Victory over Peasantry: Extractive Institutions and the Big Push*

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This draft: November 2026

Abstract

We examine how Big Push policies perform under extractive institutions. Using novel micro-data from a 1930s Soviet All-Union audit of collective farms, we exploit the rollout of a central pillar of Soviet agricultural policy, Machine Tractor Stations (MTS), to examine the impact of coordinated mechanization on farm performance, surplus extraction, and peasant grain retention. Results show that, even though technological adoption expanded rapidly, MTS failed to capitalize on the returns to mechanization. Mechanization modestly increased grain output and labor productivity, yet state extraction did not keep pace, nor did peasant grain retention improve, demonstrating the crippling effects of coercive institutions.

*Acknowledgments: The authors would like to thank Pavel Aptekar, Viktor Kondrashin, Vyacheslav Laperdin, and Andrei Markevich.

1 Introduction

The Big Push is a seductive idea for development policy (Rosenstein-Rodan, 1943; Murphy et al., 1989; Gans, 1998). The idea is that large-scale, coordinated investments can rapidly transform agricultural economies into industrial ones (Collier, 2006; Sachs, 2005; Easterly, 2006c,a). Empirically, however, such policies have shown mixed success (Hausmann et al., 2005; Easterly, 2006b; Kraay and McKenzie, 2014; Ades and Glaeser, 1999; Sauer et al., 2003; Wanjala and Muradian, 2013; Bjorvatn and Coniglio, 2012; Magruder, 2013), so it is an open question when Big Push policies are effective.[1]

The institutional environment of Big Push policies could have a dramatic influence on policy success. For instance, some of the most notorious examples of failed "Big Push" policies, such as Stalin's Soviet Union and Mao's China, were implemented using extractive institutions, which enabled a strong commitment to coordinated investment in industrialization, but also employed large levels of coercion (Acemoglu and Robinson, 2012). As is typical of high development theory (Krugman, 1995), the Big Push theory abstracts from the institutional context, so it gives no account of why a Big Push might have failed.[2] However, since institutions can play an important role in overcoming market failures and coordinating and managing technological adoption and use, one might expect the benefits and costs of Big Push policies to depend upon the institutional environment. In this paper, we investigate empirically how extractive institutions enable or cripple Big Push implementation. We focus on the adoption of increasing returns technologies, which are a core component of the theory.

We examine Soviet agriculture during Stalin's Big Push, a setting that provides two advantages from an empirical point of view. First, Soviet leadership aimed toward rapid industrial development and economic growth, so we can examine extractive institutions without confounding the effects of elite preferences that do not prioritize aggregate economic growth.[3] Second, Stalin's agenda included a comprehensive plan for agricultural modernization alongside, and in the service of, large-scale investments in manufacturing.[4] Since coercive institutions could bypass the ubiquitous market failures that plague agricultural input and output markets (Bold et al., 2015; Bohr et al., 2024), both historically and today, and speed up technological adoption in the face of peasant resistance to modernization, there is large potential for Big Push policies to increase agricultural output.[5]

[1] Examples of Big Push successes are Post-WWII Japan and the private-led examples led by German Universal Banks in late nineteenth century Germany or the Danish Cooperative Movement; examples of clear failures are Burma under the Pyidawtha plan, Malaysia in the 1980s; examples of mixed results are India in the 1950/60s, Indonesia in 1970s, Brazil 1950s, the Tennessee Valley Authority policies in the US.

[2] de Fontenay (2004) is a notable exception, showing that when firms have market power, weak institutions worsen the holdup problem associated with coordination failure.

[3] For instance, Robinson (2025) provides a telling anecdote: "At some point in the conversation the CEO looked up at me and said: 'I really don't know what your problem is, it really isn't complicated, what is it that you can't understand?' With the wind taken completely out of my sails I paused and waited for them to spell it out: 'Look' they said, 'there's plenty of money in this country for 300 people.'"

[4] The Big Push logic is commonly applied to manufacturing but it can equally be applied to agriculture. See Grabowski (2020) for an application to Ethiopia.

[5] Ciccone (2002) shows that improvements in intermediate input allocation can have a large impact on aggregate productivity in the presence of increasing returns technologies.

Moreover, in the largely agricultural economy, extractive institutions could redirect agricultural surplus from rural consumption and savings to investment in industrialization, leading to large increases in aggregate economic growth and simultaneously solving the problem of labor absorption.

Yet the Soviet Big Push policies faced all the well-documented problems of a command economy: ideological considerations, perverse incentives, moral hazard, soft budget constraints, information failures, and lack of competition (Kornai, 1986; Hayek, 1944, 1945, 1988). Whether these problems create worse production outcomes than the production gains from overcoming coordination and agricultural market failures is an empirical question.

In the end of 1920s, Stalin and the Soviet leadership adopted the course toward rapid and total collectivization, aiming to "catch up and surpass" Western Europe and the US. The inherited low levels of mechanization and agricultural productivity from the Russian Empire (Gerschenkron, 1962), together with the consequences of WWI and the Russian Civil War, meant that such a transformation implied an acute shortage of tractors and other heavy agricultural machinery and farm equipment. The devastating and brutal conversion of individual and communal peasant farms into collective farms (kolkhoz) and state-run farms (sovkhoz) adversely affected farm organization and management, livestock and draft power and peasant motivation. In order to overcome these substantial problems, the Soviets instituted Machine-Tractor Stations (MTS) as their vehicle for modernizing and disciplining collective farms. In this environment, technological adoption and use decisions were primarily determined externally to the farm by both MTS and other state planning authorities. What kind of modernization did MTS bring to the agricultural sector? Did MTS increase grain surplus extraction? Did MTS increase labor productivity, freeing up labor for reallocation to manufacturing?

Unfortunately, disaggregated quantitative evidence on how extractive institutions work in practice is quite limited. In the Soviet case, the existing literature is by now very extensive, but its evidence is aggregate and cannot answer these questions without strong assumptions (Gregory, 2009; Allen, 2003). For better understanding, scholars need microdata that would allow empirically to link together various dimensions of this multivariate puzzle.[6] For example, aggregate data cannot establish the empirical production technological frontier nor disentangle the economic impacts of nonmarket allocation from the marginal returns to mechanization.

To answer these questions, we exploit MTS rollout in the Urals, located in the Central Industrial Region of the Soviet Union, using farm-level data for 310 collective farms covering outputs, inputs, and MTS services for 1933-1934, matched with census, transportation, soil, and land allocation data.[7] The farm-level data are superior to annual farm-level reports since they come from an official audit of these reports. The audit's main objective was to obtain an accurate picture of agricultural production, aiming to correct for inaccuracies and misunderstandings in accounting practices, and

[6]We note that debates on Soviet agricultural statistics persist. Concerns center on the use of annual collective farm reports, which have survived in various local and central archives in incomplete and imperfect form (Wheatcroft, 2019; Tauger, 2006; Wheatcroft, 2007).

[7]The region is not a major agricultural producing region but is still dominated by agriculture. Our choice of this region is driven by data availability but it is also a fortuitous selection.

was designed to be representative at the district-level.[8] We match these reports with auxiliary data from the 1926 Soviet population census, settlement-level data from various sources, state agency financial reports, and local data on transportation networks, soil quality and land allocations.

We begin by regressing grain output in logs on the share of mechanized services through MTS and control variables including district-by-year fixed effects to account cross-district-year differences in the central plan and weather. We find that mechanization is associated with an increase in grain output. The magnitude of the effect is small at less than 0.2 standard deviation increase in response to one standard deviation increase of the share of mechanized services performed on a farm. Surprisingly, this small effect does not arise as a result of a balance between successes and failures; figure 2, which shows the empirical production possibilities frontier, demonstrates the convex hull barely moves as more MTS services are adopted.

Moreover, in contrast to the narrative that the Soviets were better able to redirect agricultural surplus and speed up the development of the Soviet economy, we find that the elasticity of surplus extracted to output as a result of mechanization is much less than one and labor productivity only modestly increases with mechanization.

Why were the effects so small? First, we demonstrate that MTS service allocation suffered from negative selection. We use instrumental variables estimation based on travel costs to MTS centers. The identification assumption requires that travel cost to the nearest MTS center is not associated with farm performance, conditional on a host of observable farm characteristics and district-by-year fixed effects, other than through MTS services. In Table 6, we show that these controls are necessary due to relationship between agricultural productivity and preexisting infrastructure. Accounting for negative selection, we show potential gains in output due to mechanization could have been as much as double ($\frac{e^{0.15*1.374}-1}{e^{0.15*0.734}-1}$) the average effect given by the OLS estimate. This finding is consistent with the extractive environment substantially decreasing the benefits of implementing Big Push policies.

Second, we find no evidence of scale economies, despite large variation in farms' sizes and levels of mechanization. This result is consistent with several possibilities, including the crippling and offsetting costs associated with employing MTS services at a larger scale.

Finally, we show that MTS effectively erased any incentives peasants had to use IRS technologies. Mechanization did not increase in-kind compensation per worker. It did, however, modestly reduce below-subsistence extraction, demonstrating that the Soviets effectively turned increasing returns to scale technologies (IRST) into an instrument of insurance against downside risk for peasants. The insurance is not by policy design; it is an unintended consequence of the system.

To enrich the body of evidence that extractive institutions failed to take advantage of IRST, we employ several robustness checks. First, we use an alternative IV that more closely approximates MTS decision-making. We get similar results, although the effect of MTS on labor productivity is less robust. Second, we use inverse probability weighting to account for the fact that larger farms may disproportionately appear in the audit. Reweighting in such a manner yields similar results.

[8] Farms were not randomly selected. Instead, local statisticians used available data and knowledge of the area to produce a representative sample of farms for each district.

Larger farms could also have been more likely to be selected by MTS for service contracts.[9] Third, we restrict the sample to exclude farms that are located near the railway in case differential, pre-MTS market access is a confounder. We get similar results. Fourth, weather varies considerably from 1933 to 1934; however, we show that results are similar for each year separately, with the exception of surplus extraction which was more constrained in the year of 1933.

Finally, we present the results from an alternative estimation strategy using farm-level fixed effects. This estimation strategy holds fixed any negative selection that remained constant over the years 1933-34 and instead uses within-farm changes in the level of MTS services as identifying variation. We find that share of MTS services is no longer associated with an increase in output, but it does increase labor productivity and surplus extraction. The magnitudes of the point estimates are quite large. Due to a marked decrease in within-farm variation, the standardized effects have similar magnitudes. We also no longer observe evidence of negative selection, suggesting that either it has been absorbed or farm-level omitted variables are correlated with the distance instrument and outcomes. We cannot completely reject latter interpretation, but we have examined and already ruled out some of these candidate factors. We also see an elasticity of extraction to output that is greater than one, but without a substantial increase in output, MTS is solving the problem of extraction without meaningful Big Push-style increases in output.

With these findings, we contribute to the literature on technological adoption and structural transformation (Buera et al., 2021; Foster and Rosenzweig, 2011; Gollin et al., 2002, 2014; Gottlieb and Grobovšek, 2019). Garg (2025) demonstrates that coordination failure explains delayed structural transformation. Our evidence shows that the success of resolving coordination failure (through the adoption of IRS technologies), when accompanied by extractive tools, can be quite limited.

Much of the modern misallocation literature leaves key institutional details unspecified (Adamopoulos et al., 2022; Restuccia and Rogerson, 2017; Chari et al., 2021; Hsieh and Klenow, 2009; Chen et al., 2022). Using the frictionless market economy as a benchmark conflates distortions, one set due to frictions in allocation and at least another set due to incentives in using factors of production. Hence, this counterfactual can be misleading in contexts with extractive institutions. Explicit attention to the nature of extractive institutions also allows us to contribute to the empirical literature on Big Push policies in development economics and economic history (Kline and Moretti, 2014; Wanjala and Muradian, 2013; Magruder, 2013; Easterly, 2006a; Miller et al., 2022), which typically examine settings with voluntary or user-incentivized technology adoption. [10]

[9] We do not perfectly observe farm size pre-MTS and farm size is affected by MTS. One reason is that the formation of collective farms occurred over time, consolidating the land of former peasant communes and individual farms, and done with various levels of coercion. To be clear, we do not have a perfect method to handle this issue, but we employ a variety of sensitivity checks that elucidate how serious a concern this is. To alleviate concerns, figure 3 demonstrates that the first-stage relationship is similar across farms of different sizes and, on average, larger farms are associated with a greater share of MTS services. However, there is substantial overlap even for farms very close to MTS.

[10] We distinguish between poverty trap dynamics and coordination failure. Several papers use the term big push to mean a one-time investment that is designed to move in isolation a firm, household or individual above a threshold(Bouguen et al., 2019; Bari et al., 2024; Balboni et al., 2022; Barker et al., 2024).

An additional contribution concerns the view, argued by Mokyr (2010), that the interaction between institutions and technology affects the process of human capital accumulation and innovation. Officially, Soviet policy incentivized adoption and use of mechanization through tax breaks for farms with MTS contracts as well as performance pay for MTS when farms using its services had higher yields. In a related paper on technological adoption and productivity in the early Soviet Union, Markevich and Santavirta (2025) show that human capital embodied in American Finns has a large impact on the productivity of Soviet timber industry. We note that American Finns accumulated human capital through learning-by-doing in a market environment, using the profit motive through active tinkering in response to direct information on relative scarcities. As with timber, the Soviets also engaged in international collaboration in mechanized grain production, but learning-by-doing likely transported less well in the relatively more complex and highly localized production process of grain production. In fact, our results show that, after removing the effect of mechanization on land expansion, mechanization actually increases both land and labor productivity, a result more consistent with mechanization removing distortions related to collectivization. This contrast in the process of technological diffusion illuminates the role of markets and institutions in human capital accumulation and technological adoption.

Finally, our findings contribute to the literature on Soviet economic history and, specifically, to the "Was Stalin Necessary?" debate (Cheremukhin et al., 2017; Nove, 1964) as well as the agricultural surplus debate (Ellman, 1975; Millar, 1970; Gregory, 2009).[11] A simple back-of-the-envelope calculation suggests that, assuming a 15% internal rate of return, state extraction from fully mechanized farms could have achieved $100 * (e^{0.386} - 1 - 0.15) = 47\%$ more grain surplus (and up to $100 * (e^{0.594} - 1 - 0.15) = 66\%$ more surplus by removing negative selection). Using 1931 production and world prices as a benchmark, and assuming that the Ural region is representative, which is arguable, but also probably not too distant from the average, we would see an increase in $1.32 * 5.2 = 6.87$ million tonnes or $\$15 * 6.87 = 103$ million in hard currency to finance industrialization (compared to $ 350 million spent per year in the 1930s). On the one hand, if grain constituted about 25% of agricultural exports, then full mechanization would have been able to put hard currency levels comfortably above $350/4 = 87.5$. On the other hand, full mechanization would have been entirely unrealistic for the whole Soviet Union much less a single raion in 1933-34. Strikingly, this amount is less than half of what the Soviets would have lost if they had stopped extracting grain below subsistence levels (3.96 (=0.12*0.275*120) million). Thus, our findings support the claims that agricultural surplus could have financed industrialization but also give more evidence that it clearly did not. Thus, these findings show the large economic cost of Stalin's ideological objectives.

