THE ORGANIZATIONAL AND ECONOMIC MECHANISM OF AGRICULTURAL MECHANIZATION SERVICES: A COMPLEMENTARITY MODEL

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Policy for agricultural mechanization is ordinarily designed as a problem of asset provision: how many machines to supply, on what financial terms, and to whom. Framed in this way the problem belongs to investment policy. Yet the question a farm manager actually faces is different in kind — whether to own a machine or to purchase its services, and, if the latter, how access to a shared resource is to be scheduled and how liability for it is to be allocated. That is a question of organizational design, and it is the subject of this thesis.

Theoretical position

Three established contributions locate the problem. Coase (1937) and, in a form applicable to specific assets, Williamson (1985) treat the choice between owning an asset and contracting for its services as determined by transaction costs; on that reading the observed shift towards service provision is a predictable response to falling coordination costs rather than a novelty of the digital era. Ostrom (1990) supplies the complementary insight that shared use of a divisible but rival resource is sustainable only under rules allocating access and liability among users. The empirical literature on machinery service markets confirms the practical significance of both points: Yang et al. (2013) and Zhang et al. (2017) show that outsourcing clusters in China sustain a division of labour making mechanization viable at farm sizes far below the threshold that ownership requires.

The economic consequence of the shift is a change in the variable that binds. A machine owned by one farm creates value only on that farm’s land; the same machine operated as a service unit creates value across several holdings, and its utilization rate — not its capacity — becomes the constraint on which management must act. Under the fragmented landholding structure characteristic of Khorezm, where individually owned equipment is idle for most of the season, this distinction is decisive.

The proposed model

Governance of the mechanization service market may be represented as a function of five classes of mechanism:

$$M=f(E, I, O, L, D)$$

where E denotes economic mechanisms (subsidies, leasing, credit, tax relief), I institutional mechanisms (dealer networks, service centres, advisory services), O organizational mechanisms

(supply, logistics, scheduling of shared use), L legal mechanisms (standards, certification, state programmes) and D digital mechanisms (platforms, monitoring, agro-technological mapping).

The substantive claim is not that these mechanisms matter, which would be uncontroversial, but that they are complements rather than substitutes: the marginal return to strengthening any one of them is increasing in the level of the others. Three testable implications follow. Subsidized machinery (E) delivers little where no service capacity exists to keep it operating (I). Digital monitoring (D) generates data without effect unless organizational arrangements (O) permit operations to be rescheduled in response to it. Shared-use scheduling (O) is not enforceable without a legal basis for allocating liability between users (L). The managerial corollary is that partial implementation should be expected to yield disproportionately small results — which is precisely the pattern that Daum and Birner (2020) identify across mechanization programmes that supplied machines without the surrounding service infrastructure.

Evidence from the Tuproqqal'a pilot

A pilot project implemented in 2024 by TTZ LLC on six farms cultivating 350 hectares in Tuproqqal'a district, Khorezm region, is informative because all five mechanisms were activated simultaneously, which is unusual in practice.

Table 1. Correspondence between the model's mechanisms and the components of the pilot.

Mechanism	Instrument applied on the six pilot farms
E — Economic	Provision of 90 hp tractors, cultivator, sprayer and associated implements, with a locally held spare-part stock
I — Institutional	Mobile service unit with two technicians; resident agronomist and economist attached for the season
O — Organizational	Coordinated deployment of a single machinery pool across six farms and 350 hectares
L — Legal	Implementation within the framework of Presidential Resolution No. PQ-7 of 11 November 2021
D — Digital	Field-specific agro-technological maps linked to monitoring of execution against the planned schedule

Source: compiled by the author from project documentation.

Against the previous season, yields rose by 32.8 per cent for wheat, 38.8 per cent for cotton and 27.0 per cent for rice. Against neighbouring farms in the same season, mechanization cost per hectare was 14.6–20.0 per cent lower and total cost per centner of output 14.9–27.5 per cent lower. The last measure is the more informative, because output prices moved sharply and in opposite directions over the period — cotton fell by roughly a third while rice rose by a third — so per-hectare margins are contaminated by price effects from which unit cost is free. That the cost advantage holds in all three crops indicates an efficiency effect attributable to the organization of production rather than to market conditions.

The functioning of the arrangement illustrates the complementarity claim. The agro-technological map (D) specified what should be done and when; the mobile service unit (I) ensured that equipment failure did not prevent execution; the pooling arrangement (O) made a single machinery set sufficient for six holdings; the legal framework (L) provided the basis on which shared use could be organized. A map without service capacity produces a schedule that cannot be met; service capacity without a map produces reliable execution of an unoptimized plan.

Implications for the design of support instruments

Three conclusions bear on management practice. First, mechanization support should be specified as a service package rather than as an asset transfer, since it is the package and not the machine that produced the effect observed. Second, support instruments should target the machine–tractor

aggregate rather than the prime mover: a tractor performs no field work in isolation, and instruments that subsidize tractors while leaving implements unsupported subsidize the component that cannot work on its own. Third, rules on data ownership and interoperability should be established in advance of any scaling of digital platforms, so that the informational rents generated by monitoring accrue to producers rather than to platform operators — a risk that the literature on digital agriculture treats as structural rather than incidental.

The design has a corresponding limitation. Because all five mechanisms were introduced together, the evidence identifies the effect of the bundle and not the marginal contribution of its components; establishing the latter would require a factorial design in which individual elements are withheld from different groups. Given the magnitude of the differences reported, the value of that information would be considerable.

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