0.75 / 0.19
Supplier	0.30	0.03 / −0.64 / 0.01	0.18 / −0.54 / 0.13	0.12 / −0.38 / 0.09
Research institute	0.60	−0.43 / −0.60 / −0.45	0.12 / −0.36 / 0.07	0.06 / −0.19 / 0.05
Bank (lender)	–	−0.03 / −1.85	−0.03 / −1.85	0.06 / −0.92
Sum of certainty equivalents plus bank's expected value	–	0.89	0.90	0.92
All parties join	–	no	no	yes

Table 2 shows that under M1 the processor and the research institute have negative certainty equivalents and would refuse to join, and the bank earns less than its cost of funds. The anchor firm gains most, yet the project cannot start without its partners. Pro rata sharing (M2) brings the four equity partners in, but leaves the bank's expected result negative. Under M3 every party, including the bank, has a positive value. The research institute's CVaR improves from a loss of USD 0.60 million to USD 0.19 million (69%), the supplier's from USD 0.64 million to USD 0.38 million and the bank's from USD 1.85 million to USD 0.92 million. The anchor firm accepts a deeper tail (USD 2.26 million) in return for a larger share of the upside, which matches its higher risk tolerance. The sum of certainty equivalents plus the bank's expected value rose from USD 0.89 million under M1 to USD 0.92 million under M3.

As a robustness check, the institute's risk aversion was raised from 0.60 to 1.2 and then to 2.0. Under M3 its share fell to 2.7% and 1.6% and its certainty equivalent stayed positive (USD 0.024 and 0.015 million). In the second case a small milestone schedule with an expected present value of about

[3] Source: Author's calculation; illustrative (hypothetical) Monte Carlo simulation, 100,000 runs, assumptions as stated in the Methodology. Each cell gives E(payoff) / CVaR 5% / certainty equivalent in present value. For the bank, E and CVaR are conditional on the loan being issued; a negative certainty equivalent means the party stays out.

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USD 6 thousand restored the USD 0.02 million margin. This is the practical role of milestones: they keep a cautious, cash-poor research partner in the project without changing who bears the main risks.

CONCLUSION AND RECOMMENDATIONS

The thesis set out a stage-based way to share innovation risks among cluster entities. Each risk is placed with its least-cost controller, shares of costs and revenues follow risk tolerance, and two instruments close the remaining gaps: a guarantee fund for the lender and milestone payments for the research partner. In the hypothetical example this mechanism turned a project that two partners and the bank would decline into one that all of them accept, while cutting the tail losses of the supplier, the bank and the research institute by 41% to 69%.

Four steps could help clusters use the approach. First, a model agreement for joint innovation projects with a risk register annex could accompany the cluster regulations built on Resolution No. 747 [4], much as tripartite agreements already structure agro-industrial clusters [5]. Second, partners could set cost and revenue shares by risk tolerance and control ability rather than by asset size alone. Third, a cluster guarantee fund financed by a small levy on project cash flows, with participation of partner banks, could lower lending risk for new technologies. Fourth, milestone schedules for research institutes would let universities and laboratories join projects without risking their limited budgets.

The parameters used here are assumptions, so the next step is a survey of anchor firms, processors, suppliers, research institutes and banks in cotton-textile, agro-industrial, chemical and automotive clusters to estimate stage success rates, costs and risk attitudes. Testing the mechanism on real project data would turn the illustrative results into evidence for cluster policy.

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