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ABSTRACT

Was Stalin Necessary for Russia's Economic Development?*

This paper studies structural transformation of Soviet Russia in 1928-1940 from an agrarian to an industrial economy through the lens of a two-sector neoclassical growth model. We construct a large dataset that covers Soviet Russia during 1928-1940 and Tsarist Russia during 1885-1913. We use a two-sector growth model to compute sectoral TFPs as well as distortions and wedges in the capital, labor and product markets. We find that most wedges substantially increased in 1928-1935 and then fell in 1936-1940 relative to their 1885-1913 levels, while TFP remained generally below pre-WWI trends. Under the neoclassical growth model, projections of these estimated wedges imply that Stalin's economic policies led to welfare loss of -24 percent of consumption in 1928-1940, but a +16 percent welfare gain after 1941. A representative consumer born at the start of Stalin's policies in 1928 experiences a reduction in welfare of -1 percent of consumption, a number that does not take into account additional costs of political repression during this time period. We provide three additional counterfactuals: comparison with Japan, comparison with the New Economic Policy (NEP), and assuming alternative post-1940 growth scenarios.

JEL Classification: e6, n23, n24, o4 and o41
Keywords: industrialization, Japan, Russia, Stalin and unbalanced growth

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1 Introduction

In 1962, a prominent British economic historian, Alec Nove, asked whether Russia would have been able to industrialize during the late 1920s and 1930s in the absence of Stalin's economic policies.[1] The transformation of Soviet Russia from an agrarian to an industrial economy had profound economic and political consequences. The industrialized Soviet Union played a key role in the victory over Nazi Germany during World War II and, as one of the two superpowers during the Cold War, reshaped the post-war world. The economic transformation that led to the Soviet industrialization is therefore one of the most important questions in economic history. However, there is relatively little evidence on this subject.

Understanding the ramifications of Stalin's industrialization policies is also important for academic researchers. First, from the point of view of development economics – these policies are among the most important examples of top-down structural transformation. The Soviet experience influenced development economics thinking many decades later. The celebrated Lewis' model of economic development (Lewis 1954) used Soviet economic growth as the key example of building the industry through investment and reallocation of unproductive labor from agriculture. Soviet industrialization was a key inspiration for the first formal growth theory model – the Harrod-Domar model – which has been used as the main analytical workhorse within the economic policy community for decades (Easterly 2002). Stalin's industrialization was a key inspiration for Walt Rostow's theory of stages of economic growth (Rostow 1962), most importantly for the third, take-off, stage of growth.

Stalin's industrialization served as a model for policymakers in many other developing countries, including Nehru's India and Mao's China. Li and Yang (2005) argue that Soviet collectivization and industrialization policies were the major inspiration for Mao's economic policy in 1950s and eventually for launching the Great Leap Forward in 1958. India's first Five-Year Plan (1951-56) was based on the Harrod-Domar model, which was in turn inspired by the Soviet experience (Domar, 1957). Its second Five-Year Plan and the key Industrial Policy Resolution of 1956 was based on the Mahalanobis' two-sector model of growth which was – although independently developed – very similar to Feldman's model. The latter – developed by the Soviet economist Grigory Feldman – was the theoretical basis for Stalin's policies.

[1] "Was Stalin Really Necessary?" (Nove 1962).

Even in the United States, many wondered whether the Soviet Union's ability to grow when the United States struggled with the Great Depression foreshadowed the future dominance of the centrally planned economy over its market oriented competitors. Ofer (1987) writes:

> *Until the late 1950s, the era of rapid Soviet growth and of Sputnik, the main question among Western scholars was: When would the Soviet Union catch up with and overtake the U.S.? Even sober and careful scholars like Abram Bergson (1961, pp. 297-98) did not exclude the possibility that this might be fairly imminent.*

Second, our exercise is the first modern neoclassical analysis of the socialist economy. In the spirit of Cole and Ohanian (2004), which uses the tools of modern macroeconomics to comprehensively analyze the Great Depression, we develop a model of the structural transformation and growth of Soviet Russia and map the policies into distortions. Finally, our analysis sheds light on the type of policies that may have contributed to the Soviet economy's structural transformation. Specifically, we are interested in exploring the validity of Big Push theories in which TFP improves via reallocation of resources (e.g., Rosenstein-Rodan (1943) or Murphy, Schleifer and Vishny (1989), or Acemoglu and Robinson (2012) for a recent exposition of this view).

Both proponents and critics of Stalin's policies typically point to Figure 1 as evidence for their views. This figure shows Russian per capita output and labor force composition between agricultural and non-agricultural activities. Both sides of the debate agree that Stalin's economic policies in the late 1920s and 1930s were harsh. The proponents, however, point to the rapid growth of 1928-1940 and to the fast reallocation of labor from agriculture to non-agriculture during this period. They argue that although excessively brutal, Stalin's policies allowed Russia to develop a strong modern economy that sustained a successful war effort in 1941-1945 and propelled the Soviet Union into a dominant power after WWII.[2] By comparison, critics argue that the rapid growth before WWII may simply be a result of Russia catching up to its pre-WWI trend and point out that by 1940 GDP per capita in the Soviet Union was not very different from projected trends based on economic performance during the Tsarist era.

[2]For example, according to Allen (2003) "In the absence of the communist revolution and the Five-Year Plans, Russia would have remained ... backward... This fate was avoided by Stalin's economic institutions. They were a further installment of the use of state direction to cause growth in an economy that would have stagnated if left to its own devices". Similarly, Acemoglu and Robinson (2012), while critical overall of Stalin's policies, note that "there was ... huge unrealized economic potential for reallocating ... labor from agriculture to industry. Stalinist industrialization was one brutal way of unlocking this potential".

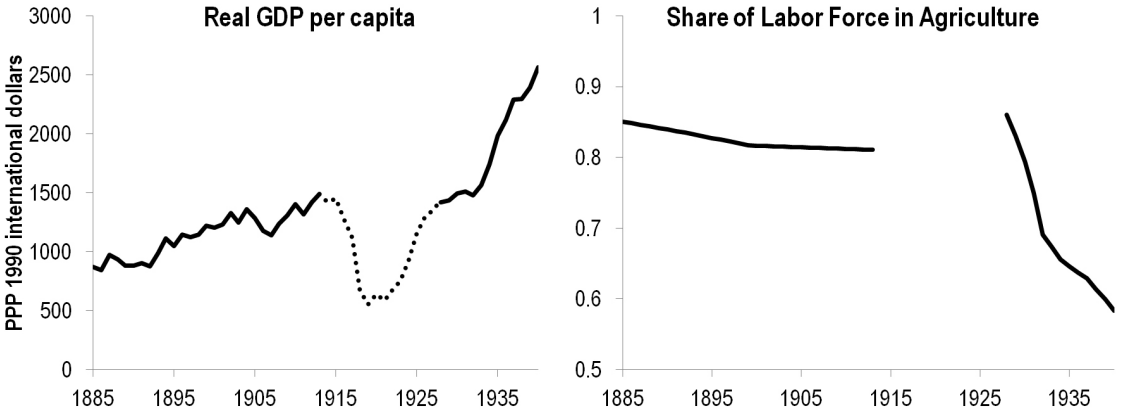

Figure 1: Real GDP per capita and sectoral labor share in Russian Empire and Soviet Union.

Both arguments have weaknesses. Figure 1, for example, does not distinguish whether the U.S.S.R. merely returned to its pre-WWI trend or if it transitioned to a higher level (with the interruption of WWII). It also says little about welfare. Real GDP, for example, is computed by holding relative prices fixed. A rapid reallocation of resources from a sector with low relative prices to a sector with high relative prices creates an impression of a fast increase in real GDP.[3] However, changes in relative prices may offset some of the gains for consumers and even make them worse off. For example, a drastic reallocation of resources from agriculture to manufacturing may lead to famine.

Our study proceeds in several steps. First, we use a standard two-sector neoclassical growth model that has been extensively employed in the literature to analyze industrialization and structural change in other contexts.[4] We follow the insights of Cole and Ohanian (2004) and Chari, Kehoe, and McGrattan (2007) that any set of policies can be mapped into a set of distortions, or wedges, in a neoclassical growth model. We systematically study these wedges and connect them to the policies and frictions in the economy under the Tsarist regime during 1885-1913 and under the Soviet regime during 1928-1940[5]. We then compare a simulated Soviet economy with Tsarist wedges after WWI to the actual Soviet economy.