[11] This debate rests on data on intersectoral balance from Barsov (1969), assumptions about prices and some residual speculation. With our findings, we can make some small progress toward Preobrazhensky's (1965) original thesis on whether agricultural surplus could finance Soviet industrialization (as opposed to whether it did). Millar (1970) argued that agricultural machines should count against agriculture in the net flows. But this is too simplistic. Agricultural machines are investments in agricultural production with a return on investment, both in terms of output and surplus extraction. What is needed then is to establish an internal rate of return and then this return could be subtracted from our estimates to obtain the residual that could contribute to surplus.

The paper proceeds as follows: Section 2 gives the context; Section 3 discusses our hypotheses; Section 4 covers the data; Section 5 sets out the empirical strategy; Section 6 presents the results; Section 7 compares them with the US case; Section 8 concludes.

2 Context

Before introducing our hypotheses and discussing the data, it is imperative to provide adequate details on the institutional and historical context. In this section, we situate the Big Push policies into their political and economic environment, provide institutional details on the Soviet-MTS system and discuss the differences between the region of study and the rest of the Soviet Union.

The empirical data we use in this study are for 1933–1934. We briefly review the preceding political and economic developments and focus on the 'Big Push', a policy designed to achieve the rapid, comprehensive modernization of the Soviet economy. Under this framework, urban industrialization and rural collectivization were to be pursued simultaneously, governed by pervasive state intervention and guided by communist ideology.

Communist ideology envisioned a type of economy based on total state ownership and mandatory and comprehensive central planning. Under this model, there was little room for market transactions as all aspects of production and consumption were directly state-administered. Within this framework, the planning system embraced all components of economic activity including production, distribution and final consumption. Planning operated with physical units while prices functioned merely as accounting units rather than reflections of real market values. Under such a system, communist ideology and the multi-layer repressive apparatus were to substitute and compensate for any loss in economic incentives. In fact, the brutal punishment for non-fulfilling the plan became a key component of the socialist economy. This vision identified independent, wealthy farmers, the 'kulaks', as 'class enemies' and a strategic threat to the socialist reconstruction of agriculture. The independent peasantry was therefore to be abolished as a distinct social and productive class. Peasants were to be divested of their land, productive assets, and the fruits of their labor. In place of small-scale independent farming, socialist agriculture was to be reorganized into large-scale collective farms integrated closely into the centralized planning system. The collective farm was "a socialist production unit", for which all inputs and outputs were predetermined within the centralized planning system. It was completely stripped of any independence in deciding what to produce, how to produce and how to use its output. While total collectivization remained the ultimate ideological objective, the pace of implementation was not predetermined; until the late 1920s, the transition towards this ideal remained relatively moderate.

By the late 1920s, on the eve of mass collectivization, the Soviet Union remained a predominantly agrarian society. According to the 1926 population census, over four-fifths of the population (82%, or 121 million out of 147 million) lived in rural areas, with 72 million individuals engaged directly in agriculture. In contrast, the urban population remained small and the industrial base underdeveloped. Though, by 1927, the economy largely recovered from the steep fall associated with the revolution and the Civil War, the total output was still less than in 1913. The same was

true for the agricultural production (Markevich and Harrison, 2011, p. 684–685). Agriculture was still based on manual labor and horse power, while mechanization was minimal.

The collective farms we study were in the Sverdlovsk region, an administrative part of the larger Urals Oblast. Although the oblast maintained a relatively developed industrial profile, approximately 86% of its population lived in rural areas during the early 1920s (Baranov et al., 2009, p. 431). Agricultural productivity remained both low and unstable with significant temporal and sub-regional fluctuations. For instance, grain yields averaged approximately 7 centners per hectare between 1927 and 1933, slightly below the national average for the USSR, with a notable decline in 1931 (Baranov et al., 2009, pp. 460–461).

The XIV Congress of the Communist Party, held in December 1925, established "socialist industrialization" and collectivization as the primary objectives for the First Five-Year Plan (1928–1932). This program aimed to transform the Soviet economy from an agrarian state into an advanced industrial power. Given that Soviet industry was technologically primitive and lacked the capacity to produce heavy machinery, realization of the program was expected to rely heavily on large-scale imports of Western equipment, technology, and engineering expertise.

To finance these industrial imports, the Soviet Union required vast reserves of foreign currency. As a primarily rural economy, it was forced to rely on agricultural exports as its principal source of revenue. This strategy echoed the theories of the economist Evgenii Preobrazhensky, who in the 1920s argued that the "initial socialist accumulation" necessary for financing industrialization should be derived from the systematic exploitation of the peasantry.

The question of how to extract agricultural surplus and channel it toward industrial needs was disputed within the Soviet leadership, between Stalin's faction and the opposition (see Gregory (2009)). Stalin and his allies advocated for a "tribute" system, wherein the rural population would be subject to unequal exchange enforced through state coercion. Conversely, his opponents maintained that operating an economy on tribute is antithetical to socialist ideals, suggesting a moral equivalence to feudalism, and that market mechanisms should be permitted to facilitate the transfer of resources. The Stalinist faction prevailed, and this strategy of forced resource reallocation became the basis of the "Great Breakthrough." Key mechanisms of this policy included increased taxation, manipulation of the "price scissors," and mandatory grain procurements that left the peasantry with little more than a subsistence minimum (or even less than that).

Debates regarding the methods and pace of collectivization persisted throughout the 1920s; however, accelerated collectivization did not emerge as a policy priority until 1928. That year, poor harvests caused by adverse weather and the peasantry's refusal to sell grain at suppressed state-controlled prices resulted in a significant shortfall in state procurement. As a result, the country grain export in 1927 made just 17% of that in 1926 (Kondrashin, 2024, p. 479). In 1913, the total Russian grain export was about 600 thousand pood (9.8 million kg), but it was only 5.6 thousand (less than 0.1 million kg) in 1927 and 26.1 (0.4 million kg) in 1928 (Kondrashin, 2024, p. 508, table 3). Table 1 compares agricultural output in 1927/28 with that in 1913 in constant prices.

Table 1 Gross Output and Commercialization of Agriculture (millions of Rbl in 1913 prices)

	Total output	Commercial output (without intra-rural consumption)	% of commercial output
1913: total agriculture	10,940	2,605	23.8
grain	4,321	987	22.8
1927/1928: total agriculture	11,926	2,180	18.3
grain	3,729	520	13.9

Source: Kondrashin "Rossiyskaya derevnya. . . ", 2024, p.483

This shortage was interpreted by Stalin's leadership as an indication that market coordination alone was insufficient for the Soviet state to secure the agricultural surplus required to sustain rapidly growing urban centers and generate the hard currency necessary for industrial imports. The shortfall threatened the viability of the industrialization drive, which remained dependent on technology and capital equipment from Western nations.

In response, the Soviet leadership opted for the coercive extraction of grain, employing "extraordinary measures" against a peasantry unwilling to trade on state-defined terms. This crisis led to the conclusion that the potential for agricultural commercialization based on small-scale private landholding was inherently limited.

For Stalin, the collectivization of agriculture was an ideological imperative, as independent farmers, the kulaks, were viewed as an existential "class enemy" to the socialist project. Nevertheless, while the long-term objective was ideologically fixed, the specific tempo of the transition remained a political variable. The need to feed a growing industrial workforce and to pay for foreign technology pushed him toward a faster move of peasants into collective farms.

MTS

To enhance productivity, the modernization and mechanization of agricultural production became a central priority. At the time, the sector remained technologically underdeveloped, relying primarily on manual labor and draft animals. In the late 1920s, "Machine-Tractor Stations" (MTS) were established to supply heavy machinery to the newly formed collective farms.

The first specialized agricultural tractor unit was established in 1928 in Ukraine, serving later as a prototype for the nationwide expansion of the MTS network. These stations carried out mechanized tasks, including sowing, harvesting, and threshing, on behalf of collective farms. The nationwide development of these stations is illustrated in Table 2.

In 1930, only 158 stations existed across the country. However, by 1931, the network expanded nearly eightfold, and the total number of units doubled again in 1932. By 1933, the MTS count reached approximately 3,000, exceeding 3,500 by 1934. This expansion exhibited significant regional variation, as the state prioritized the allocation of machinery to the primary grain-producing regions. Table 3 provides a detailed breakdown of these statistics for the Sverdlovsk Region.

As private ownership of tractors and other productive assets was prohibited, all agricultural machinery was centralized within the state-owned MTS. Each station serviced collective farms within its administrative jurisdiction to facilitate logistical access to cultivated land.

Table 2 MTS Development in the 1930s, the USSR

USSR total	1930	1931	1932	1933	1934	1935	1936
Number of MTS	158	1,228	2,446	2,916	3,533	4,375	5,000
N of tractors, total (thousands)	7.1	50.1	74.8	123.2	177.3	254.7	328.5
of them foreign brands (thousands)	6.8	29.8	31.1	33.2	20.5	18.3	9.8
N of combines (thousands)	...	...	2.2	10.4	15.2	29.3	65
% of cultivated land of collective farms served by MTS	...	37.1	49.3	58.7	63.9	72.4	82.8
Work performed by tractors (mln ha)	...	...	20.5	35.2	62.5	100.5	165
N of tractors per 1 MTS (units)	...	...	...	42	50	58	66
Engine power per 1 MTS (hp)	...	...	...	603	779	979	1,171
N of kolkhozes served by 1 MTS	...	...	...	32	31	28	32
Cultivated area by 1 MTS (ha)	...	...	...	20,356	19,682	16,695	18,289

Note: Work performed by tractors calculated as soft plowing without threshing.
Source: МТС во второй пятилетке. Госпланиздат, Москва-Ленинград, 1939, Table 1, pp. 11, 12, 14, 16.

Table 3 MTS Development in the 1930s, Sverdlovsk Region

Sverdlovsk oblast	1933	1934	1935	1936	1937
Number of MTS	24	33	43	51	60
% of arable land of collective farms served by MTS	45.4	56.3	72.2	83.0	94.3
N of tractors per 1 MTS	27	42	46	59	56
Engine power per 1 MTS	401	651	760	1,039	1,000
N of kolkhozes served by 1 MTS	31	29	30	31	29
Cultivated area by 1 MTS	15,894	14,667	15,307	15,137	14,686

Source: МТС во второй пятилетке. Госпланиздат, Москва-Ленинград, 1939.

The organizational structure of the MTS was divided into two distinct functional domains. The primary productive unit was the tractor brigade, which comprised the machinery, such as tractors and harvesters, and the technical personnel required for their operation. While the brigades managed technical and operational functions, another key unit was established in 1933: the political department (politotdel). The politotdel was tasked with maintaining general political oversight, identifying alleged "saboteurs," and enforcing labor and procurement discipline. These units were staffed by Communist Party functionaries, typically recruited from urban centers. The deputy director of the politotdel was always an officer of the NKVD, which gave the state security apparatus a direct line of subordination.

This dual structure reflected the two fundamental mandates of the MTS. The first was to raise agricultural yields through the introduction of a modern technical base. The second was to consolidate political control over the peasantry and maximize the extraction of agricultural surpluses. While the tractor brigades facilitated production, the politotdels were instrumental in the distribution and coercive procurement of output. Participation in the MTS system was mandatory for collective farms, though its implementation was gradual. Each station serviced multiple collective farms, which were required to partially subsidize the acquisition of machinery and the establishment of the station. These relationships were formalized through binding contracts, with the MTS paid a fixed share of the collective farm's total harvest.

This payment in kind was centrally determined and could comprise up to 20% of the total yield, a rate that exhibited an upward trend over time. The payment often far exceeded the marginal cost of the services provided, so the exchange between the collective farms and the state was non-equivalent, and the state extracted agricultural surplus through it. Furthermore, the financial burden of operating costs, including fuel, lubricants, spare parts, and maintenance, was shifted entirely onto the collective farms.

From a purely technocratic perspective, the establishment of the MTS system appeared to follow conventional economic logic: small-scale farms lacked the financial, technical, and human capital necessary to manage complex machinery, particularly given the seasonal nature of agricultural production. However, the primary motivations were strategic and complementary to the state's extractive institutional framework. The Soviet authorities used the MTS as an instrument of political and administrative oversight, specifically to reinforce the power hierarchy and to monitor adherence to directives and the redistribution of output. This provided the state with enhanced extractive capacity within an asymmetrical power dynamic, where increased state appropriation directly reduced the grain available for peasant consumption.

As R.W. Davies observed, "The lower level of distribution of grain, certainly displeasing to the peasants, was, however, regarded by the authorities as demonstrating the ability of the MTS system to provide better control over the economic activity of the kolkhoz" (Davies, p. 30). In this regard, the MTS functioned in stark opposition to a competitive market for agricultural services; under the Soviet command model, collective farms were denied the autonomy to opt out of the service, even when the economic costs outweighed the productive benefits.

MTS also faced significant organizational, operational and logistical challenges. Drawing on MTS internal reports as well as various central and regional government documents, Baranov et al. (2009) demonstrate that the rapid institutional expansion of the MTS system proceeded without adequately accounting for complementary institutional and material support. They document chronic shortages of machinery, spare parts, fuel, and trained personnel. For example, fewer than half of the tractors assigned to MTS stations were operational at the outset of the 1933 plowing season. The authors argue that a confluence of avoidable factors led to this outcome: inadequate winter storage, limited inventory of spare parts and lack of skilled labor for repair. Compounding these technical deficiencies was an acute shortage of horses and burdensome administrative costs, placing greater pressure on the MTS system.

Baranov et al. (2009) emphasize that the overextension of the MTS network was a structural condition of the system and the severity of conditions leading to overextension varied considerably within the Ural oblast. Differences in MTS' and collective farms' capacity as well as differences in terrain and distances separating kolkhozes from their assigned stations all varied substantially.

3 Hypotheses

Extractive institutions, by their nature, embed high-level political, ideological and economic objectives in the economic organization of society. To ensure adherence to these objectives, extractive

institutions use organizational design and coercion to limit the divergence between real and formal authority (Aghion and Tirole, 1997). As discussed in the previous section, MTS is no exception and, as such, their services represent a treatment bundle consisting of tools to enhance both productivity and state control.

Given the state objective of catching up and surpassing Western economies, one of the main advantages of the Big Push policy implemented through extractive institutions is an ability to bypass the voluntary nature of market exchange. In the market system, governed by the profit motive, taxing the agricultural sector to help finance investment in industry would decrease the return on individual farms investing in mechanization, slowing its adoption. The large-scale reallocation of labor from the countryside to the city also faces a coordination problem: if farmers believe (do not believe) a large amount of labor will move to urban areas, investing in mechanization to generate surplus in grain could benefit (adversely affect) them. Therefore, there could be multiple counterfactual market economy outcomes, one consistent with tepid adoption and slow economic growth and one consistent with coordinated adoption and widespread surplus generation. In the Soviet system, market-style coordination failure would be purged. Farms that received MTS services would not need to be concerned about whether their surplus would be marketable.

