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Technical change and the postwar slowdown in Soviet economic growth in a long run perspective, 1885–2019

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Abstract

The existing studies usually find that technical change was very important in constraining the economic growth of the Soviet Union. While these studies have been successful in quantifying the extent of technical change, they have been less successful in quantifying its nature. This paper moves a step closer to probing the essence of Soviet efficiency by splitting the aggregate technical change into its subcomponents – namely, capital and labour efficiency. I find that the Soviet Union registered strong labour efficiency gains during most of the postwar period, converging towards the labour efficiency level of the global frontier – the US. Labour efficiency growth did decrease over time, but labour efficiency was not a primary cause of Soviet growth retardation. That retardation was instead caused by a decline in capital efficiency. At a disaggregated level, I find that the decrease in capital efficiency was driven by structures. I hypothesize that labour shortages and an inadequate investment policy resulted in a large stock of unfinished, and hence idle, structures, distorting Soviet economic growth.

KEYWORDS
growth under socialism, Soviet Union, technical change

The rapid industrialization of the Soviet Union under central planning is one of the most important state-led development strategies ever attempted. By the 1950s, the Soviet Union achieved rapid industrialization through a massive mobilization of resources. It seemed capable of achieving this without the increase in inequality that is often associated with development under capitalism.[1] It is thus unsurprising that many developing countries at the time, such as China or India, sought to emulate the Soviet growth experience. The Soviet achievements, however, came at a cost. The accumulation of military and national power, made possible by industrialization, came at the expense of life quality.[2] The obsession with capital accumulation sacrificed consumption, while the reliance on coercion and terror retarded human agency.[3] Moreover, although income inequality decreased, inequality in power and in privilege in accessing consumer goods increased.[4] Nevertheless, from the 1960s onward, some of the professed advantages of the Soviet development model started corroding. Namely, the once rapid economic growth rates started gradually slowing down.[5] Success turned into failure after 1970, when the growth rate dropped substantially. Eventually, the economic growth reached a standstill, and the country disintegrated in 1991.

Many researchers have analysed the sources of the Soviet growth slowdown. They frequently find that technical change played an important role in retarding economic growth.[6] Recent research stresses that technical change was less important in the other socialist economies of Europe, but still mattered in dragging down growth.[7] While these studies have been effective in quantifying the extent of socialist technical change, they have been less successful, however, in quantifying its nature. This paper moves a step closer to probing the essence of Soviet efficiency by splitting the aggregate technical change into its subcomponents – namely, capital and labour efficiency.

Most papers that analyse the Soviet Union assumed that technical change is factor neutral. Under factor neutrality, the technical change affects all factors of production equally, whereby, for example, a unit decrease in aggregate efficiency implies that the efficiency of both capital and labour has decreased by exactly one unit. This approach implies a Manichean view where some countries 'get it right' and others 'get it wrong'. They either make the most of their capital and labour, or they fail to use any of these efficiently. Under this line of reasoning, the Soviet Union got it wrong in everything.[8]

The factor-neutral approach of using only one quantitative measure of technical change is self-limiting. It potentially masks a richer set of dynamics at a finer level, and is thus intrinsically constrained when it comes to identifying the root causes of socialist inefficiency. This paper allows technical change to be non-neutral. In this way, I allow the efficiency of capital and labour

[1] Novokmet et al., 'From Soviets'.

[2] Recent scholarship downplays the economic motives underlying the Stalin's industrialization push. See Kontorovich, 'Military origins'.

[3] See Gregory and Harrison, 'Allocation', for an excellent treatment of Stalin's command system.

[4] Henderson et al., 'Hidden inequality'.

[5] Annual gross national product (GNP) growth was high during the 1928–40 and 1950–60 periods (5.8 per cent and 5.7 per cent, respectively), before slowing down to 5.2 per cent during the 1960s. Subsequently, the annual rate dropped sharply to 3.7 per cent in 1970–5 and 2.6 per cent in 1975–80, finally hitting 2.0 per cent in 1980–5 (Ofer, 'Soviet economic growth', pp. 1778–9).

[6] See Ofer, 'Soviet economic growth', for a survey.

[7] Vonyó, 'War and socialism'; Vonyó and Klein, 'Why did'; Kukić, 'Socialist growth'; idem, 'Origins'.

[8] Kukić, 'Patterns', allows non-neutral technical change for a group of socialist economies in Europe.

to grow at different rates. Importantly, this allows me to move closer towards the fundamental explanations underpinning the Soviet growth slowdown. For instance, if capital efficiency was the primary reason for the slowdown in economic growth, researchers should focus on analysing factors that distorted capital efficiency, such as the inadequate investment policy.[9] If labour efficiency was the main contributor to the growth slowdown, researchers should focus instead on factors that distorted labour efficiency, such as the poor structure of material incentives.[10]

Using revised data and the constant elasticity of substitution (CES) production function of Caselli, I analyse the factors related to efficiency that caused the postwar slowdown in economic growth.[11] I include in the analysis, however, the interwar period, which allows me to track the roots of the postwar growth performance. I include the Russian Empire (turn of the twentieth century) and modern Russia, too, with the sole aim of contextualizing the Soviet experience better by situating it within a longer period. For comparative reasons, I also include in the analysis the United States – the global technological frontier.

Employing a novel methodology, this paper presents novel results about the Soviet economy. Labour efficiency was an important source of growth, increasing strongly during most of the postwar period. Labour efficiency growth did slow over time, but it was not a primary cause of Soviet growth sluggishness. The decrease in capital efficiency instead caused that sluggishness.

Capital efficiency decreased from the 1930s, and continued decreasing until 1990, driving the slowdown in economic growth. When disaggregating the capital input, I find that the efficiency of both equipment and structures decreased sharply in the postwar decades. The efficiency of structures, however, deteriorated more intensively, constraining growth to a larger extent than that of equipment. Hence, to understand the Soviet growth retardation, it is of primary importance to explain the inefficiency of structures.

I hypothesize that one reason why the efficiency of structures decreased is because of labour shortages. The Soviet Union adopted an input-intensive process of mass production, which became less suitable over time due to the increasing scarcity of labour. Consequently, the utilization rate of capital decreased. In the terminology of Abramovitz, the production process of the Soviet Union was hence not 'technologically congruent' with the existing labour endowment.[12] However, while labour shortages imply that there were not enough workers to staff the factories, they also imply that there were not enough workers to operate the machines. This makes it unclear whether labour shortages are sufficient to explain why the efficiency of structures decreased so strongly, at least relative to equipment.

The inadequate investment policy arguably compounded the inefficiency of structures. A distinctive feature of the Soviet investment policy was the over-concentration of investment in new firms, relative to the existing firms. One corollary of this policy is the increasing stock of incomplete factories and other structures. These stocks immobilized capital and held up production, resulting in a collapse in the efficiency of structures.

The findings of this paper shed new light on Soviet economic performance. The existing literature uses two analytical models to explain the growth slowdown. Under a Cobb–Douglas production function, the growth slowdown is usually attributed to a slowdown in total

[9] Cohn, 'Sources'; Hanson, *Trade and technology*.

[10] Kim, 'Causes'; Kim and Shida, 'Shortages'.

[11] Caselli, *Technology*.

[12] Abramovitz, 'Catching up'.

factor productivity (TFP) growth.[13] Under a CES production function with a low elasticity of factor substitution, the decline is instead attributed to a diminishing marginal product of capital (MPK).[14]

By allowing technical change to be non-neutral, my paper largely reconciles the findings of these two strands of literature. The results of the paper imply that TFP was indeed the main cause of the Soviet growth retardation, just as Voskoboynikov finds for the postwar period using revised data, or as Cheremukhin et al. find for the interwar period using a neoclassical growth model.[15] My results, however, suggest that the fall in total efficiency was primarily caused by a fall in capital efficiency, which is consistent with the literature that focuses on the role of diminishing MPK. By spanning the two strands of literature, my results are similar to Nakamura, who finds that the Soviet slowdown can be explained by both a decreasing trend in productivity growth and a low elasticity of substitution.[16] The two explanations (TFP and MPK), therefore, are not mutually exclusive.

At a deeper level, the existing literature usually attributes the Soviet growth slowdown to changes in economic policy during the postwar period, such as a shift in investment priority.[17] This paper demonstrates that capital efficiency constrained economic growth starting in the 1930s. This suggests that the postwar slowdown in growth can be traced and instead attributed to the factors that were fundamental to the operation of the central planning system.

At a fundamental level, many inefficiencies plagued central planning. Central planning and the absence of private property rendered rational economic calculation impossible.[18] Furthermore, central planning stifled innovation and the adoption of new equipment embodying new technology.[19] It demoralized labour, and ensured the survival of inefficient firms.[20] Moreover, it was unable to adapt to the requirements of flexible production technology.[21] For these reasons, Krugman concludes that the Soviet Union was doomed to fail.[22]

While the existing literature provides many theoretically plausible explanations about the root causes of Soviet inefficiency, the historiographical challenge is to determine which explanations are the most important. By allowing technical change to be non-neutral, this paper narrows the range of the principal suspects. In particular, the results demonstrate the first-order importance of the factors that distorted capital efficiency, especially that of structures. This is not to imply that other factors, such as those that influenced equipment efficiency (e.g. weak technological adoption) or labour efficiency (e.g. weak material incentives), were irrelevant. They were rather of lower importance in constraining growth.

In the remainder of the paper, section I provides an overview of the Soviet economic institutions. Section II describes the methodology I use in the paper, while section III provides a short

[13] Ofer, 'Soviet economic growth'; Allen, *Farm to factory*; Hanson, *Rise and fall*.

[14] Weitzman, 'Soviet postwar economic growth'; Easterly and Fischer, 'Soviet economic decline'.

[15] Voskoboynikov, 'Accounting'; Cheremukhin et al., 'Industrialization'.

[16] Nakamura, 'Productivity'.

[17] Allen, *Farm to factory*.

[18] Mises, *Socialism*; Hayek, 'Use of knowledge'.

[19] Berliner, *Innovation decision*; Amman and Cooper, *Industrial innovation*.

[20] For labour: Ofer, 'Soviet economic growth', pp. 1815–6. For firms: Kornai, *Socialist system*.

[21] Broadberry and Klein, 'When and why'.

[22] Krugman, 'Myth'.

description of the used data. Section IV presents the results of this paper, and section V interprets those results. Section VI concludes.