[3]When substantial structural transformation takes places, it is usually accompanied by a major change in relative prices (this is the so-called "Gerschenkron's effect" due to Gerschenkron, 1947). Thus, it matters whether GDP is calculated using relative prices from the beginning or the end of the period.

[4]See, for example, Stokey (2001), Buera and Kaboski (2009, 2012), and Hayashi and Prescott (2008), among many others.

[5]We chose these periods because there is little reliable economic data before 1885 and between 1913 and 1928.

To the best of our knowledge, there exist no data that comprise comparable sectoral variables for the Tsarist and Soviet economies. We overcome this difficulty by creating consistent measures of Russian sectoral output, capital stock, government expenditures and private consumption for 1885-1913 and 1928-1940. This novel dataset allows us to compute a consistent set of wedges for the two time periods.

Tsarist Russia in 1885-1913 was largely agrarian and had a variety of wedges and frictions. The most important feature of the economy was that agriculture provided employment for approximately 85 percent of the working-age Russian population and 50 percent of value added for the entire economy. By 1913, the prominence of agriculture declined only insignificantly. We find a sizeable inter-sector labor wedge that distorts the movement of labor from agriculture. The intertemporal capital accumulation wedge is also sizeable. The average TFP annual growth rate was 1.46 percent for agriculture and 0.66 percent for non-agriculture. International trade was important as Tsarist Russia exported about 10 percent of its agricultural production and imported primarily manufacturing goods.

We now turn to Stalin's economy. We find that the time series for wedges show two distinct sub-periods. In the first sub-period, from 1928 to 1936, most wedges exhibit dramatic changes, with the peak of the wedges coinciding with the peak of the intensity of Stalin's policies. TFP falls significantly in both sectors from 1928 to 1933: by 19 percent in agriculture from 1928 to 1932 and by 33 percent in non-agriculture. By 1936, the dramatic changes in the wedges subsided, and the economy entered a more stable period that ends with the last year before the invasion of the Nazi Germany. The levels of the wedges are generally lower than the ones in Tsarist Russia. By 1940, the level of TFP in agriculture reverts to its pre-WWI trend but the TFP in non-agriculture remains substantially below trend. These findings are consistent with the view that Stalin's policies eventually reduced intertemporal and intratemporal barriers. However, we do not find support for standard formulations of the Big Push theories that would imply that reallocating resources from agriculture would increase non-agricultural TFP.

Second, we provide a detailed discussion of the historical policies of Tsarist and Stalinist Russia and how they may lead to the estimated wedges. This both serves as a "sanity" check of our estimates and provides potential insights into the policy causes of frictions. For Tsarist Russia, the labor wedge is consistent with the institutions of *obschina*, which prescribed communal ownership of land and severely restricted exit from the commune. In addition, we discuss the

role of foreign cartels in manufacturing, credit constraints in agriculture, tariffs and the reforms of the Finance Minister Sergei Witte and argue that they provide evidence that is consistent with intertemporal investment and financial frictions.

For Soviet Russia, the drop in agricultural TFP is consistent with the realities that extraction of grain disrupted production, that de-*kulak*ization exiled or killed the most productive peasants from the villages, that the decline of livestock due to the extraction of grain decreased horse power. The drop in non-agricultural TFP is consistent with the poor quality of workers moving out of agriculture, an inefficient diversion of resources to production of agricultural machinery (to replace the draft power of fewer livestock), and the political purges of skilled workers such as engineers and other technical specialists. This fall in the quality of inputs explains why a massive expansion of inputs was not accompanied by a matching increase in outputs.

It is interesting to note that the capital stocks in 1928 and population in 1928-1940 are significantly below the trend of the Tsarist economy. The economy with Tsarist wedges, but with initial capital stock and population from 1928 USSR, would experience rapid growth as it would accumulate capital and would have a higher marginal product of labor in agriculture due to decreasing returns. This is consistent with the view of Stalin's critics that some of the growth in 1928-1940 came from reverting back to the Tsarist trend.

Finally, having analyzed the behavior of the wedges in the two economies, we turn to the welfare analysis and the counterfactual of how Russia would have developed. Our benchmark counterfactual comparison with the Tsarist economy consists of three parts. First, we use average Tsarist wedges from 1885 to 1913 and extrapolate them until 1940. We then compare economic outcomes in that simulation to the actual performance of the economy under Stalin in 1928-1940. Conceptually, we think about this exercise as how the Russian economy would have developed if all Tsarist distortions remained unchanged. Second, we study the question of how Russia would have developed under both Stalin and Tsarist distortions after 1940 in the absence of WWII.[6] One of the common arguments is that Stalin's reforms improved economic efficiency to successfully fight in WWII and projected economic and political dominance after WWII. Comparing the economic outcomes under Stalin's and Tsarist distortions allows us to

[6]USSR entered the war with Nazi Germany on June 22, 1941. The official victory day is May 9, 1945. This period is referred to as the Great Patriotic War in Russia.

assess this argument.

Our welfare assessment results are as follows:[7] Stalin's policies led to substantial short run costs (1928-1940) amounting to 24.1 percent of consumption.[8] However, in the long run, the generation born in 1940 reaped the benefits of the reduction of frictions that yielded a 16.5 percent lifetime gain. Welfare of a representative, infinitely-lived consumer born in 1928 is 1 percent lower under Stalin's policies than in an economy with Tsarist wedges. In the short run (1928-1940), the largest effect on welfare is due to the effects of the fall in TFP, with the bulk of the TFP losses coming from the drop in agricultural TFP. In the long run (post-1940), the positive effect comes from the reduction in distortions for capital accumulation and inter-sectoral labor allocation, which offset the negative effect of lower TFP. The long-run predictions (post-1940) are sensitive to the assumptions regarding the long-term growth of TFP in the absence of the WWII. Under a variety of alternative assumptions, we find big short run costs and moderate long run gains from Stalin's economic policies.

Finally, we provide three alternative counterfactuals. First, we compare performance of the Soviet economy to that of Japan.[9] This comparison is informative for the following reason. Similar to Russia, Japan undertook major economic reforms in the second half of the 19th century. It had approximately the same level and growth rates of GDP per capita prior to WWI, and our decomposition shows that many of the wedges behave similarly in the two economies. Some of the distortions and the growth rate of non-agricultural TFP changed significantly in Japan in the interwar period. Thus, a simulation of the Russian economy under these new wedges provides one plausible alternative path of Russian economic development in the absence of the communist revolution. Both the Stalinist and the projected Tsarist economy perform significantly worse than Japan after 1928. While distortions and TFP growth rates were similar in pre-WWI Japan, TFP in non-agriculture accelerated in the interwar period. As a result, while welfare is roughly similar in Stalin's and Tsarist Russia, welfare of the representative

[7] We view this analysis as a lower bound on welfare losses under Stalin's policies. The representative consumer framework ignores the fact that different parts of population bore very different consequences of Stalin's economic policies (for example, it was the rural population that mainly suffered famine in 1932-34) and repressions (which are reflected, in part, in lower population numbers). Taking these policies into account is likely to significantly increase welfare losses under Stalin.

[8] Included in this number is the effect of the lower level of capital in 1928 which is responsible for the loss of 14 percent of consumption.

[9] For Japan's economy our starting point is Hayashi and Prescott (2008). We construct the data for Japan to allow for the comparison with Russia and compute the wedges following the same procedure as in our paper.

consumer born in Japan in 1928 is about 31 percent higher than that of an individual born in Russia during the same period, and continues higher after 1940. These projections do not take into account reduction in distortions that Japan experiences after WWII (see, e.g. Hayashi and Prescott, 2008) and understate the actual economic performance of Japan.

Second, we compare the performance of the Soviet economy under Stalin to the path it would have taken if the New Economic Policy was continued after 1928. In the NEP counterfactual, collectivization is not implemented; there is no fall in TFP, and the barriers to labor and capital reallocation remain high. We find that a conservative scenario for the path of the Soviet economy under NEP (using Tsarist TFP growth) is comparable to the path of Stalin's economy: The welfare loss due to the labor barrier is outweighed by the welfare gain from higher long-run TFP. A less conservative scenario (using Japanese TFP growth) puts the NEP economy on a much higher growth trajectory that produces a 20 percent welfare gain.

Third, we consider two alternative paths of Soviet TFP for the post-1940 period. In the first one, we extrapolate trend TFP from the 1937-40 moderation period. In the second one, we use post-WWII data to inform our projections of trend TFP. In both cases, the values of the wedges are close enough to our baseline scenario, so their impact is minimal.

