The Effect of Western Technology on Soviet Industrial Development

Andrei Markevich and Torsten Santavirta*

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Abstract

During the Soviet Union's First Five-Year Plan, Western know-how and technology were extensively infused into industry through technical assistance agreements and work contracts with specialists and foreign companies. We study the causal effects of this purposeful state-led policy on labor productivity using the largest single recruitment effort of Western expertise, namely Karelian Technical Aid. This allows us to exploit exogenous variation in transfer of technology within one sector: the wood processing industry. Combining detailed individual-level data on over 5,000 North American specialists with a novel panel of accounting data on the universe of Soviet enterprises in Karelia and the Northern Region during the interwar period, we document large and persistent causal productivity gains. Important drivers of successful technology absorption were local human capital and the absence of language barriers.

JEL Classification: J24, N64, O14, O3, P2
Keywords: Industrial policy, Technology, Technical assistance, Soviet Union

*Markevich: University of Helsinki, P.O.Box 54 (Snellmaninkatu 14 A) 00014 University of Helsinki, Finland, andrei.markevich@helsinki.fi; New Economic School, Moscow, Russia amarkevich@nes.ru; CEPR. Santavirta: University of Helsinki, P.O. Box 17 (Arkadiankatu 7). FI-00014 University of Helsinki, Finland, torsten.santavirta@helsinki.fi; Institute for Housing and Urban Research, Uppsala University. Acknowledgements: We thank Paul Castaneda Dower, Ruben Enikolopov, Sergei Guriev, Mark Harrison, Adrian Haws, Chris Minns, Matti Mitrunen, Matti Sarvimäki, Seth Sanders, Fraser Summerfield, Roope Uusitalo for their insights; the participants of 2024 WEast conference in Dublin, 2025 Finnish Economic Association annual conference, 2025 IOS annual conference, 2025 Dondena-Cornell Gathering (DOCG) and seminars at U. Helsinki, U. Wisconsin-Madison, Bank of Finland, VATT for valuable comments. Sofia Pirogova and Kaarle Myllyneva provided excellent research assistance. The usual disclaimer applies.

"*A combination of American business and science with Bolshevik wisdom has created these giants in three or four years...*"

Za Industrializatsiiu, August 14, 1933.[1]

1 Introduction

In recent academic discussion on the causal impact of industrial policy (Criscuolo et al., 2019; Giorcelli and Li, 2021; Juhász et al., 2024b; Mitrunen, 2024; Choi and Levchenko, 2025; Lane, 2025; Kantor and Whalley, 2025; Bai et al., Forthcoming), the Soviet Union's technical assistance agreements with Western firms seems to be a forgotten chapter.[2] Yet, this was one of the biggest purposeful policies of Western technology adoption in a developing country. During Stalin's interwar industrialization—one of the most archetypic episodes of rapid industrial catch-up (Robinson, 2010; Cheremukhin et al., 2017)—several hundred industrial projects were designed by foreign engineers, built under foreign supervision and equipped with the most advanced technology, all in just a few years (1928-1934). What is more, thousands of Soviet specialists were either trained in the U.S. or locally by American experts.[3] Study of the impact of this industrial policy—at the heart of the Gerschenkronian view of Western technology adoption as the key remedy to economic "backwardness"—offers crucial insight into the drivers and hurdles of industrial upgrading (Bloom et al., 2013; Atkin et al., 2017; Giorcelli, 2019; Juhász et al., 2024).[4]

Specifically, this paper quantifies the causal effect of Western technology transfer on Soviet labor productivity by focusing on the wood processing industry in the Autonomous Republic of Soviet Karelia. In 1931-1933, more than 5,000 American and Canadian specialists of ethnic Finnish origin were recruited to this region—a place with almost equal representation of ethnic Finno-Ugric peoples and Russians—on two-year foreign expert contracts. This intervention, called Karelian Technical Aid, was the largest single recruitment effort of foreign expertise within the realms of the Soviet industrial policy of technology absorption in the early 1930s. The objective was to forge a cadre of skilled foremen through vocational training

[1] *Za Industrializatsiiu* or "For Industrialization" was the official newspaper of the People's Commissariat of Heavy Industry. The excerpt is also cited by Anthony Sutton, in his work, Western Technology and Soviet Economic Development, 1930 to 1945, published by the Hoover Institution Press (Stanford University), 1971.

[2] For recent reviews of the burgeoning literature studying industrial policy using the modern toolkit of applied microeconomics, see Lane (2020) and Juhász et al. (2024a).

[3] The American influence on Soviet industry was of such scale during the early 1930s that the term "Americanization" was used interchangeably with "industrialization" (Sorokin, 1944).

[4] See Verhoogen (2023) for a comprehensive overview of measurement and empirical evidence on drivers of firm-level upgrading.

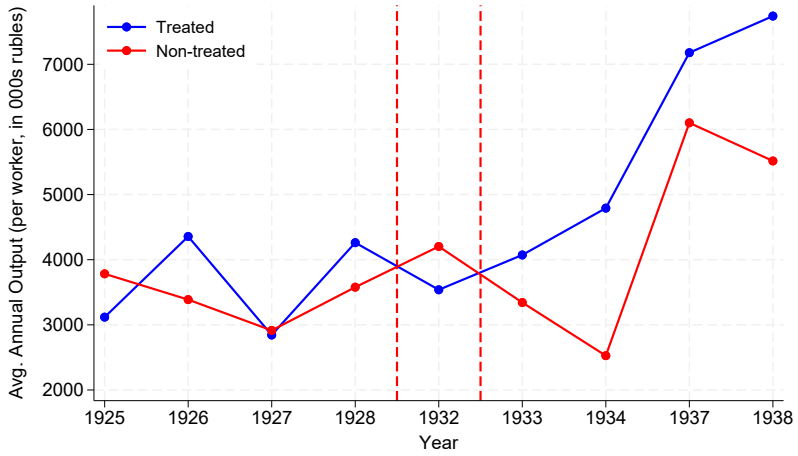
and increase (or in Bolshevik lingo, "rationalize") labor productivity in the wood processing industry, one of the main sources of export goods in interwar Soviet Union. As has been documented anecdotally (Fitzgerald, 1996), and recently causally (Jiang and Weber, 2025), the coincidence of the First Five-Year Plan (1928-1932) with the Great Depression greatly simplified attracting North American projects and expertise.

We develop two novel datasets on Karelian Technical Aid to evaluate its impact on Soviet industrial development. The geographical penetration of the program within Soviet Karelia is documented using a registry of foreign workers from the Karelian Settlement Administration, an office established to manage the work permits and assignment of North American experts to enterprises. The registry allows us to trace time of arrival, occupation, and assignments of recruited foreign workers. We combine these detailed individual-level work-related immigration records with enterprise-level accounting data on input and output in industry extracted from the archives of the Central Statistical Administration of the former USSR. Our industry dataset comprises the universe of interwar period enterprises in both Soviet Karelia and the neighboring Northern Region (*Severny Krai*). While the latter also specialized in wood processing, it did not benefit from Karelian Technical Aid, allowing us to construct a panel of treated and untreated enterprises spanning the period of 1925 to 1938, i.e., before and after the initiation of Karelian Technical Aid. Raw data on treated and untreated enterprises in the wood processing industry suggest that labor productivity was equally stagnant in the two groups in the 1920s and improved differently after the intervention (Figure 1).

Our research design compares changes in labor productivity by exposure to the technical aid program. In this two-way fixed-effects (enterprise and year) setting, we find a strong positive effect of the technical assistance program on treated enterprises' labor productivity in the wood processing industry but not for the economy as a whole. After the arrival of the North American Finns, treated enterprises' labor productivity increased on average by roughly 60 percent, and there is no evidence that resources were crowded out in the long run from enterprises not affected by the program. These results are robust to adjustment for concurrent policies such as the exploitation of forced labor and for a potential systematic difference in the implementation of the five-year plans across the two regions. A subsequent event study shows adoption of new technology two years into the program and persistence of the effect until the end of our observation period in 1938, i.e., after the return of foreign workers to North America or their displacement in Stalin's purges of the mid-1930s. We document that before the arrival of foreign experts in Soviet Karelia, treated and untreated enterprises do not display statistically significant different trends in their labor productivity. Our main empirical results are stable and statistically robust to a large battery of checks

(i.e., alternative definitions of the variables, estimation samples, functional form, alternative standard error adjustments, etc.).

Figure 1: Enterprises' Labor Productivity Trends by Exposure to Karelian Technical Aid, 1925 – 1938



Notes: The series represent averages of output per industrial worker in 1926/7 rubles in enterprises active in the wood processing industry with at least one enterprise-year observation before and after 1932, separately for treated enterprises (blue line) and non-treated ones (red line) by Karelian Technical Aid. The two dashed red vertical lines mark the interval years (1931-1932) during which the bulk of North American Finns arrived in Soviet Karelia (Table 1).

We complement our two-way fixed-effects (TWFE) analyses with an alternative identification strategy that leverages geographical settlement restrictions for foreign workers imposed by the Soviet secret police. We observe that these settlement restrictions were orthogonal to a number of background variables potentially affecting productivity, and use this source of exogenous variation in the geographical distribution of North American Finns across industrial sites in Soviet Karelia as an instrument for placement. Our IV strategy confirms the TWFE findings of a substantial effect of the presence of North American Finns on local labor productivity, suggesting an even larger effect.

To better understand the drivers of firm-level upgrading, we explore heterogeneity in post-transfer labor productivity of Soviet enterprises conditional on the baseline characteristics of technology recipients. Our triple-difference analysis highlights two key circumstances under which increased availability of technical assistance translates into greater enterprise capabilities. First, higher baseline human capital among the host population heightens the impact of foreign expertise. This aligns with the findings of Giorcelli and Li (2021) in the Sino-

Soviet context of Soviet technology transfer and assistance to China. Second, diminished or absent language barriers augment the productivity potential of technical assistance (Guillouët et al., 2024). Our paper is among the first to provide firm-level evidence on these two aspects. Moreover, our main findings of a direct causal effect of technology transfer and technical assistance are solidified by the lack of evidence of both ideological selection of foreign workers and of political capture, as measured by the share of party members among the establishments' industrial workers.

A simple cost-benefit analysis based on our estimates suggests that the policy was efficacious and would still have been viable at as much as almost four times higher wages for foreign workers—even abstracting from knowledge spillovers across regions. This aligns with the macro view of the 1920s economic potential of Soviet Karelia, where unlimited natural resources of timber and proximity to important export ports through waterways and railways constituted comparative advantages for specialization in wood processing. A few decades earlier, neighboring Finland had become one of the world's largest exporters of timber and plywood (Hjerppe, 1989; Kuisma, 1993), and it is thus unsurprising that local leadership in Soviet Karelia, many of whom were "Red Finns" (exiles from Finland's failed revolution in 1918), saw wood processing as a promising avenue for industrialization.

This paper intersects in at least three important ways with the existing literature. First, it makes a significant contribution to study of the causal impact of Western technical assistance and technology transfer on the productivity of local firms (Giorcelli, 2019; Juhász et al., 2024b). It has been shown that state-led attempts by developing countries to leapfrog more developed economies through industrial policy (Rosenstein-Rodan, 1943; Murphy et al., 1989) have relied on the import of foreign expertise and technology (Robinson, 2010). However, few studies have overcome the observability problem of gauging the causal effect of such (oftentimes complex) interventions (Juhász et al., 2024a). We address this challenge by applying modern identification techniques to micro-level data on what was arguably the largest market-based import of Western technology in modern history.[5] This approach allows us to establish the causal effect of Western technology on the performance of the Soviet economy, which case studies (Sutton, 1971; Berliner, 1976; Amman et al., 1977), complex simulation models (Green and Levine, 1976a,b), and macro-level production function analysis (Weitzman, 1979) attempted to address in the 1970s with conflicting results. At the time, a conclusion drawn was that a disaggregate strategy honing in on specific industries might make the endeavor more methodologically tractable. Yet, this was hindered by data

[5]The technical assistance that U.S. firms alone provided to the USSR in 1928–34 was worth roughly $250 million ($6.2 billion in 2025 prices) or 1.2% of 1928 Soviet GDP.

requirements. As observed in 1979 by the U.S. Office of Technology Assessment:

> More than anything else, the conflicting results obtained from these [...] approaches point to the wisdom of reverting to the study of the actual effect of Western equipment and technology on the capacity of individual sectors of the Soviet economy. A disaggregate approach in which each industry is examined individually to determine what equipment and technology has been transferred, how well and how quickly it has been absorbed and diffused, and what changes there have been in comparative levels of technology, may be more productive and accurate. It must be noted that such information is very difficult to obtain even in the West, where access to information is relatively free.

While the micro-data situation has since improved in the West, this statement remains applicable to the former Soviet Union, even long after its collapse and the opening of archives (Zhuravskaya et al., 2024). Important contributions at the macro level have nonetheless elucidated the drivers of Soviet industrialization in the interwar period (Hunter and Szyrmer, 1992; Allen, 2003; Cheremukhin et al., 2017). The economically substantial positive effect found for Karelian Technical Aid nuances the dismal view of the Soviet Union's state-led efforts to rapidly advance productivity (Cheremukhin et al., 2017). Our findings suggest that approaching Western companies and experts for technical assistance was indeed a constructive element in this industrialization drive.

The second key contribution of this paper consists of its further causal insights into firms' technology adoption in the context of a purposeful industrial policy—of interest for the current context. Indeed, the rationale behind Karelian Technical Aid is not unlike that embraced recently by the U.S. and E.U.: boost manufacturing capacity in backward regions through place-based industrial policy (European Commission, 2021; The Economist, 2023). Our results corroborate the positive causal effects found for such contemporary policies (Criscuolo et al., 2019) as well as earlier ones (Mitrunen, 2024; Cerrato and Filippucci, 2025). Moreover, the main components of Karelian Technical Aid—i.e., group- and on-the-job training by Western experts, technology transfer, and implementation of organizational practices—are drivers of know-how that have received much attention in recent academic debate on place-based policy and firm-level upgrading (Bartik, 2020; Verhoogen, 2023; Carranza and McKenzie, 2024, and references therein).[6] Our findings also build on observational and experimental studies assessing firm-level upgrading through training and management help

[6]Much of European Union's current Industry 4.0 policy deals with training and upskilling of the local labor force through an explicit "Skills Agenda," and is, notably, also a five-year plan (European Commission, 2020).

(Bloom et al., 2013; Bruhn et al., 2018; Iacovone et al., 2022; Bianchi and Giorcelli, 2022). However, the Soviet case differs from typical business training programmes in the sense that the training by American specialists was offered through the widespread system of schools of factory and plant apprenticeship (shkoly fabrichno-zavodskogo uchenichestva or F.Z.U.) and courses would typically last some six months.[7] Unlike the aforementioned studies, we are limited to examining the effect of the program in its entirety; we cannot disentangle the separate effects of its different components (e.g., group-training, technology transfer, supervision, engineering, etc.). Nonetheless, by showing that productivity gains are amplified by high baseline human capital and low language barriers, our results support findings of complementarities between technology transfer and tacit knowledge in technology adoption (Giorcelli, 2019; Giorcelli and Li, 2021). Such complementarity, along with the extent of coursework involved, the deployment of foreign technicians to local enterprises to facilitate acquired know-how application, and the low base effect, likely explain the magnitude of our documented productivity gains compared to experimental evidence on the effects of business training in developing countries (McKenzie, 2021).

Thirdly, our paper contributes to work examining the effects of skilled immigrants on productivity through knowledge spillovers. Much of the (relatively scarce) contemporary evidence is based on lotteries of firm-sponsored visas (H-1B) in the U.S. (Kerr, 2013), and offers mixed findings in terms of firm performance (Doran et al., 2022; Mahajan et al., 2024). Our context is similar, in that each North American needed to be sponsored by a Karelian enterprise in order to be granted an entry visa. More generally, our paper adds to this literature by corroborating historical causal evidence on the economic gains associated with skilled migration (Hornung, 2014; Natkhov and Vasilenok, 2022; Boberg-Fazlic and Sharp, 2024), in a context with low cultural and language barriers (Spolaore and Wacziarg, 2009).

The rest of the paper is organized as follows. Section 2 sets forth our institutional setting. Section 3 describes the data and Section 4 presents the identification strategy. Section 5 reports our results, Section 6 analyzes the drivers of our main findings, and Section 7 offers concluding remarks.

[7]Schools of factory and plant apprenticeship (F.Z.U.) were a crucial part of the Soviet vocational education system designed to rapidly train skilled workers for industrialization during the 1920s and 1930s. Most training institutions were attached to large plants, though some operated at the district (rayon) level, catering to several industries across the region. In 1931-32, 975,000 students attended one of 3,151 F.Z.U.'s (Blumenthal and Benson, 1978).

2 Institutional Setting

2.1 Soviet Karelia

Soviet Karelia is located northeast of Saint Petersburg (Leningrad between 1924 and 1991), along the Russian-Finnish border (Figure 2). According to the 1926 population census, it was mostly populated by Finno-Ugric peoples and Russians (41.5% and 57.2% respectively). In 1920, it was among the first of the former Russian Empire regions to gain autonomous status. Three years later, with the Soviet policy of indigenization (Martin, 2001), it would become the Karelian Autonomous Soviet Socialist Republic (KASSR), thereby joining the Soviet Union as part of the Russian Soviet Federative Socialist Republic (RSFSR).

Finnish socialist emigrés or "Red Finns" formed the bulk of Karelian leadership. Empowered by the ethnic and cultural concessions of the Soviet central government, the regional authorities began to implement an ambitious program to consolidate the administrative and cultural dominance of Karelian and Finnish peoples and languages in the region.[8] The aim was to eventually introduce standard literary Finnish as the second lingua franca alongside Russian throughout Soviet Karelia (Kero, 1981). From the central government's perspective, concessions to national minorities demonstrated to workers abroad that under socialism, peoples could prosper while retaining their national cultures (Gelb, 1993).

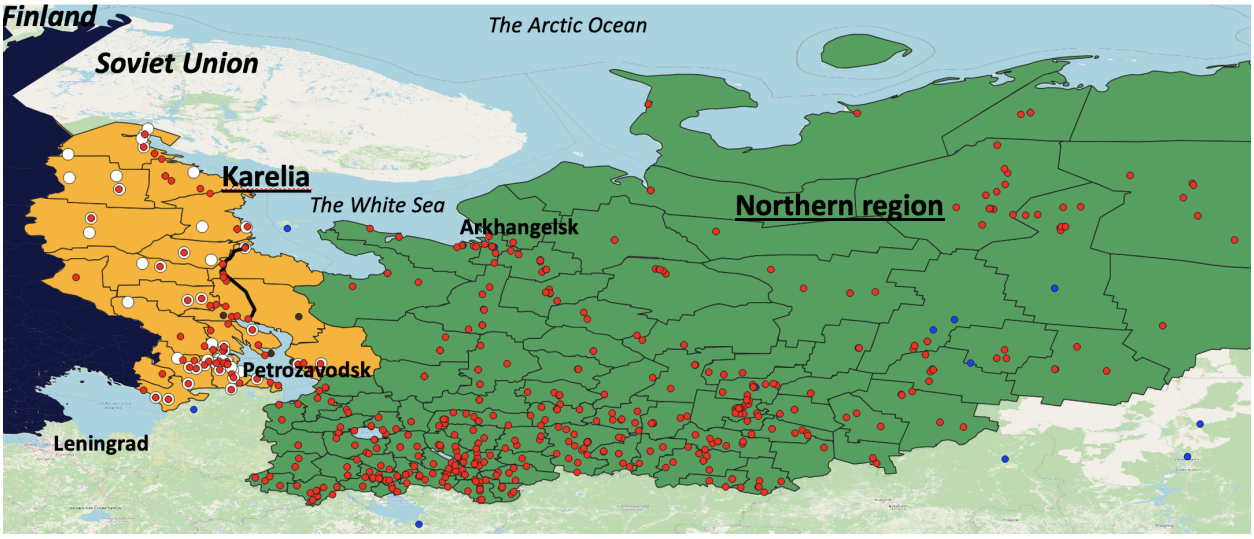
2.2 Soviet Industrialization and Western Technology

2.2.1 First Five-Year Plan

Interwar Soviet Union economic policy can essentially be divided into the rather market tolerant New Economic Policy (NEP) introduced by Lenin in 1921 and the centrally planned five-year plans implemented by Stalin in 1928. With the NEP, foreign firms operated under concessions that allowed Soviet enterprises to acquire technology they did not possess (Sutton, 1968). This changed with the introduction of the First Five-Year Plan and its goal of transforming the Soviet Union from an economically backward agrarian country to a modern industrialized nation. For the central government, this meant taking full control

[8] Language proximity between Karelian and Finnish is 13.9 on a 0-100 scaled proximity index, where lower scores indicate higher similarity; the same score between Catalan and Spanish is 23.5 (Beaufils and Tomin, 2020).