First, from a technological point of view, the main benefit of mechanization is releasing labor and horses from farm production. The indirect effect of replacing horses is substantial since land used for feed crops and labor used to care for horses can be converted to other uses, such as for producing more grain or satisfying the growing demand for labor in cities. In this respect, land productivity should not be affected much by mechanizing in a market economy. Instead, agricultural output primarily increases due to an expansion of land under crops. This leads us to our first hypothesis, a naive one that only takes into account the absence of coordination failure and discounts any deletorious effects of the coercive system.

Hypothesis 1: Performance. MTS increased grain output, primarily through land expansion.

There are, of course, additional secondary technological advantages and disadvantages of mechanization. The most important of these is that mechanization can alleviate time constraints when weather conditions are such that timing of production activities is critical. An offsetting disadvantage of mechanization can be from applying the wrong machine for the job given the particular set of agroclimatic conditions (e.g., tractors may plow too deep for the soil type) since, in the early stages of mechanization, the Soviet Union primarily relied on importing machinery from the West.

In the development literature, there is an active and ongoing debate on the inverse farm size productivity relationship. On the one hand, monitoring costs increase as more workers are hired, potentially generating severe decreasing returns to scale. Hiring workers without an adequate means to monitor and incentivize effort means larger farms will either underuse labor or will have less effective labor (not observable) per labor input (observable). The Soviets also relied on a mix of ideology, propaganda and repression to limit shirking. However, the disincentives of collectivization were real and MTS could increase labor productivity through better monitoring of shirking in farms

where it had a greater presence. Thus, under extractive institutions, an increase in productivity can reflect better monitoring and enforcement as well as access to IRS technologies. In the former case, this increase should reveal itself over and above an increase due to land expansion.

A different view is that smaller farms overinvest in inputs due to distortions in the land market. The Soviets did not face distortions in the land market that led to preponderance of small landholders. The smallest farm in our sample is over 100 hectares and the preexisting structure of former communal landholdings and the expropriation of private land allowed for land consolidation so that farm size was no longer an impediment to taking advantage of increasing returns to scale.

It is an empirical question whether Soviet agriculture is more akin to agriculture in a low-income country facing decreasing returns to scale or, instead, is closer to the mechanized farms of US that exhibit increasing returns to scale.

Tractors and other machinery were a scarce resource. In the market environment, more efficient and profitable farms would secure their demands, while less efficient would stay without access to new technology. This could drive an even larger gap between leaders and laggards and, ultimately, drive the latter out of business. In the market economy, then, land expansion on a farm should be positively correlated with total factor productivity. Farms with higher TFP would also be more likely to adopt mechanization. We should observe a positive correlation between productivity and mechanization due to selection on observable and unobservable productivity. While this correlation could be muted under certain Big Push policies that subsidize investment, for example, the voluntary nature of technological adoption still suggests the correlation should be positive. This would imply that once we account for selection, the effect of mechanization should decrease.

In the Soviet ideologically-constrained setting, where centralized targets of grain procurements were brutally enforced, the allocation rules were different. The allocation decisions were made by regional agricultural and party authorities which had no possibilities to account for local details and changing conditions. Jointly with local rural bureaucrats, they had obvious incentives to provide mechanized services to "weaker" collective farms. First, in order to maximize the number of hectares with at least some mechanization, services were spread more expansively than in a market economy. Second, “weaker" collective farms also were less likely to be able to fulfill their quota. To avoid repressions for not fulfilling district procurement plans, services were reallocated to such farms with respect to the flow of services under the market economy. In contrast, in the command economy, the non-market bureaucratic allocation of mechanization may introduce negative selection due to ideological priorities, lack of price information, or bureaucratic lobbying.

The incentives of local bureaucrats was purely to fulfill the plan, allocating resources in such a way so that as many targets could be fulfilled. Related to this issue is the problem of local knowledge. Technology must be applied to local conditions and within a local environment. Technology use and adoption depend on local knowledge. The plan did not incorporate local knowledge by definition. Instead, quotas were assigned via easily observable farm characteristics, such as landholdings. And, in a system that discouraged those with superior local knowledge to act on it, we can presume that the Soviet economy faced some constraints in this domain.

Without markets, relative scarcities are difficult to observe and prices no longer adjust to incorporate local knowledge. The accounts suggest that Soviets had mechanisms in place to monitor local conditions but without market prices they had only limited information about relative scarcities. Absolute scarcity would have been easier to observe but it is less helpful in making optimal allocation decisions. Ideological goals of spreading socialism to the maximum number of production units in the economy could have altered an economically efficient diffusion of technology. The last-shall-be-first maxim combined with the belief in the ability of modernization under socialist ideals to transform even the most backward peasant farm also affected allocation. MTS directors explicitly targeted the extensive margin of mechanization when allocating their services. This discussion suggests our second hypothesis.

Hypothesis 2: Nonmarket allocation. MTS negatively selected farms for mechanization services and generally did not follow the patterns exhibited by market-based allocation.

Third, MTS services would allow for better control over extraction, often at the expense of peasant welfare, dampening their incentives to adopt and use or complement IRS technologies. Negative selection by MTS, and more generally redistribution of resources to compensate for poorly performing farms, could also affect peasant incentives. Soviet agronomists also had access to the agricultural knowledge frontier and demonstrated this knowledge on their experimental farms. The transfer of such knowledge is a very different issue. In the market economy, through the profit motive, the transfer of knowledge to users is incentivized and enhanced through local experimentation. As Joel Mokyr has emphasized (Mokyr, 2010), tinkering with technology is a major source of economic growth. Technical knowledge alone may have limited impact without incentives for use. Under maximum extraction, farmers had little incentives to innovate and tailor the production process to use the IRST.

Hypothesis 3: Incentives. The extractive nature of MTS eroded peasant incentives to use mechanized services.

4 Data

We use a manually collected farm-level data set that covers collective farms in the Urals region for 1933–1934. Farm-level records are matched with auxiliary sources including the 1926 Soviet census, settlement data, and data on soil and transport networks. This dataset provides multidimensional picture of how the Soviet collective farms functioned in the early 1930s, and allows estimation of short-run effect of technological adoption on productivity.

Farm-level data. The core of the dataset comes from the special sampled dynamic survey of kolkhozes.[12] It was conducted in May–June 1935 by the Central Administration of National Economic Accounting (TsUNKhU) under the Planning Commission (Gosplan). For brevity, we call

[12]Detailed information about the survey, its content and administration were first reported by Soviet historian I.Zelenin in his short piece published in 1968 (Zelenin, 1968). See I.Zelenin. Dinamicheskie obsledovaniya kolkhozov za 1933-1934 gg. (Dynamic Surveys of Collective Farms for 1933-1934). In: Источниковедение истории советского общества, Vol.2, Moscow, Nauka Publisher, 1968. Pp 339-355.

it the Audit survey. Its main objective was "a systematic monitoring of economic and financial situation of kolkhozes and a verification of correctness of annual reports" (Zelenin, 1968).

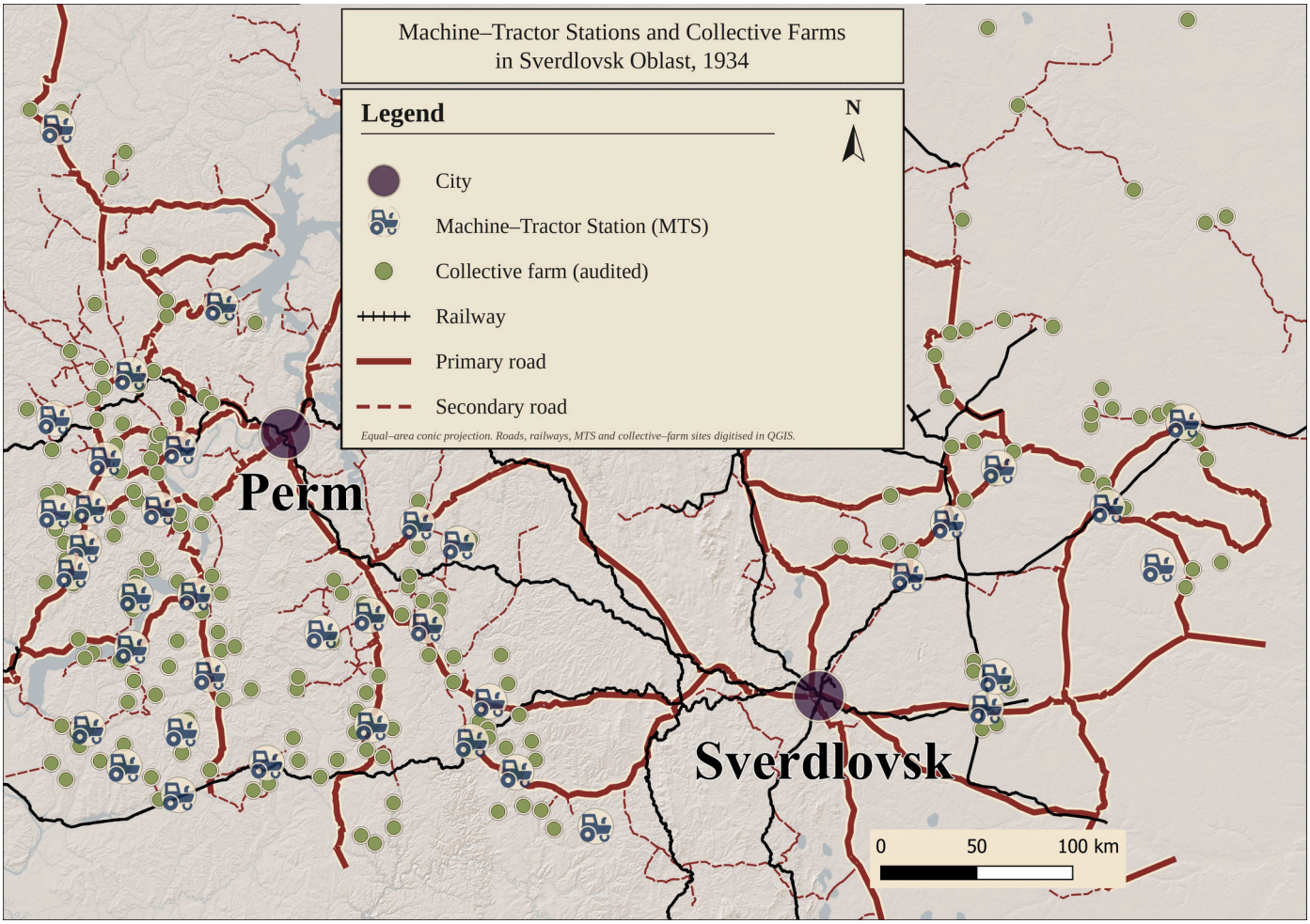
For the survey, TsUNKhU sampled 17,500 farms (about 8% of all kolkhozes in the country) with proportional regional representation. In Sverdlovsk Oblast, 450 farms (10%) were selected. The farms' records were derived from the original archival files titled "Primary Sheets of Dynamic Survey of Economic and Financial Conditions of Collective Farms for 1933 and 1934", preserved in the regional statistical archive. The collection contains 311 detailed audit reports from collective farms in Sverdlovsk Oblast (including the Perm and Ekaterinburg rayons in the Urals) (Men'shikova, 2001).

Each collective farm reported its harvests in physical units for all major crops (grain, potatoes, flax, and others). The dynamic survey is the only source of grain productivity based on harvest actually collected and put in barns (this productivity was 25-30% lower than that determined by bureaucratic productivity commissions). The list of inputs included quantities of employed labor, days worked, and sown area by crops. The records measured volumes of major field operations, like sowing, planting, cutting, harvesting, and threshing. These operations were performed either by using MTS services or by collective farms themselves using manual or horse power. The forms for 1934 provided some additional information about fertilizers, seeds, and horse feed. An important part of the audit records related to the harvest allocation, including all forms of state procurement and extraction, like taxes and obligatory procurements, and in-kind payments for the MTS services. Available data allow also reconstructing residual leftovers and payments to peasants in collective farms. Additional socio-economic indicators reported local public amenities and distances to nearby hospitals.

For consistency, we include only those farms that were established before January 1, 1933, had no organizational changes through 1934, and submitted complete annual reports. We digitized all fully completed reports (N=220); the remaining files with omitted key variables such as location, labor inputs, or horse inventories were excluded from the analysis. Figure 1 shows the locations of each farm in the audit as well as MTS locations and the rail and primary road network, which are important for our identification strategy.

While aggregated figures from the survey appear in several published studies, to the best of our knowledge, this is the first use of these data as microdata. As the aggregate Soviet statistics is likely to suffer from various manipulations, the primary data which were not intended for public use are less likely to be manipulated. Nevertheless, microdata may also suffer from a host of issues. First, they do not always contain the variables we need. In the planned economy, variables measured as monetary values, e.g., wage bills, input costs, sales or revenue data do not capture market values, as prices are not set by demand/supply considerations and are merely accounting units subjected to political goals. Second, the microdata could also be subject to politically motivated massaging, especially when there are strong incentives to misreporting (as it was in the agriculture). In fact, poor information on the actual state of the collective farms and concerns for local manipulation was one of the key reasons for conducting this audit survey with detailed

Figure 1 Map of Study Area



records of physical quantities of inputs and outputs. However, we do not observe any traces of outside manipulative interventions in the original archival documents. According to Zelenin (1968), TsUNKhU statisticians implemented robust verification procedures to reduce misreporting, to make the data less susceptible to manipulation by higher administrative levels.

Location, soil quality and climate data. As was mentioned above, we merge farm-level data with the locational and climatic characteristics. Farm locations are proxied by the centers of their respective local administrations ("selsovet") as they were shown in settlement maps from the 1928 Ural Oblast census. Using the 1935 Sverdlovsk oblast directory, we digitized MTS locations and local road networks to measure transportation accessibility for MTS services.

Soil quality and weather conditions are extremely important for agricultural output. We use historical soil maps for the European part of the USSR, and we assume that the impact of weather on output is roughly uniform across a raion in a given year. Weather measurement is rather sparse still during this period and available measures thus heavily rely on weather models. The raion-year fixed effects approach also avoids the difficult issue of how exactly and which weather variables should enter the specification.

1926 Population Census, settlement level

We use as a control variable rural population density from the 1926 population census. For every settlement in a selsoviet, the census provides population as well as distances from the settlement to nearest railway, raion center and selsoviet center. Since we geolocate all of our farms to the selsoviet center, we could construct population density directly using distance to the selsoviet center. Yet, these distances are obtained simply by asking settlement residents and could therefore contain measurement error due to subjective nature of self-reported data (e.g., resident could report distance from their home or have incorrect information about to which selsoviet their settlement belongs). As such, we triangulate using fixed locations for railways and raion and selsoviet centers to better approximate settlement locations. And then recalculate population density. The direct and adjusted measures are strongly, positively correlated, but there are notable discrepancies, making us prefer the adjusted measure.

4.1 Summary Stats

The outcomes that we consider are grain output in logs, grain surplus in logs, land area planted with grain in logs, number of workers in logs, land productivity and labor productivity.