Our paper is related to several strands of literature. Similar to Stokey (2001), Buera and Kaboski (2009, 2012), Caselli and Coleman (2001) and Hayashi and Prescott (2008), we use a neo-classical growth model to shed light on the historical episodes of structural change[10]. To the best of our knowledge, we are the first to apply a systematic wedge accounting procedure to identify distortions to a non-market economy. We are also related to a large body of economic history literature that studied economic development of Russia. Among these studies, we are most closely related to the seminal work of Allen (2003), which provides a comprehensive analysis of Soviet economic development in the interwar period. Our paper extensively builds on his historical accounts and data. Similar to us, Allen also constructs counterfactuals for different paths of economic development of Soviet Russia. We view our approaches as complementary. Allen specifies the laws of motion for various economic variables and constructs counterfactuals by changing the exogenous parameters in those laws. We instead measure distortions and estimate their impact in a general equilibrium model in which consumers make their decisions

[10]See also Alder, Lagakos, and Ohanian (2013) for the very recent macroeconomic analysis of the decline of the U.S. Rust Belt.

optimally, subject to those distortions. Our counterfactual comparisons of Soviet Russia with Tsarist Russia and Japan are also new.

The paper is structured as follows. Section 2 contains a brief overview of the main events in Russian economic history of 1885-1940. In Section 3, we present the theoretical model. In Section 4, we discuss the data and calibration. In Section 5, we describe the wedges and the relationship between government policies and wedges. In Section 6, we provide a benchmark comparison of the actual and projected Stalin's policies with the projected Tsarist economy. Section 7 provides alternative counterfactuals: comparison with Japan, with NEP and different assumptions on long-term growth rates. Section 8 describes robustness of our results. Section 9 concludes.

2 Historical overview

Because consistent, annual time series data on Russia begin in 1885, we limit our analysis to 1885-1940. This period can be roughly divided into three subperiods: first, the Tsarist years 1885-1913; second, World War I, revolution and reconstruction, 1913-1928; and, finally, Stalin's industrialization, 1928-1940.[11]

In the first subperiod, Russia was an agrarian economy attempting to industrialize. The country significantly lagged behind advanced capitalist economies, the US and UK. However, Russia's industrialization proceeded at a speed similar to some other industrializing economies, in particular, Japan. The industrialization started with the abolition of serfdom in 1861 but was slowed down by several remaining non-market institutions. Most importantly, as noted by Gerschenkron (1962), reallocation of labor to industry was hindered by the prevalence of communal rather than individual ownership of land (we discuss this barrier to mobility in Section 5.1). Reform of this institution was attempted in 1906-1910 during the so called "Stolypin's reforms".

World War I, the subsequent Communist Revolution in 1917, and the ensuing Civil War (1918-22) led to a significant fall in output and destruction of capital stock (see Davies, Har-

[11] In Chapter 1 of Davies, Harrison and Wheatcroft (1994), Davies uses four periods: Tsarist economy, War Communism (1917-20), New Economic Policy (1921-28), and Stalin's administrative economy (1928-40). But since we focus on the pre-revolutionary trends and on industrialization in 1928-40, we consider 1913-28 as a single subperiod. We do not use 1913-28 years for calibration as there are no data on capital or on inter-sectoral reallocation of labor. However, we provide a comparison with the NEP policies as one of our simulations.

rison and Wheatcroft, 1994, for a detailed account of this period). As shown in Harrison and Markevich (2011), Russian GDP in 1918 was 50 percent lower than in 1913.

In 1917, Bolsheviks came to power and abolished all major capitalist institutions. In particular, the new government confiscated land holdings and industrial capital from private owners. During the following Civil War, the so called War Communism policies involved the requisitioning of 70 percent of agricultural output. After the disastrous 1921-22 famine, War Communism policies were replaced by the New Economic Policy (NEP). NEP reintroduced limited market mechanisms, including foreign concessions. The following reconstruction period brought the economy back to the pre-WWI level of GDP per capita in 1928 in both agricultural and non-agricultural sectors (Harrison and Markevich, 2011).

In 1928, Stalin ended the New Economic Policy with a Great Turn (or a Great Break[12]) starting the five-year plans and collectivization of land. The Great Turn followed a struggle in the highest echelons of power (Khlevnyuk, 2009). In 1927, Stalin expelled his archrival Leon Trotsky, and Trotsky's allies Zinoviev and Kamenev, from the Politburo and from the Communist Party. His next rival was Bukharin who – unlike Trotsky's Left Opposition – was supporting the New Economic Policy and an even broader use of market mechanisms. The Great Turn was a bold step against Bukharin and his Right Wing and helped Stalin complete consolidation of power within the Politburo.

Collectivization was essential to Stalin's industrialization policies as those were based on confiscation of "agricultural surplus" to subsidize the industrialization and to move labor out of agriculture. Importantly, Stalin introduced the policy of "price scissors," forcing the peasants to sell grain to the state at below-market prices. The state subsequently sold the grain to industrial workers at higher prices or exported grain to pay for imports of industrial equipment. The burden of the price scissors is best reflected in the level of violence implementing those policies. In 1929, there were 1300 peasant riots with more than 200,000 participants (Khlevnyuk, 2009). This was a significant increase compared with the New Economic Policy period when the total number of riots for the two years of 1926-27 was just 63. In March 1930 alone, there were more than 6500 riots with 1.4 million peasants participating.

Industrialization was carried out in a centralized way. The central planning prescribed

[12]The term (*Velikiy Perelom* in Russian) is derived from Stalin's article "Year of the Great Turn" published in 1929.

quantitative production and investment targets at the plant level. The first three five-year plans, starting in 1928, 1933, and 1938, respectively, were not fulfilled (see Gregory and Harrison, 2005, for evidence from recently declassified archives). However, as shown in Figure 1, during 1928-40, the industrialization and collectivization did succeed in moving tens of millions of people from villages to cities and in tripling industrial production in constant prices.

3 Main Idea and Theoretical Framework

Our analysis builds on a standard multi-sector neoclassical growth model. Versions of this model have been used extensively to study industrial revolutions in England (Stokey 2001), structural transformation in the US (Caselli and Coleman 2001, Buera and Kaboski 2009, 2012, Herrendorf, Rogerson and Valentiny 2009, among others) and Japan (Hayashi and Prescott 2008). We first characterize the frictionless model. We then describe the accounting procedure determining wedges following Cole and Ohanian (2004) and Chari, Kehoe, and McGrattan (2007).

3.1 Model

There are two sectors in the economy, agricultural (A) and non-agricultural (M). Output in sector $i \in \{A, M\}$ is produced according to the Cobb-Douglas production function

$$Y_t^i = F_t^i\left(K_t^i, N_t^i\right) = A_t^i\left(K_t^i\right)^{\alpha_{K,i}}\left(N_t^i\right)^{\alpha_{N,i}}, \tag{1}$$

where A_t^i, K_t^i, and N_t^i are, respectively, total factor productivity, capital stock, and labor in sector i; $\alpha_{K,i}$ and $\alpha_{N,i}$ satisfy $\alpha_{K,i} + \alpha_{N,i} \leq 1$. We denote by $F_{K,t}^i$ and $F_{N,t}^i$ the derivatives of F_t^i with respect to K_t^i and N_t^i.

The economy is populated by a continuum of identical agents with preferences

$$\sum_{t=0}^{\infty} \beta^t U\left(c_t^A, c_t^M\right), \tag{2}$$

where

$$U\left(c_t^A, c_t^M\right) = \eta \log\left(c_t^A - \gamma^A\right) + (1-\eta)\log c_t^M,$$

c_t^A is consumption of agricultural goods and c_t^M is consumption of non-agricultural goods.[13] The subsistence consumption level of agricultural goods is denoted by $\gamma^A \geq 0$. The discount

[13] In the model, we use terms "non-agriculture" and "manufacturing" interchangeably. In the data, c_t^M corresponds to the private consumption of all non-agricultural goods and services.

factor is $\beta \in (0,1)$. Each agent is endowed with one unit of labor services that he supplies inelastically. We use notation $U^i_{c,t}$ to denote the derivative of U in period t with respect to the consumption good $i \in \{A, M\}$.

Population growth is exogenous. The total population in period t is denoted by N_t. The fraction of total labor allocated to agricultural and non-agricultural sector in period t are denoted, respectively, by $N^A_t + N^M_t$. The feasibility constraint for labor is

$$N^A_t + N^M_t = \chi_t N_t, \tag{3}$$

where χ_t is an exogenously given fraction of working age population.