Figure 2: Soviet Karelia and the Northern Region in Interwar Soviet Union.



Notes: Orange and green regions show the territories of Soviet Karelia and the Northern Region, respectively. The Northern Region was an administrative unit between 1929 and 1936. For our analysis, we define the region by the territories of its successor provinces. Black thin lines delineate administrative districts in 1939. White dots indicate the presence of North American Finns; red dots the locations of Soviet enterprises; blue dots are Gulag forced labor camps; black dots denote special settlements of detained illegal unskilled migrants from Finland; and the black bold line is the Baltic-White Sea Canal built in 1931-33.

of the country's resources and the mechanization of its industrial enterprises, including all technology transfer. After 1928, existing foreign concessions were terminated legally or illegally and replaced by state-sponsored technical assistance agreements with Western firms. These involved knowledge and technology transfers, including individual work contracts with engineers, technicians, and experienced workers (Sutton, 1968, 1971).[9] Paradoxically, this policy implied less self-sufficiency and more dependence on the Western capitalist system, given the increased need for hard currency to pay for foreign machinery, engineering, and expert know-how. Since the First Five-Year Plan coincided almost exactly with the Great Depression, traditional Soviet export markets were contracting and thereby obstructing the inflow of much needed hard currency. The Soviet Union was thus forced to increase the competitiveness of its main export goods, such as timber, oil, and grain (Sutton, 1971; Kero, 1983; Sanchez-Sibony, 2015).

In 1929, timber and paper products accounted for roughly 17% of Soviet export (SSSR, 1960). Compared to the mostly land-locked Siberian forests, those of Soviet Karelia were

[9]The scale and ambition of these agreements made them relevant to some of the most successful American companies at the time, such as Ford Motor Company, General Motors, Packard, and General Electric. For a detailed account of the industrial policy of Soviet Union's technical assistance agreements in 1928-1934, see Sutton (1971).

more favorable for Western export, given relatively easy access to the Baltic- and White Sea ports through water- and railways (Autio-Sarasmo, 2000). The otherwise undeveloped region of Soviet Karelia thus came to assume an important role in the First Five-Year Plan as one of the focus areas for the development of the wood processing industry, projected to triple during this period (SSSR, 1930). However, a lack of capital assets and low share of skilled labor limited the region's potential to fulfill its production targets (Efremkin, 2016).

To increase productivity, Soviet Karelia sought to both expand investments in paper- and sawmills and to recruit skilled workers from elsewhere in the Soviet Union.[10] The workforce did indeed grow during the First Five-Year Plan, even faster than projected. However, this was mostly thanks to increased in-migration of unskilled ethnic Russian workers, and not Finno-Ugric peoples from other parts of Soviet Union, who were supposed to make up 75% of this movement (Kangaspuro, 2000).[11] To tackle both the skill shortage and Finno-Ugric de-ethnicization, in March 1930 the Finnish leaders of Soviet Karelia proposed looking to skilled workers among the Finnish diaspora in North America (numbering roughly 400,000) for help, many of whom were unemployed due to the Great Depression (Kero, 1983).

The aim was to gain new technology and know-how from the technological frontier of the forestry industry while simultaneously reinforcing Finnish language and culture in Soviet Karelia by recruiting qualified North American Finns who could implement systematic vocational and on-the-job training of the local workforce (Kero, 1981; Gelb, 1993). The argument presented to the central government in Moscow was that experienced foreign workers could help the local workforce to "most rapidly learn foreign methods of forest harvesting" as they command "the highest labor productivity in the world" (Golubev and Takala, 2014). The initiative aligned with the decision of 16th All-Union Communist Party Congress (June 26 to July 13, 1930) to extend the practice of "sending workers and specialists abroad and inviting foreign engineers, foremen, and qualified workers to the USSR," thus intensifying "already existing technical assistance agreements" (Institute of Marxism and Leninism, 1984, p.156), and was approved fairly easily, despite secret police objections highlighting Karelia's long international border with Finland.

[10] The First Five-Year Plan prescribed a 20% population increase in Soviet Karelia to a target of 330,000 inhabitants in 1933, and 80% of all regional investments were directed to the wood processing industry (SSSR, 1930).

[11] Of the 98,000 internal immigrants who arrived in Soviet Karelia between the 1926 All-Union and 1933 Karelian Census, roughly 71% were Russians and only 18% Finno-Ugric (authors' own calculation based on census figures (KASSR, 1934)).

2.2.2 Karelian Technical Aid

The Soviet central government agreed to finance a recruitment scheme called "Technical Aid for Soviet Karelia," with headquarters in New York and Toronto and agents in the major Finnish-American and Finnish-Canadian communities. Karelian Technical Aid mainly targeted those active in the forestry industry, but also experienced workers of other trades such as tractor drivers, mechanics, carpenters, brick layers, and electricians. Only ethnic Finns were eligible to apply for work through the program.

In the years 1931-33, Karelian Technical Aid succeeded in recruiting roughly 5,000 qualified workers, technicians, and engineers among the Finnish population in North America (6,700 along with their families). Thanks to these efforts, the share of foreign workers in Karelian industry (about 4%) was substantially larger than in the Soviet Union as a whole, which did not exceed 0.2% at its peak in 1932 (Graziosi, 1988; SSSR, 1932a).

The organized settlement of the North American Finns in Karelia was managed by the Settlement Administration (*Siirtolaishallinto*), established in Petrozavodsk (the capital of Karelia) in the spring of 1931. This body was responsible for application screening, arranging work permits, obtaining final approval of entry visas from Moscow, handling job placement and settlement, and keeping registers of all foreign workers. While workers signed a two-year contract with Karelian Technical Aid, it was ultimately local Karelian officials who assigned them to specific enterprises. Enterprises meanwhile applied for foreign experts once a year and committed to sponsoring assigned worker's visa applications.

Applicants who received work permits were encouraged to invest funds in Western machinery and equipment. The Machinery Fund was one option. This was a local-government financing vehicle set up to borrow foreign currency at favorable terms. Migrants invested money in dollars, intended for the purchase of machines and equipment for Soviet Karelia, and received a signed guarantee by the head of Karelian Technical Aid of repayment by the Settlement Administration in rubles at the official exchange rate. Another option was to bring equipment and tools (e.g., cars, trucks, tractors, spare parts, saws, axes), which were compensated for upon arrival in the Soviet Union.

In Karelia, North American workers earned higher salaries (partly paid in U.S. dollars) than locals and had access to some amenities (e.g., the *Insnab* grocery stores and canteens established in 1931) that catered to the needs of a growing community of foreigners (Efremkin,

2011; Golubev and Takala, 2011, 2014).[12] Formally, they were free to leave a job and find another but in practice these workers were bound to their assigned locations by a complicated administrative procedure for transfer permission. Many found this restricted freedom, along with poor housing conditions and a scarcity of regular daily groceries an unworthy treatment of foreign experts, leading numerous workers to breach their contract. According to official records of the Settlement Administration, by the end of 1932, some 300 North American workers had already left the Soviet Union and by the end of 1935, about another 2,000 had gone, though these numbers are likely higher due to unreported departures. The return to North America for those who had not yet gained U.S. or Canadian citizenship by departure and were traveling with their old Finnish passports was much more complicated (Golubev and Takala, 2014).

2.3 Technical Assistance in Karelia

Despite ample qualitative historical research on North American foreign workers in Soviet Karelia, systematic study of their contributions is lacking. However, Dalrymple (1966) provides a helpful categorization of American technical assistance and technology transfer for Soviet agriculture: training in adapting mechanized processes; shipments of machinery and support in their operation; engineering assistance in the construction and operation of machinery plants; and imitation of unintentionally provided designs. We loosely follow this typology in elucidating the input and know-how contributed by the North American Finns.[13]

Training in adapting mechanized processes. Soviet officials' objective was to maximize the return of Karelian Technical Aid through deliberate knowledge transfer. In the short run, this meant a focus on the most pressing processes in Soviet Karelia, while the long run goal was to forge a Soviet Union-wide cadre of forestry foremen who would update their local subordinates on new methods. Soviet Karelian leadership had, however, full autonomy in the organization of the training. The North American newcomers formed a team of elite forestry workers that toured the logging camps in Soviet Karelia as well as other

[12] An experienced North American worker earned roughly 200 rubles per month, while a technician was paid between 550 to 850 rubles per month, considerably more than the monthly wage of local workers at about 120 rubles (Kero, 1983; Golubev and Takala, 2014).

[13] This subsection is based on historical assessments of the Settlement Administration archives, meeting minutes, Soviet Karelian officials' correspondence with enterprise managers, articles published in *Red Karelia* (the Soviet Karelian newspaper), and many other sources. Sources of particular note include Kero (1983), Takala (2004), Efremkin (2011), and Golubev and Takala (2014).

regions (as remote as the Urals) to teach state-of-the-art methods to local foremen. Courses in "Canadian-American forestry work processes and equipment" were, for instance, arranged on the premises of one of the larger logging camps, and could accommodate roughly 100 students per course (Kero, 1983). A course would consist of some 200 hours of theory and 600 hours of practical exercises taught by four North American Finnish instructors and one course principal, called the "rationalization comrade."[14] By the end of 1935, roughly 500 students from Karelia and other regions such as Chuvashiya, Caucasus and Siberia had, through such instruction, become "junior forestry managers."

Shipments of machinery and support in their operation. In North America, the mechanization of forestry had only begun in earnest in the 1920s, with the introduction of crawler tractors for hauling and trucks for transportation. Their acquisition through Karelian Technical Aid was therefore seen as an opportunity to leap to the technology frontier. While a small number of tractors were available at a few logging camps in Soviet Karelia before the technical assistance program, a lack of qualified mechanics and drivers limited the use of this already scarce resource, leaving loggers with horses as their only viable solution for transportation needs.[15] The arrival of American tractors and trucks along with a large number of professional mechanics and drivers from the U.S. and Canada relaxed these constraints and frictions. Training in North American forestry techniques likely also helped Soviet Karelia exploit their tractors more efficiently than elsewhere in the Soviet Union. Moreover, the newly established automotive trust (*Karjalan Auto*), essentially a garage more so than a car dealer, managed the maintenance of equipment and vehicles used in the Karelian wood processing industry, through its roughly 300 North American mechanics. This service of Western standards compensated for the endemic shortage of spare parts common in the Soviet Union (Kero, 1983).

The qualitative historical literature furthermore highlights the manual tools and semi-mechanized technology introduced by the North Americans. For example, North American horse- or tractor-driven derricks sped up the loading of timber on "double sleds," which were wider and easier to load than traditional Karelian ones. Further examples include Canadian portable frame saws, North American cross cut saws, and Canadian axes, brought in by the thousands. The Karelian state-backed Forestry Research Institute carefully measured the productivity gains granted by this machinery at so-called "model plants." Established with the arrival

[14] Skills taught included construction of derricks (lifting devices for forestry introduced by North American Finns), service and repair of axes and saws, and organizational practices on felling sites.

[15] Indeed, tractors are a textbook case of a slow-diffusion technology, even in the absence of the aforementioned human capital vintage and search frictions (Manuelli and Seshadri, 2014).

of North American Finns, the Institute regularly published research reports and manuals (Appendix Figure E.2).[16] A summary of the studies and archival documents that quantify the productivity gains of specific equipment and methods is provided in Appendix Table E.1.

Engineering assistance in the construction and operation of plants. Many Soviet Karelian factories were mechanized by machinery brought by North American Finns via their machinery fund. Specifically, they invested, imported, and supervised installation of this equipment in local factories. For example, the ski factory in Petrozavodsk, one of the largest in the Soviet Union, was mechanized by American technology. It employed some 150 North American Finns (30% of all employees), who also taught at the affiliated technical school that trained 25 to 30 local workers annually. North American Finns also participated in the construction of new industrial plants such as the Kontupohja Paper and Pulp Mill and its associated hydropower station. On-the-job training was implemented at most enterprises that recruited North Americans. Appendix Section E.1 provides further examples of the American and Canadian contributions to the so-called "Fordization" of the Soviet enterprises.

Imitation. Imitation and duplication were the primary means of enhancing the technological side of Soviet wood processing. Local mass production of North American (mainly Canadian) tools introduced by foreign workers began a few years after their arrival. The Canadian axe was first produced in 1934 at the Onegan factory in Petrozavodsk, while North American-type saw blades started being produced from 1933 onward at the Kaganovitch Steel Plant in Moscow. As policy shifted toward more autarky, it became important to erase the origin of the tools. For instance, the Caterpillar tractor was reincarnated as the *Stalinetz* (Son of Stalin), while the "Canadian" axe became the "Onegan" axe.

3 Data

This section introduces two new data sources that we combine for the purpose of this paper. The first set of records contains individual-level data on the North American Finns who were contracted to work in Soviet Karelia via Karelian Technical Aid. We use this source to measure the geography and intensity of the technical assistance program. We supplement

[16] The emergence of model plants may have been triggered by similar such stations established by the American Forest Service in the 1920s (Godfrey, 2013).

information on the settlements to which the Karelian government assigned the North American Finns with archival records containing accounting data for the population of industrial enterprises in Soviet Karelia and the Northern Region in the years before and after the Karelian Technical Aid intervention. To the best of our knowledge, we are the first to analyze systematically economic indicators of Soviet industrial enterprises in the interwar period in a panel setting.

3.1 Archives of the Settlement Administration

The individual-level records on North American Finns provide information on their basic characteristics such as surname, name, date of birth, country of outmigration, time of arrival and settlement of destination, but also individual's occupation and sometimes establishment. These records were compiled into a database comprising 6,663 North American immigrants through a linking algorithm that excludes duplicates based on harmonized names and sociodemographic characteristics across archival sources of the Settlement Administration available at the Karelian National Archive (Appendix Section D.2 describes the linking algorithm). By comparing our database to official statistics of the Settlement Administration reporting arrivals (but likely underestimating the return migration) up until the end of 1934 (n=5,411) and to the thus far most comprehensive, but self-reportedly incomplete, compilation of archival sources (n=5,557) collected by Golubev and Takala (2014), we conclude that our database must be very close to the definitive scale of American and Canadian foreign workers' presence in Soviet Karelia in the 1930s.[17]

In order to characterize the immigration to the Soviet Union, we link the individual records of the Settlement Administration to North American census records. Appendix Section D.2 describes the census linking and the resulting linked data. In total, we managed to link 1,018 foreign workers and their family members to either the 1930 U.S. Census or the 1931 Census of Canada for a match rate of roughly 15%.

[17]While the coverage of individual workers and family members is as good as complete in our dataset we lack full coverage for variables such as assigned settlement, enterprise, and occupation. To ameliorate this limitation, we complement the list of settlements identified in our individual-level records with settlements that by the archival sources of the Settlement Administration are documented to have received North American workers (Golubev and Takala, 2014).

3.2 Data on Soviet Industrial Enterprises

To evaluate the impact of Western technical assistance on Soviet industrial upgrading, we use the most disaggregated annual accounting data available centrally at the archives of the Central Statistical Administration of the USSR (known by its Russian acronym TsSU), namely statistics of industrial enterprises (*predpriyatie*). We manually extracted and digitized annual records on inputs and outputs for the universe of industrial enterprises in Karelia and the Northern Region, for which enterprise managers were mandated to provide accounts to the central government. For years 1926-1928, these data are available as comprehensive individual annual reports for each single enterprise in archival sources.[18] For the later years, large spreadsheets, available in an archive covering all Soviet enterprises, summarize annual reports (enterprise-year per row) are digitized. For 1925 and 1934, we digitized enterprise-level published statistics which is available only for these years. In total, we ascertained accounting data for roughly 2,500 enterprise-years comprising roughly 1,200 enterprises in chemical, food, forestry, leather, machinery, metal, textile, printing, wood processing, electricity, urban infrastructure, mining and beverages in Karelia and the Northern Region between years 1925 and 1938 with gaps for all enterprises in 1929-1931 and 1935-1936.[19]

After the 1917 Russian revolution Bolsheviks nationalized all major assets of industrial production. Accordingly, the state either directly owned or indirectly controlled all enterprises in our dataset. All of them operated under bigger administrative state units – most often called trusts, which in their turn, were subordinated to various Soviet local, regional and central industrial ministries. Two circumstances render our enterprise panel unbalanced. First, the Soviet government changed administrative hierarchy of the national industry many times, including mergers and splits of industrial enterprises. Second, new enterprises were established at large scale during the early five-year plans.

The information available for enterprises vary across years. For each enterprise-year, we ascertained information about each establishment's output (in 1926/27 rubles) and the number of industrial workers. Information on capital fixed assets is available for all years except 1925.

[18] In the 1920s, the Soviet business year started on October 1 and lasted until September 30 in the following year. For brevity, we refer to 1924/25, 1925/26, 1926/27 and 1927/28 as 1925, 1926, 1927, and 1928, correspondingly.

[19] The gap in existence of accounting data for 1929-1931 appears to be explained by the reorganization of TsSU and its incorporation into the different arms of the State Planning Committee (known by its Russian acronym Gosplan). As to years 1935-1936, these data do not exist in regional spreadsheet format for enterprise-years for an unknown reason. An attempt to ascertain the underlying enterprise-level data from the archival files of the Gosplan's accounting department that comprise all enterprises in Soviet Union, and categorized by industrial sector only, may in theory be feasible, although at a potentially high cost.

We also know location of most enterprises (for which we geocoded the exact coordinates), self-reported distance to closest railway and water transportation routes, subordination along administrative hierarchical lines, and birth year. Based on geocoded location, we uniquely matched the individual-level records on North American Finns to enterprise-level data. We supplement our establishment-level data with additional information on forced labor, ethnicity, human capital and political party connections. Appendix Table D.1 provides exact references to our archival sources.

3.3 Summary Statistics

Panel A of Table 1 summarizes the descriptive statistics of the North American specialist population. The data confirms the qualitative evidence by Kero (1983) and Golubev and Takala (2014) of a selective recruitment of experienced males with a particular focus on qualified loggers whose recruitment peaked in 1932. Male workers aged 15 or older were on average 36 years old upon arrival to Soviet Karelia, i.e., relatively old as compared to equivalent immigrants to the U.S. during the mass migration, who were on average 25 years old upon arrival according to the 1920 U.S. Census (Ruggles et al., 2024). Those traveling from the U.S. had typically emigrated from Finland before World War I whereas those arriving from Canada had on average spent only ten years in North America (largely reflecting entry restrictions to the U.S. after 1922).

Appendix Table A.1 summarizes the top-10 occupations to which the Settlement Administration assigned the gainful male Canadian and American workers (age 15-64) and the same occupational distribution of the population of North American gainful male workers (age 15-64) with ethnic Finnish origin (own or parents' country of birth) in the U.S. 1930 and the Canadian 1931 censuses. This descriptive evidence tells a consistent story of the Soviet Karelian Technical Aid targeting selectively experienced workers with occupation-specific expertise in fields that would benefit the development of the wood processing industry, its mechanization and the construction sector.