Grain surplus is constructed by taking grain output and then subtracting in-kind compensation to MTS and grain payments to workers as well as grain allocated to horse feed and the seed fund. The latter two variables are only available for 1934, but we predict the 1933 value based on estimates from 1934 data, allowing for separate allocation norms for horse feed by MTS and non-MTS farms.

The main variable of interest is the share of production performed by MTS services. This variable is constructed by summing across all production activities and calculating the share of hectares worked by MTS.[13]

[13]This measure is highly correlated with a measure that only uses grain production activities.

Table 4 Summary Statistics of Key Variables

	mean	sd	min	max
Total landholding size (ha)	770	500	145	2507
Land area planted with grain (ha)	490	330	44	1860
Total grain harvested (tonnes)	331	261	26	2244
Number of households	73	49	11	390
Total population (all members)	280	190	41	1630
Working-age population (able-bodied)	140	97	17	627
Horse stock (traction capacity) in the beginning of year	50	33	7	236
Total cattle (head count)	51	61	0	305
Observations	439			

5 Empirical Strategy

We are interested in estimating the causal effect of mechanized services delivered by MTS on grain output and productivity. The counterfactual used in our econometric analysis is conditional on the suite of extractive institutions of the Soviet planned economy, including collectivized agricultural units, but for MTS. In particular, this counterfactual is not the same as the decentralized, market economy without a Big Push policy. Since the state controlled access to mechanization through MTS, the counterfactual analysis cannot isolate the effect of technology alone in this extractive environment. That said, MTS was an essential pillar of the extractive institutions that governed the agricultural sector and the main vehicle for Big Push policy in the sector. The counterfactual still entertains what would have happened without a Big Push (or one implemented with less intensity). Collective farms without MTS services would not have had systematic, if any, access to mechanization simulating the "coordination failure" equilibrium (the inherited endowments of agricultural machines from the Russian Empire, which were expropriated).

Two features of the command economy influence the econometric specification and interpretation. First, major input decisions and production plans are not exclusively determined at the farm-level and hence an alternative econometric treatment is necessary. Second, while prices existed, they should not be interpreted as market prices; rather, they reflected accounting procedures. For this reason, a major advantage of our data is that we can work in quantities as opposed to revenue.

The specification that we would like to estimate is the following:

$$y_{it} = \alpha + \beta * MTS_{it} + X_i\psi + \phi_{dt} + \epsilon_{it}$$

The main dependent variable, y, is grain output and surplus extraction, but we also consider land and labor inputs as well as land and labor productivity. In addition, we examine farm worker compensation, which is itself a function of farm production. In remaining parts of the specification, we use time-invariant farm-level variables, X_i, which we will discuss more below, ϕ_{dt}, a set of raion-year fixed effects that simultaneously account for the raion-year specific production and procurement plans as well as other unobservable rayon-year specific variables such as weather conditions, and, ϵ_{it}, an idiosyncratic error term.

The main source of identifying variation comes from comparing collective farms with higher levels of MTS services to collective farms with lower levels within the same raion during the same year. In addition to intensive margin variation, a modest number of collective farms have no MTS services despite being located in raions with collective farms that have MTS contracts. Due to the complex planning environment, there could be complementarities in the state's ability to extract in raions with a MTS presence. We explore this heterogeneity in an appendix.

Fortunately, about one-third of raions have no collective farms with any MTS services in both years, allowing for more credible counterfactual estimation. The main advantage of having the farms without MTS services is that we can account for the effects of other factors on our outcome variables that could give rise to estimation problems due to their association with MTS services. These are horse and cow stocks and rural population density. Horses and cows were extremely important for farm performance, both with mechanization and without. Population density certainly centered on places with higher land productivity. Places with higher population density also likely experienced a limited form of agglomeration effects. Since MTS might have selected farms based on these characteristics, these characteristics may have their own impact on outcomes and MTS may have affected these impacts, we predict their impact on the outcomes using farms without MTS services and then remove these predicted effects from the dependent variable prior to running our main results.

One factor that we control for directly is an index of local public goods that proxies for local development and captures some agglomeration effects such as having a sauna, length of maternity leave, distance to the raion center, etc. One could think of this as a proxy for human capital of farm workers. We assume that MTS does not select on this variable, conditional on the other control variables, and does not affect the productivity of this labor since MTS supplies its own labor. We also use the effect of this variable to benchmark magnitudes of the results since these public goods would have reflected the level of economic development inherited from the Russian Empire.

We can rewrite $\epsilon_{it} \equiv \iota_{is(t)} + \lambda_{it} + u_{it}$ where u_{it} represents idiosyncratic factors that affect output and are unobservable to and unpredictable by the authorities and the farm. The error component ι represents unaccounted for factors associated with the state plan, $s(t)$, for farm i that are out of control of the farm and the local bureaucrats and unobservable to the econometrician. The error component, λ_{it}, captures unaccounted for factors under the control of local bureaucrats and/or the farm. In particular, λ could be due to local authorities making deviations from the state directives for a particular farm or it could be due to local adjustments to unobservable economic conditions to the extent that margins of adjustment were possible. Here, we assume $E[u_{it}|MTS, X] = 0$, but it is too strong an assumption to assume $E[\epsilon_{it}|MTS, X] = 0$. Thus, OLS estimation of the above equation, as N goes to infinity, yields additional "bias" terms of:

$$\rho_{MTS,\iota}\frac{\sigma_\iota}{\sigma_{MTS}} + \rho_{MTS,\lambda}\frac{\sigma_\lambda}{\sigma_{MTS}}.$$

We note that both of these terms could be of interest. Indeed, $\rho_{MTS,\iota|X}$ is a parameter of interest for Hypothesis 2. In a market economy, either $\rho_{MTS,\iota|X} = 0$, since either state policy does not fully

determine farm-level unobservable factors that affect production or, to the extent that state policy does do this, the unobservable components are uncorrelated with farm-level factors or there is no variation across farms. Typically, we would also expect $\rho_\lambda > 0$ in a market economy, leading to a positive bias and an overestimation of the true effect. In contrast, in the command economy, the sign and magnitude of ρ_λ are ambiguous in practice.

To make some progress concerning these issues, we employ instrumental variables estimation. We exploit the particular institutional and economic conditions of rural Russia in the Soviet Union during the 1930s to identify plausibly exogenous variation in the allocation of MTS services.

The first stage exploits variation in proximity to MTS and the primary road and rail network. Transporting heavy machinery, such as tractors, to the farm is costly and this cost increases the farther the travel distance and worse the road conditions. While distance is of course a "cheap" instrumental variable, it is nevertheless suitable in our context. There were many productive farms located away from urban centers and larger rural towns such that unobserved productivity, after controlling for rural population density, which we do in all regressions, likely does not correlate strongly with proximity to locations where MTS were initially placed. The grain trade developed a network of small, rough roads suitable for wooden carts that could handle the local market or local grain transport for storage. The settlement patterns had largely been fixed during a time when much grain production went for own consumption. More importantly, travel cost along these roads was essentially orthogonal to the pre-mechanization productivity. Before MTS, the primary variable determining market access in this setting would have been distance to the railroad. In a robustness exercise, we excluded farms close to the railway. Further working in favor of using distance on the road network as an instrumental variable is the fact that state pricing of MTS services were not dominated by such trivial matters of marginal cost. Still, travel distance on the road mattered considerably for the ability to deliver scarce mechanized services. The relevance of the instrument is driven by the travel cost of transporting heavy machinery within a rudimentary road/river network that connected a fairly large service area.

To construct this distance variable, D_{IV}, we digitized the primary road and rail network and take the travel distance along the road network to the closest operating MTS from the closest point on the road network to the farm. The road network is incomplete. A complete network would require digitizing the near countless secondary roads and the presence of secondary roads in the network could affect travel distance, which we therefore measure with some error. We could overestimate travel cost in areas with particularly dense secondary road networks. However, we do not expect this measurement error to correlate with outcomes after controlling for rural population density and local development. We assume conditional exogeneity, $E[\epsilon_{it}|X, D_{IV}] = 0$, and the identifying variation comes from those farms that receive higher levels of mechanization services because of cheaper transport costs, conditional on our controls.

In table 5, we present the first-stage regression results. The sign of the coefficient is negative, as expected, and statistically significant. The F-stat is 17, which is above conventional thresholds for strong instruments. In columns 5 and 6, the magnitudes of the coefficient remain stable as we

introduce rural population density, the initial level of cows and horses and the index of local public goods.

While the redundancy assumption is not testable, to bolster confidence in our identification strategy, we explore the validity of the instrumental variable in table 6. The first three columns show that the instrument is uncorrelated with key control variables. We next turn to farms with no MTS presence. Since the relationship between the distance IV and the share of MTS services is necessarily zero for these farms, we can directly test whether distance has an impact on outcomes, which we do in columns 4 and 5 of Table 6 for grain output. The estimated coefficient is not statistically significant and the point estimate is positive.

We also report an alternative instrumental variable that is designed to more closely mirror the decision-making of MTS. We conjecture that MTS is more likely to send tractors to farms that are nearby more farms, which we proxy for using number of settlements nearby the farm, and less likely to send tractors to far away farms, but instead of a continuous measure, we use distance bands.

Provided our instrumental variable is valid, the IV estimate recovers β. In our case the monotonicity assumption is likely satisfied, and to the extent that there are heterogeneous treatment effects, this estimate is a local average treatment effect for those farms that acquire MTS services due to their travel cost proximity to MTS centers, i.e., an allocation pattern that differs from the ideal state allocation. We estimate using a control function approach, since it is equivalent to 2SLS if the standard assumptions hold, but we additionally obtain a direct test of selection with the coefficient on the first-stage residual term.

We note that the difference between $\hat{\beta_{CF}}$ and $\hat{\beta_{OLS}}$ provides the sign of $\rho_{MTS,\iota}$ (assuming $\rho_{MTS,\lambda} \approx 0$) or, assuming that $\sigma_\iota \approx \sigma_\lambda$, then the difference provides the sign of $\rho_{MTS,\iota} + \rho_{MTS,\lambda}$, which would be positive in the market economy.

We note further that due to the special characteristics of the command economy, the OLS estimates have meaning on their own, particularly when $\sigma_\lambda = \sigma_\iota$. In this case, we can make a statement about the system level delivery of mechanization. Therefore, we will pay careful attention to both sets of estimates in the discussion of the results.

The state aimed to mechanize all farms, but due to insufficient resources, the rollout of MTS proceeded in stages. While the options to place MTS were quite limited, one may be worried about the selection of MTS locations. In a robustness exercise, we reshuffle the year of opening an MTS, which subsequently affects the distance to the nearest operating MTS, and control for the difference between inverse distance weighted years of MTS operation and the expected inverse distance weighted years of operation if years were randomly assigned. This measures accounts for the "natural" variation in the farm's and MTS' location in the primary road network density to isolate the endogenous factors related to an earlier or later MTS placement. In column 7 of Table 5, we demonstrate that this variable is positive, statistically significant at the 1% level and has an economically meaningful magnitude.

Finally, since we take a reduced-form approach to avoid making unnecessarily strong assumptions, we are not estimating a production function. The disadvantage of this approach is that we are

limited in what we can say about efficiency and misallocation. That said, without relative valuations over scarce resources and clearly specified planner preferences, it is unclear what misallocation or efficiency even means in this setting.

6 Results

In this section, we present the results of our analysis. We group the results into three sets, which reflect our hypotheses. The first is on the economic performance of the farm. The second investigates whether MTS allocated resources in a non-market fashion. And the third evaluates the benefits of using MTS for farmers.

6.1 Main results

We examine the effect of MTS on output and productivity, focusing on both the extensive margin and intensive margin of the relationship between factor inputs and output.

Table 7 presents OLS estimates of the effect of MTS on grain output in logs, grain surplus in logs, land planted with grain in logs, labor inputs in logs, land productivity and labor productivity. We find that MTS services were associated with an increase in total output in column 1. However, the OLS estimates have magnitudes that are not transformational. Given that, in a market context, these estimates should be biased upwards due to positive sorting, these findings are especially troubling for the Big Push narrative. One s.d. increase in MTS services is associated with an increase in output by 12% (or 0.2 s.d. increase in log output). Even going from no mechanization to fully mechanized would "only" increase output by 108%.

Surprisingly, the modest increase in output translated into an even more modest increase in grain surplus extracted. Column 2 shows that the elasticity of surplus extracted to output is much less than one (0.435 or 0.47/1.08). An elasticity below one would appear to be quite dissatisfactory for any Big Push policy that coordinates the adoption of IRST, but even more so under the constraints of extractive institutions.

As expected, the increase in output is supported by cropland expansion in column 3 and the change in land productivity is not statistically different from zero (column 5). In column 4, we do not observe a decrease in labor employed in farms more intensively serviced by MTS. For labor productivity (column 6), moving from no mechanization to fully mechanized would increase labor productivity by 10.3 centners per worker or 43% increase in labor productivity over farms without MTS services (24.05 centners per worker). In terms of standard deviations, one s.d. increase in MTS services (for those that have MTS services) increases labor productivity by 0.11 s.d. The magnitude is certainly not transformational, despite the complete overhaul associated with Soviet modernization under MTS. Separately, taken these estimates together, they are more consistent with labor scarcity rather than labor surplus, additional evidence in support of the findings in Castañeda Dower and Markevich (2018).

Hypothesis 1 is tentatively accepted. Mechanized services are associated with an increase in output, labor productivity and area under grain crops, but the effects are quite limited.

6.2 Evidence of non-market allocation

With market allocation and a convex production set, the equilibration of marginal productivity and marginal cost should imply a linear relationship between MTS services and output provided that the pricing of MTS services is uniform. In Table 8, we examine whether there are nonlinearities in the effect of MTS services. On the one hand, the results suggest that the linear specification can not be rejected for all of the outcomes except for labor productivity. On the other hand, if we take the nonlinear specification seriously, the results imply that a positive, statistically significant effect at the 10% level on output does not kick in until the share of MTS services is above about 22%, while the impact on surplus extraction is not positive and statistically significant at the 10% level until 53% and not until nearly 48% for labor productivity. Moreover, labor productivity is negative and statistically significant for MTS shares below 14% (minimum share is 3.8%). This is fairly remarkable and suggests that MTS is not allocated based on equating marginal productivity with the posted price for its services.

Turning to the IV results in Table 9, in column 1, we confirm that one of the main reasons for limited effects is due to negative selection (MTS services allocated more to weaker performing farms).[14] Thus, the selection patterns fit what we would expect to see given the planner objectives.

Farms that received greater MTS services due to their proximity to MTS experienced larger impacts, close to 23% increase in output (column 1) and 14% increase in labor productivity (column 6) from one s.d. increase in MTS services. Farms in proximity to MTS that received MTS services more vigorously expanded area under grain crops (column 3). This expansion is substantial and we begin to see transformational magnitudes with the farms that go from no mechanization to fully mechanized nearly tripling cropped land and output. However, MTS also appears to capture some of this surplus since the effect on extracted surplus does not keep pace. The elasticity of extraction to output falls even further to 0.28 (or 0.81/2.95).