We assume that the new capital I_t can be produced only in the non-agricultural sector. Capital can be allocated in any sector. Aggregate capital in period t is denoted by K_t. Capital allocated in period t to agricultural and non-agricultural sector is denoted, respectively, by K^A_t and K^M_t. The law of motion for aggregate capital is given by

$$K_{t+1} = I_t + (1-\delta) K_t, \tag{4}$$

where δ is the depreciation rate. The capital is allocated to sectors according to

$$K^A_t + K^M_t = K_t. \tag{5}$$

We assume that there exists an exogenous sequence of government consumption of non-agricultural goods, G^M_t. Let ex^A_t and ex^M_t denote net exports of agricultural and non-agricultural goods in period t, and let q_t be exogenous terms of trade for those goods.

The feasibility conditions in the two sectors are

$$N_t c^A_t + ex^A_t = Y^A_t, \tag{6}$$

and

$$N_t c^M_t + ex^M_t + G^M_t + I_t = Y^M_t. \tag{7}$$

Throughout the paper we assume that the trade balance is zero in all periods, so that the net exports satisfy

$$q_t ex^A_t + ex^M_t = 0. \tag{8}$$

In formulating trade (exports ex_t^i) exogenously we follow, for example, Stokey (2001). Stokey (2001) studied the industrial revolution in Britain treating British exports (manufacturing) and terms of trade q_t as exogenously given and finding quantities of imports from (8).

Given exogenous parameters and initial conditions, equations (2)-(8) provide a complete description of our model.

3.2 Frictionless benchmark

We proceed now to characterize a standard social planner's problem. The optimality conditions are as follows:

the intratemporal capital allocation condition across sectors is given by

$$1 = \frac{U_{c,t}^M}{U_{c,t}^A} \frac{F_{K,t}^M}{F_{K,t}^A}, \tag{9}$$

the intratemporal labor allocation condition is given by

$$1 = \frac{U_{c,t}^M}{U_{c,t}^A} \frac{F_{N,t}^M}{F_{N,t}^A}, \tag{10}$$

and the intertemporal (Euler) condition is given by

$$1 = \left(1 + F_{K,t+1}^M - \delta\right) \beta \frac{U_{c,t+1}^M}{U_{c,t}^M}. \tag{11}$$

The solution to this social planner's problem coincides with and can be decentralized as a competitive equilibrium. We omit the formal definition of the competitive equilibrium, as it is standard. In the competitive equilibrium, all agents pool their income and maximize their utility (2) subject to a budget constraint in each period

$$\begin{aligned} & p_t^A N_t c_t^A + N_t c_t^M + K_{t+1}^A + K_{t+1}^M \\ & = w_t^A N_t^A + w_t^M N_t^M + \left(1 + r_t^A - \delta\right) K_t^A + \left(1 + r_t^M - \delta\right) K_t^M + \Pi_t^M + \Pi_t^A - T_t, \end{aligned}$$

where w_t^i, r_t^i, Π_t^i are, respectively, the wage, the rate of return on capital, and the profit in sector i; p_t^A is the price of agricultural goods in terms of non-agricultural goods; and T_t is the lump sum taxes.

Firms in sector i hire capital and labor to maximize profits

$$\Pi_t^i = \max_{\left\{K_t^i, N_t^i\right\}} p_t^i A_t^i \left(K_t^i\right)^{\alpha_{K,i}} \left(N_t^i\right)^{\alpha_{N,i}} - w_t^i N_t^i - r_t^i K_t^i,$$

where $p_t^M = 1$.

Maximization behavior of the firms implies that w_t^i and r_t^i are equal to the marginal product of capital and labor in sector i in each period. Maximization behavior of consumer implies that w_t^i and r_t^i are equalized across sectors.

We will show that data rejects the implications of this frictionless competitive equilibrium.

3.3 Wedges accounting

Our description of Russian economy showed a large number of institutional frictions and government policies that distorted household and firm decisions. Modeling each of these frictions explicitly is difficult, as there were a large number of such frictions, and there is not enough data to realistically estimate the magnitude of each of them. Instead, we follow a different path. We use the insights of Cole and Ohanian (2004) and Chari, Kehoe and McGrattan (2007) that any policies can be mapped into wedges in a prototype competitive equilibrium model. Policies and frictions manifest themselves in different wedges. By studying these wedges, we can identify likely sources of these distortions.

Specifically, we define three wedges, each equal to deviations in the right hand side of equations (9), (10), and (11) from unity. These three wedges correspond to the intratemporal distortions in capital and labor allocations between sectors and to intertemporal distortion.

In addition to these three wedges, we also explicitly focus on one of the most important of Stalin's economic policies – price scissors, discussed in Section 2. This policy introduces a wedge between the relative prices that a producer of agricultural goods faces, and the prices that consumers are willing to pay. Specifically, if producer of agricultural goods faces a price $p_{A,t}$ and a consumer faces a price $\tilde{p}_{A,t}$, then the *price scissor wedge*, $1+\tau_{C,t}$, is given by $1+\tau_{C,t} = \tilde{p}_{A,t}/p_{A,t} = \frac{U_{c,t}^A}{p_{A,t}U_{c,t}^M}$. Thus, using additional data on the producer relative prices (for the first

three wedges), we define four wedges, $\tau_{R,t}, \tau_{W,t}, \tau_{C,t}$ and $\tau_{K,t+1}$ as follows

$$
\begin{aligned}
1+\tau_{R,t} &\equiv \frac{F^M_{K,t}}{p_{A,t}F^A_{K,t}} = \frac{r^M_t}{r^A_t}, \\
1+\tau_{W,t} &= \frac{F^M_{N,t}}{p_{A,t}F^A_{N,t}} = \frac{w^M_t}{w^A_t}, \\
1+\tau_{C,t} &= \frac{U^A_{c,t}}{p_{A,t}U^M_{c,t}}, \\
1+\tau_{K,t+1} &= \left(1+F^M_{K,t+1}-\delta\right)\frac{\beta U^M_{c,t+1}}{U^M_{c,t}}.
\end{aligned}
\tag{12}
$$

Note that the intratemporal distortions for capital and labor implied by the right hand side of expressions (9) and (10) are given by $(1+\tau_{R,t})/(1+\tau_{C,t})$ and $(1+\tau_{W,t})/(1+\tau_{C,t})$. These normalized wedges (as well as the intertemporal wedge) do not require knowledge of the prices.

The normalized intratemporal labor wedge, for example, implies that a reduction is a misallocation of labor between agriculture and manufacturing that can be achieved either by reducing the wedge $\tau_{W,t}$, which is determined by the ratio of the wages paid in the two sectors and in many models is often related to the size of barriers to labor mobility, or by *increasing* $\tau_{C,t}$, which measures distortions between consumer and producer prices. This distinction helps us to evaluate the effect of different policies.

Additionally, one can also think of $\left\{A^M_t, A^A_t, ex^i_t, G^M_t\right\}_{t=0}^T$ as wedges. We want to emphasize that our analysis is essentially an accounting procedure. Given initial K_0, competitive equilibrium allocations with wedges $\left\{A^M_t, A^A_t, \tau_{R,t}, \tau_{W,t}, \tau_{C,t}, \tau_{K,t}, ex^i_t, G^M_t\right\}_{t=0}^T$ match data exactly. This allows one to compute the marginal contribution of each wedge to the deviations of data from undistorted allocations.

4 Data and calibration

In this section we discuss the construction of the data for a systematic comparison of the structural transformation during the Stalin years and during the Tsarist years.[14] To our knowledge, this comprehensive construction of the data is new. Most importantly it details the sectoral variables, calculation of capital series, and recalculation of GDP in market prices of 1913.

[14] We refer the reader to Appendix A for the detailed and comprehensive discussion of our data sources.

4.1 Data sources and construction of the data

The principal source of economic data for output, consumption and investments for Russia in 1885-1913 is Gregory (1982). Gregory compiled data on net national income and its components using a variety of historical sources, most of them based on the official Tsarist statistical publications. His data is sufficiently disaggregated and allows us to construct series for consumption and investments for agricultural and non-agricultural sectors and to use a perpetual inventory method to impute capital stock. Unfortunately, he does not provide enough information to separate residential housing stock and non-residential capital in agriculture. This leaves us no choice but to include rural residential housing stock in our measure of agricultural capital. For the reasons explained in the Appendix, we exclude urban residential capital from any measure of capital stock. The data on value added by sector is scanter – we have those estimates only for a few select years.