Panel B of Table 1 presents summary statistics of our enterprise-level panel dataset. We observe 170 establishments in Karelia and roughly 1,000 establishments in Northern Region. Three quarters of Karelian establishments in our data are located in settlements to which the foreign workers were recruited. There are no such settlements in the Northern Region as the Karelian Technical Aid exclusively recruited North American Finns to Soviet Karelia (Kero, 1983). In other aspects Karelian and Northern Region's enterprises are comparable.

On average, they do not differ in terms of age or labor productivity (as measured by output per worker). However, on average Karelian enterprises employed more workers and had more capital and were located closer to the Finnish border and to forced labor sites.

Table 1: Summary Statistics

Panel A: Soviet Karelian Settlement Administration Records

	USA		Canada		North America§	
	Mean	Obs.	Mean	Obs.	Mean	Obs.
Year of birth	1899	2,973	1903	2,077	1897	211
Share of male	0.63	3,523	0.65	2,557	0.61	583
Arrival age	32.40	2,969	28.57	2,073	34.90	198
Year of immigration to North America†	1910	649	1921	364		
(Share of lumberjacks | Male)‡	0.39	1,372	0.54	999	0.25	64
Arrival year:						
1930		66		33		8
1931		1,363		858		80
1932		1,402		1,086		304
1933		486		298		82
1934		87		106		59
1935		101		170		15

Panel B: Enterprise-level Panel Data, years 1925-1938

	Karelia		Northern Region			
	Mean	Observations	Mean	Observations		
Enterprises		170		1,014		
Share of enterprises with North American Finns	0.75	170	0	1,014		
	Karelia		Northern Region			
	Mean	Enterprise-years	Mean	Enterprise-years	Difference	S.E.
Birth year	1915	306	1919	1062	-3.88	2.76
Number of workers	296.11	463	247.14	1,980	48.98*	22.41
Output per worker (in 1926/27 in thousand rubles)	5,908.41	463	6,046.16	1,980	-137.75	463.75
Capital per worker (in nominal thousand rubles)	3,114.83	431	1,464.31	1,635	1,650.52***	352.82
Distance to forced labor camps (km)	162.33	463	276.06	1,980	-113.730***	8.46
Distance to White Sea Canal (km)	122.56	463	485.20	1,980	-362.64***	9.14
Distance to forced labor camps with illegal immigrants from Finland (km)	103.98	463	418.60	1980	-314.62***	8.87
Distance to Finnish border (km)	161.29	463	605.78	1,980	-444.49***	9.06
Distance to railways (km)	26.73	54	47.33	198	-20.59	11.92
Minimum distance to water- or railways (km)	8.96	60	16.82	249	-7.87	7.48

Notes: Statistics reported in Panel A refer to the foreign workers recruited to the USSR through the Soviet Karelian Technical Aid (see Section 2.2.2 for a detailed description of the recruitment policy). No North Americans Finns are documented to have settled outside the borders of the Autonomous Republic of Soviet Karelia. §North America refers here to immigrants whose source country is simply "North America" in the Settlement Administration records. †Data on year of immigration to North America come from the sub-sample of North American Finns from the Soviet Karelian immigration records that was successfully matched to the complete count 1930 U.S. Census or to the complete count 1931 Canadian Census. ‡Occupational statistics on share of lumberjacks refers to share male immigrants with HISCO code 63110 (see Leeuwen et al. (2002) for the historical occupational code (HISCO) classification), the basis being all male immigrants aged 14-64 for which occupation is known. Occupation is observed for 85% of all male immigrants. Statistics from Panel B summarize establishment-level panel dataset. All accounting years in this dataset until 1930 refer to the erstwhile Soviet accounting year October-October. For simplicity, we report the 1924/25 year as 1925 and similarly for all other years until 1930. The central planner switched to non-market prices after the start of the First Five-Year Plan. The Soviet enterprises, however, (along with output in current prices) continued reporting output in so-called 1926/7 fixed prices which were, if not equilibrium market prices, at least reflecting supply and demand from the corresponding year. Accordingly, in our estimates, we use these market prices for post-1928 years and adjust 1925, 1926 and 1928 prices using the industrial goods inflation index developed by Allen (1997).

While Karelia is substantially smaller than Northern Region, which comprises contemporary Arkhangelsk, Vologda and Komi regions, most socioeconomic characteristics in the 1920s, i.e., before the initiation of Karelian Technical Aid, were similar across the regions (Appendix Table A.2). Both Karelia and the Northern Region are peripheric regions far from Moscow; they were sparsely populated in the interwar period with both low degree of urbanization and low share of literacy. In 1931, 60.9% and 51.9% of the territory of Karelia and Northern Region respectively was covered by forest (SSSR, 1932b, p. 68). Panel A of Appendix Table A.3 documents balance of wood processing enterprises between Karelia and the Northern Region in terms of output, inputs, birth year and distance to transportation routs. We follow the Soviet industry classification tradition (Helle, 1926; Autio-Sarasmo, 2000) and define wood processing industry broadly to include forestry as well as all activity in which wood enters as the main intermediate input (NACE: A2, C16, C17, C18, C31). Panel B of Appendix Table A.3 reiterates this balancing test only this time with all non-treated enterprises both in the Northern Region and within Karelia in the comparison group.

3.4 Reliability of Internal Soviet Statistics

As this paper uses enterprise-level data from Stalin's Soviet Union, a discussion on data quality is warranted. Some readers will know from the interviewees' accounts in Berliner (1952) that Soviet managers were known for misreporting to the higher levels of hierarchy. However, as Bergson (1953) and many others after him have concluded (e.g., Grossman, 1960), Soviet statistics are not quite so flawed and Soviet managers did not in general resort to widespread falsification or double bookkeeping. We analyze the same set of confidential disaggregated and detailed enterprise-level records as the Soviet central government had at its disposal. There are no alternative sources of statistical records in the former Soviet archives (Gregory and Harrison, 2005).[20] The Soviet government needed reliable enterprise-level information for decision making. To this end the central government closely monitored information flows and penalized misreporting (Bergson, 1953; Markevich, 2011). Harrison (2011) shows that the distribution of detected falsifications implies limited space for constant upward-biased misreporting since such practice would accumulate fraud and thereby increasing probability of detection. Moreover, if some enterprises in our dataset were notoriously misreporting, the inclusion of enterprise-level fixed effects in our models should deal with this culture.

[20] Granular statistics may however be available in multiple sources. Our cross check of enterprise-level accounting data across two sources (Appendix Figure B.1) demonstrate striking similarity of statistics.

4 Empirical Strategy

This section outlines the empirical model that will test our central hypothesis that North American technical assistance and technology transfer had an effect on labor productivity in USSR.

4.1 Two-Way Fixed Effects Model

We explore the effect of exposure to Karelian Technical Aid – measured with the presence of North American Finns D_i – of Soviet enterprise i on its labor productivity using a two-way fixed effects model

$$y_{it} = \alpha_i + \gamma_t + \mathbf{X}_{it}'\eta + \beta(\text{POST}_t \times D_i) + \epsilon_{it}, \tag{1}$$

where y_{it} is *revenue* labor productivity measured as the enterprise's log output in 1926/7 sector-level product prices in rubles (i.e., real revenue) per industrial worker in year t, α_i represents a full set of enterprise fixed effects, γ_t stands for a full set of year dummies and X_{it} is a vector of time-varying enterprise-specific covariates that might influence labor productivity.[21] The main explanatory variable of interest is the interaction term $\text{POST}_t \times D_i$ with coefficient β. Here, POST_t is a dummy variable that takes a value equal to one for the post-1932 years, i.e., the period by which 79% of the total influx of foreign workers had arrived via the Soviet Karelian Technical Aid and D_i is a dummy variable taking a value equal to one if the enterprise was exposed to Karelian Technical Aid.

Our interest in labor productivity is motivated by the real life concerns of its low level in Soviet Karelia just like elsewhere in the Soviet Union in late 1920s, mostly due to an unskilled work force (Siegel, 1953; Efremkin, 2016). These concerns greatly contributed to the central government's support for recruitment of foreign engineers, skilled workers and consultants (Institute of Marxism and Leninism, 1984). More generally, labor productivity was believed to be the "most important national economic index" in Soviet Union (Slovar' Spravochnik, 1948).

Vector $\mathbf{X}_{it}$ includes the following controls for concurrent policies:

[21] Enterprise-level output is reported from 1932 onward in sector-level product prices fixed to 1926/27. For the years in 1920s, annual enterprise-level output is deflated using a universal index for wholesale prices of industrial goods developed by Allen (1997), which potentially masks sector-specific shocks. Since much of our analysis focuses on one industry, namely the wood processing industry, this limitation is mitigated. As to potential enterprise-specific price shocks (De Loecker and Warzynski, 2012), they are of less concern in our context at least after 1928 as annual prices for output and input in the command economy were determined by the central planner and applied universally to the whole of Soviet Union.

1. Soviet five-year plans - An interaction of a dummy taking on value one if the enterprise is located in the region of Soviet Karelia, to which the Soviet Karelian Technical Aid recruited North American experts and experienced workers and zero if located in the control region (Northern Region) with a post-1928 period dummy to allow for a difference in five-year plans targets for the treated region and the control region.

2. Forced labor - Second order polynomials of euclidean distances to location with presence of forced labor of different types – time-varying locations of headquarters operating Gulag forced labor camps (which we also interact with the post-1928 dummy to account for the change in Soviet penal policy, after which interns were used as labor input on industrial sites on a large scale (Khlevniuk, 2004)), special settlements of interned illegal unskilled migrants from Finland (who could potentially have been exploited as forced labor in the enterprises in which the North American Finns operated) – interacted with a dummy taking on value one after the relevant year (1931).

3. White Sea Canal combine - Second order polynomial of euclidean distances to the canal, which was constructed in 1931-1933 mainly by forced labor, interacted with a post-1930 dummy. This is to account for the fact that the combine also managed natural resources and industrial facilities built along the canal route (Joyce, 2003).

We also consider the following variant of equation (1)

$$y_{it} = \alpha_i + \gamma_t + \mathbf{X}_{it}^{'}\eta + \beta(\text{POST}_t \times D_i) + \theta(d_{1932} \times D_i) + \epsilon_{it}, \tag{2}$$

where d_{1932} is a dummy for year 1932. The interaction term $d_{1932} \times D_i$ works as a prespecification test that informs whether there are any differential trends in labor productivity between enterprises that did or did not receive technical assistance.

We further estimate a more flexible event-study version of equation (1) of the form

$$y_{it} = \alpha_i + \gamma_t + \mathbf{X}_{it}^{'}\eta + \sum_{t \neq 1928} \beta_t(d_t \times D_i) + \epsilon_{it}, \tag{3}$$

where the term with the summation stands for a separate coefficient for 1925 and each subsequent year (except 1928 which is the reference year) and d_t is a dummy for year t. Relative to equations (1) and (2), the model in equation (3) allows both time-varying post-treatment effects and also a more flexible investigation of whether there are any differential trends in enterprises' labor productivity by treatment status in any of the years up to 1933.

To account for potential serial correlation of the observations from the same enterprise, we adjust the standard errors by allowing for an arbitrary variance-covariance matrix within each enterprise over time. We also computed standard errors adjusted for spatial correlation using the statistical package developed by Colella et al. (2023). In practice, as we show in the main results beginning with Table 2 and in Appendix Table A.8, this adjustment does not have much effect on the standard errors and does not vary substantially across the level within which this so-called clustering is assumed to occur.

A key question is how to measure D_i, i.e., the spread of the Karelian Technical Aid program within Karelia. We consider all enterprises within the same settlement to be treated if the Settlement Administration records document the assignment of North American Finns to a settlement within 15 km radius around the enterprise (our results are robust to radius of 1km, 3km, 5km, and 30km). This assumption is made since we are able to associate substantially more foreign workers to locations than to enterprises.[22] In this sense, our definition of treatment D_i does directly measure whether North American technical assistance and technology entered as input to the specific enterprise's production process. We assume that an enterprise's production technology is exposed to the presence of North American technical assistance and technology at the location where it operated.

The key identifying assumption in estimating equations (1), (2) and (3) is that in the absence of Karelian Technical Aid, enterprises with different treatment status D_i would on average *not* have experienced differential changes in labor productivity in the post-1932 period. As it would be naïve to think that North American Finns were randomly assigned to enterprises, we pay particular attention to equations (2) and (3) that allow us to use the pre-1933 data to assess the validity of the identifying assumption by looking for differential trends prior to the North American Finns' placement to Soviet Karelian enterprises. The results below reassuringly show little evidence of such pre-existing trends, lending support to our key identifying assumption.

4.2 Exogenous Variation from Secret Police Directives

In Section 2.2.2, we document that the foreign workers were assigned to enterprises and locations by the Settlement Administration and entered the Soviet Union via enterprise-sponsored visas. This circumstance strongly limited their self-selection to specific industrial

[22] In particular for the North American Finns who were recruited to enterprises active in lumbering, it was common practice to associate them with the Karelian forestry trust *Karelles* (under which the majority of forestry enterprises in Soviet Karelia were subordinated), and only specify the settlement.

sites. However, assignment of foreign workers to enterprises could be correlated with time-varying enterprise-specific factors that are unobserved to the researchers but associated with labor productivity which would bias our estimates of β in equations (1), (2) and (3). Another potential source of bias is that we are not able to link all foreign workers included in the Settlement Administration records to Soviet enterprises due to missing information of establishment assignment, which could generate estimates of β attenuated towards zero. To address these concerns, we take advantage of a source of exogenous variation, namely the state security considerations that as such are arguably orthogonal to labor productivity.

The recruitment of workers from North America faced strong opposition from the Soviet secret police, which in 1923-1934 was called the Unified State Political Administration (known by its Russian acronym, OGPU, which we will use hereafter). However, as discussed in Section 2.2.1, leaning towards the 1930 All-Union party decision to invite foreign experts and experienced workers, the Soviet Karelian government managed to persuade the Bolshevik leadership in Moscow that the recruitment of North Americans would contribute to the economic development of the region and help to finance the First Five-Year Plan (Gelb, 1993; Takala, 2002). Despite the central government's approval, the local OGPU office in Leningrad (under which Karelian affairs were subordinated) persisted in opposing the recruitment plans and issued directives of how a potential settlement, if any, should be implemented. According to these directives no North American Finns would be allowed to settle in the proximity to the White Sea Canal construction which exploited forced labor or in the Kemi and Uhtua sub-districts due to the strategic importance of the Uhtua road and the Kemi harbor (Takala, 2002, p. 28). Even though the compliance by the Soviet Karelian government and the Settlement Administration with these OGPU directives was only partial (presumably because the directives were never formally authorized by Moscow), we exploit these directives to construct an instrument based on this source of exogenous variation in the enterprises to which North American Finns were assigned. The secret police settlement directives concern Karelia only. To extend our instrument beyond its borders, we assume that no North American Finn was ever recruited to the Northern Region.[23]

We complement our instrument derived from secret police directives with the buffer zone principle, which rejected the presence of foreigners in proximity to the foreign border throughout of Soviet Union (Kolosov and Polyan, 2009), operationalized by instrumenting D_i by the distance of the location of enterprise i from the Finnish border. While exogeneity of a firm's

[23]Karelian Technical Aid was confined only to enterprises within the Autonomous Republic of Soviet Karelia. The New York office of Intourist, Soviet Union's travel agency, handled recruitment to other parts of Soviet Union but there are no known projects in the Northern Region that would have contracted any North American technical assistance (Sutton, 1971).

location to its country's border may be contestable (in almost any context), the buffer zone policy's relevance and its documented orthogonality to many economic factors (Appendix Table A.5) is likely to rid some endogeneity from the β when used as an instrument for D_i. As in the case of the secret police instrument, we construct a buffer zone instrument by measuring the distance from the Finnish border for Karelian enterprises only (assuming in practice that all enterprises in the Northern region belonged to this buffer zone, i.e., attaining value zero).

5 Results

This section presents the empirical analysis of the effects of North American technical assistance and technology transfer on labor productivity in the interwar USSR. We exploit the variation in assignment of North American experts and technology to enterprises and in the labor productivity of Soviet enterprises between 1925 and 1938.

5.1 Two-Way Fixed Effects Results

Table 2 presents the two-way fixed-effects (TWFE) results for the full sample of 1,184 enterprises and the sample of 384 wood processing enterprises located in Soviet Karelia or the Northern Region. Column 1 suggests that North American technical assistance and technology transfer had a statistically significant effect on labor productivity in the treated enterprises. Taken at face value, the estimate of the key parameter β implies that on average, North American skilled workers and technology increased enterprises' labor productivity by roughly 28 log points. Column 2 investigates whether any differential growth in labor productivity between treated enterprises and control enterprises was present in 1932 before Karelian Technical Aid gained full momentum. The estimate of the key parameter β changes sign and is no longer significant whereas the coefficient θ on the interaction between the 1932 dummy and the assignment of North American skilled workers ($d_{1932} \times D_i$) is negative and significant, suggesting differential pretrends (perhaps due to the preferential status of foreign workers, discussed in Section 2.2.2, which is known to have generated ethnic tensions at the outset of the program (Kero, 1983)). Essentially, relative to 1925-1928 (we do not observe years 1929-1931) 1932 appears to have been a bad year for enterprises that were assigned North American Finns. However, when turning in columns 3-6 to the sub-sample of enterprises active in the wood processing industry, we find a statistically significant 62%

increase in labor productivity in treated enterprises (column 3).[24] This effect is robust to our prespecification test (column 4), which reassuringly shows no detectable differential pre-trends between treated and control enterprises: the coefficient of θ is small in magnitude and insignificant.

Table 2: Average Impact of Western Technology on Labor Productivity: Evidence from Karelian Technical Aid

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: log(Labor productivity)$_{it}$					
	Full sample		Wood processing			
POST$_t \times D_i$	0.277***	-0.357	0.480***	0.628***	0.426***	0.495**
	(0.097)	(0.284)	(0.151)	(0.230)	(0.147)	(0.234)
	[0.059]	[0.291]	[0.203]	[0.216]	[0.159]	[0.144]
$d_{1932} \times D_i$		-0.731**		0.180		0.0813
		(0.299)		(0.254)		(0.258)
		[0.324]		[0.106]		[0.143]
log(Capital per worker)$_{it}$					0.193***	0.192***
					(0.054)	(0.054)
					[0.031]	[0.032]
Observations	2,443	2,443	971	971	915	915
Number of enterprises	1,184	1,184	384	384	371	371

Notes: The dependent variable is log of output per worker in 1926/7 prices in rubles. The table reports results from estimating eqs. (1)-(2) by ordinary least squares (OLS). All regressions include enterprise and year fixed effects. The data cover years 1925-1938. POST is an indicator variable for the years 1933–38. The variable d_t is an indicator variable for year t. The variable D_i is a dummy for the presence of North American Finns in the settlement in which enterprise i is located in year 1933. Included time varying controls within enterprises are: An interaction of a dummy taking on value one if the enterprise is located in the region of Soviet Karelia and zero otherwise with a post-Five-year-plans period dummy; a polynomial of distance to forced labor camps and its interaction with a post-1928 indicator; a polynomial of distance to the White Sea Canal interacted with a post-construction year (year 1930) indicator; and a polynomial of distance to Finnish settlements interacted with a post-treatment year (year 1931) indicator. Standard errors (in parentheses) are clustered at the enterprise level and Conley standard errors [in brackets] adjust for two-dimensional spatial dependence using 250 km as cutoff threshold. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In columns 5 and 6 of Table 2 we document that our findings of a positive treatment effect for the wood processing industry are robust to controlling for capital investments. Because the value capital assets is missing for 56 observations we lose roughly 6% of the observations in

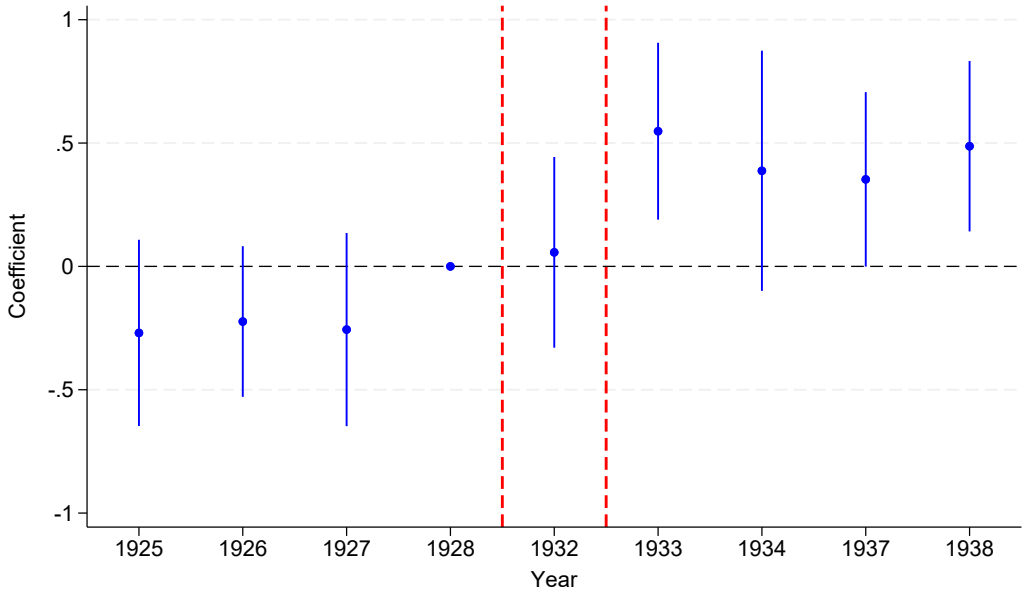
[24] Obtained by exponentiating the estimate for interpretation of the results as percentage changes ($100 \times (\exp(\hat{\beta}) - 1)$).

these two regressions. Once we account for capital assets per industrial worker, the coefficient β in column (5) becomes 10% smaller (relative to column 3). This is as expected because our measure of capital assets incorporates the machines and equipment purchased through the North American Finns' machinery fund.