I | HISTORICAL BACKGROUND

This section describes the central economic institutions of the Soviet Union, as well as their impact on different facets of efficiency to contextualize the results. In 1914, Russia entered the First World War, followed by the abdication of the Tsar and the Bolshevik Revolution in 1917, culminating in the civil war that lasted until 1921. Under the strains of the civil war and the radical institutional changes that resulted in total state control – the system of 'War Communism' – the economy imploded.[23]

Faced with the threat of a rebellion, the communist leadership under Lenin introduced the New Economic Policy (NEP) in 1921.[24] The central feature of the NEP was the retreat into a market economy.[25] By 1928, per capita income had recovered to its pre-war levels.[26] The pressing question became what to do now that recovery was achieved.

Stalin's answer was to reverse the NEP. Beginning in 1928, Stalin rapidly put in place the institutions of central planning that defined the Soviet economic system – collectivized agriculture, output targets, soft budget constraints, and five-year plans. These institutions launched unprecedentedly rapid economic growth that lasted into the 1950s.

To finance the Soviet industrial revolution, consumption was squeezed.[27] Moreover, the agricultural surplus was expropriated, and peasants were forced to join the collective farms.[28] These farms received compulsory quotas for grain procurement at below-market prices. The collectivization campaign caused a catastrophic fall in agricultural productivity.[29] The mass famine of 1932–3 ensued, claiming millions of lives.[30]

Many scholars have examined whether collectivization was necessary for rapid industrialization. Alec Nove argues that, in an autarkic state, it was.[31] Collectivization extracted the agricultural surplus that provided the necessary resources to increase industrial investment. It also pressured farmers to move to factories, fuelling the industrialization drive. Cheremukhin et al., however, do not agree with Alec Nove, arguing that collectivization caused a severe misallocation of labour, and retarded the incentive to work.[32] By extension, it severely constrained labour efficiency.

Beginning in 1928, five-year plans were introduced. They were extremely ambitious in their objective to boost industrial output quickly.[33] In this environment of haste, ministries were translating the plan into practice by setting compulsory annual output targets for individual firms.

[23] Nove, *Economic history*, pp. 57–68.

[24] Ibid., pp. 68–78.

[25] Davies et al., *Economic transformation*, p. 8.

[26] Markevich and Harrison, 'Great War'.

[27] Allen and Khaustova, 'Russian real wages'.

[28] Nove, *Was Stalin really necessary*.

[29] Cheremukhin et al., 'Industrialization'.

[30] Markevich et al., 'Political-economic causes'; Naumenko, 'Political economy of famine'.

[31] Cheremukhin et al., 'Industrialization'.

[32] Ibid.

[33] Nove, *Economic history*, p. 190.

Substituting output targets for profits as the governing objective of firms had a profound impact on efficiency. It effectively resulted in the end of cost control. It led to a phenomenon that Kornai termed the 'soft budget constraint'.[34] To assure the fulfilment of output targets, firms could use more resources than initially planned. Poorly performing firms were rarely allowed to fail. They were kept solvent through ample credit, and could disregard costs in their quest to reach the output target. This motivated firms to build excess capacity, mostly in the form of new plants, causing capital misallocation. An additional problem is that many of these new plants were never finished, causing a fall in the efficiency of structures.[35] The soft budget constraint, therefore, bred capital inefficiency, but it also stimulated investment in a backward economy otherwise starved of capital.

Equivalent to boosting investment, the soft budget constraint also stimulated labour demand.[36] To fulfil the output target, the firms could hire as much labour as they wanted and was available – cost was a non-issue. This behaviour ensured a sharp increase in the employment rate. It also induced labour shortages by creating excess demand for workers, and thus caused a decrease in the capital utilization rate – there were too few workers to productively operate the capital.[37]

Allen argues that, overall, output targets and soft budget constraints were an effective policy mix that rapidly increased output until the 1950s.[38] These institutions quickly mobilized resources, resulting in an extensive growth pattern based on factor accumulation. The extensive growth strategy, however, eventually reached its limits, and economic growth started slowing down from the 1960s onwards. The Soviet Union needed to make a transition to an intensive growth model, based on innovation and efficiency improvements, to sustain growth.

The incentive to innovate and to use the resources efficiently, however, was highly distorted. The research and development sector was disjointed from the production enterprises, and the reward system was unsuitable at all relevant stages of the innovation process.[39] To the extent that technology is mostly embedded in equipment, and not in structures, this caused equipment inefficiency, and thus cut into capital efficiency. This is not to imply that innovation had no impact on the efficiency of structures – it certainly did, at least partially. It does imply, however, that the main channel connecting innovation and capital efficiency was equipment.[40]

The emphasis on short-term output targets further distorted capital efficiency. Firm managers were hesitant to adopt new equipment for fear of disrupting the existing production process and missing the pressing targets.[41] They hence preferred to use the tried and trusted equipment. Besides limiting the rate of technological progress, this behaviour extended the service lives of equipment, increasing production costs and decreasing equipment efficiency. Allen considers this tendency to use old equipment to be a major constraint on Soviet TFP.[42]

Additionally, chronic shortages of consumer goods appeared, which were a logical outcome of the soft budget constraint and the low priority that planners attached to the consumer industry.[43]

[34] Kornai, *Socialist system*.

[35] Hanson, *Trade and technology*, pp. 49–80; Dyker, *Investment*, pp. 35–8.

[36] Kornai, *Socialist system*.

[37] Ofer, 'Soviet economic growth', pp. 1782–3.

[38] Allen, *Farm to factory*.

[39] Berliner, *Innovation decision*; Amman and Cooper, *Industrial innovation*.

[40] For global empirical findings, see DeLong and Summers, 'Equipment', and Caselli, 'Accounting'.

[41] Cohn, 'Sources'.

[42] Allen, *Farm to factory*.

[43] Kornai, *Socialist system*.

These shortages retarded labour motivation, further cutting into growth by decreasing labour efficiency. To avert these effects, the wage bill was kept higher than the realized consumption bill. This backfired by causing repressed inflation, adding another source of consumer frustration.[44] An informal economy developed alongside the main, tolerated because of its beneficial effect on work motivation.[45] Heavy drinking was another refuge from frustration and inability to satisfy consumer wants, decreasing population health and deteriorating labour effort and efficiency further.[46]

The Soviet leadership was aware of these issues.[47] Nevertheless, the central planning institutions remained largely the same during the postwar period. Only Gorbachev in the late 1980s made real changes. He dismantled central planning, but without offering a viable alternative.[48] The Soviet Union disintegrated in 1991, and each successor state embarked on a transition process to a market economy.

II | METHODOLOGY

In this section, I use the framework developed by Caselli.[49] His method enables me to determine the efficiency of capital and labour inputs separately, allowing me to move closer towards pinpointing the fundamental factors that may have shaped the Soviet growth process. To identify the possible differences in capital and labour efficiency, it is critically important to use the flexible CES production function:

$$Y = \left[(A_K K)^{\sigma} + (A_L L)^{\sigma}\right]^{1/\sigma} \tag{1}$$

where Y is the output, K is the physical capital, and L is the labour augmented by quality (human capital). σ determines the elasticity of substitution, $1/(1-\sigma)$, with which capital and labour are combined to produce output. Capital and labour are weak substitutes, relative to a Cobb–Douglas production function case, if $\sigma < 0$. The inputs are relatively good substitutes if $\sigma > 0$. The Cobb–Douglas production function is a special case of Equation (1) when inputs can be exchanged at a rate of one-to-one while maintaining the same level of output ($\sigma = 0$).

In the CES production function, A_K denotes the efficiency of capital, while A_L denotes the efficiency of labour. Many factors can influence capital or labour efficiency, including technology, factor misallocation, factor quality, managerial quality, utilization rate, and spillover effects.[50] The previous section discussed the specific factors that could have negatively influenced the Soviet capital and labour efficiency.

Moving further, first-order conditions of Equation (1) yield:

[44] Kim, 'Causes'.

[45] Kim and Shida, 'Shortages'.

[46] Ofer, 'Soviet economic growth', p. 1816.

[47] Hanson, *Rise and fall*, pp. 140–8.

[48] Nove, Economic history, pp. 394–419.

[49] Caselli, *Technology*.

[50] Jones, 'Facts'.

$$mpl = (A_L)^{\sigma}\left(\frac{Y}{L}\right)^{1-\sigma} \tag{2}$$

$$mpk = (A_K)^{\sigma}\left(\frac{Y}{K}\right)^{1-\sigma} \tag{3}$$

where mpl is the marginal product of labour, and mpk is the marginal product of capital. In Equations (2) and (3), the marginal product of input depends on the productivity (second term of each equation) and efficiency (first term of each equation) of that input. The elasticity of substitution determines the strength of these relationships.

Equations (2) and (3) can be rearranged to back out the efficiency of each input:

$$A_L = \left(\frac{mplL}{Y}\right)^{\frac{1}{\sigma}}\frac{Y}{L} \tag{4}$$

$$A_K = \left(\frac{mpkK}{Y}\right)^{\frac{1}{\sigma}}\frac{Y}{K} \tag{5}$$

These equations yield the intuitive result that a high level of capital (labour) productivity and mpk (mpl) implies a high level of capital (labour) efficiency. The ratio within the parenthesis of Equations (4) and (5) is the share of output produced by capital (α) and labour ($1-\alpha$), $(mpkK)/Y = \alpha$ and $(mplL)/Y = 1-\alpha$, respectively.[51] More formally:

$$A_L = (\alpha)^{\frac{1}{\sigma}}\frac{Y}{L} \tag{6}$$

$$A_K = (1-\alpha)^{\frac{1}{\sigma}}\frac{Y}{K} \tag{7}$$

In Equations (6) and (7), a high level of efficiency in capital (labour) increases the effective supply of capital (labour). This will increase the capital (labour) share of output if labour and capital are good substitutes ($\sigma > 0$), and reduce it if they are poor substitutes ($\sigma < 0$).

Assuming perfectly competitive markets, where capital is paid its marginal product, the share of output produced by capital can be measured by the share of national income paid out as rent to capital. Synonymously, the labour share of output can be measured by the share of income paid out as wage to labour. These are the CES equivalents of the Cobb–Douglas assumption that, under perfect competition, the elasticity of output for each input can be measured by the share of that input in national income.

In the Soviet Union, however, inputs were not paid for their marginal product. The assumption of perfectly competitive markets is thus invalid. Nevertheless, this assumption provides a useful starting point in establishing a benchmark value for the α parameter. Growth accounts commonly use the value of one-third for α, estimated from the national accounts of advanced, market economies. I make this assumption for the United States, which makes the labour share two-thirds. For centrally planned economies, the capital share is estimated to be higher. Following Easterly and Fischer, I assume a capital share of 0.4, resulting in a labour share of 0.6.[52] In the

[51] Under constant returns to scale, α and $1-\alpha$ sum to unity.