We obtain Soviet economic data from Moorsteen and Powell (1966). They use official Soviet data to construct sectoral outputs, capital stock, and value added according to Western definitions. Although the official price series may not be representative of true market clearing prices, there seems to be a consensus among economic historians that the underlying quantities are generally reliable (see, e.g., a discussion in Appendix A of Allen 2003). Using data in Moorsteen and Powell (1966), as well as additional data from Allen (1997), Davies (1990), and Davies et. al. (1994), we compile sectoral outputs, investment, capital stock, and consumption for agricultural and non-agricultural sectors in Soviet 1937 prices. To convert these values to 1913 prices, we use Harrison and Markevich (2011) estimates of Soviet sectoral value added in 1928 in 1913 prices. That is, we implicitly assume that intra-sectoral prices remain unchanged, and infer sectoral relative price conversion from their data. The details are in the Appendix.

Since the role of government changed dramatically between 1913 and 1928, we define government purchases narrowly as military spending. We count all other government expenditures as non-agricultural consumption.

Calculating sectoral employment or even the labor force is difficult both for the Tsarist and for Soviet periods. Unlike data on economic aggregates, there is little reliable data on sectoral employment before 1913. Tsarist Russia conducted only one national census, in 1897. There are employment records from the administrative data in some heavy industries, but for the rest of

the economy there are only sporadic surveys. For this reason, Gregory (1982) does not provide annual employment numbers but only estimates of growth rates of labor force for agriculture, manufacturing and services for 1883-87 to 1897-1901 and for 1883-1897 to 1909-1913. An early Soviet economic historian Gukhman used census and archival data to estimate composition of the labor force in 1913, which was then reproduced in Davies (1990). As in the census as well as Gukhman and Davies, we define sectoral employment for each worker according to self-reported primary occupation. This definition seems to be the only way to obtain a consistent definition of sectoral labor force for Tsarist Russia, the Soviet Union, and Japan. It almost certainly overestimates the true employment in agriculture and underestimates employment in manufacturing. There is substantial evidence that agricultural workers spent a part of their time in non-agricultural activities, such as seasonal manufacturing work in the city and self-employment (*promysly).* As a robustness check, we recompute our wedges under assumption that 10 percent of time of agricultural workers is spent on non-agricultural activities, which is consistent with estimates of Moorsteen and Powell (1966) for the Soviet period. The results of this robustness check are reported in the online appendix.

We also need to take a stand on how to treat employment of women. The available employment records before 1913 are from select heavy industries that predominantly employed men. As the non-agricultural sector expanded dramatically after 1928, so did the fraction of women in non-agricultural employment. Based on this evidence one may be tempted to conclude that female labor force participation significantly increased. At the same time, there is evidence that before 1913 female labor force participation in agriculture was very high, as women had to replace men who were employed as migrant workers in urban industries. For example, Crisp (1978) in her study of pre-WWI Russian labor markets points out that although in factory industries there were only 800,000 women compared with several million men, in peasant farms "the proportion of women undoubtedly exceeded that of male, especially if all-year-around averages are taken into account". Since there are no reliable figures regarding female labor force participation, we do not treat women and men differently and assume that all of the working age population is a part of the labor force.

We have data series for real GDP growth in 1913 rubles for Russia. We also have real GDP in 1990 international dollars for 1913. To construct real GDP per capital, we use real GDP per capita in international dollars for 1913, and then apply real GDP growth rates (in

constant rubles and dollars) to construct real GDP in international dollars for other years in the 1885-1913 period. This series may differ slightly from real GDP in international dollars for other years, as relative prices might have changed. However, our index captures well the general patterns. The fraction of agricultural value added measures the ratio of agricultural value added in 1913 prices to real GDP in 1913 prices. Sectoral net imports and exports are shown relative to the sectoral value added.

4.2 Summary of the data

Figures 2 and 3 show aggregate and sectoral, agricultural and non-agricultural, data for both Tsarist and Soviet Russia.

1885-1913

The Russian economy in 1885-1913 grew rather significantly, with a 1.91 percent average rate of growth of real GDP per capita. However, the economy did not experience structural transformation from agriculture. The primary occupational area for about 85 percent of the working-age Russian population was agriculture in 1885, and this fraction declines very slowly, to 81 percent in 1913. The role of agriculture in the economy was also very important, with about 53 percent of value added produced in agriculture in 1885, declining only to 46 percent in 1913. International trade was rather important – Tsarist Russia exported about 10 percent of its agricultural production, and imported primarily manufactured goods.

Soviet Russia (1928-1940)

The level of GDP per capita and the structural composition of the Russian economy in 1928 is approximately the same as it was in 1913.[15] This reflects the years of turmoil following the fall of Tsarist Russia and the subsequent years under the communist rule.

We now turn to Russia in 1928-1940. Growth in real GDP (measured in 1913 rubles) is very rapid. This coincides with a rapid increase in investments and reallocation of labor from agriculture to non-agriculture.

The bottom row shows agricultural and non-agricultural per capita value added in 1913

[15] We do not report the data for Tsarist Russia during World War I (1914-1917) or for the period following February Revolution (1917) to 1927. This period covers October (Bolshevik) Revolution, the Civil War, War Communism, and the New Economic Policy (NEP). This is because the availability and quality of the data do not allow us to construct the dataset comparable to the one we constructed. Even though Harrison and Markevich (2011) provide many time series for this period, there is still no data on capital. That is why we are not able to estimate TFP and wedges for those periods.

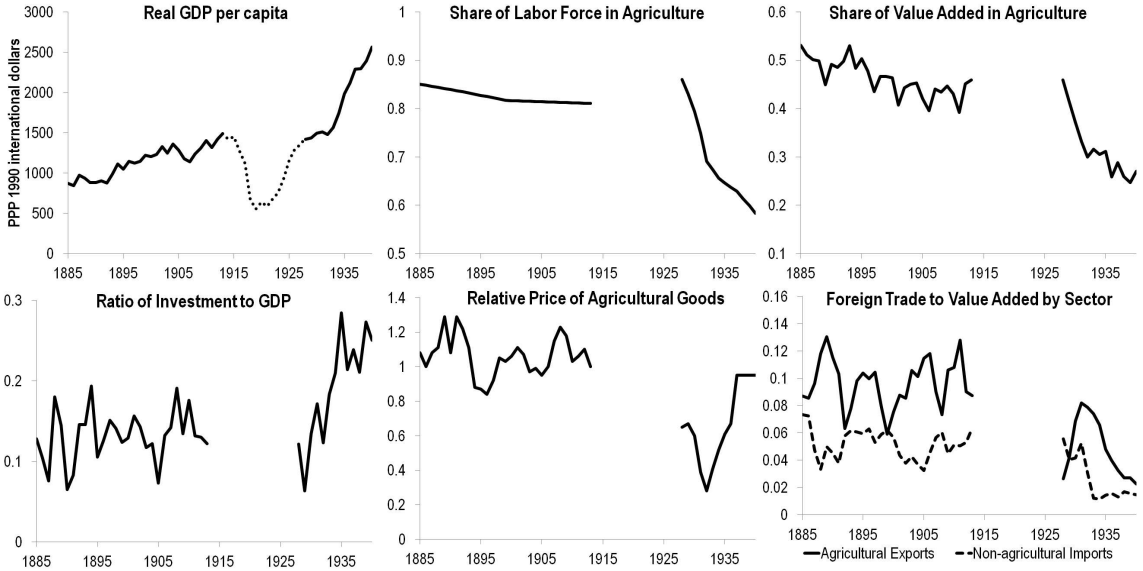

Figure 2: Aggregate economic indicators in Russia in 1885-1940.