Figure 3 reports the TWFE event-study coefficients for each calendar year, relative to 1928. The coefficient for year 1928 is normalized to zero. This allows a further investigation of the identifying assumption as well as an examination of the timing and persistence of the labor productivity response to Karelian Technical Aid. The results indicate that relative to their 1928 labor productivity, enterprises that were assigned North American Finns in 1931-1933 did not experience a significant change in labor productivity in the years before receiving this technical assistance relative to enterprises that did not receive any technical assistance. The large differences in labor productivity between treated enterprises and untreated enterprises materialize from 1933 onward, i.e., after the placement of North American Finns, with the annual point estimates being statistically significant at the 10% level. Given that pretrend estimates are neither individually or jointly statistically different from zero, we are tempted to interpret our event-study results as causal evidence in support of the North American technical assistance and technology transfer increasing enterprises' labor productivity in the Soviet Karelian wood processing industry. Replacing the discrete definition of treatment with total number of North American workers observed in enterprises' location, we observe a similar pattern in the continuous treatment TWFE event study results (Appendix Figure B.2).

Reassuringly, Figure 1 demonstrates an increase in raw averages of labor productivity in both treated and control enterprises during the second half of the period under study. Compared to the largely stagnant trend in the 1920s, both groups of enterprises substantially increased average output per industrial worker by the end of the 1930s, but in control enterprises this boost was delayed and remained on a slower growth path. This pattern provides little evidence of treated enterprises crowding out resources from non-treated enterprises in wood processing industry in Soviet Karelia in the 1930s. Note however the decline in average labor productivity in non-treated wood processing enterprises in 1934 which does not allow us to exclude short-term crowding out across wood processing enterprises in the initial phase of Karelian Technical Aid.

Figure 3: TWFE Event-Study Estimates of Western Technology on Labor Productivity in Wood Processing Industry



Notes: The figure plots TWFE event-study annual coefficients (relative to 1928) and their 90% confidence intervals from the regression of estimating eq. (3) with a dummy for the presence of North American Finns in the settlement in which enterprise i is located in year 1933 (D_i) interacted with year dummies (d_t) for the wood processing industry sample (n=971). The two dashed red vertical lines mark the interval years (1931-1932) during which the bulk of North American Finns arrived in Soviet Karelia (Table 1). The dependent variable is log of output per industrial worker in 1926/27 prices in rubles. The regression includes enterprise and year fixed effects. For additional time-varying enterprise-level control variables included in the regression, see table notes of Table 2. All standard errors are clustered at the enterprise level. p-value for chi-squared test of joint significance of $\hat{\beta}_{1925} = ... = \hat{\beta}_{1932} = 0$ is 0.31. See Column 2 of Table A.4 for the corresponding parameter estimates and standard errors.

To further exclude potential cross-industry crowding out, Appendix Figure B.3 compares trends of raw averages of labor productivity of Karelian enterprises excluding wood-processing industry with All-Union industrial labor productivity series, constructed from published and declassified archival materials, which serves as a rough benchmark for the productivity trend outside of wood processing in Karelia.[25] For salience, we include in the figure the trend of raw average labor productivity in Karelian wood processing enterprises. Appendix Figure B.3 shows little evidence of a crowding-out effect in Karelia at the industry level over the interwar period. Average labor productivity in other Karelian industries followed a declining

[25]Data limitations prevent us from excluding either Karelia or wood processing industry from the All-Union aggregate data. Their influence is nevertheless modest as Karelian industrial workers account for less than one percent of All-Union industrial labor force, and wood processing industry accounted for roughly 19% of industrial workers in the Soviet Union in 1936 (TsUNKhU, 1936).

trend before 1933 and improved dramatically thereafter. These dynamics and the observed levels are mostly in line with the dynamics and corresponding levels of labor productivity in the Soviet industry as whole, especially after the start of Stalin's industrialization in 1928. Labor productivity in Soviet industry decreased during the first Five-Year Plan (1928-1932) and rapidly increased after that. However, the difference in labor productivity between Karelian non-wood-processing industry and Soviet industry as a whole in the first postintervention year (1933) may indicate short-term crowding out of Karelian enterprises outside wood processing industry initially as foreign workers started to arrive (e.g., preferential treatment of foreign workers may have required temporal redistribution of consumption away from local workers in non-treated industries). In the full sample, as was shown in column 2 of Table 2, the imprecisely estimated negative treatment effect may be telling the same story about some cross-industry crowding out. Our TWFE event study results for the full sample (Appendix Figure B.4), suggest that, if anything, this crowding out was short lived and relative to Northern Region labor productivity recovered during our study period. Alternatively, one might read these results as confirmation of earlier anecdotal evidence of adjustment problems (Autio-Sarasmo, 2000). Relative the Northern Region, the event-study results suggest a catch-up toward the second half of the 1930s.

5.2 Instrumental-Variable Results

Thus far, our TWFE results tell a fairly consistent story of a large positive causal effect of the North American technical assistance and technology transfer on the labor productivity in the Soviet Karelian wood processing industry. We do however note that the point estimate of our treatment variable is roughly 30% larger in column 4 as compared to column 3 of Table 2, which suggests that time-varying enterprise-specific unobserved factors may be confounding our baseline TWFE estimates. We proceed to report our instrumental variable estimations that exploit secret police directives and buffer zone policy as exogenous variation in the assignment of North American Finns to enterprises. Our parameter of interest in the second stage is no longer β_{it}^{TWFE} in equation (1) but rather β_{it}^{IV}, estimated by two-stage least squares (2SLS).

Column 1 of Panel A in Table 3 reports the (2SLS) estimate of β_{it}^{IV} to be marginally significant (10% level) and implies a roughly 98% increase in labor productivity of the presence of North American workers in the enterprise. Further in Panel A, column 2 adds supportive evidence by using the buffer zone instrument for the assignment of North American technical assistance, motivated by the corresponding Soviet policy, and column 3 reports results from a

2SLS regression that includes both proposed instruments in the first-stage regression. Taken together, our estimates of β_{it}^{IV} document rather stable effects that are roughly 30% larger than our estimates of β_{it}^{TWFE}, suggesting that downward bias in our benchmark estimates likely due to both measurement error and negative selection bias.

The first stage of the instrumental-variables approach, reported in Panel B of Table 3 documents strong instrument relevance. The Kleibergen-Paap F-test statistic in column 3 eliminates at 44.4 concerns of weak instrument bias.

The reduced-form relationship between our instrument based on secret police directives of settlement and labor productivity is negative and statistically significant at 1% level, the coefficient (standard error) of interest is -0.446 (0.227). The reduced-form relationship between the buffer zone instrument and labor productivity is positive and statistically significant at 1% level, the coefficient (standard error) of interest is 0.096 (0.031). To address the concern that our instruments might have a direct effect on labor productivity, we show correlations between the instruments and a range of enterprise-level variables from the 1920s in Panel A Table A.5. By 1928, enterprises which were affected by the secret police directives are not more capital intensive, larger, older, closer to railways or closer to any transportation routs (water- or railways, whichever is closer). These results are reproduced in the wood processing industry sub-sample in the second part of Panel A Table A.5. As for our buffer zone instrument (Panel B), we find that enterprises located further away from the border are more capital intensive. A caveat when interpreting the results of this test is that our sample size is small and the estimates are imprecise. They serve though the purpose to suggest that enterprises' labor productivity was not part of the secret police's objective function when issuing its directives. It also seems that distance to the border in many respects was orthogonal to factors affecting labor productivity.

Finally, a discussion on causality of our estimates is warranted. The extent to which it is even meaningful to think of an RCT as the ideal design to approximate as closely as possible is debatable in quantifying efficacy of industrial policy (Juhász et al., 2024a; Giorcelli and Li, 2021; Lane, 2025). Our estimate of β of our main estimating equation (1) identifies the average treatment effect on the treated (ATT), which is particularly policy relevant in our context. Karelian Technical Aid was in the first place intended to ameliorate the skill shortage and acute productivity deficiencies of the enterprises that it targeted. In the recruitment of foreign experts, Karelian leaders were strategically promoting a specific industry and, within it, likely placed foreign workers with precision to enterprises that were expected to capitalize on new knowledge. Causal analysis in such a context of heterogeneous treatment effects

(Heckman et al., 2006), calls for a design that would allow for the estimation of local average treatment effects. However, Heckman et al. (1998) show, as Lane (2025) has recently pointed out in the context of sectoral industrial policy, that if selection on enterprises' expected responses remains constant over time, then common trends assumption will, if being satisfied, allow for placing a causal interpretation on the difference-in-difference estimator. We find it unlikely that, in a relatively rigidly planned context, selection on expected responses would have changed over time, but cannot fully exclude Karelian policymakers' updating of priors.

Table 3: IV Estimates of the Effect of Western Technology on Labor Productivity

	(1)	(2)	(3)
Panel A: Second-stage regressions			
	Dependent variable: log(Labor productivity)$_{it}$		
POST$_t \times D_i$	0.644*	0.693***	0.683***
	(0.389)	(0.231)	(0.243)
	[0.282]	[0.212]	[0.201]
	[[-0.082; 1.443]]	[[0.254; 1.137]]	
Observations	971	971	971
Number of enterprises	384	384	384
Panel B: First-stage regressions			
	Dependent variable: POST$_t \times$ D_i		
POST$_t \times$ Secret police directives$_i$	-0.692***		-0.280*
	(0.111)		(0.160)
	[0.155]		[0.145]
POST$_t \times$ Buffer zone$_i$		0.139***	0.118***
		(0.018)	(0.024)
		[0.025]	[0.023]
Observations	971	971	971
Number of enterprises	384	384	384
Kleibergen-Paap F-statistic	39.22	58.16	44.36

Notes: The dependent variable is log of output per worker in 1926/27 prices in rubles. The table reports results from estimating eq. (1) by two-stage least squares (2SLS) for the sub-sample of enterprises operating in the wood processing industry. The data cover years 1925-1938. All regressions include enterprise and year fixed effects. POST is an indicator variable for the years 1933–38. The variable D_i is a dummy for the presence of North American Finns in the settlement in which enterprise i is located in year 1933. For additional time-varying enterprise-level control variables included in the first and the second-stage regressions, see tabled notes of Table 2. Standard errors (in parentheses) are clustered at the enterprise level and Conley standard errors [in brackets] adjust for two-dimensional spatial dependence using 250 km as cutoff threshold. Confidence intervals in double brackets report the VtF 95% confidence intervals (Lee et al., 2023). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

How do the productivity gains of Karelian Technical Aid compare to similar policies? Our ATT estimates appear larger relative to findings in other studies quantifying effects of industrial policy. Giorcelli and Li (2021) study a similar-minded state-led intervention to transfer technology and know how from Soviet Union to the Peoples Republic of China, though in the context of heavy steel industry and roughly ten times larger units than the enterprises in our data; the authors find a total factor productivity increase of 15% six years after the initiation of the transfer (and larger effects in the long run). In a recent paper, Lane (2025) finds that for the 1970s Korean state-led heavy industry drive that combined investment incentives with trade policy, labor productivity increased by roughly 15% in treated industries, the effects materializing in roughly five years. The order of magnitude found in our context is also notably larger as compared to typical average treatment effects (5-10%) found in experiments on worker training on firm performance in the contemporary development context (McKenzie, 2021). In the higher end are two recent experimental studies by Bloom et al. (2013) and Iacovone et al. (2022) evaluating extensive management training to find effects of roughly 10-17 percentage points for total factor productivity and labor productivity. Like ours, the context in both studies is small- and medium sized firms.

Our estimated effect is likely larger due to several factors. As to the intervention itself, the Soviet practice of signing relatively long (two-year) contracts with foreign specialists and their deployment in enterprises' operations alongside group training could be crucial. The simultaneous transfer of technical equipment could be equally important. Our anecdotal evidence put forth in Section 2 also suggests that baseline productivity in Karelian forestry was very low relative to the source country of the technical assistance (this discrepancy was likely larger in Karelia than in the two aforementioned training experiments) and hence the scope for improvement was large. Indeed, in the 1920s, the wood processing industry (i.e., lumber and wood products, furniture and fixtures, paper and allied products) at the technological frontier of the U.S. experienced the highest TFP growth relative to other periods of national history in the last century, with average annual rates between 2.5% and 4.5% (Field, 2011). In contrast, having already lagged behind before, the Soviet economy collapsed during the Civil War and managed to recover only to the 1913 level by 1928 (Markevich and Harrison, 2011). Soviet officials illustrate this productivity gap in the late 1920s with a reference to the share of kiln-dried lumber in Soviet Union (1%) as compared to the West (more than 60%) (Sutton, 1968, p. 160). Moreover, at the outset of the First Five-Year plans, Karelia was not a national timber champion; labor productivity in the wood processing industry was reportedly 89% of the All-Union average in 1925 (SSSR, 1927a,b). Further, studies conducted at Karelian research stations show as much as manyfold

productivity gains of methods and inputs introduced by North American Finns (Appendix Table E.1).

5.3 Robustness

Our main finding of a large statistically significant positive effect of North American technical assistance and technology transfer on labor productivity in the wood processing industry have thus far been shown to be robust to our prespecification tests and across both TWFE and IV estimation strategies. We show next that they remain robust to a variety of modifications of the baseline specification and sample restrictions. Appendix Table A.6 documents in a continuous difference-in-differences design that the main result remain robust to marginal changes in treatment rather than discrete ones.[26] Appendix Table B.2 confirms these results in an event-study design and Table A.7 confirms these findings using our IV strategy. Further, Appendix Table A.8 demonstrates that our results stay resilient to a linear functional form, the exclusion of controls, alternative approaches to cluster standard errors, the choice of radius length used to define geographical reach of exposure, regional and enterprise size sample restrictions. The magnitude of the coefficient of interest is remarkably stable. Panel A of Appendix Table A.8 shows that excluding all control variables for concurrent policies, the treatment effect becomes 40% smaller than in the baseline specification. This is likely explained by failing to account for the forced labor, which use was concealed from the sight of foreign experts and abstracted from in official statistics. Panel D shows reassuringly that our results are not affected by excluding the peripheral parts of the control region, i.e., the Northern Region. Panel E shows that excluding non-treated enterprises located inside the borders of Karelia slightly bolsters the coefficient of interest which is rationalized by the presence of technology spillovers. Lastly, we estimate effects on total factor productivity (TFP). Appendix Table A.9 finds a positive effect of the American technical assistance and technology transfer on log industrial output in the TWFE design, controlling for labor and capital inputs (also in logs). Unfortunately, we do not have information on intermediate inputs, such as materials or fuel, to implement more sophisticated TFP estimation methods.

[26] Continuous treatment difference-in-difference designs require a stronger parallel-trends assumption to rule out selection bias (Callaway et al., 2024).

5.4 Drivers of Firm-Level Upgrading

The results in the previous subsections show that the effects on enterprises' labor productivity of Western technical assistance in the wood processing industry were substantial. As the size of the work force in Soviet Karelia in this industry comprised at baseline in 1932 roughly 64,000 individuals and was rapidly growing, the North American experienced workers accounted for at most 8% of the number of employees. It is therefore clear that the substantial increase in labor productivity induced by the North American experts and its persistence after their departure could not be explained by a local-foreign worker productivity differential. Rather, our reading of the results is that the technical assistance was successful at training the local work force, mechanizing processes and implementing organizational practices. This section examines more in-depth potential drivers behind the causal effect of Karelian Technical Aid.

5.4.1 Human Capital

Human capital in the receiving population is an understudied driver when it comes to the study of state-led industrial policy. To our knowledge, only Giorcelli and Li (2021) uncovers the role that receiving units' own ex-post training plays for the persistence of the productivity effect of foreign technology acquisition. In our context, given that the gains from technical assistance materialized quickly, the relevant question to ask is whether these gains were amplified by the baseline human capital in the receiving enterprises. Given the low literacy rate in the Soviet Union, which was below 50% in both Karelia and Northern region in 1926, we focus on heterogeneity in literacy at the sub-district level, collected from the population census, as a proxy for the level of local human capital.

Column 1 of Table 4 reports the results of a triple-difference estimator that interacts the treatment term ($\text{POST}_t \times D_i$) with the demeaned (i.e., deducting the sample mean) share of literates within the sub-district r in which the enterprise operates, Literacy_r. In order to place a causal interpretation on the coefficient of this triple-difference term, one would need to assume that no other factors than Literacy_r generates a difference in differential trends in enterprises' labor productivity. The coefficient is positive and statistically significant at the 5% level, suggesting that the labor productivity gains from receiving high-skilled North American workers were larger in locations with more human capital. A one standard deviation increase in the local pretreatment literacy rate (0.11) augments the treatment effect by 0.34 (0.11×3.084) log points. This amplifies the efficacy of Karelian Technical

aid for the enterprise located in the subdistrict with the 1926 literacy rate one standard deviation above the sample mean (0.55 for the wood processing sample) to a 94% increase in labor productivity ($100 \times \exp((0.326 + 0.34) - 1)$). The effect of technical assistance and technology transfer for the enterprise with the sample mean 1926 literacy rate is 39% ($100 \times (\exp(0.326) - 1)$).

5.4.2 Language Barriers

A recent literature points towards a key obstacle in foreign technology acquisition, namely the importance of instruction in conveying the tacit knowledge crucial for the adaptation of new technology (Giorcelli, 2019; Giorcelli and Li, 2021; Juhász et al., 2024b). A recent experimental study on contemporary multinationals documents that language barriers hinder communication between the (foreign) top and (native) middle management layers and that reducing these barriers increases communication (Guillouët et al., 2024).