In the market economy with functioning intermediate input markets, land expansion should account for most, if not all, of the increase in output. To the extent that labor is also released, there may be an additional effect on labor productivity even after accounting for land expansion, while land productivity should be unaffected unless marginal lands are brought into production. In Table 10, we present results from rerunning the OLS and IV specifications for modified dependent variables that remove the land expansion effect by subtracting from the dependent variable the product of the estimated contribution of an additional hectare of grain planted on output and the amount of hectares planted with grain. We find that the positive effects on output and extracted surplus remain in columns 1 and 2. Surprisingly, for output, the OLS estimate gives roughly the same magnitude as the one that does not account for land expansion. This is not the case for extracted surplus. The elasticity of the increase in surplus extraction to the increase in output due to mechanization increases substantially (but is still below one), suggesting that the main benefit of MTS is not through economies of scale but through better monitoring and enforcement. In columns

[14] Figures 4, 5 and 6 demonstrate suggestive evidence that allocation did not follow the logic of the market, which suggests that farm size should be positively correlated with productivity.

3 and 4, the effects on both land and labor productivity increase, but the effect on land productivity remains statistically insignificant. Given that MTS does not appear associated with labor release as discussed earlier, from the market perspective, these results are puzzling and we must qualify our acceptance of Hypothesis 1. While land expansion plays a role, it does not primarily explain the productivity effects.

To be clear, the effect on labor productivity is roughly the same no matter if we account for the impact on land expansion or not. One explanation consistent with these results is the fact that machines shirk less than labor. This interpretation is supported by the fact that negative selection remains once we remove the land expansion effect for output but now is also present for labor productivity and surplus extraction. Once we account for land expansion, which again occurred more intensively on farms with MTS services, negative selection is more acute, consistent with the interpretation that MTS could better monitor farms that were closer to it. The elasticity of surplus extraction to output also increases and approaches but remains below one.

An alternative explanation to MTS services substituting for unproductive labor is that land expansion occurs on weakly performing farms, allowing MTS to activate economies of scale. To account for the manner in which collective farms were formed, we consider a farm as having greater potential for economies of scale as one that has more than 10 hectares (roughly median) per household and more than 650 hectares of land (roughly the median). In column 1 of Table 11, we see that MTS services do not have a larger impact on output for such farms and the coefficient is not statistically different from the one for farms not of this type. Larger farms should benefit more from access to MTS and, yet, we see no evidence that this is the case. After accounting for negative selection, we see that MTS is no better at extraction on larger farms and mechanization still does not exhibit increasing returns to scale (the sum of the coefficients in the first two rows of column 2 is positive and below one).

Next, in Table 12, we turn to see how the nonmarket allocation plays out at the local level. First, we assess how the estimate of effect changes when we impose complementarity by taking the minimum share of MTS services across plowing and harvesting. The estimates are presented in Table 12. The estimates suggest no presence of complementarities, with the standardized magnitude of the point estimate decreasing somewhat. The standardized effect is about 7% smaller.

Second, to assess the importance of ex-post local adjustments, we create two dummy variables, one for whether the share of harvesting performed by MTS is more than one standard deviation higher than the share of plowing by MTS and the other for whether the share of harvesting performed by MTS is less than the share of plowing by MTS minus one standard deviation. We then interact these dummy variables with both the control function and the minimum share of MTS services (with the reference category as receiving more evenly spread services). It is reasonable to think local interactions could be at the heart of these discrepancies and thus the indicators are proxies for λ factors. While these indicators are endogenous, it is instructive to see how estimates change after their inclusion and whether they affect selection. The extent of negative selection increases for output and surplus extraction, suggesting that the allocation of additional services does not follow

the logic of production and technical efficiency. Moreover, there is an asymmetric effect. Farms that receive much less harvesting services have higher output, while those that receive much more harvesting do no better. These results are consistent with MTS reallocating harvesting services to struggling farms so that they meet minimum production targets and hence not much surplus is obtained.

Hypothesis 2 is confirmed since results demonstrate multiple pieces of evidence on nonmarket allocation.

6.3 Evidence on incentives

In Table 13, we examine workers' incentives as a result of access to MTS services. In the market economy, mechanization should be paid a return, but since workers are also more productive, they should be compensated with a higher wage. Legally, state grain procurement and MTS payments should have been largely proportional to sown area, with limited adjustments based on yield.[15] Under such a system, farms with higher harvests should have retained more residual grain after fulfilling obligatory deliveries. Yet, we do not observe this pattern. We see that worker's compensation does not improve in the OLS specification in column 1. After accounting for negative selection in column 2, we still do not see a positive effect of mechanization on worker compensation, although the coefficient increases. Regardless of statistical significance, the magnitudes associated with peasant compensation is severely depressed relative to a competitive market return (10.32 centners per worker in OLS or 17.39 centners per worker in IV).

In columns 3 and 4, we examine whether there are heterogeneous effects of MTS by levels of services. Splitting farms in terciles, we see that the effects for the lowest and highest terciles are not statistically different from the effect for the middle tercile. The evidence suggests that peasants received little benefits from MTS mechanized services. One could speculate that the system effectively extracted surplus by overpricing MTS services.

Regardless of the mechanism, many peasants' grain retention on MTS farms were near subsistence levels. Mean compensation per capita, at 2.6 centners, is basically the level of subsistence and the median is less than 2, which is below subsistence, with half of the farms in the audit retaining grain at or below subsistence levels. For reference, the top 10% of farms experienced grain retention of above 5 centners per capita. On average, the share of grain surplus extracted from farms that is a result of directly extracting below subsistence levels is a staggering 19%. In columns 5-8, we investigate whether mechanization at least provided some insurance against falling below subsistence to offset the fact that compensation is below labor productivity. In column 5, we see the point estimate is negative but not statistically significant. Furthermore, the magnitude of the point estimate is small: one s.d. increase in MTS services is associated with a decrease in the amount extracted below subsistence by less than one percentage point, still leaving many farms that use MTS services below subsistence levels. In column 6, even after accounting for negative selection, i.e., weaker farms with higher levels of extracted surplus below subsistence were targeted, the estimated decrease is

[15] By law, MTS compensation norms should reflect farm productivity, with more productive farms obligated to give higher grain payments (See https://istmat.org/node/25207). Table 26 in the appendix reports the results without adjusting for these norms. We see similar results.

less than two p.p. (but not statistically significant). Columns 7 and 8 provide some evidence that more intensive use of MTS services may reduce the amount extracted below subsistence. One s.d. increase in MTS services (not from the average, but from a farm that is already receiving two-thirds MTS share) would decrease the share below subsistence by 8.25 p.p., nearly 43% of the mean.

The Big Push narrative of structural transformation implies a standard of living above subsistence levels after policy implementation. Under extractive institutions, on average, mechanization is not associated with a reduction in below subsistence extraction nor an increase in compensation per worker. The system was designed for maximal rate of extraction, often leaving farmers below subsistence levels. We see that the primary benefit of an IRST for workers is one of insurance. For the highest levels of mechanization, there is some evidence that there would be much fewer individuals receiving grain below subsistence levels.

Hypothesis 3 is confirmed.

6.4 Robustness checks

In this subsection, we investigate the robustness of our results. First, we propose an alternative instrumental variable. Instead of using distance as a direct cost shifter, we try to more closely simulate the decision-making process of MTS. We construct 10 distance bands emanating from the closest MTS. We take the rank and then divide the rank by the square root of the number of settlements within 5km of the assigned selsoviet. For example, this measure would give the same value for a collective farm that has 100 nearby settlements located in distance band 10 as it would a farm with 1 nearby settlements in distance band 1. In Table 14, we present the results that largely confirm the results with the simple distance instrumental variable with one exception. For surplus extraction, the coefficient on share of MTS services is positive, smaller in magnitude than the one for output, but no longer statistically significantly different from zero.

Since both of these instruments are essentially based on the pedestrian instrumental variable of distance, we next employ a sample restriction whereby we kick out farms located within 20km of the railroad. In Table 15, the results are similar and become even more precisely estimated with both higher magnitudes and smaller standard errors.

A related concern is that distance is correlated with farm size and larger farms are more likely to appear in the audit (as well as possibly receive MTS services). We use inverse probability weights to account for the fact that there is a positive association between farm land size and appearing in the audit. Table 16 shows reweighting confirms the basic narrative and again the coefficient on share of MTS services is not statistically significant for surplus extraction.

In the appendix, we also show results run for each year separately (Tables 21 and 22), which give similar results for both years with again the surplus extraction exception – only in 1934 do we see a statistically significant effect. We also show that our results are robust to using a binary treatment variant (Tables 23 and 24) and to excluding raions with no MTS (Table 25).

In the final set of robustness checks, we tackle two difficult issues that we have skirted up until now, the simultaneous production of food and technical crops and heterogeneity in the resistance to collectivization. Here, we merely explore how sensitive the results are to alternative specifications

that try to get at these problems. First, nearly two-thirds of the farms in our sample fall under an agricultural planning region that calls for technical crop production (in addition to food crop production). The main technical crop for this region is flax and nearly all of our farms report some flax production. However, only a handful of farms have MTS contracts for flax production. Still, one may be concerned that additional extractive pressures could surface for farms with greater technical crop production. Since technical crop production is an important source of extraction for the state, we take this criticism seriously. However, we note that the first stage relationship between our instrument and share of MTS services is not sensitive to flax area sown, so this is unlikely to be a confounder. To handle this criticism, we exclude farms with more or less than one standard deviation in the within raion-year sown area of flax and rerun our results. The new sample gives a more homogeneous set of farms and we find similar results as above.

Second, many peasants resisted collectivization and the reorganization of agricultural production into collective farms proceeded according to various levels of coercion. We examine whether farms that are created before the main coercive collectivization drive occurred had different productivity levels. We also control for distance to large and small railway stations, variables that allow for less costly repression and could affect our outcome variables (Table 18). The results are robust to this sensitivity analysis.

The second omnibus approach is to use farm fixed effects or first differences estimators to isolate the within-farm response to MTS. In Tables 19 and 20, we see that there is a magnitude reversal with respect to output and grain surplus extraction, there is no longer an effect on land expansion, while there is still an effect on labor productivity. Since the identifying variation excludes time-invariant factors such as the fixed ideological factors of the planned economy, one needs to be careful in interpreting these results. But the reversal is consistent with ex-post adjustments by local bureaucrats or MTS primarily being aimed at increasing extraction, increasing labor productivity most likely through substituting machines for unproductive labor without meaningful increases in the production possibilities frontier.

7 Discussion and comparison to US case

In this section, we discuss the comparison to the US case during roughly the same period. In the US, the move from subsistence (according to the standards in the literature, one worker producing enough to feed the worker plus three other adult equivalents) in the nineteenth century to marketed surplus (one worker producing enough to feed the worker plus nine others) in the 1920s to quite substantial marketed surplus in the 1940s (one worker producing enough to feed thirteen others) represents a 250% increase in labor productivity, a 333% increase in surplus from the perspective of the worker and an infinite increase in the marketed surplus (due to starting from none).

While Russia maintained large volumes of grain exports during the early twentieth century, in part due to its low levels of urbanization, but also due to the high productivity of the Black Earth region, many farms were still operating at the subsistence level, making nineteenth century US a useful comparison.

According to the audit data, farms with no access to mechanization, had average labor productivity of about 24 centners per worker (roughly 11 centners per worker would be considered subsistence for a household). This would yield a surplus to feed about another household, so a little lower than the US in the 1920s. If Big Push enabled rapid development and catching up to the technological frontier, then we would expect to see at least an increase of 23 centners per worker (13*2.75 - 13). This is more than the magnitude of going from zero to full mechanization according to our estimates and, thus, lower than what the US achieved without achieving mechanization at half of this level. Alternatively, a 250% increase in labor productivity as the US experienced would imply an increase of about 33 centners (2.5*(24-11)).

Still, one may consider a more accurate comparison would be the relative increase in the US from the 1920s to 1940s. In this case, labor productivity increases by 40%, marketed surplus increases by 44% (from 9 to 13 adult equivalent subsistence consumption). In fact, we would expect the Big Push policy to, if anything, outperform the slower technological diffusion of the US. The ability of Big Push policies to centrally coordinate investment and, in our setting, directly invest in mechanization on behalf of the collective farms should constitute a major advantage in technological diffusion. In a market economy without Big Push policies, technological adoption may diffuse slowly, following an S-shaped curve and is driven by decentralized decisions weighing private costs and benefits which are plagued with externalities. A central planner can adopt technology in a first-best manner where the social benefit exceeds the social cost. We can thus compare the speed of adoption of mechanization to the US case. In the initial period of adoption, the adoption rate hovered around 1% of farms per year with the fastest rate of adoption at about 3.5% per year. In our case, the "adoption" rate is much more rapid at 11.3 percentage points between 1933 and 1934 from a baseline of 37% of farms already having adopted some mechanization services during the brief period of existence of MTS. However, what technological adoption (not to mention technological use) means in the market economy is not the same as what it means in the command economy. If we examine also the intensive margin of adoption of mechanized services, we see an increase of 5.3 percentage points in 1934 relative to a base of 12.8%.

Putting the pieces together, we can now use the US to construct a market-based counterfactual.[16] Taking a conservative approach for the overall US impact of 44% gain over 30% total adoption gives an elasticity of about 1.47. Given the adoption rate of 5.3 p.p. increase multiplied by 1.47, should give a 7.8 p.p. gain in surplus from 1933 to 1934. Instead, the estimates suggest an increase of only 2 p.p. ($e^{(0.053\times(0.39))} - 1 = 0.021$) or about one quarter of what would have been brought to the market under a voluntary market economy with as high adoption rates. And this figure is achieved through maximum extraction rates, leaving peasants no better off and, in some cases, below subsistence levels. Taking the fastest rate of US adoption of 3.5% adoption rate would also outperform the Soviet economy at (0.035×1.47) over 5 p.p. increase in surplus extraction. However, the US average rate of adoption at 1% would under perform.

[16] Of course, the US did not implement Big Push policies, but other New Deal policies were implemented that increased the rate of adoption. Therefore, while one must take care in making such a comparison, they still provide a reasonable benchmark estimate of what mechanization could achieve.

An alternative analysis would be what would have productivity looked like had MTS not negatively selected farms. Here, the increase in surplus would have been larger, 3.2 p.p. ($e^{(0.053\times(0.594))}-1$ = 0.032), but still quite below the implied US gains at Soviet adoption rates or US rapid rates of adoption. If, however, we assume that there had been no leakage and assume all the gains from an increase in labor productivity could be extracted, then surplus could have increased by as much as 7.1 p.p. (0.053*(17.4/13) using the base of (24-11)), nearly performing as well as but not catching the market economy (at any of the adoption rates). However, the counterfactual exercise of removing negative selection is not plausible and, in fact, would imply a change to the Soviet apparatus that would amount to nothing short of an existential threat.