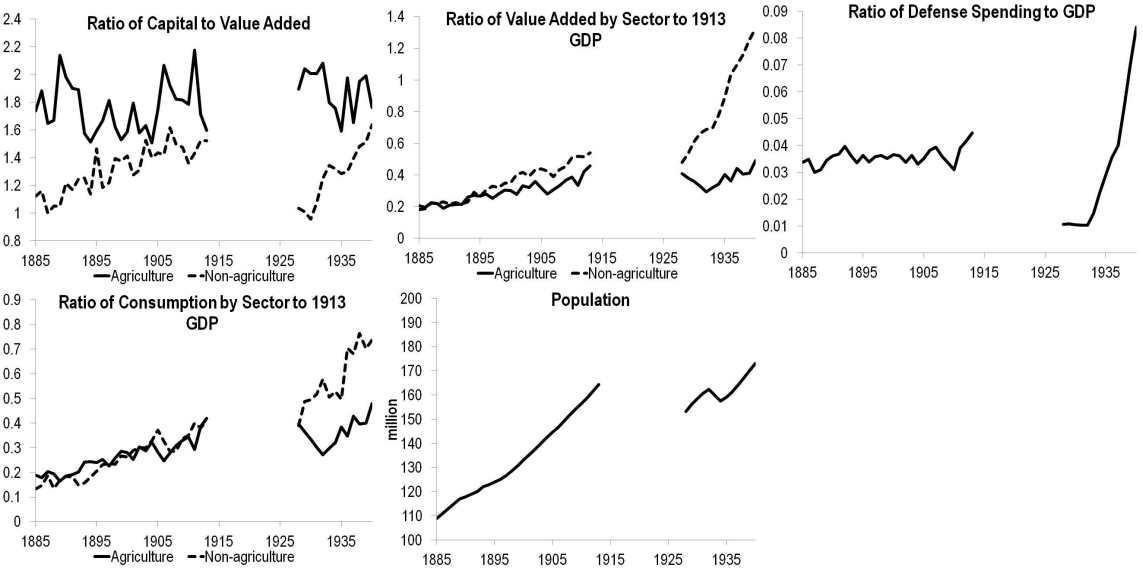

Figure 3: Sectoral economic indicators, government expenditures, and population in Russia.

prices, capital stock, and government expenditures. Non-agricultural value added shows remarkable growth. Agricultural value added drops during collectivization in 1928-1933 then returns towards its trend. The capital stock in 1928 is approximately the same in agriculture as it was in 1913, and is significantly smaller in non-agriculture. The military expenditures in Soviet Russia were generally low in the late 1920s and early 1930s followed by a significant military build-up starting in the mid-1930s.

A special discussion of price series is needed for Soviet Russia. While in market economies various price series (e.g. retail, wholesale prices or official procurement prices) are highly correlated, that is not the case for Soviet Russia. After 1928, there is a host of different official prices set by the state that often diverge substantially from each other. For most of our analysis this is not an issue since we measure quantities in 1913 prices.[16] Price information is needed only to construct the price scissor wedge $\tau_{C,t}$.[17] This wedge captures the terms of trade for the producer of agricultural goods. We follow Allen (1997) and define this relative price as a ratio of official procurement prices of agricultural goods relative to the free retail non-agricultural consumption basket. Allen argues that this is the best measure to capture the terms of trade that a private agricultural producer faced after 1928.

4.3 Calibration

To calibrate the model we need to choose values of eight parameters and the initial value of capital stock. The five technology parameters include the elasticities of production functions in the agricultural and manufacturing sectors with regard to capital and labor, $(\alpha_{Ki}, \alpha_{Ni})$, and the depreciation rate, δ. Three preference parameters include the discount factor, β, the asymptotic agricultural consumption share, η, and the subsistence level in agriculture, γ^A.

Some parameters that we choose are rather uncontroversial, we draw on Hayashi and Prescott (2008) for them and provide extensive robustness checks in the online appendix. The depreciation rate is set to $\delta = 0.05$, and the discount factor is set to $\beta = 0.96$. The asymptotic consumption shares of agricultural and non-agricultural goods are set to $\eta = 0.15$ and

[16] We use 1913 relative prices for agriculture vs. non-agricultural goods. Certainly, there were also distortions due to non-market prices *within* each sector. We neglect these distortions as we have no reliable way to adjust for them.

[17] Prices also feature in our definitions of $\tau_{W,t}$ and $\tau_{R,t}$. The prices drop out, however, if we consider normalized intra-sectoral labor and capital distortions, $(1 + \tau_{W,t}) / (1 + \tau_{C,t})$ and $(1 + \tau_{R,t}) / (1 + \tau_{C,t})$.

$1-\eta=0.85$, correspondingly.[18] One difference between our model and the model of Hayashi and Prescott is that we do not have intermediate goods. We account for this difference by assuming that all intermediate goods used in the production of manufactured goods represent labor. We set the corresponding factor shares for the manufacturing sector to $\alpha_{K,M}=0.3$ and $\alpha_{N,M}=0.7$. Instead, we assume that all intermediate goods used in the production of agricultural goods represent land. We set the remaining capital and labor shares to $\alpha_{K,A}=0.14$ and $\alpha_{N,A}=0.55$ (thus assuming that land's elasticity is 1-0.14-0.55=0.31). The values for these parameters are also in the range of values adopted by Caselli and Coleman (2001) and Stokey (2001) and calibrated using direct estimates for the U.S. and the U.K.[19]

We choose the initial capital stock to match the observed level of capital in 1885. We do not have data needed to directly determine the subsistence parameter, γ^A. We set the subsistence level to 28 rubles per capita per year in 1913 prices. This subsistence level accounts for 72 percent of agricultural consumption per capita in 1885. If we set it higher than 81 percent of consumption of 1885, the simulated economy would go below the subsistence level during Tsarist years. As we discuss in the online appendix, our main results are robust to alternative values of γ^A below this value. Finally, for χ_t, the fraction of labor force in the population, we set $\chi_t=0.53$ for all t, which is the fraction in the Russian census of 1897. This number is slightly higher than fraction of labor force from 1926 and 1939 censuses, but fitting those numbers produces only small differences for the analysis.

5 Connecting wedges to policies

We now proceed with the calibrated model to compute wedges using equations (12).[20] Figure 4 shows wedges for Russia with solid lines and their average level (or trends, for the case of TFPs) with dashed lines.

The behavior of the wedges can be grouped in three main periods. The first is tsarist

[18] Parameter η only enters as a constant in one first-order condition and determines the scale of the price scissors wedge, $\tau_{C,t}$. By the same token, since the relative price of agricultural to manufacturing goods is measured in the data as an index, the scale of the price scissors wedge, $\tau_{C,t}$, means little, so we normalize it to be zero in 1885.

[19] Caselli and Coleman (2001) use the values $\alpha_{K,M}=0.6$, $\alpha_{N,M}=0.34$, $\alpha_{K,A}=0.21$ and $\alpha_{N,A}=0.6$. Stokey calibrates $\alpha_{K,M}=0.5$, $\alpha_{N,M}=0.5$, $\alpha_{K,A}=0.17$ and $\alpha_{N,A}=0.38$.

[20] The wedge $\tau_{K,t}$ can only be computed up to 1939 using available data. Wedge $\tau_{K,1940}$ is determined by the expected consumption in 1941, for which we do not have data. To impute $\tau_{K,1940}$ we assume that expected consumption growth in 1940 is the average of expected consumption growth in 1937-1940.