Even though our context of small and medium-sized wood processing enterprises (with on average 300 workers), is more hands-on than complex multinational organizations, the introduction of new technology, organizational change and new practices requires unhindered communication. The North American skilled workers were native in Finnish language but had no or limited knowledge of Russian (or literacy in Cyrillic alphabet for that matter). As discussed in Section 2.1, the native population in Soviet Karelia was almost equally divided between Russians (57.2% in 1926), and Finno-Ugric peoples (37.4% Karelians, 3.2% Veps, and 0.9% Finns). Even though the Karelian leadership promoted bilingual (standard literary Finnish and Russian) education few ethnic Russian residents had yet acquired Finnish proficiency by the early 1930s whereas Karelians and speakers of other Finno-Ugric languages could communicate with North American Finns. Given this ethno-cultural setting, we hypothesize that the productivity gains from receiving technical assistance are bigger in sub-districts with a greater proficiency in Finno-Ugric languages. Column 2 of Table 4 reports the results of a triple-difference estimator that interacts the treatment term with the sub-district share of Finno-Ugric speakers (in contrast to Literacy, we do not demean the share of Finno-Ugric speakers as the share is zero for many sub-districts in our data). We find that the coefficient of our triple-difference term is positive but imprecise and small. Ethic Finns, Karelians and Veps are a heterogeneous triple of peoples (56.2% of all Finns but only 22.4% of all Karelians and 28.7% of all Veps were literate, according to the 1926 census, which reports literacy by ethnicity only for all citizens, i.e. including preschoolers, and only for the whole republic), we therefore disentangle language from human capital by including

both triple-interactions in the same model (column 3). Here, larger local share of speakers of a Finno-Ugric language, and hence lower language barriers, amplify local enterprises' labor productivity gains from the technical assistance. A one standard deviation increase in the local pretreatment share of Finno-Ugric speakers (0.21) augments the treatment effect by 0.23 (0.21×1.078) log points. Further, as the coefficient on the double interaction in column 3 shows, the effect of Karelian Technical aid for the enterprise from a districts with no Finno-Ugric speakers and sample mean 1926 literacy rate is statistically and economically zero. To confirm these results, we extend the triple-difference estimator with an extra contrast and report the results of this quadruple-difference estimator in column 4. As expected the coefficient of the quadruple-difference term is positive and marginally significant. Taken together, our evidence suggests that communication is important for the transmission of know-how and supports the hypothesis that removing language barriers increase the gains of foreign technical assistance.

5.4.3 Political Connections

We further explore the role of political connections. Using enterprise-level data on the share of party members (members of the Soviet Communist Party over total number of workers), we explore the role of enterprises' political connections for the impact of the technical assistance. In the average enterprise, roughly 15% of the workers were party members. More politically connected enterprises could potentially have exploited these connections to leverage the technical assistance policy, e.g., by attracting additional unobserved resources or advantages. Unfortunately, we observe these unusually detailed statistics only for a part of Karelian enterprises and for one year, namely 1932. Column 5 of Table 4 tests for the proposed concern by estimating a triple-difference estimator that interacts the treatment term with the demeaned (i.e., deducting the 1932 non-missing sample average) enterprise's share of party members. We do not find evidence of political connections playing a role for the gains of technical assistance (the coefficient on the main interaction of interest remains stable in magnitude while imprecisely estimated). Another way to read the results is that they present evidence against one of the most loud critiques of industrial policy, namely the concern about *political capture* (Juhász et al., 2024a). Specifically, the concern in our context is that more politically connected enterprises may have been more able to lobby the Settlement Administration to assign them North American skilled workers. Even though proven to be productivity enhancing, the industrial policy may not be socially optimal if self-interest of politically connected managers and politicians colluded to influence the assignment of the technical assistance.

5.4.4 Ideology

Understanding the incentives of the North American workers taking recruitment in Soviet Karelia is important for the predictive value of our results. Karelian Technical Aid was promoted in Finnish language socialist newspapers and workers' assembly halls throughout North America and is likely to have attracted left-leaning unionized workers. The current consensus by historians is though that only a small fraction (roughly 15%) of the participants chose to take recruitment via the Karelian Technical Aid for political reasons (Takala, 2004). Historical research concludes that mainly economic and cultural forces were pushing North American Finns to this decision (Efremkin, 2011). Employment in regions, such as the Great Lakes, home to the largest Finnish communities, and in industries such as lumber industry, in which Finnish immigrants were overrepresented, decreased particularly much during the Great Depression (Wallis, 1989).

We run earnings regressions in the population of ethnic Finns in the Canadian Census of 1931 which was matched to the Karelian Settlement Administration records to identify all Karelian Technical Aid participants. The advantage of the 1931 Canadian Census (as compared to the 1930 U.S. Census) is that annual earnings (earnings in the past 12 months) is recorded at the individual level as opposed to imputed occupational averages, allowing for including occupation fixed effects in earnings regressions. Appendix Table A.10 shows that the Canadian Finns who chose to participate in the Soviet Karelian Technical Aid earned roughly 18% less than their within-industry ethnic Finnish counterparts.[27] While we cannot exclude the possibility that leavers' earnings would have been depressed in Canada due to ideological labor market discrimination, our reading of these results is that participating in the program had an economic rationale.

We turn to the U.S. for data on socialist political activity. Kostiainen (1978) presents state-level statistics on membership in the Finnish branches of the two main socialist parties in the U.S. of the 1920s, i.e., the Socialist Party of America (in 1917) and the Workers Party of America (in 1923). He relates the number of members in each organization to the number of individuals born in Finland per state in the 1920 U.S. Census. Figure E.1 compares these measures of socialist party activity among ethnic Finns with the state-level share of matched Karelian Technical Aid participants among the Finnish population in the 1930 Census (authors' own calculation). The histograms do not overlap particularly well,

[27] We confirm by re-running the same exercise as presented in Table A.10 using imputed occupational median income (OCCSCORE) for both the U.S. and Canada, that this earnings differential between emigrants to Soviet Karelia and their left-behind ethnic counterparts is driven by within-industry or even within-occupation earnings variation. These results are available from the authors.

suggesting the leavers were not overrepresented in states with a larger share of socialist party members in the local Finnish population.

Taken together, our evidence on drivers of firm-level upgrading shows that human capital among the receiving population and language proficiency in the language spoken by the foreign specialists, or put differently low communication barriers, both increase the productivity gains from foreign technical assistance.

Table 4: Drivers of Firm-Level Upgrading: Triple-Difference Estimates

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: $\log(\text{Labor productivity})_{it}$				
$\text{POST}_t \times D_i$	0.326**	0.421**	-0.0161	-0.0659	0.535
	(0.142)	(0.190)	(0.186)	(0.183)	(0.417)
	[0.159]	[0.185]	[0.093]	[0.122]	[0.226]
$\text{POST}_t \times D_i \times \text{Literacy}_r$	3.084*		4.853***	3.803*	
	(1.598)		(1.780)	(1.972)	
	[1.054]		[1.274]	[1.059]	
$\text{POST}_t \times D_i \times$ Finns & Karelian speakers pc_r		0.141	1.078*	2.566**	
		(0.712)	(0.617)	(1.004)	
		[0.662]	[0.477]	[0.392]	
$\text{POST}_t \times D_i \times$ Finns & Karelian speakers $\text{pc}_r \times \text{Literacy}_r$				36.78*	
				(18.947)	
				[8.764]	
$\text{POST}_t \times D_i \times$ Party penetration $(\text{members/enterprise})_i$					-1.753
					(2.112)
					[1.384]
Observations	971	971	971	971	107

Notes: The dependent variable is log of output per worker in 1926/7 prices in rubles. The table reports results from estimating eq. (1) adjusted with additional triple and quadruple interactions as discussed in the text by ordinary least squares (OLS) for the sub-sample of firms operating in the wood processing industry. All regressions include enterprise and year fixed effects. POST is an indicator variable for the years 1933–38. The variable D_i is a dummy for the presence of North American Finns in the settlement in which enterprise i is located in year 1933. The following variables are measured in the 1926 census at the sub-district level r: Literacy_r, which measures the demeaned share of literates, and Finns & Karelian speakers pc_r, which tellingly measures the share of ethnic Finns, Karelians and Veps. Party penetration (members/enterprise) measures at the enterprise level i the demeaned share of party members per workers on January 1, 1932. All (triple- and quadruple difference) models are fully saturated, coefficient estimates for the complete set of interactions are available from the authors. For additional time varying controls within enterprises, see the table notes of Table 2. Standard errors (in parentheses) are clustered at the enterprise level and Conley standard errors [in brackets] adjust for two-dimensional spatial dependence using 250 km as cutoff threshold. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

6 Discussion

6.1 Cost-Benefit Analysis

Productivity enhancing know-how and leading technology are almost without exception desirable to enterprises, but when acquired at market prices from foreign companies, as in the Karelian instance, the cost of these must be weighed against future profit gains. Using our estimates of the effect of the Karelian Technical Aid on labor productivity, we evaluate the cost-benefit of the program against a counterfactual scenario of no North American presence in Soviet Karelia in the early 1930s. We compare actual and counterfactual Karelian output and personnel costs in wood processing industry. Appendix Section C provides the details behind our back-of-the-envelope calculations. We find that, in the absence of North American Finns, holding capital and other inputs constant, output in the wood processing industry would be smaller by more than one third. This foregone output would only partly be compensated by lower personnel costs (18.5%). Hence, the Karelian Technical Aid was an efficacious industrial policy in the sense that it upgraded Karelian wood processing enterprises and generated substantial profit for the Soviet government (counterfactual surplus, defined as revenue from sales minus personnel costs, would be almost eighty percent smaller). We show that the policy would remain profitable even at 3.8 times higher foreign workers' wages. Interestingly, our back-of-the-envelope estimates also suggest that the Soviets compensated North American workers at competitive wages as converted to the source country's currency, which is consistent with our findings on economic motivation for the migration from North America to the Soviet Union.

6.2 Managerial Incentives

An aspect that warrants consideration in a paper that deals with enterprises in a command economy is the question of managers' objectives, i.e., do managers want to maximize profit? To be fair, this question extends to entrepreneurship in developing countries more generally and the evidence on the matter is thus far scarce (Kremer et al., 2019; Verhoogen, 2023). The pioneering work on management of Soviet enterprise by Berliner (1957) and Gerschenkron (1962) shows how managers of enterprises under the Soviet planning system were forced to operate an informal system behind the static formal one to literally keep the wheels rolling. We acknowledge this principal-agent problem which post-1991 archival work documents to

have prevailed as early as from the first days of the command economy (Gregory and Harrison, 2005).

However, three circumstances suggest that managers responded to financial incentives. First, in many industries the middle-management and foremen were paid piece rate (Schwarz, 1952). Specifically, the emerging Karelian cadre of foremen in wood processing industry who were trained in North American techniques were paid at piece rate, e.g., by cubic meter of timber (Kero, 1983).[28] Second, the fulfillment of targets entitled workers to bonuses and inputs were temporarily fixed as planned, leaving managers with labor productivity as a more viable parameter to optimize in the short run (Berliner, 1957). If the local management of treated enterprises had better skills to lobby and bargain with the central planner or had better informal connections, a concern would be that the plans themselves could have been manipulated. We do not find statistical difference in political connections between treated and non-treated wood processing enterprises (Table 4).[29] Third, even though no anomalies in planned targets were discerned, managers may have acted on the assumption that the short term priority was to meet output targets instead of adhering to quality standards. However, as much political capital was invested in Karelian Technical Aid both by the central government and the local Karelian leadership it was a well monitored intervention by all levels of government. Output of many Karelian enterprises played a key role for export and acquisition of foreign currency (Autio-Sarasmo, 2000). If quality vs. quantity manipulation had been particularly prevalent among foreign experts, it would have soon been detected through complaints by foreign buyers.

6.3 Concluding Remarks

This study shows that Western technical assistance and technology transfer causally increased labor productivity in the wood processing industry during the Soviet Union's interwar industrialization drive. Specifically, our sectoral design isolates the effect for treated enterprises within one region. In this concluding section, we discuss the extent to which our results have predictive value more generally.

Thanks to Karelian Technical Aid, the scale at which foreign experts were recruited to the Soviet Union was largest in Soviet Karelia. Yet, when comparing the share (roughly 4%)

[28] Piece rates were topped up with bonuses for fulfillment of the norm including a particular progressive booster on all output that exceeded the norm (Tonkel, 1932).

[29] Fulfillment of production targets and the exposure to Karelian Technical Aid are also not correlated in 1938, the only year, for which we observe production targets at the enterprise level (the regression results are available from the authors upon request).

of North American specialists deployed in Karelian industrial projects with that in other industrial projects elsewhere in the Soviet Union, the numbers are fairly comparable. For example, the Stalingrad tractor plant, a flagship project, employed one American foreman for every 20 to 30 Russian workers (Dalrymple, 1966). While we cannot directly extrapolate our results to Western technical assistance outside the Soviet wood processing industry, we can speculate about long-term union-wide within-sector gains through successful diffusion of what colloquially became known as "North American methods."[30] In an economy reliant on foreign innovation, the extent and speed at which the economy adjusts to new technology is crucial. Studies in other contexts characterized by similar spatial frictions suggests that new knowledge takes many years to diffuse (Kantor and Whalley, 2019). While the Soviet Union was relatively good at distributing information on foreign techniques, it was notoriously slow at adjusting equipment and input materials to these new ideas (Sutton, 1973). If applicable to Karelian Technical Aid, persistently lower labor productivity growth in wood processing industry in the control region after the intervention is thus likely due to a lack of necessary inputs as opposed to information flows. In the long term, scaling up domestic production of equipment through copying could have reduced these institutional barriers. We observe that, in 1959, labor productivity in the Karelian wood-processing industry was on par with that of two of three successor provinces of former Northern Region, namely Arkhangelsk and Vologda (Kessler and Markevich, 2020). In the republic of Komi, the most remote province of former Northern Region seen from Karelia, labor productivity was still lagging behind, being one third lower than in Karelia. We take this as suggestive evidence of a diffusion process with spatial frictions.

Broadly, the Stalinist development strategy of aggressive emphasis on heavy industry and large industrial projects at the expense of the agricultural sector was arguably ill-suited to the country's comparative advantages. Even positive evaluations of Stalin's industrialization drive such as Allen (2003) highlight failures to modernize agriculture, which contributed to excess mortality in the millions during the 1932-1933 famine (Naumenko, 2021; Markevich et al., 2024). Nonetheless, certain components of the policies adopted during Soviet industrialization deserve closer scrutiny. As the case of Karelian Technical Aid demonstrates, exploiting Western technical assistance and technology generated rapid economic improvement.

Many of the world's largest countries struggle with deficient education systems and are far from achieving technological convergence with the West. This makes understanding

[30]Note that labor productivity in Soviet industry broadly, as demonstrated by Figure B.3, started to grow rapidly in 1933, i.e., exactly after the peak period (1931-32) of technical assistance.

the efficacy of technical assistance a priority. As we have shown in this paper, exploiting diasporas of Western-educated experts in strategic sectors, coupled with inputs such as machinery imports, can lead to large productivity gains. Market distortions aside, the fiscal cost of attracting foreign know-how may be an argument against such policies, contemporary approaches might nonetheless take advantage of push factors—just as the Soviets did during the Great Depression.

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Appendix

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A Additional Tables

Table A.1: The Top-10 Occupations for North American Finns in the Soviet Union and North America in the Early 1930s

Karelian Settlement Administration Records				**1930 U.S. and 1931 Canadian censuses pooled**			
Occupation	Freq.	Percent	HISCLASS	Occupation	Freq.	Percent	HISCLASS
Forestry worker	1,242	44.50	10	General worker	21,157	17.01	11
Carpenter	541	20.25	7	Farmer	17,556	14.11	8
General worker	250	9.36	11	Farm worker	12,327	9.91	12
Driver	183	6.85	9	Miner	11,053	8.88	9
Sawyer	98	3.67	9	Carpenter	10,275	8.26	7
Mechanics	85	3.18	7	Forestry worker	6,954	5.59	10
Brick layer	56	2.10	7	Other prod worker	5,257	4.23	11
Farm worker	52	1.95	12	Mechanic	4,079	3.28	7
Miner	50	1.87	9	Manager	3,668	2.95	2
Machinist	38	1.52	9	Driver	3,497	2.81	9
Total (top 10)	2,595	93.00		Total (top 10)	95,823	77.02	
Outside top 10	195	7.00		Outside top 10	28,584	22.98	
Total	**2,790**	**100.00**		**Total**	**124,407**	**100.00**	

Notes: Both samples restricted to men aged 15 to 64. HISCLASS is a 12-class categorization system indicating the social class of each occupation (Maas and Van Leeuwen, 2016).

Table A.2: Karelia and Northern Region in the 1920s

	Karelia	Northern Region
Territory (km^2)	146,045	1,165,178
1926 Soviet Census:		
Population	269,734	3,104,260
Population density (per km^2)	1.85	2.66
Number of urban settlements	14	46
Share of urban population	0.23	0.09
Share of Russians	0.57	0.93
Share of Karelians	0.41	0.004
Share of Finns	0.01	0
Literacy among age 9+	0.49	0.47
Number of large enterprises in 1926	30	91
Industrial output in 1926 (thousands of rubles)	17,855	55,597
Export of timber in 1930 (thousands of rubles)	21,192	50,749
Agricultural output per hectar in 1928 (tons)	1.03	0.84

Notes: Territory and the 1926 Census figures are from official 1926 publications. Number of enterprises, industrial output and agricultural output per hectar are from SSSR (1932b).

Table A.3: Summary Statistics for Enterprises Active in Wood Processing Industry

Panel A: Karelia vs. Northern Region

	Karelia		Northern Region			
	Mean	Observations	Mean	Observations		
Enterprises		81		303		
Share of enterprises with North American Finns	0.69	81	0	303		
	Karelia		Northern Region			
	Mean	Enterprise-years	Mean	Enterprise-years	Difference	S.E.
Birth year	1919	178	1920	492	-1.47	2.18
Number of workers	440.74	234	515.86	737	-75.12	39.85
Output per worker (in thousands of 1926/27 rubles)	4,248.57	234	3,638.32	737	610.25	395.10
Capital per worker (in thousands of nominal rubles)	1,311.16	220	1,015.70	708	295.46	198.44
Distance to forced labor camps (km)	164.29	234	273.76	737	-109.48***	12.36
Distance to White Sea Canal (km)	119.75	234	442.82	737	-323.07***	12.64
Distance to forced labor camps with illegal Finnish immigrants (km)	112.62	234	386.69	737	-274.08***	12.11
Distance to Finnish border (km)	169.15	234	576.82	737	-407.67***	12.28
Distance to railways (km)	20.67	30	48.58	83	-27.92	18.21
Minimum distance to water- or railways (km)	7.78	33	14.33	116	-6.56	12.19

Panel B: Treated Enterprises by Karelian Technical Aid vs. Non-treated

	Treated		Non-treated			
	Mean	Observations	Mean	Observations		
Enterprises		56		328		
Share of enterprises with North American Finns	1	56	0	328		
	Treated		Non-treated			
	Mean	Enterprise-years	Mean	Enterprise-years	Difference	S.E.
Birth year	1919	130	1920	540	-1.20	2.44
Number of workers	483.35	165	500.70	806	-17.35	45.46
Output per worker (in thousands of 1926/27 rubles)	4325.03	165	3674.91	806	650.12	449.99
Capital per worker (in thousands of nominal rubles)	1351.66	157	1031.59	771	320.07	225.13
Distance to forced labor camps (km)	163.09	165	264.64	806	-101.55***	14.27
Distance to White Sea Canal (km)	119.57	165	415.19	806	-295.62***	16.02
Distance to forced labor camps with illegal Finnish immigrants (km)	105.16	165	364.76	806	-259.60***	14.87
Distance to Finnish border (km)	155.19	165	544.78	806	-389.59***	16.16
Distance to railways (km)	24.12	162	43.98	97	-19.86	23.23
Minimum distance to water- or railways (km)	9.82	18	13.30	131	-3.49	15.54

Notes: All reported statistics are based on the enterprise-level panel data (years 1925-1938) described in detail in 3.2. In Panel B, the category of non-treated enterprises includes, in addition to all Norther Region enterprises, also Soviet Karelian ones located in settlements that did not receive American or Canadian technical assistance.