8 Conclusion

Big Push theory explains underdevelopment through coordination failure. Coercive institutions should ease the implementation of Big Push policies. In this paper, we show that an extractive state is able to coordinate the adoption of an increasing returns to scale technology, agricultural mechanization; yet, perverse incentives and negative selection that accompanied this coercive coordination undermined the gains from adoption. In fact, if we focus on peasant grain retention alone, the primary benefit of mechanization is to reduce the share of surplus extracted below subsistence levels, effectively reducing mechanization to an insurance mechanism. Victory over the peasantry, which to the Soviets signified achieving agricultural modernization by overcoming peasant attachment to traditional ways of farming, is a Pyrrhic one.

An important caveat to this conclusion is that political leaders, as was the case with Stalin, are willing to sacrifice economic efficiency and citizen welfare for ideological or political goals (Castañeda Dower et al., 2021; Gregory, 2009). Therefore, we cannot comment on whether MTS is a policy failure with respect to its role in the overall Soviet system.[17] Stalin repeatedly stressed the importance of the speed of Soviet industrialization. Although the rapid reorganization of the economy in the 1930s, of which MTS was an integral part, had (unintended) negative economic consequences, the complete overhaul had a clear benefit of political holdup. The cost of undoing the command economy, and not its particular adeptness to channel resources more fairly or effectively than the market economy, could have been the source of Soviet stability. From this perspective, MTS, through the rapid cultivation of the command economy's extractive institutions within the agricultural sector, achieved a political victory over the peasantry, the early Soviet Union's most populous group.

The Soviet experience shows how extractive systems can generate technological adoption without meaningful productivity improvements. Concerning external validity, the reader should take note of three conditions: the study covers two years, 1933 and 1934; one region, the Urals; and only the short run.

[17] Given that MTS is eventually abandoned suggests that there were economic or political disadvantages. However, MTS could also have run its course after fulfilling its purpose.

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Figure 2 (Empirical) Production Possibilities Frontier by Levels of MTS Services

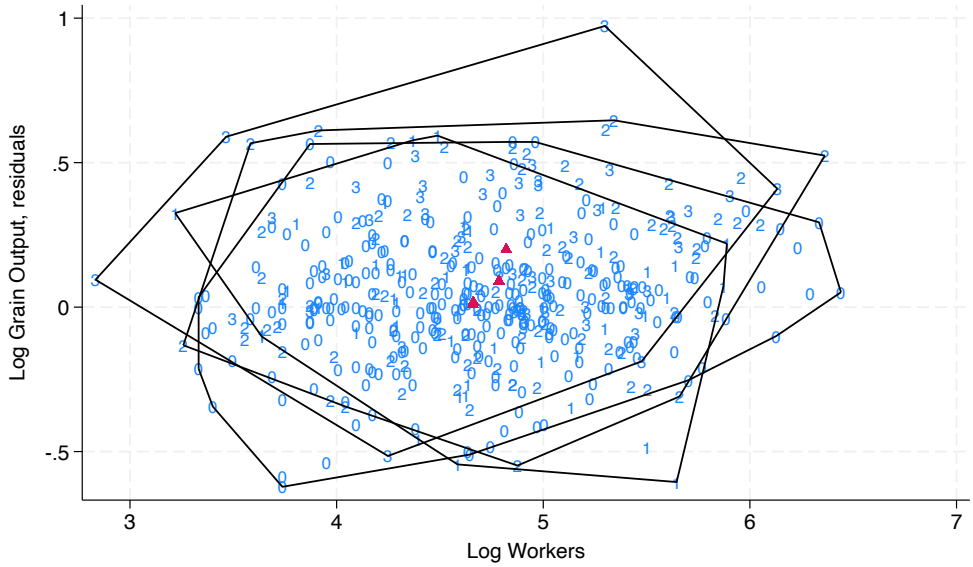

Figure 3 Heterogeneity of first-stage relationship by farm size

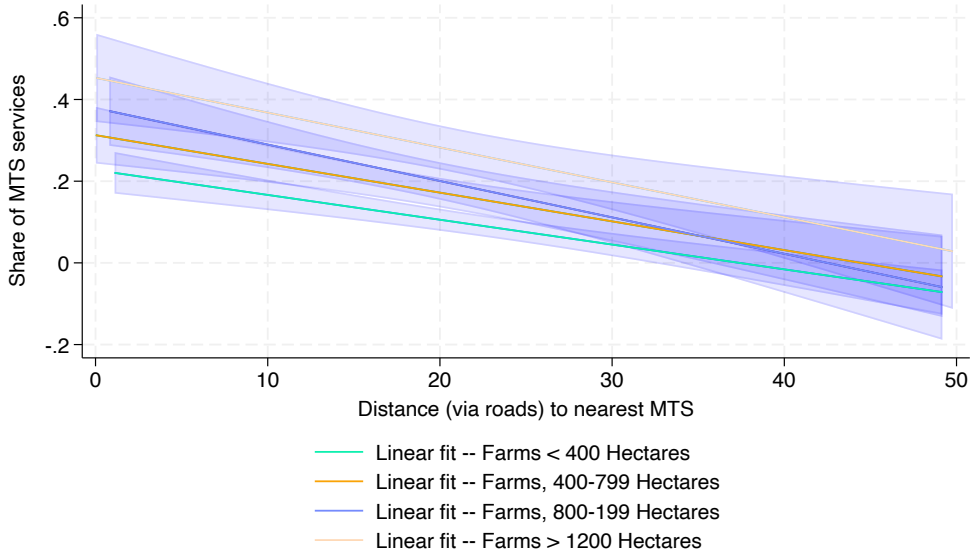

Figure 4 Productivity and MTS

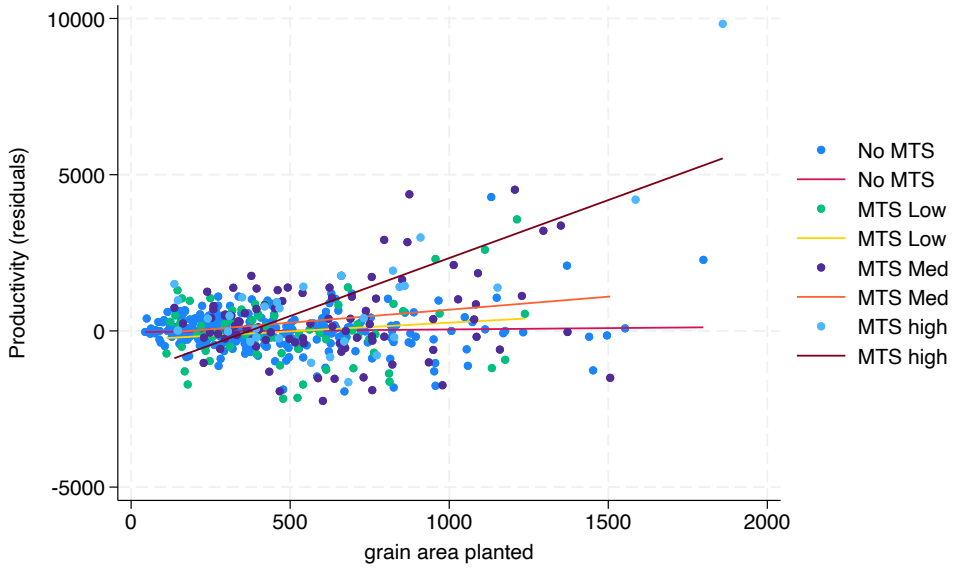

Figure 5 Land productivity and MTS

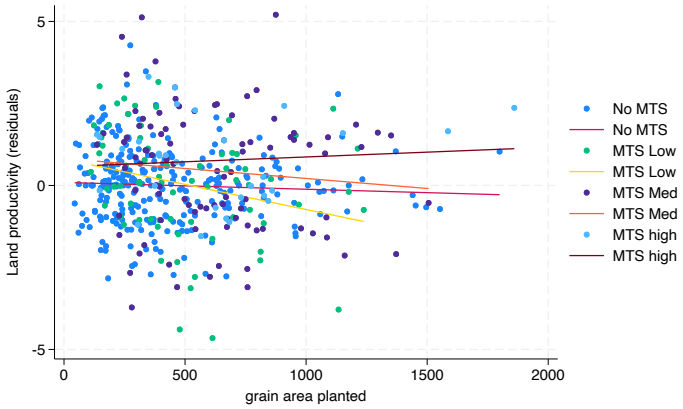

Figure 6 Labor productivity and MTS

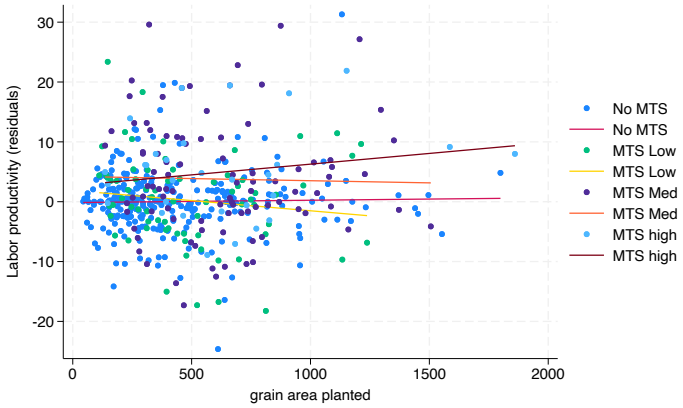

Table 5 First-stage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
good	0.074	-0.038	-0.034	-0.076	-0.067	-0.067	-0.071
	(0.050)	(0.074)	(0.075)	(0.083)	(0.083)	(0.083)	(0.082)
medium1	-0.039	-0.137**	-0.132**	-0.081	-0.080	-0.079	-0.096
	(0.032)	(0.061)	(0.063)	(0.058)	(0.062)	(0.062)	(0.064)
medium2	0.039	-0.192***	-0.185**	-0.189***	-0.181**	-0.181**	-0.180**
	(0.044)	(0.073)	(0.080)	(0.069)	(0.077)	(0.077)	(0.078)
Index of local public goods			-0.033			-0.008	-0.008
			(0.081)			(0.079)	(0.074)
$\ln\text{rural}_p op_5 km$			0.029**		0.027*	0.027*	0.025*
			(0.014)		(0.014)	(0.014)	(0.014)
horse33			0.001*		0.001**	0.001*	0.001**
			(0.001)		(0.001)	(0.001)	(0.001)
Cows in 1933			-0.000		-0.000	-0.000	-0.000
			(0.000)		(0.001)	(0.001)	(0.000)
Distance (via roads) to nearest MTS				-0.004***	-0.004***	-0.004***	-0.002**
				(0.001)	(0.001)	(0.001)	(0.001)
Difference in MTS exposure due to year of MTS establishment							0.137***
							(0.039)
Mean Dep. Var.	0.16	0.16	0.16	0.16	0.16	0.16	0.16
SD of Dep. Var.	0.22	0.22	0.22	0.22	0.22	0.22	0.22
R^2	.0508134	.3843229	.4225072	.4322336	.4641119	.4641294	.4869468
Number of Clusters	91	91	91	91	91	91	91
Observations	432	432	430	430	428	428	428
F-stat	2.941264	3.943718	2.837205	17.39229	16.69368	16.61751	4.165039
p-value	.037339	.0108092	.0288428	.0000699	.0000952	.0000985	.0441958

Notes: The dependent variable is the share of work performed by MTS services. F-stat refers to soil quality dummies in columns 1 and 2, farm characteristics (baseline) and community development characteristics in column 3, the instrumental variable in columns 4 - 7.

Table 6 Instrumental Variable Balance and Validity

	IV Balance			Validity	
	(1)	(2)	(3)	(4)	(5)
lnrural$_p op_5 km$	-0.725	-0.665	-0.221		
	(1.245)	(1.220)	(1.593)		
horse33	-0.024	-0.034	-0.074		
	(0.031)	(0.031)	(0.050)		
Cows in 1933	-0.061	-0.060	-0.018		
	(0.043)	(0.043)	(0.051)		
good	-8.530	-8.539	-11.360		
	(5.706)	(5.726)	(9.286)		
medium1	15.838***	15.369***	10.891		
	(5.246)	(5.056)	(7.945)		
medium2	1.557	1.542	-3.700		
	(4.190)	(4.144)	(7.580)		
Index of local public goods		7.796	9.296	0.340**	0.350**
		(5.645)	(7.516)	(0.143)	(0.156)
Distance (via roads) to nearest MTS				0.000	0.001
				(0.001)	(0.001)
Mean Dep. Var.	30.85	30.85	33.00	0.01	0.00
SD of Dep. Var.	26.56	26.56	28.06	0.31	0.33
R^2	.7761627	.777158	.814556	.0251644	.030905
Number of Clusters	91	91	87	74	72
Observations	428	428	322	220	172
F-stat	1.504442	1.743639	1.133033		
p-value	.2187979	.1473383	.3464077		

Notes: The dependent variable is distance to nearest MTS in columns 1-3 and log harvest in columns 4-5.

Table 7 The effect of MTS on productivity

Dep. Var. =	Total grain output (centners in logs)	Extracted Surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Share of work performed by MTS	0.734***	0.386**	0.703***	0.367**	0.049	10.323***
	(0.134)	(0.160)	(0.144)	(0.140)	(0.508)	(3.754)
Index of local public goods	0.320**	0.584**	0.130	-0.163	0.670	11.415**
	(0.132)	(0.235)	(0.168)	(0.174)	(0.730)	(4.681)
Mean Dep. Var.	7.23	6.34	5.36	4.35	6.92	18.67
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.51
R^2	.7150461	.6697519	.6930836	.5240189	.6744789	.5542746
Number of Clusters	91	88	91	91	91	91
Observations	430	405	430	430	430	430

Notes: Standard errors are clustered at the district-year level. Full set of controls included. Only soil type is shown.

Table 8 The effect of MTS on productivity

Dep. Var. =	Total grain output (centners in logs)	Extracted Surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Share of work performed by MTS	0.654***	0.250	0.663***	0.361*	-0.498	7.935
	(0.227)	(0.286)	(0.231)	(0.189)	(0.775)	(5.604)
Share of MTS services subtracted from 33rd-tile × Low share of work performed by MTS	-0.546	-1.328	-0.730	0.435	0.715	-30.963***
	(0.563)	(0.954)	(0.530)	(0.456)	(1.993)	(11.346)
Share of MTS services minus the 66th-tile × High share of work performed by MTS	0.316	0.495	0.095	0.096	2.796	7.296
	(0.575)	(0.772)	(0.704)	(0.670)	(2.757)	(18.140)
Index of local public goods	0.325**	0.585**	0.131	-0.161	0.719	11.524**
	(0.134)	(0.235)	(0.164)	(0.170)	(0.726)	(4.531)
Mean Dep. Var.	7.23	6.34	5.36	4.35	6.92	18.67
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.51
R^2	.7168323	.6745317	.6955435	.5252723	.6758798	.5621211
Number of Clusters	91	88	91	91	91	91
Observations	430	405	430	430	430	430

Notes: Standard errors are clustered at the district-year level. Full set of controls included. Only soil type is shown.