[52] Easterly and Fischer, 'Soviet economic decline'.

Appendix, I experiment widely with these values, pushing the capital share to as high as 0.8 or as low as 0.2, far outside all bounds found in the literature. The results, however, remain qualitatively identical. Therefore, while the assumption of perfectly competitive markets is conceptually problematic, it is empirically unproblematic – deviating from the benchmark value of the α parameter keeps the direction of the efficiency trends unchanged.

Concerning the Soviet elasticity of the substitution parameter, I assume that it is 0.55, based on Easterly and Fischer.[53] Many papers estimate the Soviet substitution parameter econometrically.[54] The majority of papers find a value close to one.[55] With a higher elasticity of factor substitution, I would increase the importance of capital efficiency in driving the Soviet growth deterioration (Appendix). By using a lower elasticity value, my baseline results provide a lower-bound estimate of the capital efficiency effect.[56] In general, when faced with a wide choice of plausible parameters and data, I prefer using those that are biased against my results. In this way, I provide a conservative estimate of the effect that capital or structure efficiency had in constraining economic growth.

The CES production function also allows me to decompose the aggregate capital input into two sub-inputs – structures, N, and equipment, M. This decomposition matters because it permits me to narrow the range of potential suspects that drove the evolution of capital efficiency. I can rewrite Equation (1) as:

$$Y = \{[(A_N N)^{\eta} + (A_M M)^{\eta}]^{\sigma/\eta} + (A_L L)^{\sigma}\}^{1/\sigma} \tag{8}$$

where A_N is the efficiency of structures and A_M is the efficiency of the equipment. The parameter η determines the elasticity of substitution, $1/(1-\eta)$, with which equipment and structures are combined into aggregate capital.

The first-order conditions of Equation (8) imply:

$$A_M = \frac{Y}{M}\alpha_M^{1/\eta}\alpha^{\left(\frac{\eta-\alpha}{\eta\alpha}\right)} \tag{9}$$

$$A_N = \frac{A_M M}{N}\left(\frac{\alpha_N}{\alpha_M}\right)^{1/\eta} \tag{10}$$

where α_M is the share of output generated by equipment and α_N is the share of output generated by structures. I take these parameters from the Central Intelligence Agency (CIA) factor cost estimates of the Soviet economy, which imply that $\alpha_M = 0.21$ and $\alpha_N = 0.19$, summing up to the aggregate capital share of 0.4.[57] Since factor shares are difficult to determine for centrally planned economies, I report robustness checks using a wide range of share values in the Appendix.

There are no estimates of the substitution parameter between equipment and structures for the Soviet Union. I take this parameter from Temple, who estimates it at a global level, and finds

[53] Easterly and Fischer, 'Soviet economic decline'.

[54] Weitzman, 'Soviet postwar economic growth'; Desai, 'Total factor productivity'; Bairam, 'Elasticity'; Nakamura, 'Productivity'.

[55] For the United States, I take the elasticity of substitution (0.7) from Oberfield and Raval, 'Micro data'.

[56] The lowest substitution parameter for the Soviet Union is that of Nakamura, 'Productivity', −0.25. The Appendix uses this parameter – it cannot overturn the results.

[57] The CIA, *Measures*.

a value of 0.8.[58] Other studies typically find a much greater value.[59] Using a higher value of the substitution parameter would effectively put greater weight on the efficiency of structures in decreasing growth, relative to that of equipment, reinforcing the results (Appendix).

The assumption of fixed parameters over time can be challenged, but the assumption concerning the elasticity of substitution is a reasonable one. The elasticity of substitution is influenced by institutions, which remained largely identical over the central planning period.[60] Therefore, there is no strong reason to believe that the elasticity parameters changed during the Soviet period – the focus of research.[61] The labour share parameter, however, may have changed over the years. The Appendix hence experiments with the time-varying capital share parameter for different subperiods. This exercise, however, is highly sensitive to the (subjective) choice of the cut-off year when the parameter changes. The literature that analyses long-run economic growth thus prefers keeping the parameters constant.[62]

Finally, but perhaps most fundamentally, the formal theory for aggregation of economic quantities indicates that aggregate production functions do not exist, except in unlikely special cases,[63] of which the Soviet Union is certainly not one. By dividing aggregate efficiency into its subcomponents, I at least implicitly acknowledge the need to disaggregate the aggregate production function. Nevertheless, my results, as in all growth accounting exercises, cannot aspire to be more than an organizing framework for the parables we tell ourselves about the growth process.

III | DATA

This section outlines the main data for the Soviet period. As in any study that analyses long-run economic growth, it is challenging to merge various data sources based on different prices and methodologies. By providing extensive data description in the Appendix, alongside the exact sources, the interested reader will be able to follow each step I took and make changes that they consider appropriate.

The official data sources of the Soviet Union are highly problematic. While the physical output indicators are considered reliable, aggregates expressed in values are distorted by numerous issues, including index number problems, fixed prices, and hidden inflation.[64] These issues result in overestimated output growth. In response, Western researchers have invested an enormous effort into eliminating the statistical biases that plague the official output data.

Bergson was an early pioneer in estimating Soviet output during the interwar period.[65] He created measures of GNP that are fully comparable to market economies. During the postwar period, the most substantial work was carried out by the CIA and the Joint Economic Committee of the US Congress, using the same methodology that Abram Bergson proposed.

[58] Temple, 'Equipment'.

[59] See Chirinko, 'σ', for a survey.

[60] Easterly and Fischer, 'Soviet economic decline', pp. 362–3.

[61] The appendix experiments with time-varying alternative elasticity of substitution parameter for the Russian Empire and Federation.

[62] Jones, 'Facts'.

[63] Temple, 'Aggregate'.

[64] Ofer, 'Soviet economic growth', pp. 1770–5.

[65] Bergson, *Soviet national income*.

The alternative output estimates, however, are not uncontroversial. Khanin and Seliunin focused their attention on the CIA figures, claiming that they overestimate Soviet growth, mostly because they underestimate the extent of hidden inflation.[66] Some of the results of Khanin and Seliunin, however, are non-replicable, and they seem to have neglected serious index number problems when estimating hidden inflation.[67] I thus adhere to the CIA estimates for the 1950–90 period, which were revised and refined after the work of Khanin and Seliunin was published.[68] For the earlier period (1928–49), I use the output data from Moorsteen and Powell, who based their estimates upon Abram Bergson.[69]

The problems that afflict the official output data also afflict the official investment data. Hidden inflation is particularly problematic. It could overestimate investment growth by as much as three percentage points during the 1970s.[70] I hence take the investment data from the researchers that tried to correct these statistical distortions, including the problem of hidden inflation. For the 1928–49 period, I take investment from Moorsteen and Powell, while for the 1950–90 period, I take investment from the CIA.[71] These investment series are widely used in economic history research.[72]

Physical capital is composed of equipment, structures, and livestock.[73] For the 1928–49 period, I take the net physical capital stock from Moorsteen and Powell – by far the most comprehensive work on Soviet capital stock.[74] For the remaining period of analysis (1950–90), I estimate the annual net capital stock using the perpetual inventory method with geometric depreciation. To make the capital stock series internally consistent over the whole period of analysis, I also take the depreciation rate for each asset from Moorsteen and Powell. This makes the depreciation rate 3 per cent for structures and 11 per cent for equipment.

These depreciation rates are similar to what is typically assumed in papers that analyse developing, market-oriented economies during the same period, such as Spain.[75] They are higher, however, than in Vonyó and Klein, who analyse central European economies under socialism.[76] The Appendix shows that, under lower rates of depreciation, the growth rate of the capital stock would be faster, and the fall in capital efficiency would be faster as well (see Appendix also for results when using higher depreciation).

The official labour statistics of the Soviet Union are generally trustworthy.[77] I thus use labour data from the researchers who based their estimates upon the official data (see Appendix for exact sources). I express the annual employment data in full-time equivalents and adjust it for hours worked. This adjustment is important because the average hours worked have fallen significantly

[66] See Harrison, 'Soviet growth', for an overview of their work.

[67] Ibid., p. 159.

[68] CIA, *Measures*, pp. 54–7; idem, *Handbook*, p. 64.

[69] Moorsteen and Powell, *Soviet capital*, pp. 361–2.

[70] Bergson, 'On Soviet real investment'.

[71] Moorsteen and Powell, *Soviet capital*, p. 386; CIA, *Measures*, pp. 69–72; idem, *Handbook*, p. 64.

[72] Harrison, 'Trends'; Allen, *Farm to factory*; Cheremukhin et al., 'Industrialization'.

[73] The appendix shows the results when excluding livestock from capital.

[74] Moorsteen and Powell, *Soviet capital*, p. 315.

[75] Prados de la Escosura and Rosés, 'Sources'.

[76] Vonyó and Klein, 'Why did'.

[77] Lane, *Labour*.

since Stalin's death in 1953. If unadjusted, the headcount of workers would overstate the trend of labour input and understate labour efficiency growth.

I adjust labour for quality using the Mincerian approach, following Hall and Jones.[78] Namely, I transform average years of schooling into Mincerian human capital by adjusting for the efficiency of labour with education, relative to the efficiency of labour without education.[79] I assume that the efficiency of labour is measurable by the return to education. I also assume that the return to education is constant – there is no evidence of diminishing returns to education in the Soviet Union.[80]

I assume that the return to education is 6.6 per cent, following Brainerd.[81] She estimated the return to education for the period of the early 1990s, when Russia embarked on a transition process to a market economy. The research that focuses on the central planning period, however, typically finds much lower returns to education than 6.6 per cent.[82] By assuming a lower return to education, I would attach a lower weight to human capital as a source of growth. The Appendix shows that this would boost the contribution of labour efficiency to growth, increasing the relative importance of capital efficiency in constraining growth.

Nevertheless, the low return to education during the central planning period does not necessarily imply that socialist workers were inefficient. Egalitarian pressures compressed wage differentials in socialist countries, and workers were not paid their marginal product. Basing the return to education on the period of the early transition, when wages were liberalized but the economic structure still resembled that of the Soviet Union, intends to capture the efficiency of Soviet workers as closely as possible.

Figure 1 reports some of the data I constructed for 1885–2019. At the turn of the twentieth century, the Russian Empire experienced modest, but roughly consistent, labour productivity gains (panel a). In contrast, productivity gains in the Soviet Union were highly volatile between 1928 and the late 1940s. During this period, there were bursts of labour productivity growth (the start of central planning in the 1920s, the consolidation of it during the mid-1930s, and the postwar recovery), interspersed with periods of adverse economic performance (the famine of 1932–3, the Stalinist purges of the late 1930s, and the Second World War).