Table A.4: TWFE Event-study Regression Coefficients

	(1)	(2)
	Dependent variable: log(Labor productivity)$_{it}$	
	Full sample	Wood processing
$d_{1925} \times D_i$	-0.189	-0.129
	(0.244)	(0.282)
	[0.144]	[0.234]
$d_{1926} \times D_i$	0.0755	-0.0124
	(0.168)	(0.203)
	[0.092]	[0.164]
$d_{1927} \times D_i$	-0.0734	-0.296
	(0.246)	(0.203)
	[0.201]	[0.104]
$d_{1932} \times D_i$	-0.797***	0.118
	(0.279)	(0.256)
	[0.277]	[0.124]
$d_{1933} \times D_i$	-0.465*	0.613**
	(0.275)	(0.249)
	[0.252]	[0.216]
$d_{1934} \times D_i$	-0.513*	0.413
	(0.276)	(0.268)
	[0.269]	[0.147]
$d_{1937} \times D_i$	-0.323	0.436*
	(0.267)	(0.255)
	[0.271]	[0.196]
$d_{1938} \times D_i$	-0.267	0.574**
	(0.264)	(0.248)
	[0.259]	[0.165]
Observations	2,443	971
Number of enterprises	1,184	384
Pre-1933 $\hat{\beta}_t$ joint p-value	0.02	0.31

Notes: The dependent variable is log of output per worker in 1926/27 prices in rubles. The table reports results from estimating eq. (3) by ordinary least squares (OLS). All regressions include enterprise and year fixed effects. The variable d_t is an indicator variable for year t. The variable D_i is a dummy for the presence of North American Finns in the settlement in which enterprise i is located in year 1933. The omitted category is $d_{1928} \times D_i$. For additional time varying controls within enterprises, see the table notes of Table 2. The joint p-value is reported for a chi-squared test of joint significance of $\hat{\beta}_{1925} = ... = \hat{\beta}_{1932} = 0$. Standard errors (in parentheses) are clustered at the enterprise level and Conley standard errors [in brackets] adjust for two-dimensional spatial dependence using 250 km as cutoff threshold. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.5: Exogeneity of the Instruments

	Capital assets (1)	Industrial workers, th. (2)	Birth year (3)	Distance to railways (4)	Min distance to water- or railways (5)
Panel A: Secret police directives IV					
	Full preintervention sample				
Secret police directives	226.8	0.04	3.71	0.74	0.24
	(856.2)	(0.10)	(16.36)	(1.71)	(1.81)
Mean of dependent variable	2,279.5	0.18	1903	2.36	-0.31
Observations	165	179	172	160	175
	Wood processing industry				
Secret police directives	599.5	-0.05	3.45	0.36	-0.80
	(704.1)	(0.18)	(19.11)	(1.96)	(1.54)
Mean of dependent variable	1,324.4	0.35	1905	2.24	-0.71
Observations	67	74	74	66	73
Panel B: Buffer zone IV.					
	Full preintervention sample				
Buffer zone	-1585.3**	0.06	40.37	-1.39	-1.44
	(762.5)	(0.10)	(27.08)	(1.44)	(1.21)
Mean of dependent variable	2,279.5	0.18	1903	2.36	-0.31
Observations	165	179	172	160	175
	Wood processing industry				
Buffer zone	-1314.5*	0.16	-5.32	-1.90	-1.31
	(727.2)	(0.12)	(13.22)	(1.39)	(1.16)
Mean of dependent variable	1,324.4	0.35	1905	2.24	-0.71
Observations	67	74	74	66	73

Notes: Table shows OLS estimates of regressions of enterprise characteristics against our proposed instruments for a cross-sectional sample of enterprises in the preintervention period (1925-1928). The variables use information for the last observed preintervention year available for each enterprise. First parts of Panel A and B include all enterprises while second parts of Panel A and B include the sub-sample of enterprises active in wood processing industry. Included enterprise-level controls are: A polynomial of distance to forced labor camps; a polynomial of distance to the White Sea Canal; and a polynomial of distance to Finnish settlements. Year dummies are included to account for the differential measurement years (in the unbalanced panel). Standard errors (in parentheses) are clustered at the sub-district level and Conley standard errors [in brackets] adjust for two-dimensional spatial dependence using 250 km as cutoff threshold. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.6: Continuous Treatment TWFE Estimates of Western Technology on Labor Productivity

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: $\log(\text{Labor productivity})_{it}$					
	Full sample		Wood processing			
$\text{POST}_t \times n_i$	0.009	-0.025	0.033**	0.057	0.028*	0.046
	(0.009)	(0.028)	(0.015)	(0.038)	(0.015)	(0.038)
	[0.004]	[0.010]	[0.006]	[0.007]	[0.006]	[0.007]
$d_{1932} \times n_i$		-0.043		0.034		0.024
		(0.029)		(0.040)		(0.040)
		[0.011]		[0.009]		[0.008]
$\log(\text{Capital per worker})_{it}$					0.202***	0.201***
					(0.057)	(0.056)
					[0.042]	[0.041]
Observations	2,443	2,443	971	971	915	915
Number of enterprises	1,184	1,184	384	384	371	371

Notes: The dependent variable is log of output per worker in 1926/7 prices in rubles. The table reports results from estimating eqs. (1) and (2) by ordinary least squares (OLS). All regressions include enterprise and year fixed effects. POST is an indicator variable taking value one for the years 1933–38. The variable d_t is an indicator variable for year t. The variable n_i measures the number of North American Finns (in hundreds) in the settlement in which enterprise i is located in year 1933. For additional time varying controls within enterprises, see the table notes of Table 2. Standard errors (in parentheses) are clustered at the enterprise level and Conley standard errors [in brackets] adjust for two-dimensional spatial dependence using 250 km as cutoff threshold. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.7: IV Estimates of Continuous Treatment Effect of Western Technology on Labor Productivity

	(1)	(2)	(3)
Panel A: Second-stage regressions			
	Dependent variable: log(Labor productivity)$_{it}$		
POST$_t \times n_i$	0.0512*	0.131**	0.0552*
	(0.030)	(0.057)	(0.030)
	[0.022]	[0.091]	[0.022]
	[[-0.001; 0.119]]	[[0.035; 0.288]]	
Observations	971	971	971
Number of enterprises	384	384	384
Panel B: First-stage regressions			
	Dependent variable: POST$_t \times$ n_i		
POST$_t \times$ Settlement prohibition$_i$	-8.695***		-8.308***
	(2.268)		(2.343)
	[1.959]		[[1.888]
POST$_t \times$ Distance to border$_i$		0.731***	0.111
		(0.221)	(0.093)
		[0.419]	[0.100]
Observations	971	971	971
Number of enterprises	384	384	384
Kleibergen-Paap F-statistic	14.70	10.95	8.963

Notes: The dependent variable is log of output per worker in 1926/7 prices in rubles. The table reports results from estimating a variant of eq. (1) with continuous treatment (presence of number of foreign workers) by two-stage least squares (2SLS) for the sub-sample of enterprises operating in the wood processing industry. The data cover years 1925-1938. All regressions include enterprise and year fixed effects. POST is an indicator variable for the years 1933–38. Variable n_i measures the number of North American Finns (in hundreds) in the settlement in which enterprise i is located in year 1933. For additional time-varying enterprise-level control variables included in the first and the second-stage regressions, see tabled notes of Table 2. Standard errors (in parentheses) are clustered at the enterprise level and Conley standard errors [in brackets] adjust for two-dimensional spatial dependence using 250 km as cutoff threshold. Confidence intervals in double brackets report the VtF 95% confidence intervals (Lee et al., 2023). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.8: Robustness Checks

	TWFE coefficient (β)	Standard Error	Robust s.e.	Observations
Panel A: Controls and Functional Form				
Excluding controls	0.293**	0.132	0.132	971
Labor productivity, in levels	1475.8***	513.2	506.9	971
Labor productivity, in levels, excl. controls	1047.9**	454.3	307.5	971
Panel B: Clustering of Standard Errors				
Sub-district level	0.480***	0.151	0.170	971
Spatial cluster 100km	0.480***	0.151	0.162	971
Spatial cluster 500km	0.480***	0.151	0.202	971
Panel C: Radius Around Settlement				
1km	0.324**	0.151	0.145	971
3km	0.391***	0.145	0.148	971
10km	0.391***	0.145	0.148	971
30km	0.447***	0.148	0.175	971
Panel D: Regional Sample Restrictions				
Excluding Arkhangelsk	0.488***	0.168	0.218	670
Excluding Vologda	0.447***	0.155	0.196	774
Excluding Komi	0.475***	0.153	0.206	922
Excluding Severo-Dvinsk	0.426***	0.154	0.204	848
Panel E: Enterprise Sub-samples				
Excl. Karelian non-treated enterprises	0.507***	0.162	0.202	902
Large enterprises only	0.384**	0.166	0.201	529

Notes: The table reports robustness checks of our baseline estimates presented in column 3 of Table 2. Panel A presents results without controls and with the dependent variable, labor productivity, in levels. Panel B presents results with standard errors clustered at the sub-district level and adjusted for two-dimensional spatial dependence, using cutoff thresholds of 100km and 500km. Panel C presents results with the definition of treatment being altered by the maximum distance of an enterprise from the settlement to which North American technical assistance were assigned using distances 1km, 3km, 10km and 30km (in contrast to the 15km radius at baseline). Panel D presents results with alternative definitions of area covered by the control region. Panel E presents sub-sample analyses excluding the non-treated Karelian enterprises and excluding small enterprises (using the official Soviet definition of "large" enterprises). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.9: Average Impact of Western Technology on Total Factor Productivity: Evidence from Karelian Technical Aid

	(1)	(2)	(3)	(4)
	Dependent variable: $\log(\text{Output})_{it}$			
	Full sample		Wood processing	
$\text{POST}_t \times D_i$	0.239***	-0.192	0.404***	0.452**
	(0.088)	(0.250)	(0.149)	(0.200)
	[0.053]	[0.245]	[0.156]	[0.144]
log of labor (l_{it})	0.625***	0.626***	0.637***	0.638***
	(0.055)	(0.055)	(0.073)	(0.073)
	[0.018]	[0.020]	[0.022]	[0.022]
log of capital (k_{it})	0.157***	0.157***	0.0491	0.0482
	(0.048)	(0.048)	(0.057)	(0.057)
	[0.011]	[0.011]	[0.029]	[0.030]
$d_{1932} \times D_i$		-0.490*		0.0562
		(0.268)		(0.217)
		[0.277]		[0.075]
Observations	2,034	2,034	915	915

Notes: The dependent variable is log of output in 1926/7 prices in rubles (y_{it}). Total factor productivity is estimated assuming a standard firm-level production function of the Cobb-Douglas type, $Y = f(K, L)$ in which primary inputs (log of) capital k_{it} and (log of) labor (number of industrial workers) l_{it} are included as explanatory variables. The model is similar in all other respects to estimating equation (1), estimated by ordinary least squares (OLS). All regressions include enterprise and year fixed effects. The data cover years 1926-1938. POST is an indicator variable for the years 1933–38. The variable d_t is an indicator variable for year t. The variable D_i is a dummy for the presence of North American Finns in the settlement in which enterprise i is located in year 1933. Included time varying controls within enterprises are: An interaction of a dummy taking on value one if the enterprise is located in the region of Soviet Karelia and zero otherwise with a post-Five-year-plans period dummy; a polynomial of distance to forced labor camps and its interaction with a post-1928 indicator; a polynomial of distance to the White Sea Canal interacted with a post-construction year (year 1930) indicator; and a polynomial of distance to Finnish settlements interacted with a post-treatment year (year 1931) indicator. Standard errors (in parentheses) are clustered at the enterprise level and Conley standard errors [in brackets] adjust for two-dimensional spatial dependence using 250 km as cutoff threshold. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

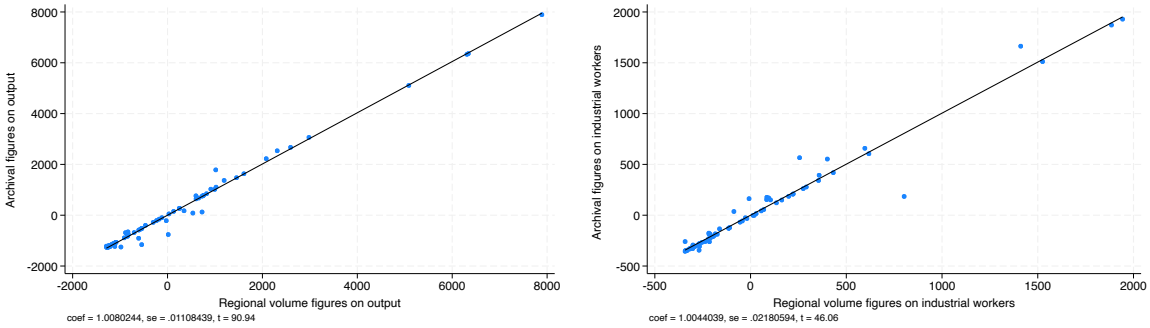
Table A.10: Worker Selection Regressions, Matched Soviet Immigration Records and 1931 Canadian Complete Count Census

	Dependent variable: $\log(\text{Earnings})_j$		
	(1)	(2)	(3)
Recruited by Karelian Technical Aid	-0.188*	-0.202**	-0.192**
	(0.099)	(0.092)	(0.083)
Age	0.0388***	0.0385***	0.0312***
	(0.006)	(0.005)	(0.008)
Age^2	<-0.001***	<-0.001***	<-0.001***
	(0.000)	(0.000)	(0.000)
Speaks English	0.416***	0.354***	0.274***
	(0.021)	(0.028)	(0.011)
Unemployed		-0.575***	-0.526***
		(0.031)	(0.022)
Province fixed effects		Yes	Yes
Occupation fixed effects			Yes
Observations	10,421	10,421	10,421

Notes: The sample includes working-age (15–64 years) men whose own or parents' place of birth is Finland in the 1931 Canadian Census. The dependent variable is the logarithm of annual earnings (past 12 months) of individual j. The explanatory variable "Recruited by Karelian Technical Aid" is defined as positive individual-level match with the Settlement Administration records of Soviet Karelia. For the details of matching individuals across the mentioned administrative data, see Appendix Section D.2. Nine province dummies are included in columns 2 and 3. We define occupation based on the 2-digit HISCO code, 59 occupation dummies are included in column 3 (see Leeuwen et al. (2002) for the historical occupational code (HISCO) classification). Standard errors (in parentheses) are clustered at occupation level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

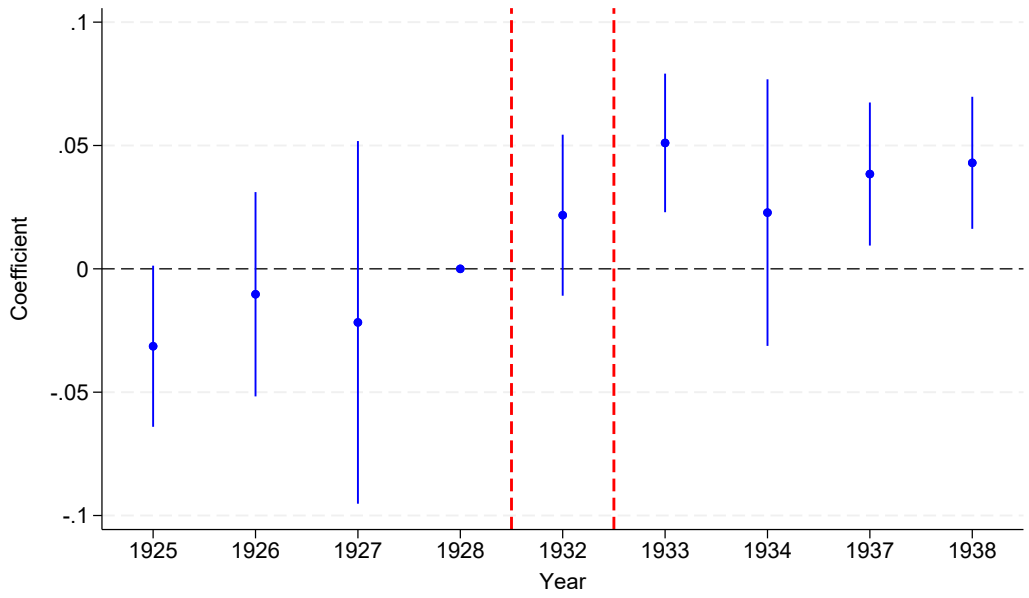
B Additional Figures

Figure B.1: Cross-Checks of Karelian Enterprise-Level Statistics Reported in Two Different Sources



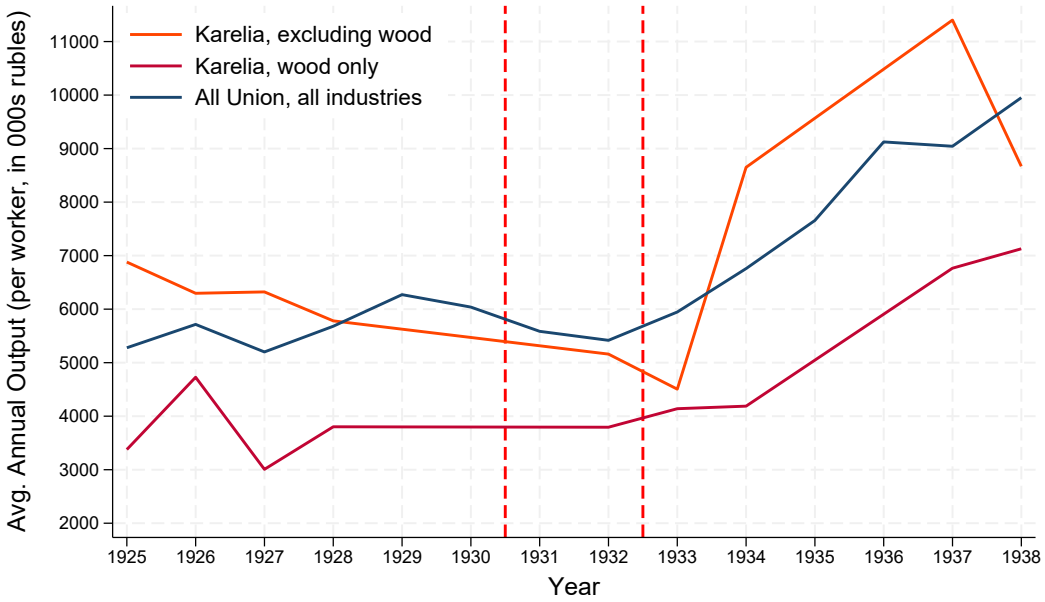
Notes: Added-Variable Plots of pairwise regressions of archival and published annual statistics for Karelia in 1932 and 1933 on Output (left) and Number of industrial workers (right). Statistics reported in archival source are from RGAE F. 1562, Op. 8, D. 864; F. 1562, Op. 8, D. 1261. Published statistics are from KASSR (1934).