Table 9 The effect of MTS on productivity: Evidence of non-market allocation

Dep. Var. =	Total grain output (centners in logs)	Extracted Surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.374***	0.594***	1.311***	0.822***	0.453	17.392**
	(0.189)	(0.229)	(0.210)	(0.234)	(1.055)	(6.887)
Index of local public goods	0.307**	0.590***	0.116	-0.170	0.680	11.189***
	(0.129)	(0.205)	(0.161)	(0.161)	(0.642)	(4.089)
e.adjlnharv						
cf(mtssh$_n ew$)	-0.774***					
	(0.274)					
e.adjlngrainsurplus						
cf(mtssh$_n ew$)		-0.254				
		(0.309)				
e.adjlnland						
cf(mtssh$_n ew$)			-0.734**			
			(0.294)			
e.adjlnlabor						
cf(mtssh$_n ew$)				-0.549**		
				(0.274)		
e.adjland$_p rod$						
cf(mtssh$_n ew$)					-0.489	
					(1.267)	
e.adjlabor$_p rod$						
cf(mtssh$_n ew$)						-8.545
						(7.849)
Mean Dep. Var.	7.23	6.34	5.37	4.36	6.92	18.70
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.53
R^2	.6870578	.6691867	.6616663	.5111761	.6776701	.545943
Number of Clusters	91	88	91	91	91	91
Observations	428	404	428	428	428	428

Notes: Standard errors are clustered at the district-year level. Full set of controls included. Only soil type is shown.

Table 10 The effect of MTS on productivity: Removing land expansion

Dep. Var. =	Total grain output (centners in logs)	Extracted Surplus (centners in logs)	Land productivity (centners per hectare)	Labor productivity (centners per worker)	Total grain output (centners in logs)	Extracted Surplus (centners in logs)	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	OLS	OLS	OLS	OLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
main								
Share of work performed by MTS	0.767***	0.498***	0.780	11.052***	2.370***	1.951***	1.856**	28.766***
	(0.162)	(0.189)	(0.492)	(3.364)	(0.334)	(0.348)	(0.855)	(6.284)
Index of local public goods	0.842***	1.081***	1.568*	6.843	0.787***	1.098***	1.562**	6.229
	(0.219)	(0.275)	(0.821)	(4.388)	(0.218)	(0.245)	(0.722)	(3.941)
e.adjlandlnharv cf(mtssh$_n ew$)					-2.167***			
					(0.386)			
e.adjlandlngrainsurplus cf(mtssh$_n ew$)						-2.001***		
						(0.435)		
e.adjlandland$_p rod$ cf(mtssh$_n ew$)							-1.340	
							(1.079)	
e.adjlandlabor$_p rod$ cf(mtssh$_n ew$)								-22.894***
								(7.592)
Mean Dep. Var.	6.24	5.44	7.59	24.23	6.23	5.43	7.58	24.26
SD of Dep. Var.	0.58	0.80	2.30	13.32	0.58	0.79	2.29	13.33
R^2	.6540991	.6524162	.6342514	.5536965	.4154067	.5465632	.6254886	.4973243
Number of Clusters	91	88	91	91	91	88	91	91
Observations	432	407	432	432	428	404	428	428

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 11 The effect of MTS on productivity: IRS

Dep. Var. =	Total grain output (centners in logs)	Extracted Surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.282***	0.507*	1.216***	0.817***	0.517	13.461*
	(0.204)	(0.277)	(0.233)	(0.259)	(1.285)	(7.026)
Share of work performed by MTS × Farm has more than 650 hectares and 10 hectares per household	-0.117	0.131	-0.268	0.170	0.709	-4.438
	(0.186)	(0.293)	(0.203)	(0.217)	(0.827)	(6.117)
Farm has more than 650 hectares and 10 hectares per household	0.152***	0.093	0.251***	-0.099	-0.602**	6.553***
	(0.059)	(0.094)	(0.060)	(0.061)	(0.285)	(2.088)
Index of local public goods	0.247**	0.509**	0.026	-0.144	0.891	8.493**
	(0.121)	(0.224)	(0.145)	(0.163)	(0.636)	(3.585)
e.adjlnharv						
cf(mtssh$_n$*ew*)	-0.690**					
	(0.293)					
e.adjlngrainsurplus						
cf(mtssh$_n$*ew*)		-0.252				
		(0.346)				
e.adjlnland						
cf(mtssh$_n$*ew*)			-0.622**			
			(0.315)			
e.adjlnlabor						
cf(mtssh$_n$*ew*)				-0.585**		
				(0.288)		
e.adjland$_p$*rod*						
cf(mtssh$_n$*ew*)					-0.622	
					(1.390)	
e.adjlabor$_p$*rod*						
cf(mtssh$_n$*ew*)						-4.895
						(8.033)
Mean Dep. Var.	7.23	6.34	5.37	4.36	6.92	18.70
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.53
R^2	.7100783	.6734686	.7002733	.5081303	.681604	.5793735
Number of Clusters	91	88	91	91	91	91
Observations	428	404	428	428	428	428

Notes: Standard errors are clustered at the district-year level. Full set of controls included. Only soil type is shown.

Table 12 The effect of MTS on productivity: local adjustment

Dep. Var. =	Total grain output (centners in logs)	Extracted Surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Minimum of pre or post MTS share	1.558***	0.608**	1.594***	0.974***	-0.388	17.840**
	(0.246)	(0.288)	(0.264)	(0.296)	(1.231)	(8.408)
Much lower ex post MTS share	0.008	-0.054	0.007	-0.139	-0.092	4.679
	(0.129)	(0.189)	(0.138)	(0.127)	(0.582)	(3.842)
Minimum of pre or post MTS share × Much lower ex post MTS share	1.069**	0.972	0.659	1.176*	3.307	-5.306
	(0.491)	(0.947)	(0.630)	(0.694)	(3.280)	(16.581)
Much higher ex post MTS share	0.007	-0.004	-0.066	-0.025	0.283	-1.235
	(0.110)	(0.146)	(0.145)	(0.128)	(0.626)	(4.008)
Minimum of pre or post MTS share × Much higher ex post MTS share	0.335	0.496	0.398	-0.166	0.643	26.787
	(0.616)	(0.783)	(0.757)	(0.671)	(3.212)	(20.426)
Index of local public goods	0.363***	0.622***	0.146	-0.160	0.876	12.720***
	(0.129)	(0.200)	(0.154)	(0.160)	(0.662)	(4.081)
e.adjlnharv						
cf(minpostpre)	-0.896***					
	(0.302)					
cf(minpostpre) × Much lower ex post MTS share	-2.067***					
	(0.648)					
cf(minpostpre) × Much higher ex post MTS share	-0.338					
	(0.939)					
e.adjlngrainsurplus						
cf(minpostpre)		-0.152				
		(0.348)				
cf(minpostpre) × Much lower ex post MTS share		-2.460**				
		(1.060)				
cf(minpostpre) × Much higher ex post MTS share		-0.718				
		(1.240)				
e.adjlnland						
cf(minpostpre)			-0.822**			
			(0.324)			
cf(minpostpre) × Much lower ex post MTS share			-1.571*			
			(0.838)			
cf(minpostpre) × Much higher ex post MTS share			-0.875			
			(1.254)			
e.adjlnlabor						
cf(minpostpre)				-0.568*		
				(0.332)		
cf(minpostpre) × Much lower ex post MTS share				-2.206		
				(1.360)		
cf(minpostpre) × Much higher ex post MTS share				0.016		
				(0.789)		
e.adjland$_p rod$						
cf(minpostpre)					-0.614	
					(1.499)	
cf(minpostpre) × Much lower ex post MTS share					-3.225	
					(3.530)	
cf(minpostpre) × Much higher ex post MTS share					2.642	
					(4.776)	
e.adjlabor$_p rod$						
cf(minpostpre)						-11.364
						(9.796)
cf(minpostpre) × Much lower ex post MTS share						10.158
						(29.437)
cf(minpostpre) × Much higher ex post MTS share						-24.439
						(22.537)
Mean Dep. Var.	7.23	6.34	5.37	4.36	6.92	18.70
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.53
R^2	.6652904	.6617047	.6384483	.4942997	.6819191	.5388638
Number of Clusters	91	88	91	91	91	91
Observations	428	404	428	428	428	428

Notes: Standard errors are clustered at the district-year level. Full set of controls included. Only soil type is shown.

Table 13 The effect of MTS on worker incentives

Dep. Var. =	In-kind compensation (centners per worker)				Share of extracted surplus below subsistence			
Estimation:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
main								
Share of work performed by MTS	-0.532	1.795	3.295	5.034	-0.022	-0.077	0.104	0.034
	(2.721)	(5.836)	(3.662)	(6.714)	(0.071)	(0.123)	(0.107)	(0.155)
Index of local public goods	4.132	4.110	3.904	3.888	-0.032	-0.044	-0.040	-0.050
	(3.297)	(2.905)	(3.344)	(2.932)	(0.080)	(0.071)	(0.083)	(0.073)
Share of MTS services subtracted from 33rd-tile × Low share of work performed by MTS			14.960	14.594*			-0.189	-0.218
			(9.167)	(8.005)			(0.256)	(0.229)
Share of MTS services minus the 66th-tile × High share of work performed by MTS			-16.491	-16.552			-0.632*	-0.510*
			(13.735)	(12.083)			(0.368)	(0.300)
e.adjinkindcompperworker								
cf(mtssh$_n ew$)		-2.835		-2.115				
		(6.933)		(6.957)				
e.adjshbelowsub								
cf(mtssh$_n ew$)						0.041		0.028
						(0.138)		(0.139)
Mean Dep. Var.	-1.32	-1.26	-1.32	-1.26	0.38	0.38	0.38	0.38
SD of Dep. Var.	8.13	8.11	8.13	8.11	0.44	0.44	0.44	0.44
R^2	.4014978	.3929786	.4112748	.4039732	.8331685	.8437949	.8356418	.8456757
Number of Clusters	90	90	90	90	88	88	88	88
Observations	416	414	416	414	407	404	407	404

Notes: Standard errors are clustered at the district-year level. Full set of controls included. Only soil type is shown.

Appendix

Table 14 The effect of MTS on production outcomes: Alternative IV

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.277***	0.319	1.224***	0.879***	0.579	13.373**
	(0.201)	(0.238)	(0.238)	(0.249)	(1.146)	(6.733)
Index of local public goods	0.310**	0.587***	0.119	-0.173	0.675	11.330***
	(0.127)	(0.206)	(0.158)	(0.163)	(0.644)	(4.106)
e.adjlnharv						
cf($\text{mtssh}_n ew$)	-0.638**					
	(0.287)					
e.adjlngrainsurplus						
cf($\text{mtssh}_n ew$)		0.079				
		(0.325)				
e.adjlnland						
cf($\text{mtssh}_n ew$)			-0.611**			
			(0.311)			
e.adjlnlabor						
cf($\text{mtssh}_n ew$)				-0.601**		
				(0.274)		
e.adjland$_p rod$						
cf($\text{mtssh}_n ew$)					-0.623	
					(1.411)	
e.adjlabor$_p rod$						
cf($\text{mtssh}_n ew$)						-3.578
						(7.477)
Mean Dep. Var.	7.23	6.34	5.37	4.36	6.92	18.70
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.53
R^2	.6984778	.6712414	.6713667	.5031717	.6770899	.5527424
Number of Clusters	91	88	91	91	91	91
Observations	428	404	428	428	428	428

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 15 The effect of MTS on production outcomes: Excluding farms near railway

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.458***	0.982***	1.613***	0.807***	-1.256	20.543***
	(0.245)	(0.325)	(0.291)	(0.284)	(1.153)	(7.095)
Index of local public goods	0.303*	0.655**	0.115	-0.192	0.669	9.710**
	(0.158)	(0.275)	(0.174)	(0.186)	(0.631)	(4.080)
e.adjlnharv						
cf(mtssh$_n ew$)	-0.835**					
	(0.336)					
e.adjlngrainsurplus						
cf(mtssh$_n ew$)		-0.752*				
		(0.411)				
e.adjlnland						
cf(mtssh$_n ew$)			-1.092***			
			(0.383)			
e.adjlnlabor						
cf(mtssh$_n ew$)				-0.490		
				(0.322)		
e.adjland$_p rod$						
cf(mtssh$_n ew$)					1.911	
					(1.273)	
e.adjlabor$_p rod$						
cf(mtssh$_n ew$)						-12.642
						(7.952)
Mean Dep. Var.	7.19	6.30	5.33	4.35	6.88	17.55
SD of Dep. Var.	0.57	0.78	0.58	0.49	2.43	12.69
R^2	.7097378	.6856593	.6567738	.5902719	.7060872	.5876775
Number of Clusters	87	83	87	87	87	87
Observations	322	303	322	322	322	322

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 16 The effect of MTS on production outcomes: Inverse probability weighting accounting for uneven farm size

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.201***	0.328	1.109***	0.691***	0.690	16.585**
	(0.167)	(0.233)	(0.177)	(0.215)	(1.104)	(7.112)
Index of local public goods	0.312**	0.594**	0.110	-0.234	0.783	12.518***
	(0.138)	(0.238)	(0.162)	(0.167)	(0.719)	(4.014)
e.adjlnharv						
cf(mtssh$_n ew$)	-0.660***					
	(0.246)					
e.adjlngrainsurplus						
cf(mtssh$_n ew$)		-0.051				
		(0.282)				
e.adjlnland						
cf(mtssh$_n ew$)			-0.550**			
			(0.269)			
e.adjlnlabor						
cf(mtssh$_n ew$)				-0.446*		
				(0.259)		
e.adjland$_p rod$						
cf(mtssh$_n ew$)					-1.000	
					(1.347)	
e.adjlabor$_p rod$						
cf(mtssh$_n ew$)						-9.098
						(8.403)
Mean Dep. Var.	7.24	6.36	5.38	4.35	6.87	19.09
SD of Dep. Var.	0.54	0.75	0.55	0.45	2.51	13.73
R^2	.670382	.6306988	.6654333	.4953147	.6736907	.5456636
Number of Clusters	91	88	91	91	91	91
Observations	424	400	424	424	424	424

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 17 The effect of MTS on production outcomes: Excluding farms with one s.d. more or less than rayon mean flax production

Dep. Var. =	Total grain output	Extracted surplus	Area under grain crops	No. of workers	Land productivity	Labor productivity
	(centners in logs)		(hectares in logs)	in logs	(centners per hectare)	(centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.264***	0.418	1.114***	0.817***	1.165	16.477**
	(0.204)	(0.279)	(0.222)	(0.246)	(1.172)	(7.808)
Index of local public goods	0.324**	0.455**	0.082	-0.240	1.076	13.280***
	(0.157)	(0.189)	(0.190)	(0.186)	(0.766)	(4.888)
e.adjlnharv						
cf(mtssh$_n ew$)	-0.698**					
	(0.305)					
e.adjlngrainsurplus						
cf(mtssh$_n ew$)		-0.140				
		(0.357)				
e.adjlnland						
cf(mtssh$_n ew$)			-0.570*			
			(0.327)			
e.adjlnlabor						
cf(mtssh$_n ew$)				-0.635**		
				(0.303)		
e.adjland$_p rod$						
cf(mtssh$_n ew$)					-1.197	
					(1.450)	
e.adjlabor$_p rod$						
cf(mtssh$_n ew$)						-4.521
						(8.439)
Mean Dep. Var.	7.25	6.37	5.36	4.36	7.04	18.94
SD of Dep. Var.	0.55	0.71	0.55	0.46	2.52	13.31
R^2	.6969437	.6992935	.6704485	.5100679	.6745988	.5614581
Number of Clusters	91	88	91	91	91	91
Observations	381	359	381	381	381	381