By the 1950s, the Soviet economy had entered calmer waters. During the 1950s, labour productivity gains averaged 4.1 per cent on an annual basis – the highest that the Soviet Union ever achieved. These growth rates, however, are mediocre when placed within a European postwar perspective.[83] Moreover, they soon started decreasing (see table 1 later in the text).

With the disintegration of the Soviet Union and the transition to a market-based economy, labour productivity imploded. Russia attained the productivity level of the late Soviet period in the late 2000s, and subsequent labour productivity growth has been weak. The modern Russian economy, therefore, does not seem capable of delivering (much) higher productivity growth rates than the old Soviet economy. Of course, due to size differences, one should exercise caution in comparing modern Russia to the Soviet Union – the change in the estimated trend for any variable

[78] Hall and Jones, 'Why'.

[79] Average years of schooling are from Lee and Lee, 'Human capital'.

[80] Brainerd, 'Winners and losers'.

[81] Ibid. For the United States, I make the standard assumption that the return to education is 10 per cent.

[82] Ibid.

[83] Crafts and Toniolo, 'Aggregate growth', table 12.9.

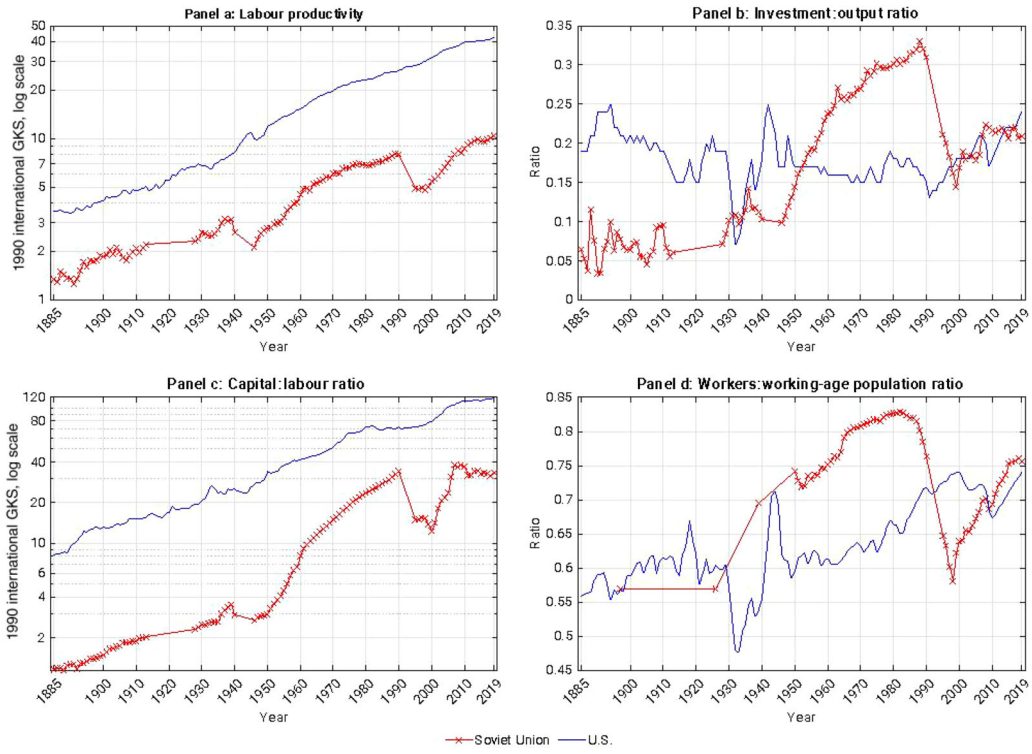

FIGURE 1 Macroeconomic data of the Soviet Union (Russian Empire/Russian Federation) and the United States at an aggregate level, 1885–2019 [1990 Geary–Khamis dollars (GK$)]. *Source*: Own calculations based on data described in section III and the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com]

between the two state entities is only indicative of the actual trend (the same holds for comparing labour and capital efficiency later in the text).

Regarding factor accumulation, the Soviet Union experienced rapid growth in capital (panels b and c) and labour (panel d) until the late 1980s. Nevertheless, the Soviet Union did not manage to converge significantly towards the labour productivity level of the United States during the twentieth century (figure 1a). This suggests that efficiency is the principal factor that constrained the relative economic performance of the Soviet Union.

Figure 2 situates the Soviet growth performance (GDP per capita) within a wider context. The Soviet Union during the 1928–89 period grew faster than most advanced, market-oriented economies. The Soviet Union, however, sits below the fitted (convergence) line. This means that the country did not grow very fast from a comparative perspective, given its initial level of development (panel a).

The Soviet growth performance remains below the sample average in figure 2b when controlling additionally for the investment rate and education (i.e. the expansion of physical and human capital). This further suggests that efficiency constrained the relative economic performance of the Soviet Union during the 1928–89 period.

Focusing only on the later phase of development (1960–89) paints an even bleaker picture (panels c and d). Figure 2d implies that the Soviet growth rate should have been about twice as high as in the actual state during the 1960–89 period, conditional on the included controls. From

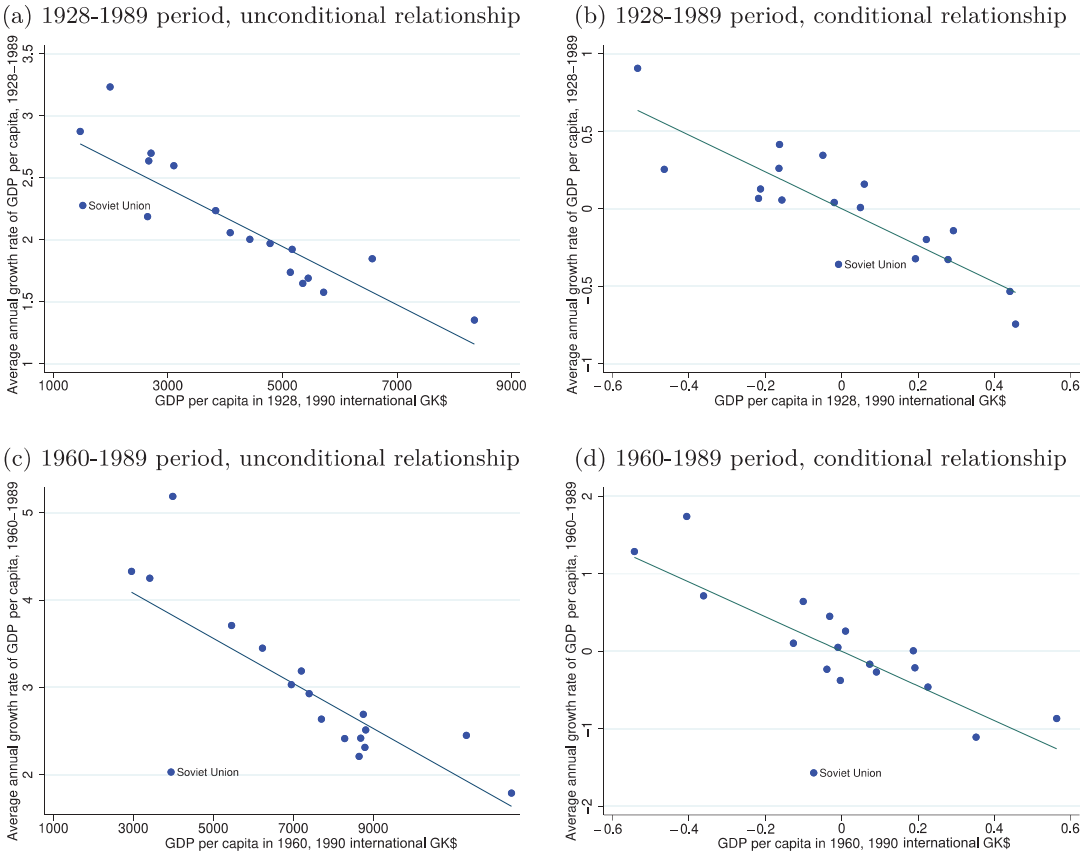

FIGURE 2 Economic growth and convergence in the Soviet Union and advanced economies. *Note*: The relationship between economic growth and initial GDP per capita in subfigures b and d is conditional on the average annual investment rate and the average annual growth rate in years of schooling during the periods 1928–89 and 1960–89, respectively. The period of Second World War (1939–45) is excluded from the analysis. The regression line is fitted to the actual values of the observations. The unlabelled observations are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States. *Source*: Own calculations. Data for the Soviet Union is described in section III. Data for other countries are taken from Jorda *et al.*, 'Macrofinancial history', and Lee and Lee, 'Human capital'. [Colour figure can be viewed at wileyonlinelibrary.com]

a comparative perspective, the economic growth of the Soviet Union hence became severely retarded from the 1960 onwards.

IV | RESULTS

Figure 3 depicts the evolution of labour efficiency. The Russian Empire at the turn of the twentieth century experienced strong growth in labour efficiency. This labour efficiency growth continued into the early Soviet period, although with the initial setbacks associated with the collectivization of agriculture in 1930–3 and the Second World War.

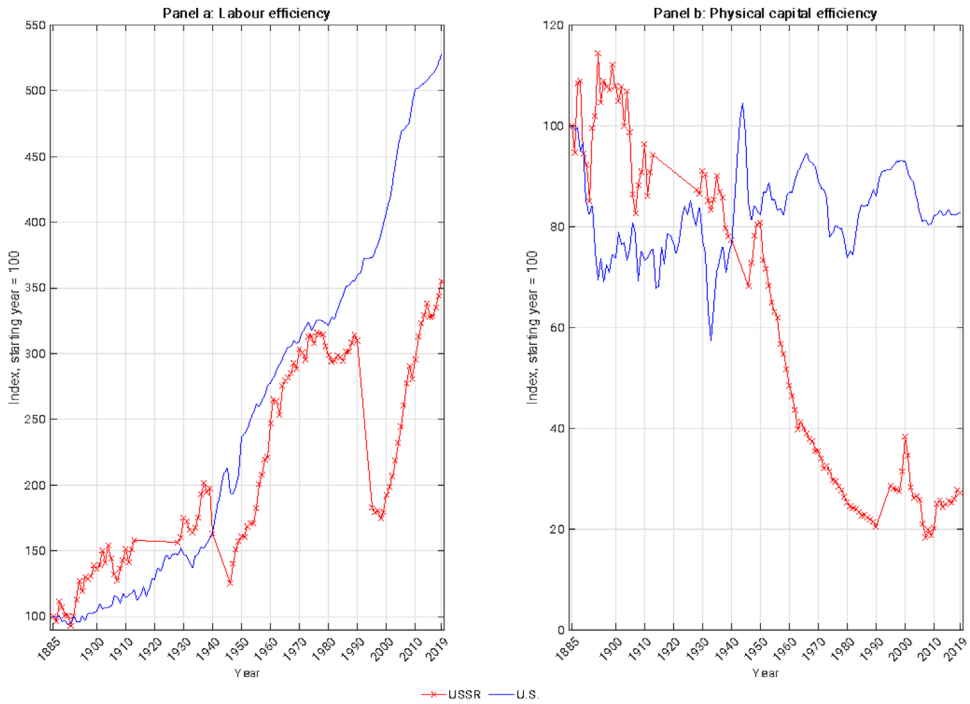

FIGURE 3 Evolution of capital and labour efficiency in the Soviet Union (Russian Empire/Russian Federation) and the United States, aggregate level, 1885–2019, 1885 = 100 (index). *Source*: Own calculations based on data in section III and the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com]

From 1945 until the early 1960s, labour efficiency grew at a rapid pace. Although the labour efficiency growth rate subsequently slowed down, it remained high until the mid-1970s. During this period, the Soviet Union experienced faster labour efficiency gains than the United States, converging towards the labour efficiency level of the technological frontier. At the turn of the 1980s, however, the Soviet Union experienced a sharp reversal in trend – labour efficiency decreased, severely handicapping growth during that period.