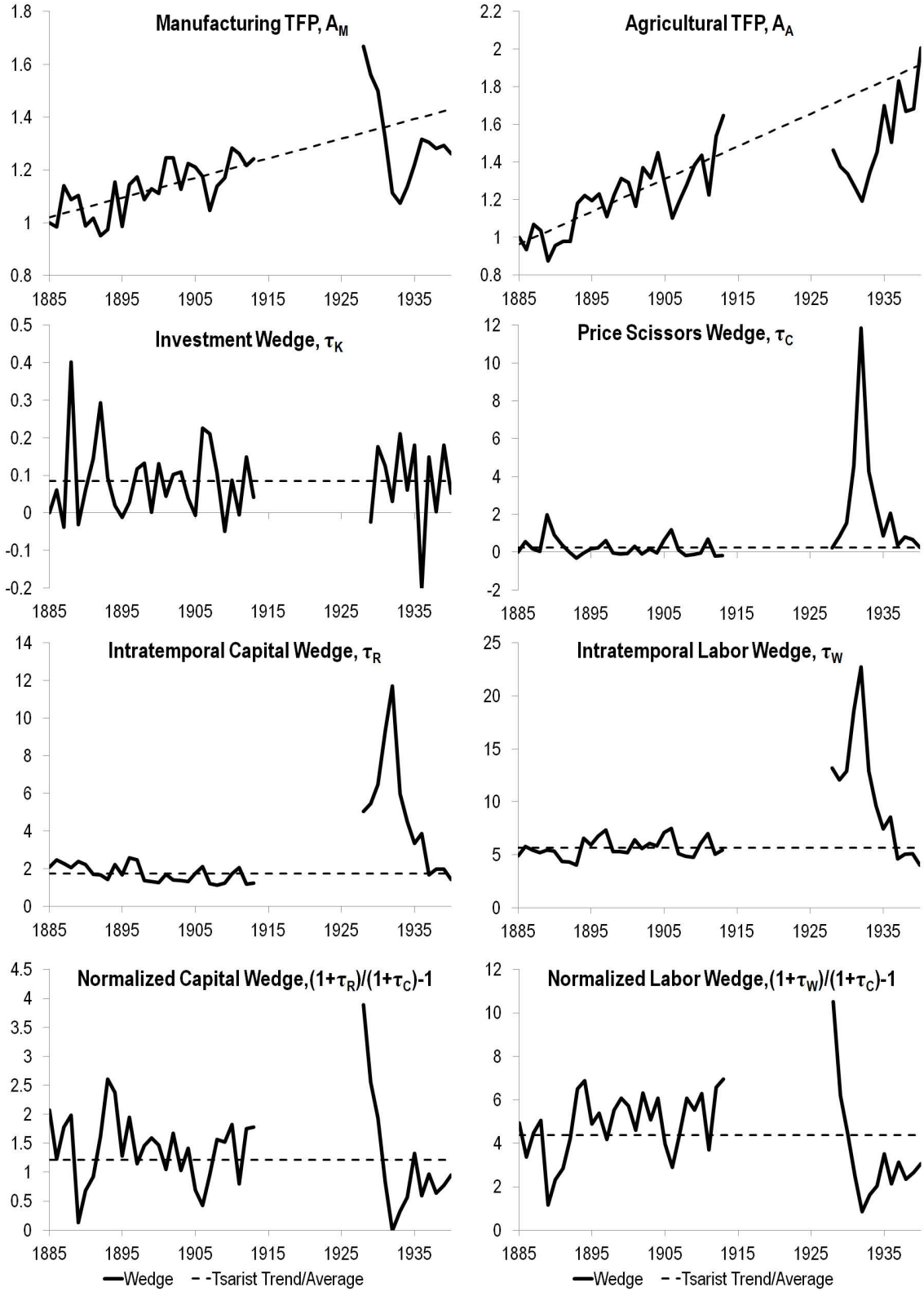

Figure 4: Russia: Wedges

Russia (1885-1913). The second is the initial period of industrialization and collectivization (1928-1935) when the wedges exhibited dramatic changes. The third period is that of the stabilization of wedges (1936-1940) that ends with the entry of Russia into the WWII .[21] We present the average wedges for different periods in Table 5 in the appendix.

5.1 Wedges in 1885-1913 (Tsarist Russia)

The first period is Tsarist Russia. The TFP and the wedges exhibit some fluctuations but are certainly less variable than during Stalin's period. The average TFP annual growth is 1.45 percent in agriculture and 0.66 percent in non-agriculture. The four wedges defined in (12) are noisy but do not exhibit any trend in 1885-1913. Observing these wedges it becomes evident that Russia faced significant distortions in its economy. The average intersectoral labor and capital wedges were equal to $\tau_W = 5.7$ and $\tau_{C,t} = 1.75$, respectively. The average normalized intratemporal (inter-sector) labor wedge, $(1 + \tau_{W,t}) / (1 + \tau_{C,t})$, is equal to 5.9. The average normalized intratemporal (inter-sector) capital wedge, $(1 + \tau_{R,t}) / (1 + \tau_{C,t})$, is equal to 2.4. The average intertemporal (investment) wedge is equal to 0.085. The average size of the intratemporal labor wedge in Russia is higher than in Caselli and Coleman (2001), who report the ratio of the farm wage to the manufacturing wage to be 0.20 in the US in 1880, and the corresponding wedge equals 4.

Connecting wedges to the policies/distortions.

Intratemporal labor wedge. The large size of the intratemporal labor wedge stands out. This is consistent with the view of Gerhenkron (1962) that the unusually slow decline of agriculture's share of GDP in Tsarist Russia can be explained by the barriers to the rural-urban migration, in particular, by the institutions of obschina. *Obschina* effectively prescribed communal ownership of land and existed in 38 out of 50 European provinces of Russia (Chernina et al., 2011). In other provinces either there were no communes or were the hereditary communes (with individual ownership of land). The hereditary commune allowed for exit – as long as the exiting individual or household could sell to an individual or household within the commune. In the repartition communes (*peredelnaya obschina*), exit required the consent of the commune; there was no

[21] Davies (1998) adopts a slightly more nuanced view of the sub-phases of economic development in 1928-41: 1928-30; 1930 spring/summer-1932; 1933; 1934-1936; 1937-June 22, 1941. His description of the periods up to and including 1933 fits our initial period identically. We could have started the "stabilization period" from 1934. However, we view 1934-1935 as the recovery from the low base of the disaster of the initial phase of Stalin policies. Beginning the stabilization period in 1935 (rather than 1936) changes our results only insignificantly.

right to sell land and get compensation. At the beginning of the twentieth century most of the peasant households lived in the communes (Davies 1998, p. 8).

There was another feature of the communal land ownership in Russia that was particularly important: Individual peasant strips were subject to repartition and redistribution. This temporary character of land ownership, as argued by Gerschenkron (1965), significantly decreased incentives to improve the land or invest in it. In our setup, this aspect of obschina is likely reflected in the low agricultural TFP levels and growth rates.

Reforms of Witte and Stolypin and the behavior of the wedges. Several issues with the structure of the Tsarist economy and its policies are also important to note.[22] The study of Von Laue (1963), shows how the Finance Minister Sergei Witte persuaded the Tsar Nicholas II that state-encouraged industrialization was needed for the survival of the political regime. The main elements of the Witte's reform were: introduction of the gold standard, state subsidies and financing for expanding the railway network (in addition to direct support, the state arranged and guaranteed foreign loans), encouragement of foreign investment (especially in the iron and steel industries). Von Laue's and Gerschenkron's (Gerschenkron 1965) opinion was that the state played an important role in Russia's industrialization. This view was challenged in an influential study by Kahan (1967) who argued that the taxes and other costs state intervention, as well as introduction of the gold standard, outweighed the benefits of the state interventions. Our calculation of the wedges per se does not give a clear answer and resolution to these debates (until we compare the wedges to the counterfactual of Japan in Section 7.1). Likely, there is truth in both sides of the argument. What we take from this debate is that there were likely very significant distortions to financing that necessitated the state's involvement, either through facilitating loans or channeling resources for construction of railroads, and through encouragement of foreign investment in heavy industries that we discuss next. These financial frictions coupled with a generally low level of development of Russian financial markets lead us to believe that the intertemporal wedge that we find in our analysis was, indeed, quite significant.

Following the revolution of 1905, the Tsarist government started a major agrarian reform. Prime Minister Stolypin's reform (a series of decrees issued in 1906-1910) allowed individual

[22]The discussion of the literature and the assessment of the state of the debate that follows in this section is based on an excellent summary of the Tsarist economy in the book by Davies (1998).

sales of land and greatly facilitated exit from the repartition communes. The main goal of the policy was encouragement of villagers to leave the commune and establish their separate individual holdings. However, Davies argues (1998, p.10) that by 1914 the reforms had not affected a significant portion of the village households.[23] It is not surprising in light of this evidence that we do not observe a major change in the labor barriers.

Cartels, credit constraints, tariffs. Another interesting aspect of the Russian economy was the eminence of cartels (*syndikaty*), especially post 1899-1902 recession, in the capital goods industries (steel, coal, iron, railroad engineering). These cartels were to a large extent foreign owned. *Syndikaty* established prices and the market quotas. The cartelization of an important part of the heavy industries likely played an additional role in restricting the size of the manufacturing sector relative to a competitive market. Cole and Ohanian (2004) argue for the importance of the cartels in the slow recovery from the Great Depression in the US. In their model with endogenous labor, cartels appear as the labor wedge. In our two sector economy, the cartels would appear as a part of the intratemporal labor and capital allocation wedge, decreasing the capital and labor inputs to the manufacturing sector relative to competitive markets. Allen (2003, p. 45) also argues that there were significant credit constraints, especially strongly affecting agriculture, citing the findings of the government committee on farm credit that found existing credit institutions were inadequate. In our model, this friction can be modeled as the intratemporal credit wedge distorting allocation of capital to the agriculture. Of course, our connections of the policies and the wedges may have different interpretations. For example, there is now a large body of literature that argues that financial frictions may represent themselves as TFP losses (e.g., Buera, Kaboski, and Shin 2011, Khan and Thomas 2011, Midrigan and Xu 2013, Moll 2012, among others) or a labor wedge (e.g., Arellano, Bai, and Kehoe 2011). The same caveat about a connection of policies to wedges applies to other wedges.