Figure B.2: Continuous Treatment TWFE Event-Study Estimates of Western Technology on Labor Productivity, Wood Processing Industry



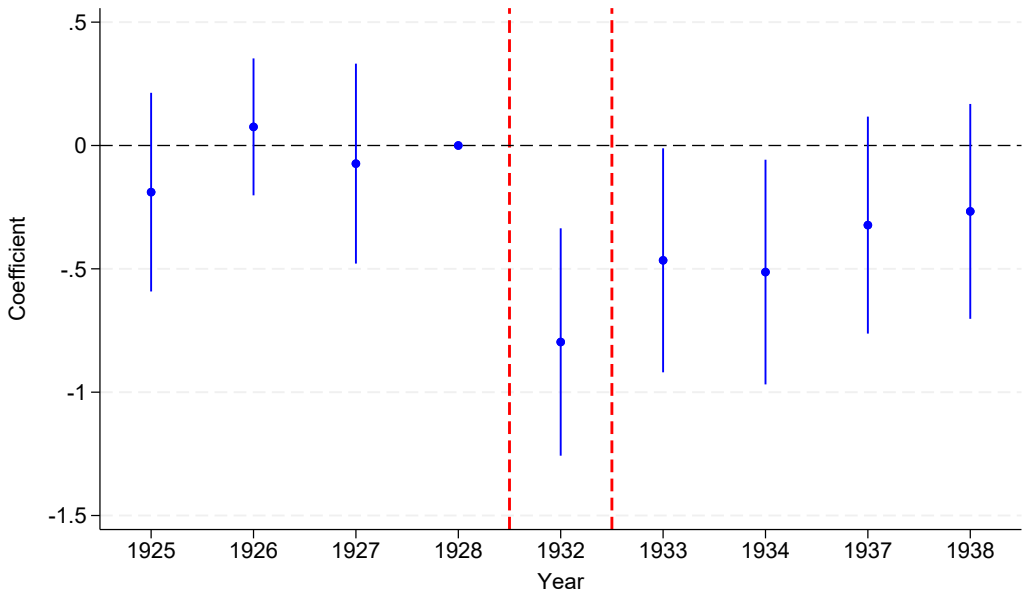
Note: The figure plots TWFE event-study annual coefficients (relative to 1928) and their 90% confidence intervals for the wood processing industry sub-sample (n=971) from regressions with the continuous variable n_i measuring the number of North American Finns (in hundreds) in the settlement in which enterprise i operating in the wood processing industry is located in year 1933 interacted with year dummies (d_t). The data cover years 1925-1938. The two dashed red vertical lines mark the interval years (1931-1932) during which the bulk of North American Finns arrived in Soviet Karelia (Table 1). The dependent variable is log of output per worker in 1926/7 prices in rubles. All regressions include enterprise and year fixed effects. For additional time-varying enterprise-level control variables included in the first and the second-stage regressions, see tabled notes of Table 2. All standard errors are clustered at the enterprise level. p-value for chi-squared test of joint significance of $\hat{\beta}_{1926} = ... = \hat{\beta}_{1932} = 0$ is 0.09.

Figure B.3: Labor Productivity Trends in Karelia and the Soviet Union, 1925 – 1938



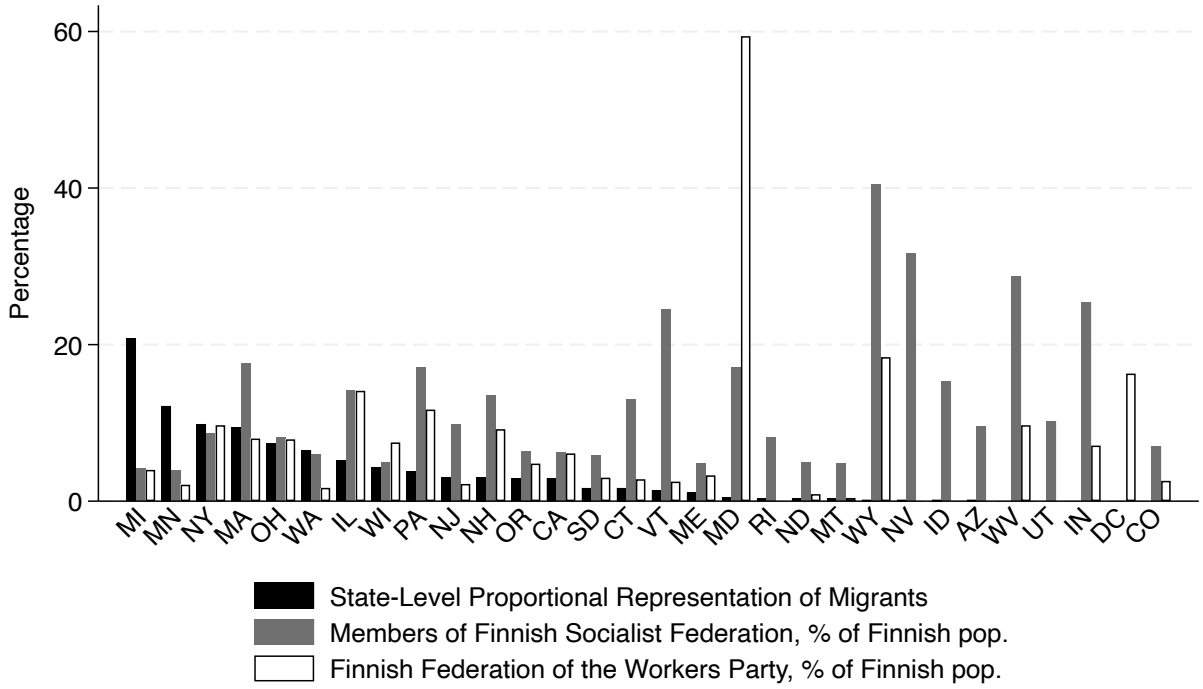
Notes: Karelian series represent averages of output per industrial worker in 1926/7 rubles in enterprises with at least one year-enterprise observation before and after 1932, separately for enterprises in wood industry (orange line) and outside wood industry (cranberry line). In Karelia, we exclude beverage enterprises because of the Soviet policy of gradual removal of alcohol prohibition in 1925-30. We linearly extrapolate values for missing years in both Karelian series. All-Union series (blue line) represent output per industrial worker in the whole Soviet Union in 1926/27 rubles, estimated for the years before 1937 by dividing annual industrial output in 1926/27 rubles on industrial employment and for 1937-38 taken directly from a 1946 declassified archival statistical memo (RGAE. F. 1562, Op. 329, D. 1912, L. 47). Industrial output is from another declassified 1946 archival statistical memo (RGAE. F. 1562, Op. 329, D. 1593, L. 6). We use official statistical publications (VTsSPS, 1926; TsUNKhU, 1934, 1936; TsSU, 1956) to construct a harmonized industrial labor force series. The two dashed red vertical lines mark the interval years (1931-1932) during which the bulk of North American Finns arrived in Soviet Karelia (Table 1).

Figure B.4: TWFE Event-Study Estimates of Western Technology on Labor Productivity, Full Sample



Notes: The figure plots TWFE event-study annual coefficients (relative to 1928) and their 90% confidence intervals from regression with a dummy for the presence of North American Finns in the settlement in which enterprise i is located in year 1933 (D_i) interacted with year dummies (d_t) for the full sample (n=2,443). The two dashed red vertical lines mark the interval years (1931-1932) during which the bulk of North American Finns arrived in Soviet Karelia (Table 1). The dependent variable is log of output per worker in 1926/7 prices in rubles. The regression includes enterprise and year fixed effects. For additional time-varying enterprise-level control variables included in the regression, see tabled notes of Table 2. All standard errors are clustered at the enterprise level. $\hat{\beta}_{1926} = ... = \hat{\beta}_{1932} = 0$ is 0.03. See Column 1 of Table A.4 for the corresponding parameter estimates and standard errors. See Figure 3 for the corresponding figure for the wood processing industry (n=971).

Figure B.5: Migrant Selection: State-Level Share of Ethnic Finnish Migrants and Socialist Party Members



Notes: Calculations of share of Karelian Migrants relative to ethnic Finnish population by State in the 1930 U.S. Census are authors' own and are based on matched immigration records of the Autonomous Republic of Soviet Karelia and the complete count of the census (Ruggles et al., 2024). See Appendix D.2 for the details of the automated matching algorithm. The data on party membership rates come from Kostiainen (1978) and relate state-level membership to the Finnish Socialist Federation (as measured in 1917) and state-level membership to the Finnish Federation of the Workers Party (as measured in 1923) to the ethnic Finnish population by State in the 1920 U.S. Census. The figure includes only the states presented in his research.

C Cost-Benefit Analysis

This section discusses the details of the cost-benefit analyses summarized in subsection 6.1 by walking the reader through the calculations presented in Table C.1. For simplicity, we assume that all 5,000 working-age Americans and Canadians recruited to Soviet Karelia worked in the wood processing industry or in its backend support, such as construction of housing and infrastructure. We estimate that the number of native workers in the wood processing industry in 1933 amount to 59,000 by deducting foreign workers from total employment (64,000). We normalize labor productivity in the counterfactual to one and increase it by the magnitude of our estimated treatment effect in column (3) of Table 2 to obtain ex-post labor productivity in wood processing industry (1.62). The share of labor force treated by Karelian Technical Aid is set equal to the share of employment in treated wood processing enterprises among all wood processing Karelian enterprises in our data in 1933 (0.74). We estimate counterfactual total output in wood processing industry from the 1933 official figure (121,464 thousand rubles) decreasing it proportionally to the change in the number of effective units of labor if Karelian Technical Aid did not start. This change consists of two parts: first, the labor force affected by the program would be less productive in the counterfactual scenario, and second, the labor force would be smaller in the absence of North American Finns. Specifically, we estimate the counterfactual output as $121,464 \times (59/(64 \times 0.74 \times 1.62 + 64 \times 0.26 \times 1))$.

Monthly wage in wood processing industry in 1931-1933 comes from (KASSR, 1934, p. 191). To deflate to 1926/7 rubles, we use the wholesale industrial price index developed by Allen (1997). Monthly wage of American and Canadian workers are from (Golubev and Takala, 2014, pp. 120, 227), deflated to 1926/7 rubles. To account for investments by foreign workers in a machinery fund and the documented illiquidity of these investments, we adjust foreign workers monthly wages by assuming that everyone invested equally much in the machinery fund and that the documented ruble repayments were shared equally by al workers (Golubev and Takala, 2014, p. 89, 90). The negative difference between raised and repaid funds is treated as a write-off. The total amount of capital raised was $262,000 ($162,146 to the Machinery Fund plus machinery and equipment brought by North American Finns of about

$100,000 value (Golubev and Takala, 2014, pp. 89-90)), which we transform into 1,507 thousand rubles using the conservative Torgsin U.S. dollar to ruble exchange rate (1 to 5.75). By conservative, we mean that the Torgsin – a Soviet state-run hard-currency shop – used almost three times higher exchange rate than the official exchange rate (1 to 2). Then, to get the total write-off, we deduct the repaid compensation for the fees to the Machinery Fund (304,629 rubles – (Golubev and Takala, 2014, p. 89)) and the compensation for brought equipment estimated using the official exchange rate (200,000 rubles). We deduct the write-off from monthly wages by assuming a linear write-off scheme over the whole span of the two-year work contract.

Total personnel costs were computed based on the number of workers and reported monthly wages (i.e. abstracting from pensions, social security and income tax).[31] Surplus is computed as the difference between total output (i.e. sales) and personnel costs.

We use Canadian average annual earnings from the 1930 Canadian Census (i.e., reported in 1931 Canadian dollars) for the matched Canadian workers contracted by Karelian Technical Aid as the reservation wage of the foreign workers (individual-level earnings are not available for Americans in the 1930 U.S. Census). To arrive at the competitive wage in rubles (i.e., that would match Canadian reservation wage), we use the standard foreign worker contract practice under technical assistance agreements and apply 0.8 and 0.2 as weights for payments in hard currency (Torgsin) and official exchange rate, respectively (Sutton, 1971).

On the last row of Table C.1, the maximum wage satisfying the condition of strictly positive surplus implies the maximum monthly compensation to the foreign workers (in 1926/27 rubles) that would still leave the Karelian Technical Aid intervention marginally profitable for the social planner.

[31] All foreign workers paid their own travel costs.

Table C.1: Cost-Benefit Analysis Table

	Karelian Technical Aid			
	Did occur (realized)	Did not occur (counterfactual)	Dif. (1) – (2)	Dif. as % of (1)
	(1)	(2)	(3)	(4)
Total employment (without self-employed and collective farmers) in Karelia in 1933 (in thousands)	133	128	5	3.8
Total employment in wood processing industry in 1933 (in thousands)	64	59	5	7.8
Including				
Local workers (thousands)	59	59	0	0
American and Canadian workers (thousands)	5	0	5	100
Ex-post labor productivity in wood processing industry	1.62	1	0.62	38.3
Share of labor force affected by the program in wood-processing industry	0.74	0	0.74	100
Total output (revenue from sales) in wood-processing industry in 1933 (thousands of 1926/7 rubles)	121,464	76,651	44,813	36.9
Monthly wage in wood processing industry:				
Local workers (1926/7 rubles)	105.6	97.90	7.7	7.3
American and Canadian workers (1926/7 rubles)				
Unadjusted	170.7	-	-	-
Adjusted for foregone repayments of investments	163.6	-	-	-
Personnel costs (thousand 1926/7 rubles)	85,027	69,315	15,712	18.5
Surplus, defined as revenue from sales minus personnel costs (thousand 1926/7 rubles)	36,437	7336	29,100	79.9
Canadian competitive monthly wage (1926/7 rubles)	161.5	-	-	-
Max wage satisfying the program profitability condition (1926/7 rubles)	655.7	-	-	-

Notes: Estimations and sources are as described in Appendix Section C above.

D Data Appendix

D.1 Historical Sources

Table D.1: List of Historical Sources

Data	Year	Source
A. *Individual-level records**		
Registration lists of North American Finns	1933-34	NA RK (hereafter refers to National Archive of Republic of Karelia) F. P-3, Op. 6, D. 12774.
Files of the Settlement Administration of Karelia	1931-36	NA RK F. R-685 Op. 1 D. 1, 3, 4, 5, 34, 36, 37, 40, 43, 72, 73, 96, 99, 120, 124, 153, 162, 164, 166; NA RK F. R-685 Op. 2, D. 10, 11, 12, 13, 16, 17, 24, 26, 30, 34, 58, 60, 62, 64, 65, 67, 70, 71, 89, 91, 96, 98, 99, 100, 105, 109, 110, 111, 112, 117, 119, 120, 121, 122, 124, 125, 126, 128, 129, 130, 131, 133, 134, 136, 138, 139, 140, 143, 152, 166, 167, 170, 171, 173, 174, 175, 196, 246, 248, 249, 263, 300, 340; NA RK F. R-685 Op. 15, D. 8
Files of Karelian Council of Ministries	1931-38	NA RK F. R-690, Op. 1, D. 181; NA RK F. R-690, Op. 3, D. 46, 466, 630; NA RK F. R-690, Op. 13, D. 17.
Ski factory files	1931-38	NA RK F. R-1503, Op. 3, D. 3, 22, 36, 65
Files of other Karelian agencies	1931-38	NA RK R. P-630, Op. 2, D. 21, 218; NA RK F. R-721, Op. 16, D. 29, 72; NA RK F. R-676, Op. 1, D. 137; NA RK F. R-689, Op. 15, D. 7, 8; NA RK F. R-1042, Op. 2, D. 20; NA RK F. R-2883, Op. 1, D. 8; NA RK F. P-3, Op. 6, D. 10792;
B. *Establishment-level data from the Central Statistical Administration files and other sources*		
Output, Number of industrial workers	1925	SSSR (1927a)
Output, Number of industrial workers Capital asset, Birth year, Self-reported distance to railways and waterways	1926, 1927	RGAE (Hereafter refers to the Russian State Archive of Economy) F. 1562, Op. 8 D. 2, 6, 8, 40, 45, 63, 64, 67, 91, 95, 111, 117, 118, 126, 132, 153, 169, 180, 183, 209, 303, 340, 341, 344, 406, 408, 411, 422, 437, 439, 443, 462, 477, 480, 485, 499, 521, 522, 525.
Output, Number of industrial workers Capital asset, Birth year, Self-reported distance to railways and waterways	1928	RGAE F. 1562, Op. 8, D. 614, 623, 626, 643, 647, 655, 656, 664, 676, 685, 688, 689, 720, 722, 726, 737, 744, 757, 758, 774, 776, 784, 785, 791, 802, 810.
Output, Number of industrial workers, Capital asset	1932	RGAE F. 1562, Op. 8 D. 856, 864.
Party membership	1932	Karelobkom (1932)
Output, Number of industrial workers, Capital asset	1933	RGAE F. 1562, Op. 8, D. 1261.
Output, Number of industrial workers, Capital asset	1934**	KASSR (1934)
Output, Number of industrial workers,	1937, 1938	RGAE F. 1562, Op. 53, D. 1231, 1236, 1238,

Continued on next page

Table D.1: List of Historical Sources (continued)

Data	Year	Source
Capital asset		1239, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1249, 1250, 1251, 1252, 1253, 1255, 1256, 1257, 1258, 1259, 1261, 1262, 1263, 1265, 1266, 1267, 1269, 1270, 1272, 1274.
C. Subdistrict-level data from the 1926 Population Census		
Literacy, Speaking language	1926	SSSR (1928)
D. Maps		
Forced labor camps with Finnish unskilled labor	1931-1933	Hand-made using Takala (2002)
Headquarters of Gulag forced labor camps	1925-1938	Kapelko and Markevich (2014)
Administrative map	1926	Markevich et al. (2024)
*D. Other Sources****		
Labor productivity in Soviet Industry	1937-1938	RGAE. F. 1562, Op. 329, D. 1912, L. 47.
Industrial output in Soviet Union	1925-1936	RGAE. F. 1562, Op. 329, D. 1593, L. 6.

Notes: *Archival sources with individual-level records are available online at *uf.rkna.ru* as a part of the electronic database "North American Finns in forestry industry of Soviet Karelia in 1920s and 1930s" by M. Jaaskelainen, I. Takala, and E. Usacheva; **reported output is for the first half of the year which is multiplied by two to impute annual output. *** available online at *istmat.org* as a part of the electronic database "Historical materials".

D.2 Matching the Settlement Administration Records to the 1930 U.S. Census and 1931 Canadian Census

D.2.1 Settlement Administration Records

The two main archival sources consist of a registry by the Karelian Settlement Administration on Canadians (n=1,840) and Americans (n=2,585) who were living in Soviet Karelia as of January 1934. We cleaned these records and linked them based on first name, last name, birth year, occupation, arrival date in the Soviet Union, and workplace in Karelia to other archival sources of the archives of the Settlement Administration. Duplicates arising due to foreign workers appearing in multiple archival sources are removed (deduplication algorithm available from the authors), for a final dataset of 6,663 unique individuals.

D.2.2 Matches in the 1930 U.S. Census

The immigrants from the United States (or North America, source country unknown) were linked to the complete count of the 1930 U.S. Census made available by Ruggles et al. (2024). All 336,773 first or second generation Finnish immigrants to the U.S., defined based on own birthplace, mother's or father's birthplace, were linked to the Settlement Administration records based on first names, surname and birthdate. In total, 649 individual matches between the Soviet Karelian and the U.S. data sources were found for a linking rate of roughly 18.5%.

D.2.3 Matches in the 1931 Canadian Census

The immigrants from Canada (or North America, source country unknown) were linked to the complete count of the 1931 Canadian Census recently made available by Statistics Canada (2023). The Canadian census sample includes all individuals whose ethnicity is recorded as "Finn" or "Finnish". Additionally, individuals whose ethnicity is recorded as "Swedish" but

who were born in Finland are included, as they are likely Swedish-speaking Finns. Of the 38,113 Canadian Finns in the 1931 Canadian census that fit these criteria, we matched 364 individuals to the Settlement Administration records for a linking rate of roughly 14.2%.[32]

D.2.4 Linking North American Finns to Records Across the Continents

The Soviet Karelian immigration records are linked to the 1930 U.S. Census and 1931 Canadian Census using the following algorithm:

Starting with the complete count U.S. Census that covers over 122 million observations, these census data are first filtered to retain only records where Finland is listed as the individual's, mother's, or father's place of birth. These restrictions yield a dataset of 336,773 observations, consisting of Finnish first-generation immigrants and their children. Next, the name variables are cleaned by removing non-alphanumeric characters and suffixes such as "Mr." or "Mrs.". A variable for middle-name initial is generated, and nicknames are standardized by replacing them with their formal equivalents. The Soviet Karelian immigration records are prepared in a similar manner. The complete Settlement Administration sample of foreign workers arriving through the Soviet Karelian Technical Aid program contains 6,663 observations, of which 3,523 list the United States as the country of origin, 2,557 list Canada, and 583 only lists "North America" as the place of origin. Observations with missing country of origin are first included in the U.S. Census linking process. Unmatched observations among these 583 records with ambiguous country of origin are re-used in the Canadian Census linking process. The Soviet Karelian dataset firstly used in the U.S. Census linking thus contains 4,106 (3,523+583) observations.