This labour efficiency decrease can be associated with a sequence of harvest failures in agriculture, caused by a set of weather shocks in 1975, 1979, 1980, and 1981.[84] The fall in agricultural output was particularly severe between 1978 and 1981, exactly at the time when labour efficiency registered a strong decrease. During this period, agricultural output fell by about 20 per cent, decreasing the overall output per efficiency unit of labour. In general, despite the rapid industrialization, Soviet agriculture during the postwar period still employed a large share of labour – about 25 per cent during the 1980s. Fluctuations in agricultural labour efficiency thus loomed large over the labour efficiency of the overall economy.[85]

Nevertheless, the decrease in labour efficiency was only temporary. In 1982, agricultural output started recovering, and so did labour efficiency (figure 3).[86] Therefore, it is possible that the

[84] Hanson, *Rise and fall*, p. 150.

[85] The agricultural share of total capital was much lower – see Moorsteen and Powell, *Soviet capital*.

[86] Hanson, *Rise and fall*, p. 152.

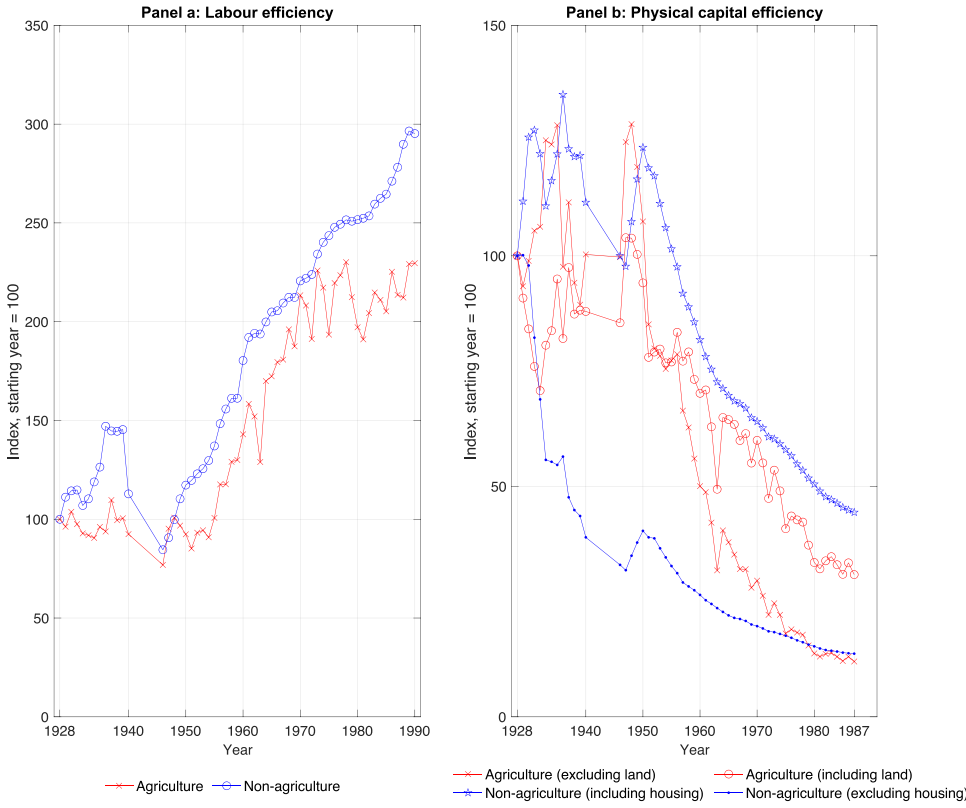

FIGURE 4 Evolution of capital and labour efficiency in the Soviet Union at sectoral level, 1928–90. *Note*: Agricultural land is not included in the measure of the aggregate capital stock in any of the exercises of the main text. *Source*: Own calculations based on data in section III and the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com]

transitory factors in agriculture drove the evolution of labour efficiency during the 1970s and the 1980s.

Decreased population health and increased shortages of consumer goods may have also influenced labour efficiency, but probably to a lesser extent. The shortages of consumer goods were stable during the postwar period, increasing only at the very end of the 1980s.[87] They are thus unlikely to be of high importance in shaping the labour efficiency decline of the late 1970s and the early 1980s. Concerning health, the Appendix adjusts labour efficiency for it, and the efficiency time series still registers a decline.

Figure 4 presents the evolution of labour efficiency at the sectoral level – agriculture and non-agriculture.[88] Just as the previous analysis suggests, labour efficiency in agriculture largely stagnated from the late 1970s onwards. In contrast, labour efficiency gains in non-agriculture were strong during the 1980s.[89] More generally, the labour efficiency growth in agriculture was

[87] Kim and Shida, 'Shortages'.

[88] Data-wise, it is impossible to disaggregate the economy into more sectors over the whole Soviet period.

[89] Labour efficiency growth did stagnate at the turn of the 1980s – the deterioration in health certainly mattered in constraining efficiency gains in non-agriculture at the turn of the 1980s.

weaker than in non-agriculture over the whole 1928–90 period. This aligns with the notion that collectivization severely retarded the incentive to work, and thus constrained labour efficiency (section I).

The performance of the agricultural sector was dismal in the early decades of central planning, with labour efficiency stagnating until the 1950s. From the mid-1950s onwards, however, agriculture registered strong labour efficiency gains, approaching those of non-agriculture by the mid-1970s.

This may be related to changes in agricultural policy after the death of Stalin in 1953. Under Nikita Khrushchev (1953–64), the Soviets abolished compulsory deliveries from the peasants' household plots.[90] Moreover, the prices that the state procurement agency offered for agricultural products increased, enabling rural income and the return to labour to rise. Simultaneously, rates of payment in kind for collective farm work increased, and peasants could pasture their household livestock on collective farms. After a generation of extreme exploitation of the countryside, these policy changes presumably instigated efficiency gains by substantially improving the incentive of peasants to work productively. Nevertheless, it seems that these changes were insufficient to sustain labour efficiency gains into the 1980s, and agriculture remained the Achilles' heel of the Soviet economy.

When the Soviet Union disintegrated in 1991 and Russia embarked on a transition process to a market economy, aggregate labour efficiency imploded (figure 3). This, in turn, presumably caused a major increase in unemployment, by decreasing the demand for the now less efficient labour.[91] Only in the early 2010s did Russia attain the labour efficiency levels of the 1980s Soviet Union.

There are many possible factors that caused this collapse in labour efficiency: the disintegration of the common Soviet market and the decrease of the domestic market potential, the reorientation of international trade flows and the change in terms of trade, the sharp increase in alcohol-induced mortality, and the overall chaotic environment of the early 1990s – hyperinflation, institutional vacuum caused by the breakdown of old institutions, and the slow emergence on new ones, etc.[92]

I now turn to the evolution of aggregate capital efficiency (figure 3). From the 1930s onwards, the Soviet Union experienced chronic declines in capital efficiency, which were salient during the postwar period. In contrast, capital efficiency in the United States remained roughly constant over the twentieth century, although with strong fluctuations. The evolution of capital efficiency in the Russian Empire largely stagnated as well, but with a somewhat downward drift towards the First World War.[93] After the disintegration of the Soviet Union in 1991, Russia achieved higher capital efficiency levels compared with the late 1980s Soviet Union. This may be related to mass privatization and large-scale capital retirements that characterized the early 1990s.[94] Although the privatization process was at least partially corrupt, it may have increased capital efficiency by retiring the less efficient capital stock.

[90] Hanson, *Rise and fall*, pp. 52–4.

[91] For unemployment, see Campos and Coricelli, 'Growth in transition'.

[92] For market potential effects, see Redding and Sturm, 'Costs of remoteness', for the German reunification case. For alcohol-induced mortality, see Zaridze et al., 'Alcohol'. See Campos and Coricelli, 'Growth in transition' for a survey.

[93] Although Tsarist Russia kick-started modern economic growth, the prevalence of corruption and red tape that imposed an extra levy on capital constrained that growth (Owen, *Dilemmas*).

[94] Campos and Coricelli, 'Growth in transition'.

TABLE 1 Sources of growth in the Soviet Union at an aggregate level, 1928–90: average compound annual growth rate (%)

	1928–90	1928–39	1940–9	1950–9	1960–9	1970–9	1980–90
Labour productivity growth	2.0	2.8	0.3	4.1	2.7	1.4	1.6
Labour efficiency	0.7	1.4	−0.3	2.3	1.2	0.1	0.3
Capital efficiency	−0.6	−0.4	0.2	−1.6	−0.9	−0.7	−0.6
Factor accumulation	1.9	1.9	0.4	3.4	2.4	2.0	1.9
Percentage of labour productivity growth due to:							
Labour efficiency	37	48	−83	56	45	5	17
Capital efficiency	−30	−13	51	−39	−32	−50	−37
Factor accumulation	93	65	132	83	87	145	120

Note: Sources of labour productivity growth are based upon the constant elasticity of substitution (CES) in Equation (1) of section II. The contribution of each variable is isolated by holding constant the value of all the remaining variables to their initial, 1928, level. Factor accumulation includes physical and human capital. *Source*: Own calculations based on data in section III and the appendix.

After the initial boost of the 1990s, capital efficiency fluctuated, but with an overall stagnating trend – modern Russia is incapable of achieving a sustained increase in capital efficiency. Russia, however, seems to have arrested the efficiency decline that characterized the Soviet Union.