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 18 The effect of MTS on production outcomes: Exclusion restriction and proxies for resistance to collectivization

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.358***	0.605**	1.307***	0.804***	0.374	17.291**
	(0.197)	(0.239)	(0.221)	(0.235)	(1.132)	(6.773)
fcbefore1930	0.002	0.012	-0.062	0.090**	0.389**	-2.884**
	(0.049)	(0.066)	(0.052)	(0.043)	(0.174)	(1.249)
farm$_l$*arge$_d$ist*	-0.001	-0.001	-0.001	-0.001	0.005	0.005
	(0.001)	(0.002)	(0.001)	(0.001)	(0.007)	(0.023)
farm$_s$*mall$_d$ist*	-0.000	-0.002	-0.001	0.001	0.014**	-0.017
	(0.002)	(0.003)	(0.002)	(0.001)	(0.007)	(0.040)
Index of local public goods	0.303**	0.597***	0.141	-0.210	0.479	12.307***
	(0.130)	(0.216)	(0.162)	(0.158)	(0.647)	(4.169)
e.adjlnharv						
cf(mtssh$_n$*ew*)	-0.767***					
	(0.279)					
e.adjlngrainsurplus						
cf(mtssh$_n$*ew*)		-0.276				
		(0.318)				
e.adjlnland						
cf(mtssh$_n$*ew*)			-0.723**			
			(0.299)			
e.adjlnlabor						
cf(mtssh$_n$*ew*)				-0.563**		
				(0.277)		
e.adjland$_p$*rod*						
cf(mtssh$_n$*ew*)					-0.510	
					(1.327)	
e.adjlabor$_p$*rod*						
cf(mtssh$_n$*ew*)						-7.736
						(7.647)
Mean Dep. Var.	7.23	6.34	5.37	4.36	6.92	18.70
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.53
R^2	.6901598	.6713608	.6663793	.5213673	.6873339	.5531967
Number of Clusters	91	88	91	91	91	91
Observations	428	404	428	428	428	428

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 19 The effect of MTS on production outcomes: Collective farm fixed effects

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	LSDV	LSDV	LSDV	LSDV	LSDV	LSDV
	(1)	(2)	(3)	(4)	(5)	(6)
Share of work performed by MTS	0.155	0.794	-0.120	-0.324	1.256	15.500**
	(0.218)	(0.519)	(0.128)	(0.235)	(1.056)	(7.537)
Mean Dep. Var.	7.23	6.34	5.36	4.35	6.92	18.67
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.51
R^2	.962941	.9185754	.9797292	.9246799	.9289009	.8637217
Number of Clusters	91	88	91	91	91	91
Observations	430	405	430	430	430	430

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 20 The effect of MTS on production outcomes: First differences

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
D.Share of work performed by MTS	0.977	4.059**	-0.431	-0.232	5.869	65.354*
	(0.922)	(2.045)	(0.688)	(0.859)	(7.208)	(33.466)
De.adjlnharv						
cf(D.mtssh$_new$)	-0.702					
	(0.872)					
De.adjlngrainsurplus						
cf(D.mtssh$_new$)		-3.111				
		(2.008)				
De.adjlnland						
cf(D.mtssh$_new$)			0.226			
			(0.699)			
De.adjlnlabor						
cf(D.mtssh$_new$)				-0.070		
				(0.891)		
De.adjland$_prod$						
cf(D.mtssh$_new$)					-3.322	
					(7.041)	
De.adjlabor$_prod$						
cf(D.mtssh$_new$)						-50.863
						(33.214)
Mean Dep. Var.	0.46	0.69	0.13	0.00	2.13	12.28
SD of Dep. Var.	0.31	0.63	0.18	0.30	1.99	13.17
R^2				.0159687		
Number of Clusters	45	43	45	45	45	45
Observations	208	186	208	208	208	208

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 21 The effect of MTS on production outcomes: only 1933 observations

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.184***	0.551	1.015***	0.791**	1.040	5.349
	(0.309)	(0.433)	(0.311)	(0.368)	(1.446)	(9.014)
Index of local public goods	0.320*	0.782**	0.007	-0.145	1.019	7.115
	(0.176)	(0.304)	(0.234)	(0.260)	(0.800)	(5.353)
e.adjlnharv						
cf(mtssh$_n ew$)	-0.506					
	(0.391)					
e.adjlngrainsurplus						
cf(mtssh$_n ew$)		-0.130				
		(0.515)				
e.adjlnland						
cf(mtssh$_n ew$)			-0.393			
			(0.387)			
e.adjlnlabor						
cf(mtssh$_n ew$)				-0.409		
				(0.393)		
e.adjland$_p rod$						
cf(mtssh$_n ew$)					-0.973	
					(1.606)	
e.adjlabor$_p rod$						
cf(mtssh$_n ew$)						0.676
						(8.572)
Mean Dep. Var.	7.00	5.99	5.30	4.36	5.83	12.43
SD of Dep. Var.	0.54	0.80	0.56	0.46	2.26	8.72
R^2	.7128581	.6111154	.6933623	.5567141	.6455802	.5355549
Number of Clusters	45	43	45	45	45	45
Observations	210	197	210	210	210	210

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 22 The effect of MTS on production outcomes: only 1934 observations

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.459***	0.547***	1.464***	0.809***	0.054	27.620***
	(0.206)	(0.206)	(0.272)	(0.288)	(1.501)	(10.247)
Index of local public goods	0.304	0.429*	0.234	-0.193	0.327	15.628***
	(0.187)	(0.252)	(0.212)	(0.194)	(0.976)	(5.667)
e.adjlnharv						
cf(mtssh$_n ew$)	-0.913***					
	(0.354)					
e.adjlngrainsurplus						
cf(mtssh$_n ew$)		-0.264				
		(0.309)				
e.adjlnland						
cf(mtssh$_n ew$)			-0.907**			
			(0.411)			
e.adjlnlabor						
cf(mtssh$_n ew$)				-0.625*		
				(0.369)		
e.adjland$_p rod$						
cf(mtssh$_n ew$)					-0.217	
					(1.832)	
e.adjlabor$_p rod$						
cf(mtssh$_n ew$)						-16.248
						(12.580)
Mean Dep. Var.	7.46	6.67	5.43	4.36	7.97	24.74
SD of Dep. Var.	0.47	0.54	0.55	0.47	2.26	14.57
R^2	.5141161	.5457699	.6246627	.4740285	.5659451	.3831789
Number of Clusters	46	45	46	46	46	46
Observations	218	207	218	218	218	218

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 23 The effect of MTS on production outcomes: binary treatment variable

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
mtspresence	0.242***	0.077	0.233***	0.156**	-0.044	2.019
	(0.074)	(0.095)	(0.072)	(0.062)	(0.223)	(1.903)
Index of local public goods	0.328**	0.584**	0.138	-0.161	0.674	11.635**
	(0.131)	(0.241)	(0.165)	(0.169)	(0.731)	(4.836)
Mean Dep. Var.	7.23	6.34	5.36	4.35	6.92	18.67
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.51
R^2	.6881917	.6633099	.6689288	.520657	.6745113	.5395825
Number of Clusters	91	88	91	91	91	91
Observations	430	405	430	430	430	430

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 24 The effect of MTS on production outcomes: binary treatment

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
mtspresence	0.503***	0.138	0.454***	0.291***	0.420	7.018*
	(0.076)	(0.125)	(0.071)	(0.095)	(0.478)	(3.596)
Index of local public goods	0.320***	0.592***	0.129	-0.162	0.666	11.304***
	(0.121)	(0.210)	(0.151)	(0.150)	(0.641)	(4.320)
e.adjlnharv						
cf(mtspresence)	-0.314***					
	(0.101)					
e.adjlngrainsurplus						
cf(mtspresence)		-0.074				
		(0.155)				
e.adjlnland						
cf(mtspresence)			-0.266***			
			(0.100)			
e.adjlnlabor						
cf(mtspresence)				-0.162		
				(0.117)		
e.adjland$_{prod}$						
cf(mtspresence)					-0.558	
					(0.588)	
e.adjlabor$_{prod}$						
cf(mtspresence)						-6.012
						(4.241)
Mean Dep. Var.	7.23	6.34	5.37	4.36	6.92	18.70
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.53
R^2	.6698918	.6641366	.6516736	.5255496	.6736787	.5205327
Number of Clusters	91	88	91	91	91	91
Observations	428	404	428	428	428	428

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 25 The effect of MTS on production outcomes: excluding raions with no MTS presence

Dep. Var. =	Total grain output (centners in logs)	Extracted surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Share of work performed by MTS	0.733***	0.386**	0.702***	0.367***	0.051	10.299***
	(0.132)	(0.158)	(0.142)	(0.138)	(0.502)	(3.726)
Index of local public goods	0.425***	0.696**	0.244	-0.119	0.542	13.014**
	(0.151)	(0.270)	(0.184)	(0.197)	(0.777)	(5.430)
Mean Dep. Var.	7.26	6.36	5.41	4.37	6.83	19.29
SD of Dep. Var.	0.57	0.79	0.57	0.47	2.53	13.88
R^2	.7113613	.6624496	.689758	.502241	.7092979	.5679487
Number of Clusters	65	63	65	65	65	65
Observations	341	321	341	341	341	341

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 26 The effect of MTS on worker incentives, not adjusting for productivity norms

Dep. Var. =	In-kind compensation (centners per worker)				Share of extracted surplus below subsistence			
Estimation:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
main								
Share of work performed by MTS	0.884	3.208	0.831	1.702	-0.062	-0.120	-0.001	-0.079
	(1.462)	(2.640)	(2.106)	(3.466)	(0.053)	(0.078)	(0.064)	(0.084)
Index of local public goods	2.273	2.259*	2.293	2.255*	-0.202***	-0.211***	-0.206***	-0.213***
	(1.469)	(1.303)	(1.430)	(1.273)	(0.066)	(0.057)	(0.064)	(0.056)
Share of MTS services subtracted from 33rd-tile × Low share of work performed by MTS			6.257				-0.102	-0.130
			(6.186)				(0.204)	(0.180)
Share of MTS services minus the 66th-tile × High share of work performed by MTS			1.100	-3.238			-0.310	-0.185
			(6.728)	(8.614)			(0.230)	(0.158)
e.adjnoyninkindcompperworker								
cf(mtssh$_n ew$)		-2.831		-2.967				
		(3.533)		(3.489)				
e.adjnoynshbelowsub								
cf(mtssh$_n ew$)						0.043		0.036
						(0.082)		(0.082)
Mean Dep. Var.	2.41	2.41	2.41	2.41	0.25	0.25	0.25	0.25
SD of Dep. Var.	5.60	5.61	5.60	5.61	0.33	0.32	0.33	0.32
R^2	.4945668	.4898263	.4963401	.4894726	.8470335	.8568664	.8481335	.8575617
Number of Clusters	90	90	90	90	88	88	88	88
Observations	416	414	416	414	407	404	407	404

Notes: Standard errors are clustered at the district-year level. Full set of controls included.

Table 27 The effect of MTS on productivity: Evidence of non-market allocation

Dep. Var. =	Total grain output (centners in logs)	Extracted Surplus (centners in logs)	Area under grain crops (hectares in logs)	No. of workers in logs	Land productivity (centners per hectare)	Labor productivity (centners per worker)
Estimation:	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
main						
Share of work performed by MTS	1.326***	0.512*	1.312***	0.799***	-0.136	16.554**
	(0.186)	(0.275)	(0.187)	(0.213)	(1.068)	(6.771)
Share of MTS services subtracted from 33rd-tile × Low share of work performed by MTS	-0.693	-1.381	-0.872*	0.340	0.636	-32.842***
	(0.495)	(0.847)	(0.473)	(0.404)	(1.756)	(10.097)
Share of MTS services minus the 66th-tile × High share of work performed by MTS	0.292	0.486	0.071	0.080	2.787	6.959
	(0.499)	(0.673)	(0.620)	(0.579)	(2.407)	(16.010)
Index of local public goods	0.311**	0.592***	0.115	-0.168	0.731	11.238***
	(0.131)	(0.205)	(0.158)	(0.156)	(0.636)	(3.951)
e.adjlnharv						
cf(mtssh$_n ew$)	-0.812***					
	(0.283)					
e.adjlngrainsurplus						
cf(mtssh$_n ew$)		-0.320				
		(0.323)				
e.adjlnland						
cf(mtssh$_n ew$)			-0.784**			
			(0.306)			
e.adjlnlabor						
cf(mtssh$_n ew$)				-0.529*		
				(0.275)		
e.adjland$_p rod$						
cf(mtssh$_n ew$)					-0.438	
					(1.272)	
e.adjlabor$_p rod$						
cf(mtssh$_n ew$)						-10.402
						(7.748)
Mean Dep. Var.	7.23	6.34	5.37	4.36	6.92	18.70
SD of Dep. Var.	0.55	0.76	0.56	0.46	2.50	13.53
R^2	.6845895	.6726226	.6589294	.5145005	.6792369	.5497453
Number of Clusters	91	88	91	91	91	91
Observations	428	404	428	428	428	428

Notes: Standard errors are clustered at the district-year level. Full set of controls included. Only soil type is shown.

Table 28 Summary Statistics of MTS Services (Farms with MTS Contract, N = 188)

Variable	Mean	SD	Min	Max
Winter crop plowing services				
MTS fallow plowing (ha)	70.18	85.49	0	500
MTS double fallow plowing (ha)	44.60	74.58	0	400
MTS winter sowing with disc (ha)	17.48	47.72	0	250
Fall crop plowing services				
MTS autumn plowing (ha)	71.03	127.03	0	1118
MTS spring plowing (ha)	108.24	111.50	0	547
MTS spring sowing with disc (ha)	19.66	51.89	0	361
Harvest-related services				
MTS grain harvesting with combines (ha)	12.26	42.53	0	292
MTS grain mowing (ha)	37.15	76.65	0	572
MTS grain harvesting with thresher (ha)	258.25	239.30	0	1250
Mechanization level				
MTS share of work (unweighted) (%)	0.36	0.19	0.04	0.88
MTS share of work (*) (%)	0.25	0.15	0.01	0.84
Totals and prices				
Total MTS services (ha)	391.49	370.22	10.5	2644.85
In-kind payment to MTS (tonnes)	39.85	45.48	0	417.6
Grain harvest (tonnes, farms with MTS)	387.08	283.21	47.78	2244.3
Price of MTS services (*) (kg/unit)	113.48	82.08	2.21	709.14

(*) Variables are computed in *conditional plowing equivalents*, i.e. services transformed into comparable units of plowing work (e.g., sowing = 0.3, mowing = 0.45, harvesting with combine = 0.5, harvesting with thresher = 0.35).