The linking algorithm follows a rule-based approach proposed by Abramitzky et al. (2012, 2014). The linking process is conducted in two stages. In the first stage, only observations with information on birth year are included. The algorithm begins by creating blocks of

[32] According to Korkiasaari (1989), there were 43,585 first or second generation Canadian Finns in the 1931 census suggesting that our search criteria do not fully capture the entire population of Canadian Finns in the 1931 Canadian census, in particular the second generation Canadian Finns. This shortcoming should be innocuous for our analysis as most Canadian immigrants to Soviet Karelia were first generation immigrants.

observations based on the initials of the first and last names. This blocking step is necessary to reduce computational demands by limiting comparisons to records with matching initial letters in both first and last names. However, this approach may exclude potential matches when initials differ due to spelling variations (e.g., Vihtori vs. Wihtori).

Within these blocks, the algorithm compares birth years and calculates Jaro-Winkler (JW) string distances for both first and last names of each possible pair. JW-thresholds for the distance scores are set at 0.12 for last names and 0.15 for first names.[33] If a pair exceeds both thresholds, their birth years are compared. If multiple matches share the same name and birth year, the match is considered non-unique and is rejected. If only one match with the same name and birth year exists, it is accepted. In cases of no exact match, the closest match within an age difference of ± 2 years is retained, provided the match is unique (i.e., both records having exactly the same first and surname). Only same-sex matches are accepted. In linking the Settlement Administration records to the 1930 U.S. Census, the first stage yields 631 matches.

The identified matches are set aside, and the second stage begins with all remaining observations, regardless of whether birth year is observed. The process is otherwise identical to the first stage, except birth year is considered. Linking is based solely on name variables, with the same Jaro-Winkler thresholds as in the first stage. This second stage results in 18 additional matches.

The two-stage linking approach is necessary because 22.5% of the Soviet Karelian immigration records lack birth year information. Combining the results yields a dataset of 649 matched individuals, corresponding to a match rate of 15.8%. The linking procedure for the 1931 Canadian Census closely follows the method used for the U.S. Census. In this case, the Soviet Karelian dataset, containing only observations with Canada or the remaining un-

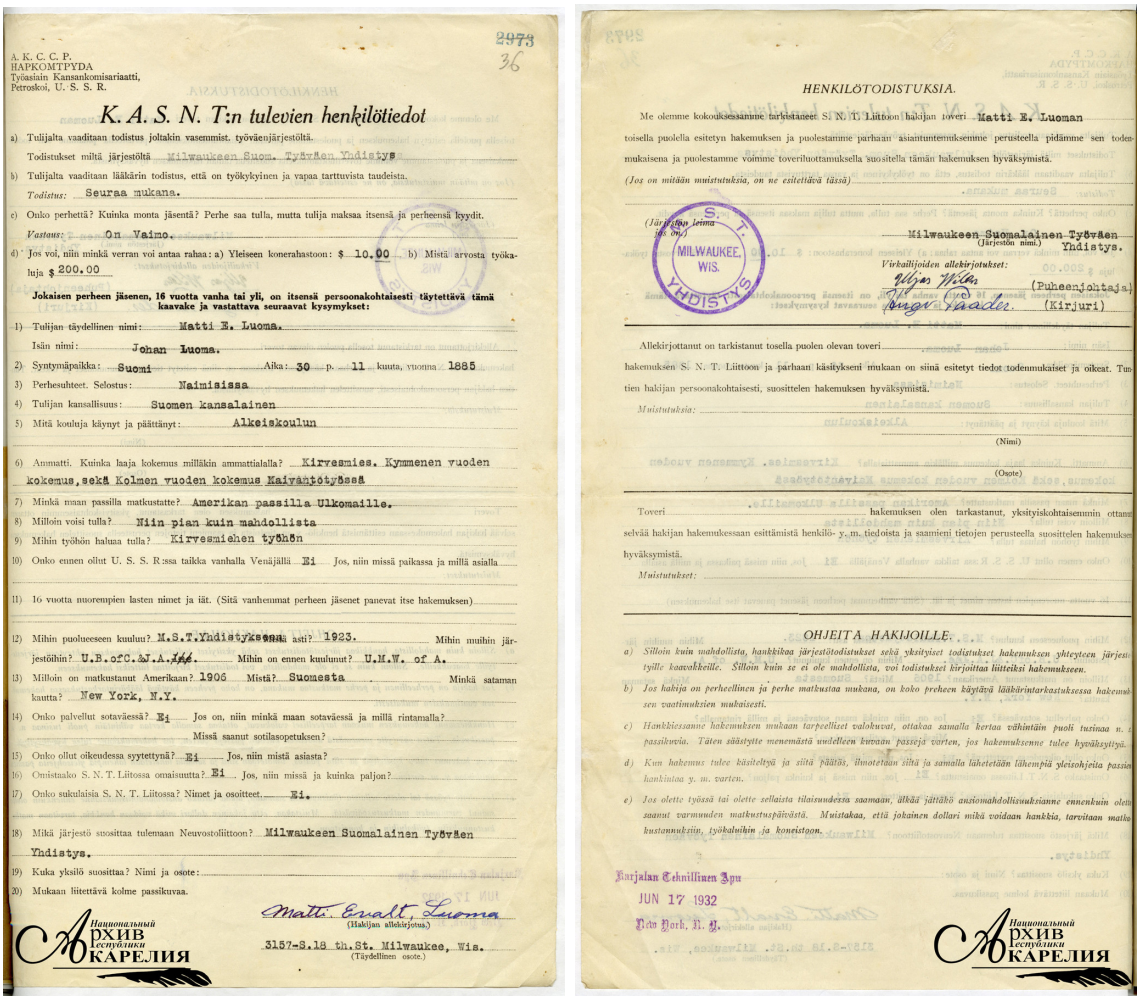
[33]The thresholds for JW-scores are determined empirically by iterating and refining the routine. Since JW-similarity gives higher weight to the initial characters of a string and does not heavily penalize differences in string length, only matches differing by a maximum of two characters are tolerated. This rule is particularly important for Finnish names, as many Finnish surnames stem from the same word but differ only with respect of the suffix, e.g., Mäki, Mäkilä, Mäkinen are all distinct surnames, but their JW-similarity score is 0.086, implying that the algorithm reads them as one and the same name at conventional thresholds.

matched observations with North America as the country of origin, includes 3,108 records. A total of 364 matches are identified, resulting in a match rate of 11.7%.

E Soviet Karelian Technical Aid

The selection of North American applicants included the following stages. People who wished to participate in the program had to fill out an application form and obtain a reference from a local workers' organization. The references were considered by commissions in New York and Toronto, and the lists of the selected applicants were sent on to Petrozavodsk. The authorities of Karelia confirmed the lists and matched the applications to enterprises' expressions of interest, after which the documents were sent to Moscow for entry visas to be issued. The formal criteria for selection of applicants included the workers' professional experience and a worker's union background. However, the selection process of Karelian Technical Aid was guided by other considerations than ideology. Ideology seems to have been secondary to relevant work experience or occupational mismatch (We found in the archives of the Settlement Administration rejection letters motivated by these two reasons). Apart from work experience, the amount of tools and equipment that worker's intended to bring along and their ability to invest hard currency in a newly formed machinery fund, seem to have played an important role. Of particular note is that these two intentions were among the first things inquired in the application form (see below for the contents of the complete application form).

Figure E.1: Application Form



A. K. C. P.
HAPKOMTPYDA
Työasiain Kansankomisariaatti,
Petroskoi, U. S. S. R.

2973
36

K. A. S. N. T:n tulevien henkilötiedot

a) Tulijalta vaaditaan todistus joltakin vasemmist. työväenjärjestöltä.
Todistukset miltä järjestöltä Milwaukeen Suom. TyöväEen Yhdistys

b) Tulijalta vaaditaan lääkärin todistus, että on työkykyinen ja vapaa tarttuvista taudeista.
Todistus: Seuraa mukana.

c) Onko perhettä? Kuinka monta jäsentä? Perhe saa tulla, mutta tulija maksaa itsensä ja perheensä kyydit.
Vastaus: On Vaimo.

d) Jos voi, niin minkä verran voi antaa rahaa: a) Yleiseen konerahastoon: $ 10.00 b) Mistä arvosta työkaluja $ 200.00

Jokaisen perheen jäsenen, 16 vuotta vanha tai yli, on itsensä persoonakohtaisesti täytettävä tämä kaavake ja vastattava seuraavat kysymykset:

1) Tulijan täydellinen nimi: Matti E. Luoma.
Isän nimi: Johan Luoma.
2) Syntymäpaikka: Suomi Aika: 30 p. 11 kuuta, vuonna 1885
3) Perhesuhteet. Selostus: Naimisissa
4) Tulijan kansallisuus: Suomen kansalainen
5) Mitä kouluja käynyt ja päättänyt: Alkeiskoulun
6) Ammatti. Kuinka laaja kokemus milläkin ammattialalla? Kirvesmies. Kymmenen vuoden kokemus, sekä Kolmen vuoden kokemus Kaivantötyössä
7) Minkä maan passilla matkustatte? Amerikan passilla Ulkomaille.
8) Milloin voisi tulla? Niin pian kuin mahdollista
9) Mihin työhön haluaa tulla? Kirvesmiehen työhön
10) Onko ennen ollut U. S. S. R:ssa taikka vanhalla Venäjällä Ei Jos, niin missä paikassa ja millä asialla
11) 16 vuotta nuorempien lasten nimet ja iät. (Sitä vanhemmat perheen jäsenet panevat itse hakemuksen)
12) Mihin puolueeseen kuuluu? M.S.T.Yhdistyksessä asti? 1923. Mihin muihin järjestöihin? U.B.of C.&J.A.~~W.~~. Mihin on ennen kuulunut? U.M.W. of A.
13) Milloin on matkustanut Amerikaan? 1906 Mistä? Suomesta Minkä sataman kautta? New York, N.Y.
14) Onko palvellut sotaväessä? Ei Jos on, niin minkä maan sotaväessä ja millä rintamalla?
Missä saanut sotilasopetuksen?
15) Onko ollut oikeudessa syytettynä? Ei Jos, niin mistä asiasta?
16) Omistaako S. N. T. Liitossa omaisuutta? Ei Jos, niin missä ja kuinka paljon?
17) Onko sukulaisia S. N. T. Liitossa? Nimet ja osoitteet. Ei.
18) Mikä järjestö suosittaa tulemaan Neuvostoliittoon? Milwaukeen Suomalainen Työväen Yhdistys.
19) Kuka yksilö suosittaa? Nimi ja osoite:
20) Mukaan liitettävä kolme passikuvaa.

Matti Evalt, Luoma
(Hakijan allekirjotus.)
3157-S.18 th.St. Milwaukee, Wis.
(Täydellinen osoite.)

Национальный АРХИВ Республики КАРЕЛИЯ

HENKILÖTODISTUKSIA.

Me olemme kokouksessamme tarkistaneet S. N. T. Liittoon hakijan toveri Matti E. Luoman toisella puolella esitetyn hakemuksen ja puolestamme jarhaan asiantuntemuksemme perusteella pidämme sen todenmukaisena ja puolestamme voimme toverilluottamuksella suosittella tämän hakemuksen hyväksymistä.
(Jos on mitään muistutuksia, on ne esitettävä tässä)

(Järjestön leima jos on.)

S. T. MILWAUKEE, WIS. YHDISTYS

Milwaukeen Suomalainen Työväen (Järjestön nimi.) Yhdistys.
Virkailijoiden allekirjotukset:
Yljas Niitas (Puheenjohtaja)
Inga Raader. (Kirjuri)

Allekirjottanut on tarkistanut tosella puolen olevan toveri hakemuksen S. N. T. Liittoon ja parhaan käsityksen mukaan on siinä esitetyt tiedot todenmukaiset ja oikeat. Tunnen hakijan persoonakohtaisesti, suosittelen hakemuksen hyväksymistä.
Muistutuksia:
(Nimi)
(Osoite)

Toveri hakemuksen olen tarkastanut, yksityiskohtaisemmin ottamalla selvää hakijan hakemuksessaan esittämistä henkilö- y. m. tiedoista ja saamieni tietojen perusteella suosittelen hakemuksen hyväksymistä.
Muistutukset:

OHJEITA HAKIJOILLE.

a) Silloin kuin mahdollista, hankkikaa järjestötodistukset sekä yksityiset todistukset hakemuksen yhteyteen järjestyille kaavakkeille. Silloin kuin se ei ole mahdollista, voi todistukset kirjoittaa liitteiksi hakemukseen.
b) Jos hakija on perheellinen ja perhe matkustaa mukana, on koko perheen käytävä lääkärintarkastuksessa hakemuksen vaatimuksien mukaisesti.
c) Hankkiessanne hakemuksen mukaan tarpeelliset valokuvat, ottakaa samalla kertaa vähintäin puoli tusinaa n. s. passikuvia. Täten säästytte menemästä uudelleen kuvaan passeja varten, jos hakemuksenne tulee hyväksytyä.
d) Kun hakemus tulee käsiteltyä ja siitä päätös, ilmoitetaan siitä ja samalla lähetetään lähempiä yleisohjeita passien hankintaa y. m. varten.
e) Jos olette työssä tai olette sellaista tilaisuudessa saamaan, älkää jättäkö anzionahdollisuuksianne ennenkuin olette saanut varmuuden matkustuspäivästä. Muistakaa, että jokainen dollari mikä voidaan hankkia, tarvitaan matkakustannuksiin, työkaluihin ja koneistoon.

Karjalan Teknillinen Apu
JUN 17 1932
New York, N. Y.

Национальный АРХИВ Республики КАРЕЛИЯ

Translation of the Application Form "K.A.S.N.T:n tulevien henkilötiedot" (Personal Information of Soviet Karelian Technical Aid Applicants)

Preliminary Requirements:

1. The applicant is required to provide a certificate from a leftist workers' organization.

2. The applicant is required to provide a doctor's certificate, stating they are fit for work and free from contagious diseases.

3. Do you have a family? How many members? The family may come, but the applicant must pay for their own and their family's transportation.
   Response: _____

4. If you are able, how much money can you invest: a) In the general machinery fund: $ _____ b) In tools: $ _____

For each family member, 16 years or older, this form must be filled out personally and the following questions answered:

1. Applicant's full name: _____
2. Place of birth: _____ (Date: Day ___, Month _____, Year _____)
3. Family relations. Description: _____
4. Applicant's nationality: _____
5. What schools have you attended and graduated from: _____
6. Occupation. How extensive is your experience in each occupation you have worked in? _____
7. On which country's passport do you travel? _____
8. When could you travel? _____
9. What kind of work do you expect to be recruited to? _____
10. Have you been in the USSR or in old Russia before? __ If yes, in what place and on what business? _____

11. Names and ages of children younger than 16. (Older family members must file their own application). __

12. Which party are you affiliated with? _____ Since when? _____ To what other organizations? _____ What organizations have you belonged to in the past? _____

13. When did you travel to America? _____ From where? _____ Through which port? _____

14. Have you served in the military? __ No. If yes, in which country's military and on which frontier? _____ Where did you receive military training? _____

15. Have you been prosecuted in court? __ No. If yes, for what matter? _____

16. Do you own property in the S.S.R. Union? __ No. If yes, where and how much? _____

17. Do you have relatives in the S.S.R. Union? Names and addresses. _____

18. Which organization recommends you to come to the Soviet Union? _____

19. Which individual recommends you? Name and address: _____

20. Three passport photos must be attached.

E.1 North American Organizational Innovations

The organization of felling sites and the hauling of timber offers a case study of how North American workers introduced new organizational practices. According to the pocket guide by Bekrenev (1932), available in both Russian and Finnish and intended to serve as manual for local workers, the Canadian logging model divided the felling site into 30 meter wide plots, each to which one logger was assigned. Ice roads were built between each plot to reduce the friction in hauling. Hauling began immediately after the first plot was felled. The hauling was done using several fast-loading double-sleds each pulled by a pair of horses (as compared to the traditional Karelian one-horse sled), or crawler tractor. A logging team would consist of two to three sleds with one driver each, two loaders and five to six fellers. These between nine to eleven workers formed a team that would be called "brigade" in the Bolshevik lingo whereas the local model of organization was mostly pairs of loggers or so-called Yatcheikas that consisted of three to four workers with primitive division of tasks and fairly unorganized felling sites. The North American style brigade's horse-drawn transports unloaded directly the load onto a tractor-drawn sled that carried it to the side of a truck route. Empty sleds were transported back to the felling sites on different roads to avoid blocking the road of loaded sleds and also to preserve the roads. Figure E.2 provides some examples of these manuals that were published shortly after the arrival of the North American workers.

Several other organizational changes were introduced by North American Finns, for example they use clocks and regular schedule (instead of operating on a solar clock), improved the hygiene in workers' canteens which are known to have been on a different level in logging camps where North American Finns worked (Golubev and Takala, 2014).

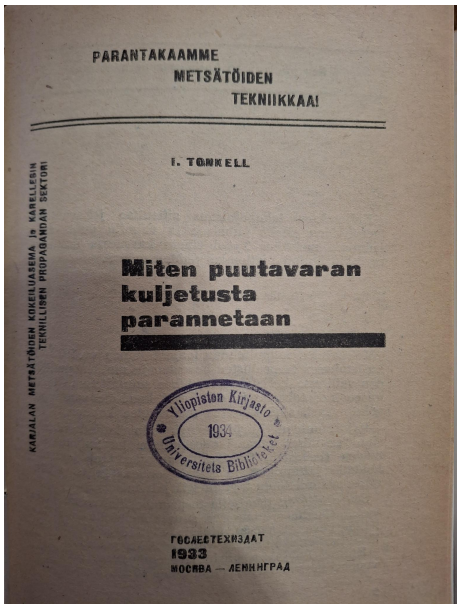
Table E.1: Productivity Gains of North American Methods and Technology

Technology	Measurement year	Unit	Productivity gain	Reference
Primary felling	Harvesting seasons 1930-31 and 1931-32	time	53.2%	Bekrenev (1932)
Frame saw	Harvesting seasons 1930-31 and 1931-32	time	33.6%	Bekrenev (1932)
Forest thinning (with axe)	Harvesting seasons 1930-31 and 1931-32	time	63.2%	Bekrenev (1932)
Gain of foreign worker in North American type logging team	Harvesting seasons 1930-31 and 1931-32	volume	74.9%	Bekrenev (1932)
Gain of foreign worker in a traditional Yatcheika	Harvesting seasons 1930-31 and 1931-32	volume	127.5%	Bekrenev (1932)
Loading of unit of timber on Canadian sled vs. local sled	Harvesting season 1931-1932	time	500%	Tonkel (1932)
Single foreign lumberjack gain per day in volume	Harvesting season 1931-1932	volume	283 %	NARK, f. R-286, o. 1, d. 22/200, l. 12
"North American methods" (Matroosa) gain per day in volume	Harvesting season 1931-1932	volume	400%	NARK, f. R-286, o. 7,
Log bucking	1933	volume	$\sim$ 200%	NARK, f. R-690,op. 3, d. 466, l. 17

Notes: Karelian Forestry Research Institute studied closely the organization of labor in logging teams of North American workers to create a scientific model of effective timber-harvesting methods, and many of the researchers were employed at the research station of Paatjärvi (Golubev and Takala, 2014). The cited research reports do not reveal whether the results are based on randomized controlled trials. We interpret them as observational studies.

Figure E.2: Manuals of North American Methods in Forestry

(a) Manual on timber hauling



(b) Planning of hauling roads



(c) Canadian frame saw manual



(d) Saw sharpening instructions



Note: Figures E.2a and E.2b come from a manual published in 1933 describing North American hauling methods and construction of transport roads to felling sites (Tonkel, 1933a). Figures E.2c and E.2d come from a manual manual published in 1933 providing instructions on how to build, apply and service a Canadian frame saw (Tonkel, 1933b). Both manuals are in Finnish but appear to be translations from Russian.