From a comparative perspective, therefore, the sharp decline in capital efficiency emerges as a salient fact of the Soviet growth performance. I reserve a discussion for what may have caused that fact for section V, and now turn briefly to the evolution of sectoral capital efficiency trends that characterized the Soviet period.

Estimating the sectoral capital efficiency trends depends on defining the relevant capital stock measures. If I exclude land from agriculture and include housing in non-agriculture (matching the aggregate capital stock measure), the capital efficiency decline in agriculture is sharper than in non-agriculture (figure 4).[95] Land, however, should be included in capital.[96] Moreover, the method of calculating output in the housing sector effectively precludes the possibility of productivity change, mitigating the estimated decline in capital efficiency.[97] Figure 4 shows that excluding housing from non-agriculture and including land in agriculture results in a capital efficiency decline that is sharper in non-agriculture. This makes intuitive sense: Capital expansion and the associated efficiency costs were concentrated in industry, which the non-agricultural sector resembles more closely when it excludes the housing sector – see the Appendix for a wider discussion.

Table 1 establishes the contribution of aggregate capital and labour efficiency to the labour productivity growth rate of the Soviet Union. Just as the previous analysis implies, it shows that labour efficiency was an important source of growth, accounting for 37 per cent of labour productivity gains during the 1928–90 period. The contribution of labour efficiency was particularly strong during the 1950s, accounting for 51 per cent of labour productivity gains.

Although labour efficiency growth subsequently slowed down, and severely constrained growth during the 1970s, capital efficiency played a primary role in retarding the Soviet economic performance over the long run. Capital efficiency decreased labour productivity growth by about

[95] The appendix provides the results when including agricultural land in the aggregate capital.

[96] Caselli and Feyrer, 'Marginal'.

[97] Moorsteen and Powell, *Soviet capital*, p. 294.

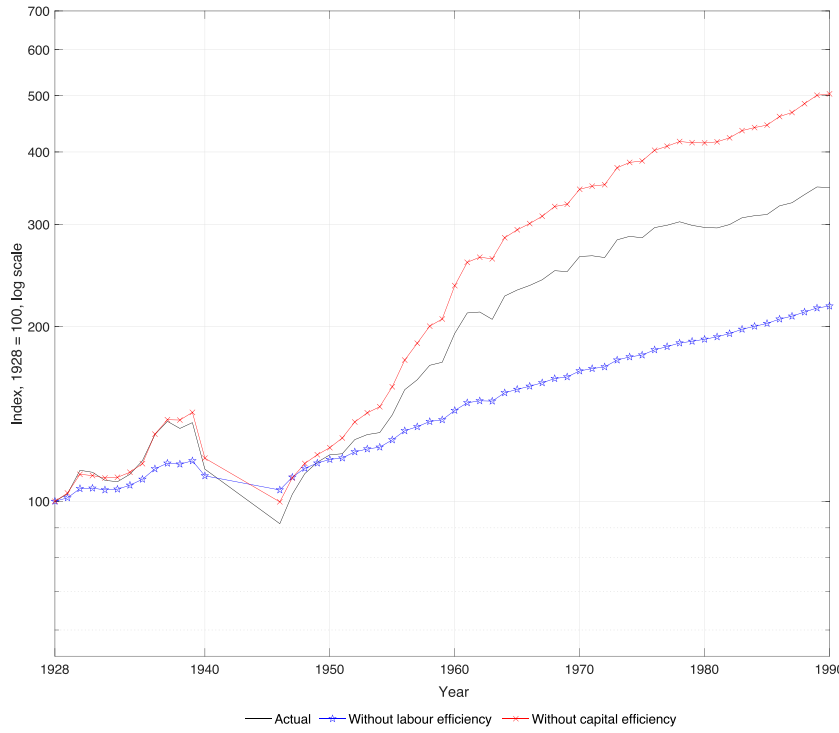

FIGURE 5 The actual evolution of labour productivity versus the counterfactual evolution of it (without labour efficiency or without capital efficiency), aggregate level, 1928–90, Soviet Union. *Note*: The line 'without labour efficiency' holds constant labour efficiency, while allowing all the other sources of growth to vary (capital efficiency, human and physical capital). It thus indicates what labour productivity would have looked like if labour efficiency had not grown at all. The interpretation of the line 'without capital efficiency' is completely synonymous to that of the previous line. The counterfactual output levels are derived from the constant elasticity of substitution (CES) in Equation (1) in section II. *Source*: Own calculations based on data in section III and the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com]

30 per cent during the 1928–90 period. It had a debilitating effect on growth during the 1970s, decreasing it by about 50 per cent.

Segmenting periods is a useful quantitative summary of results, but can obfuscate the dynamic dimension. I now seek to reinforce the finding that capital efficiency drove the postwar slowdown in economic growth. Figure 5 first charts the contribution of aggregate labour efficiency to economic growth. It plots the evolution of labour productivity under the counterfactual scenario where labour efficiency is held constant (the line 'without labour efficiency'), while all the other sources of growth are allowed to vary (e.g. human capital). This counterfactual line indicates what labour productivity would have looked like if labour efficiency had not grown at all. The discrepancy between this line and the actual path of labour productivity is caused by labour efficiency. If the two lines move in parallel, it means that labour efficiency accounts for a constant share of growth. If they diverge, it means that the share of growth that labour efficiency accounts for has changed.

Figure 5 reveals that approximately until the mid-1950s, the actual path of labour productivity and the counterfactual path in the absence of labour efficiency growth (the line 'without

labour efficiency') track each other closely. This means that the combined physical capital, human capital, and capital efficiency can replicate most of the economic growth. During the 1950s, the gap between the two lines gradually widens, and then stabilizes during the remaining postwar decades. This means that labour efficiency gradually accounted for a larger share of growth during the 1950s, and subsequently supported growth in a relatively consistent, although less forceful, manner. At the turn of the 1980s, however, labour efficiency severely constrained growth (the gap between the two lines narrows).

Nevertheless, aggregate capital efficiency debilitated growth to a much greater extent. During the 1930s, the actual path of labour productivity is slightly below the counterfactual path where capital efficiency is held constant (the line 'without labour efficiency') – it then falls sharply behind in the postwar decades. This means that capital efficiency constrained growth starting in the 1930s, and drove the slowdown of the economy during the postwar period. The results imply that, if capital efficiency was constant, the level of labour productivity by 1990 would be 55 per cent higher than in the actual state. Comparatively, the Soviet Union would have attained 49 per cent of the US labour productivity level, instead of the 32 per cent it attained in 1990.

To gauge further the relative significance of the various aggregate sources of growth, figure 6 displays the marginal contribution of each source of growth. It adds to the CES model in Equation (1) one at a time the growth rate of factors of production (physical and human capital), the growth rate of capital efficiency, and, finally, the growth rate of labour efficiency. These sources of growth in tandem match the actual evolution of labour productivity (the line 'actual'). When the sequential addition of a variable makes the simulated path of economic growth move more in tandem with the actual path of economic growth, the newly added variable is responsible for that movement.

Figure 6 reveals that the path of the actual output and the path of the counterfactual output determined by factor accumulation (the line 'factor accumulation') track each other closely over the whole period of analysis. This means that the expansion of physical and human capital can explain most of the economic growth that the Soviet Union achieved. When capital efficiency is added to the model containing factor accumulation, the discrepancy between the two lines gradually widens starting in the 1950s, reconfirming the notion that capital efficiency drove the Soviet growth slowdown. Adding labour efficiency to the model containing factor accumulation and capital efficiency (the line 'actual') reconfirms that further (the line of labour productivity is now higher starting in the 1950s).

To narrow the search for the fundamental factors that caused the Soviet growth sluggishness, figure 7 decomposes the aggregate capital input into structures and equipment. In contrast to the aggregate capital input, the efficiency of equipment increased during the interwar period. This makes intuitive sense: Stalin's industrialization push of the 1930s aimed to equip factories with the most advanced technology for the standards of the time (mass production).[98] To the extent that equipment embodies technology, this implies high equipment efficiency at least in the early years of industrialization, before other problems set in.

The problems set in during the 1950s, when equipment efficiency embarked on a steady downward trend. As identified by the existing literature (section I), one of these problems was the preference to use tried and trusted equipment. Such old equipment required an ever-increasing expenditure on maintenance and repair to be kept in use. Western estimates of the investment series that I use show that capital repairs as a percentage of investment increased sharply over time

[98] Davies *et al.*, *Economic transformation*, pp. 136–57.

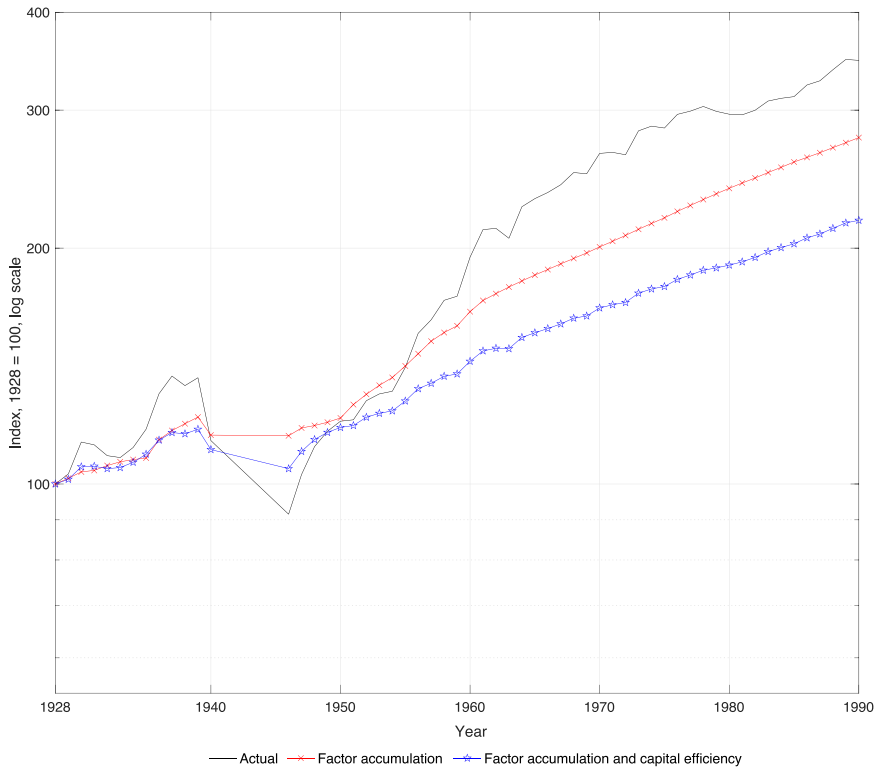

FIGURE 6 Simulations of labour productivity versus the actual movement, aggregate level, 1928–90, Soviet Union. *Note*: This exercise adds to the constant elasticity of substitution (CES) model in Equation (1) (section II) one at a time the expansion of factors of production, capital efficiency, and labour efficiency. The three sources of growth in tandem match the data (the line 'actual'). When sources of growth are added sequentially, I keep the remaining sources of growth fixed to their initial 1928 level. Thus, for example, when examining the contribution of factor accumulation to economic growth, I keep the labour and capital efficiency fixed to their initial 1928 level. *Source*: Own calculations based on data in section III and the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com]

– from about 10 per cent in the 1930s to about 20 per cent in the 1980s. Consequently, production costs increased over time, and equipment efficiency presumably decreased.

Another problem was the weak innovative capacity, which, perhaps, constrained equipment efficiency further. The technological upgrading of the interwar period was based on importing and implementing the Western mass production techniques by the central directive.[99] This does not detract from the argument that the incentives that firms faced when making an innovation decision by their own initiative was inadequate (section I). Once the potential for the adoption of Western mass production technology was gradually exhausted, the problem of weak, domestically generated technology became salient.

By the 1980s, equipment efficiency declined sharply. The decline in the efficiency of structures, however, was more severe. It already declined during the 1930s (figure 7), dragging down the efficiency of the aggregate capital input alongside it (figure 3). The efficiency of structures continued

[99] Ibid., pp. 136–57.

FIGURE 7 The efficiency of equipment and structures in the Soviet Union, aggregate economy, 1928–90. *Source*: Own calculations based on data in section III and the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com]

decreasing after 1950, typically at a faster rate than that of equipment, implying that structures drove the capital efficiency decline of the Soviet Union.

Figure 8 charts the contribution of equipment and structures to Soviet economic growth over the 1928–90 period. As the above discussion implies, it shows that the efficiency of structures was more important than equipment efficiency in constraining economic performance – for that matter, about twice as important. Explaining the efficiency of structures, therefore, is of primary importance in improving our understanding of Soviet growth sluggishness. Explaining that of equipment or of labour is less important.

V | INTERPRETATION OF RESULTS

I hypothesize that the decrease in the efficiency of structures was driven by an inadequate investment policy, combined with increasing labour shortages. This interpretation is not new – I draw it from the existing literature. It has been frequently overlooked, however, in studies that only analysed aggregate efficiency. By using the factor-neutral approach, they are intrinsically limited in narrowing the root causes of inefficiency among the possible suspects.

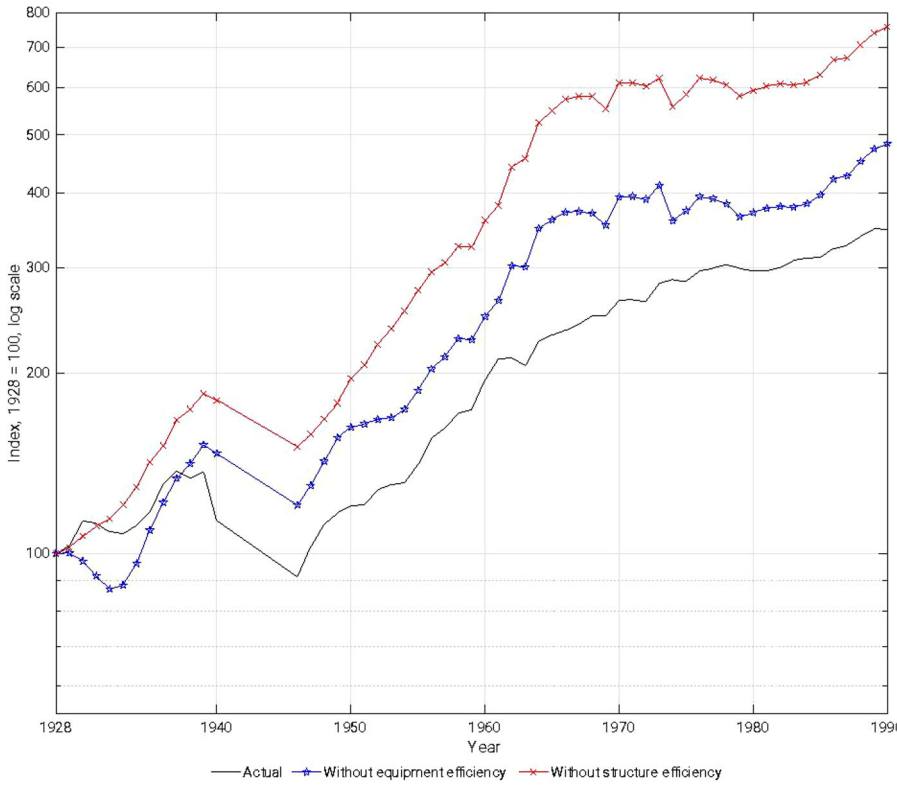

FIGURE 8 The contribution of equipment and structure efficiency to economic growth, counterfactual analysis, aggregate economy, 1928–90, Soviet Union. *Note*: The line 'without equipment efficiency' holds constant equipment efficiency, while allowing all the other sources of growth to vary (efficiency of structures, human and physical capital). It thus indicates what labour productivity would have looked like if equipment efficiency had not grown at all. The difference between this line and the actual output is thus due to equipment efficiency growth. The interpretation of the line 'without structure efficiency' is completely synonymous to that of equipment efficiency. The counterfactual output levels are derived from the constant elasticity of substitution (CES) in Equation (1) in section II. *Source*: Own calculations based on data in section III of the main text and the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com]

The chronic shortage of labour is one of these suspects. Although labour shortages already occurred in the 1930s, they became acute in the postwar period.[100] The agricultural surplus labour was gradually exhausted (indicated by figure 9), and the labour force participation eventually reached its ceiling. The consistent reduction of the official work week starting in the 1950s constrained the expansion of the labour supply further.

One indicator of increasing labour shortages is the shift coefficient of workers – the ratio of total employment (night and day) to the number of workers in the largest shift. The official sources report that the shift coefficient progressively decreased over time: 1.54 in 1960, 1.42 in 1970, 1.37 in 1980, and 1.34 in 1990.[101] This indicates that labour shortages caused a decrease in the utilization

[100] Nove, *Economic history*, pp. 197–201; Ofer, 'Soviet economic growth', pp. 1782–4.

[101] Goskomstat, *Narodnoye khozyaystvo SSSR v 1990*; idem, *Narodnoye khozyaystvo SSSR za 70 let*.

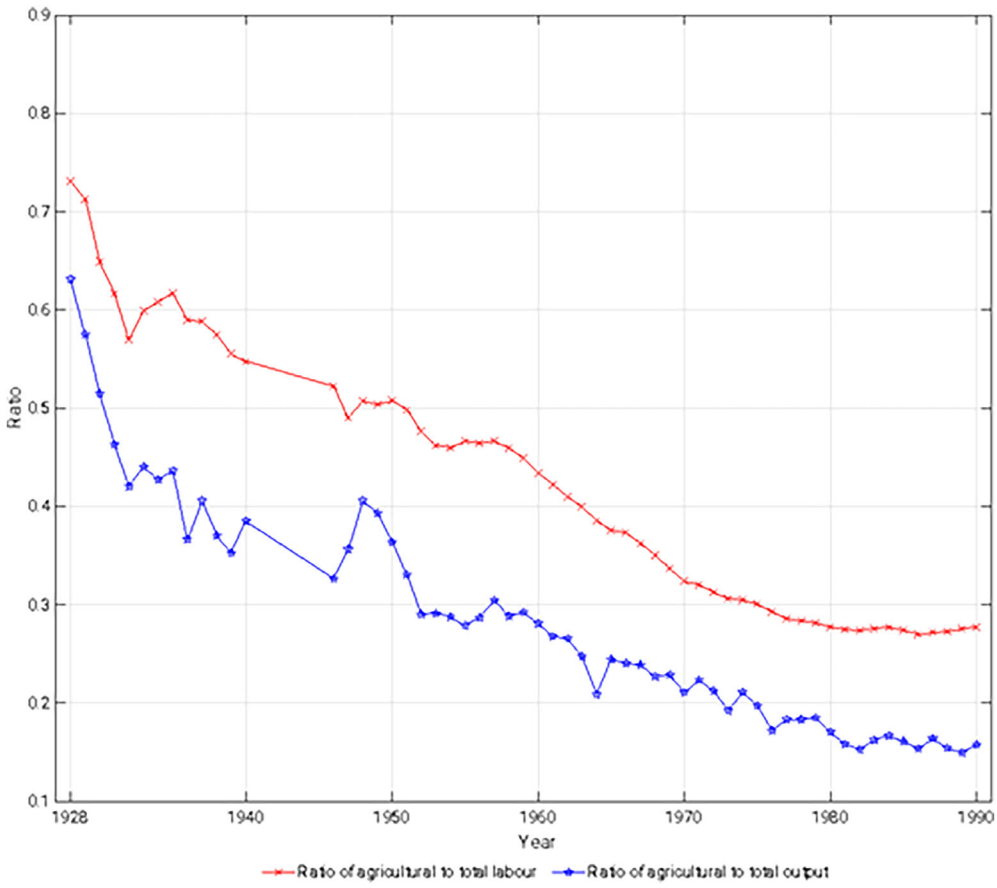

FIGURE 9 Agricultural fraction of total labour and total output, Soviet Union, 1928–90. *Note*: Labour is the total hours worked. The output is GNP. *Source*: Labour for the 1928–49 period is from Moorsteen and Powell, 'Soviet capital stock', p. 365, Rapawy and Kingkade, 'Estimates and projection', pp. 42–3 for the 1950–85 period, and from Goskomstat, 'Narodnoye khozyaystvo SSSR v 1990', for the 1986–90 period. Output for the 1928–49 period is from Moorsteen and Powell, 'Soviet capital stock', pp. 361–2, CIA, 'Measures', pp. 54–7, for the 1950–87 period and from CIA, 'Handbook', p. 64, for 1988–90. See the Appendix for details about the merging of the sectoral data that is expressed in different prices. [Colour figure can be viewed at wileyonlinelibrary.com]

rate of structures. Kontorovich estimates that the decline in capital utilization due to labour shortages averaged 0.7–0.8 per cent per year in the postwar period, pushing down TFP growth rates.[102]

Of course, many other countries in postwar Europe during the 'Golden Age' of economic growth experienced labour shortages as well. The Soviet labour shortages were salient for two reasons. First, the soft budget constraint induced an excess demand for inputs, including labour. Second, the Soviet population losses during the Second World War were immense. Additionally, millions of people perished earlier during the famine of 1932–1933. Allen estimates that, in the absence of collectivization and the Second World War, the Soviet population at the end of the 1980s would have been 30 per cent higher.[103]

[102] Kontorovich, 'Soviet growth slowdown'.

[103] Allen, *Farm to factory*, pp. 119–20.

It is thus possible that labour shortages retarded the efficiency of structures, at least during the postwar period. But it is equally possible that they also retarded the efficiency of the equipment. While labour shortages imply that there were not enough workers to work in factories, farms, and offices, they also imply that there were not enough workers to operate the machines and tractors and work behind desks. Therefore, it is unclear whether labour shortages are sufficient to understand why the efficiency of structures decreased so strongly, at least relative to equipment.

I hypothesize that the inadequate investment policy compounded the decline in the efficiency of structures. A distinctive feature of the Soviet investment policy was the over-concentration of investment in new enterprises, compared with reconstructing the existing enterprises.[104] This pattern, although natural in the early stages of industrialization, prevailed in the Soviet Union throughout the central planning period. The main reason for this is the relative ease of planning and directing new plants from the centre, compared with planning and enforcing investment in the existing plants.[105]

An additional reason for the over-concentration of investment in new plants is that enterprises had strong incentives to expand capacity. Accumulated excess capacity helped firms to meet output targets while operating in an environment characterized by frequent shortages.[106] Moreover, under the soft budget constraint, the managers did not have to worry about financing additional plants.[107] Once the investment project was started, the investment finance would eventually follow.

As figure 10 shows, one corollary of the Soviet investment policy, combined with the general pressure on current production within an environment characterized by labour shortages, was the high stock of unfinished construction work.[108] Such stock immobilized capital, held up production and presumably caused a decrease in capital efficiency. If so, a major problem with the Soviet growth was that a large fraction of the capital stock was unused in production, indicating a wasteful allocation of resources. Although the stock of unfinished construction increased during the first five-year plan, it increased more intensively during the postwar period. Overall, it increased from about 2 per cent of output in 1928 to about 25 per cent during the 1980s – a 12.5-fold increase. Of course, the overall capital:output ratio also increased in this period. But by a much smaller magnitude – a factor of 3.8.

The underlying data on unfinished construction, however, is beset by problems.[109] The valuation of the changing stock of assets, finished or otherwise, is subject to distortion arising from the changing price level of investment goods, changes in their prices relative to others, and the difficulty of measuring deprecation. Moreover, the ratio of unfinished construction in figure 10 is calculated using different sources, prices, and coverage (Appendix). The constructed data is hence conjectural, and the estimated trend is at best only indicative of the true one.

Nevertheless, the increase in the ratio of unfinished construction is very sharp. This is consistent with the observation that 50 per cent of investment projects did not meet their planned completion date, although these dates were often anything but ambitious, at least in the postwar

[104] Cohn, 'Sources'; Hanson, *Trade and technology*.

[105] Ofer, 'Soviet economic growth', p. 1808.

[106] Cohn, 'Sources'.

[107] Kornai, *Socialist system*.

[108] Dyker, *Investment*, pp. 35–8.

[109] For an extensive discussion of the issues, see Harrison, 'Investment mobilisation', pp. 61–4.

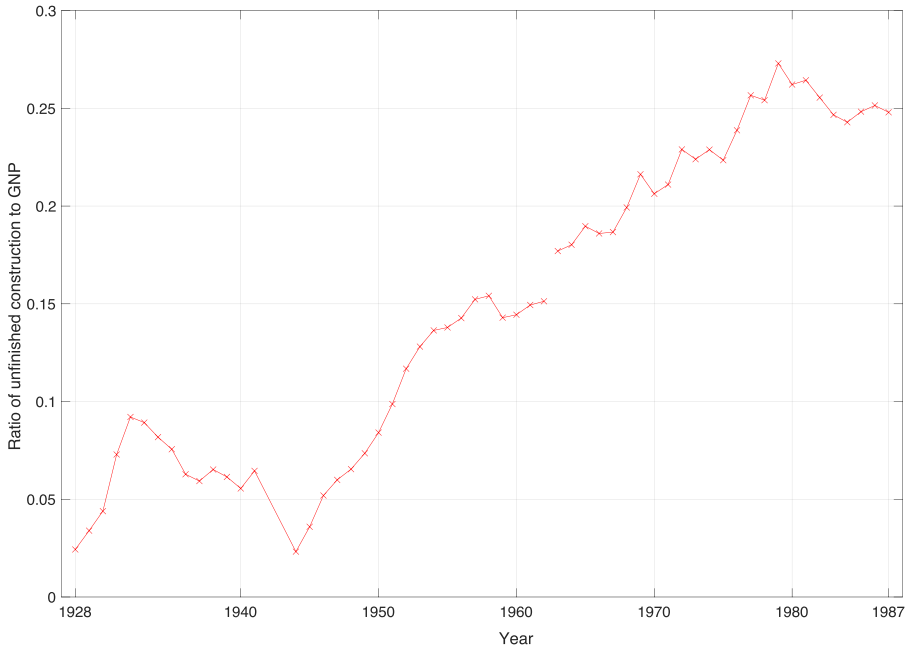

FIGURE 10 The ratio of unfinished construction to GNP, Soviet Union, 1928–87. *Note*: The years between 1941 and 1944 are interpolated – there is no data for these years. *Source*: Unfinished construction data for the 1928–62 period is taken from Moorsteen and Powell, 'Soviet capital', (1966, p. 339) and from Slavic-Eurasian Research Center (SERC), 'Uncompleted construction', for the 1963–87 period. The evolution over time of unfinished structures is only indicative of the true trend, due to differences in sources, prices, and coverage – see the Appendix for details. GNP is taken from Western researchers described in section III of the main text and the Appendix. [Colour figure can be viewed at wileyonlinelibrary.com]

period.[110] As such, in the 1960s, the total lead-time (from design to capacity operation) for large enterprises was about 2–2.5 times longer than what, on the basis of foreign experience, could be considered 'normal'.[111] The underlying problem was that existing enterprises were kept in operation to avoid labour dislocation and ensure that output targets would be achieved. If the old enterprises were scrapped, the scarce resources could have been channelled into new capacity at faster rate, decreasing lead time.

This set of evidence may indicate that the efficiency of structures collapsed over time because a large fraction of it was unfinished. For that matter, the movement in the efficiency of structures (Equation (7) shadows the movement of incomplete construction projects (figure 10). For example, from 1950 until the beginning of the 1980s, the stock of unfinished projects sharply increased, and the efficiency of structures sharply dropped. Subsequently, the stock of unfinished construction reached its plateau, and the decrease in efficiency somewhat decelerated. The two variables are closely linked over the earlier, interwar period, too. It is thus unsurprising that the correlation coefficient between unfinished construction and structure efficiency is extremely high (−0.97).

[110] Dyker, *Investment*, p. 36.

[111] Ibid., p. 36.

There are, naturally, additional factors that may have shaped the efficiency of structures. Allen provides a prominent, alternative explanation.[112] He argues that there was a shift in investment priority during the 1970s. The depletion of old oil fields and coal mines led to a redirection of investment from Europe to Siberia. According to him, the construction of new plants and mines involved huge capital expenditure, but yielded little return. In turn, this caused a fundamental change in the trajectory of TFP – whereas TFP growth rates were positive before, they now turned negative.

The main problem with Allen's argument is that of timing. The efficiency of structures, and of capital in general, started declining from the 1930s, not from the 1970s. Any change in investment policy during the postwar period, therefore, cannot be responsible for an outcome that preceded it. Of course, it could be that this shift in investment priority amplified the pre-existing efficiency decline.

Other policy changes may have also amplified it. One of these is Khrushchev's *Sovnarkhoz* reform of the 1950s, which made regional officials responsible for the industrial development of their regions. The reform's aim was to stimulate national productivity by boosting the incentives of local officials. In practice, as Markevich and Zhuravskaya argue, it resulted in increased regional autarky.[113] Regional plans were often made at other regions' expense, and hence national development. For example, in 1960, Tataria refused to cooperate with Bashkiria to exploit oil fields located on the border of the two regions, which caused an increase in the oil extraction expenditures of Bashkiria.[114] The Khrushchev's reform, therefore, may have caused negative externalities and diseconomies of scale, reinforcing the efficiency decline. But it cannot be of fundamental importance, because of its short duration (1957–65).

It is possible, however, that regional development patterns – broadly defined – were fundamentally important. For political reasons, Stalin located many new factories in the Urals and Siberia.[115] These were highly remote regions characterized by poor market potential – locations where, in a market economy, factories would not normally emerge. This suboptimal geographic distribution of investment probably induced diseconomies of scale, undermining the efficiency of capital.

It is likely that this policy had a particularly debilitating effect on structures. The new factories in remote regions required complementary investment in infrastructure – an extremely expensive undertaking.[116] Unfortunately, the quantitative research on the Soviet economies of scale is extremely limited. The paucity of empirical research on regional development is particularly striking, given that equitable development was a major policy aim. With limited quantitative scholarship, one can only speculate about the possible magnitude of these spatial effects.

VI | CONCLUSION

The growth slowdown of the Soviet Union has inspired much research by economists and historians alike. These scholars usually attribute the slowdown to a growing inefficiency of resource allocation under central planning. This paper makes a novel contribution to the literature by

[112] Allen, *Farm to factory*, pp. 198–205.

[113] Markevich and Zhuravskaya, 'M-form'.

[114] Ibid., p. 1552.

[115] Davies *et al*., *Economic transformation*, p. 138.

[116] Allen, *Farm to factory*, p. 204.

studying the Soviet technical change at a disaggregated level. It takes a more nuanced approach to efficiency compared with the existing studies, offering novel results.

This paper demonstrates that the Soviet Union registered strong labour efficiency gains until the 1970s. Labour efficiency growth did slow over time, but it was not a primary cause of the Soviet growth retardation. Capital efficiency instead drove that retardation. Although the efficiency of equipment decreased, that of structures decreased more, resulting in a capital efficiency collapse. I hypothesize that this collapse was caused by labour shortages and an inadequate investment policy that resulted in a large stock of unfinished structures.

More research is required. The analysis in this paper is focussed on the country level as the basic unit of analysis. Further progress in understanding the root causes of the uncovered efficiency patterns could come from industry-level and regional-level analysis. The most promising avenue of research may lie in the interaction between regional industrial location, (dis)economies of scale, and national development.

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DATA AVAILABILITY STATEMENT

Data (will be) openly available in a public repository that issues datasets with DOIs.

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