We briefly note that Tsarist Russia imposed steep tariffs on food imports and also used tariffs to protect and encourage infant manufacturing industries (textiles, for example). These tariffs would likely have an opposite effect on intratemporal wedges (food tariffs encouraging allocation of resources to agriculture; manufacturing tariffs encouraging the allocation to industry). Likely,

[23] Chernina et al. (2011) show that over 1906-1915, 22% of eligible households privatized their land (14% of eligible communal land).

also the tariffs had the usual effect of restricting competition and, thus, potentially decreased the size and the TFP of the affected sectors.

5.2 Wedges 1928-1935

From 1928 to approximately 1935, most wedges exhibit dramatic changes. TFP falls significantly in both sectors from 1928 to 1933. TFP in agriculture decrease by almost 20 percent from 1928 to 1932. TFP in non-agriculture decreased by 36 percent between 1928 and 1933. The TFP then bounces back and reaches the level of 1928 for agriculture only in 1934, while manufacturing does not achieve the level of 1928 TFP even by 1940.

Wedges $\tau_{R,t}$, $\tau_{W,t}$ and $\tau_{C,t}$ also follow the same patterns, first increasing dramatically, then decreasing. The peak of all increases coincides with the peak of collectivization policies. From 1928 to 1932, we observe the following behavior of the wedges. The price scissor wedge jumped tenfold. The intrasectoral labor wedge and the intrasectoral capital wedge double. The normalized labor wedge decreased tenfold and the normalized intersector capital wedge almost became zero. There is no discernible pattern in terms of the intertemporal capital wedge.

To understand this pattern, it is useful to think about the implications for wedge decomposition of the behavior of the sectoral data in Figure 2. This figure shows a substantial drop in agricultural output, together with substantial reallocation of labor force from agriculture to non-agriculture. This coincides with a substantial decrease in $p_{A,t}/p_{M,t}$ ratio, which is consistent with the policy of price scissors. The response of the economy under Stalin's policy to a drop in agricultural output is exactly the opposite from the predictions of a frictionless neoclassical growth model. In the frictionless two sector growth model, non-homotheticity in consumption of agricultural goods implies that in response to a drop in agricultural TFP (and, hence, a fall in production and consumption of agricultural goods) relative prices of agricultural goods increase by *more* than the fall in TFP. This creates incentives to reallocate labor *into* agriculture to increase the output of food, which became more valuable. Stalin's policy of price scissors led to the opposite effect. By keeping producer prices of agriculture artificially low, he created incentive for labor to move from agriculture, exacerbating the food problem. The effect of price scissors is so large that the labor wedge $\tau_{W,t}$ had to increase to partially offset the effect of price scissors.

Connecting wedges to the policies.

We now further elaborate on the connection of the policies to the wedges.[24]

We first note that it is not surprising that the wedges change dramatically and that the wedges fluctuate so significantly. The policies of industrialization and collectivization were overwhelmingly significant and at the same time quite erratic. In 1929, the drive to collectivize started with exceptionally ambitious plans to completely restructure the economy. Stalin calls 1929 the year of the Great Break (Stalin, November 7, 1929) and a "decisive advance" on the path to industrialization "leaving behind Russian backwardness". On March 2, 1930, Stalin publishes an article in Pravda, "Dizziness from Successes", signifying a partial retreat from the first push of collectivization. Davies (p. 15-17 in Davies, et. al 1994) describes the 1928-1930's period as that of "Utopian concepts of the emerging socialist order prevailing in official circles", the period of Spring/Summer 1930-summer 1932 as when "economic policy and practice were confused and ambitious" with greater realism settling in, and only by late 1933 the realism (but not the brutality of the policies) prevails.

Policies and the fall in agricultural TFP. We now proceed to describe evidence that is consistent with the drastic fall of the agricultural TFP that we observe in the data. Davies and Wheatcroft (Chapter 6 in Davies, et. al. 1994) describe key factors affecting agricultural production in these years. First, the state exaction of grain from peasants on its own created dramatic disruption in agricultural production. There were virtually no incentives to work on the collectivized land. The system of crop rotation was severely disrupted and not restored even by 1935 when crop rotation was used only on 50 percent of the sown area. The grain requisition led to a drastic fall in livestock because of the lack of food for humans and animals. This fall in the quantity of livestock, exacerbated by the careless application of the available manure, in turn led to a significant reduction of manure to fertilize the land and again lowered its productivity. Second, the dekulakization campaign of 1929-1931 affected five to six million peasants, one million out of 25 million peasant households (Wheatcroft and Davies, p. 68 in Davies et al 1994). These most successful and knowledgeable peasants were in the best case exiled, and in the worst case executed. Third, there was a significant decline in skills and technical training. A part of this can be attributed to dekulakization itself. Another part was due to the lack of experience among urban workers who were sent to run the collectivized farms. Additionally, the purges of the "bourgeois" elements bled the agricultural (as well as

[24]For a significant part of the discussion here, we follow Davies, et al 1994.

non-agricultural) sector of trained specialists. Fourth, the system of centralized control and planning led to a variety of erroneous decisions. Neither Stalin and the top brass of the Soviet elite, nor the regional party secretaries had experience in agriculture. Wheatcroft and Davies (p. 124 in Davies et al 1994) argue that the positive elements of the centralized planning (economy of scale, some new advanced farming methods, increase in mechanization, etc.) were outweighed by the "great disadvantages ... from the ignorance of politicians". By July 1933, available horsepower dropped to 16 million horses from 27 million in 1928. Tractors in 1933 only amounted to 3.6-5.4 million horsepower equivalents. These five key factors closely coincide with the assessment of Nove (1992, p. 176), who concludes that the "... peasants were demoralized. Collective farms were inefficient... [there were] appallingly low standards of husbandry with 13 percent of the crop remaining unharvested as late as mid-September in the Ukraine, and some of the sowing delayed till after June 1". For completeness, we also mention that one exogenous factor in the agricultural TFP is weather. However, Wheatcroft and Davis (p. 128 in Davies et al 1994) argue that throughout 1930s, weather was not a major factor behind low agricultural yields and certainly much smaller factor than the policies.

Price scissors and the labor wedge. As discussed in Sah and Stiglitz (1984) and Allen (2003), price scissors were an important policy for expropriating the "agricultural surplus". The state forced the peasants to sell the agricultural output at prices that were substantially below the prices for the same output in cities.

The magnitude of price scissors was substantial. Based on Barsov (1969), Ellman (1975, Table 6) shows that black market prices for grain were more than twice as high as the state procurement prices in 1929. In 1930, the difference was 4.5 times; in 1931, 7 times; and in 1932, 28 times! This mechanism is consistent with the traditional historical narrative of collectivization (see, e.g. Conquest, 1986). The consensus is that the price scissors policies certainly went too far even for their own sake. Millar (1974) calls these policies an "unmitigated economic policy disaster": Attempting to expropriate agricultural surplus, price scissors and mass collectivization destroyed the surplus resulting in the decline of agricultural output and eventually a great famine (costing several million lives). Millar (as well as Hunter, 1983) argues that food production declined so much that peasants slaughtered livestock decreasing the traction power (see the numbers above); instead of investing in industrial capital stock, the state had to produce or import tractors for restoring the traction power. This further reduced

net agricultural surplus.

However, the huge decrease in rural living standards did accelerate rural-urban migration. As Davies and Wheatcroft (2004) note, "By the autumn of 1932, peasants were moving to the towns in search of food. The growth of urban population ceased, and was partially reversed, only as a result of restrictions on movement and the introduction of an internal passport system" (p. 407). As we discussed above, Stalin's policies had to keep people in the villages to produce food. The introduction of the passport system (that restricted rural-urban mobility) can be viewed as providing evidence for the increase in the labor wedge already discussed.

Realizing the fact that price scissors were too high, after 1932 the government decreased them substantially. Moreover, in 1932, the state legalized agricultural markets (so called collective farm markets, *kolkhoznye rynki*) where peasants could freely sell output that they produced in excess of their planned delivery quotas; the quotas were also relaxed (Davies et al., 1994, p.16). This allowed the peasants to reap at least some benefits of the high market prices for food and also reduced incentives to migrate to the cities.

Policies and the non-agricultural TFP. We now turn to the behavior of the non-agricultural TFP[25]. Some factors that we already described in the case of the fall and fluctuations of agricultural TFP are also relevant for the case of the non-agricultural TFP, specifically, wild swings in policies and the repression of "bourgeois" specialists. We now present other evidence supporting our findings regarding the impact of Stalin's policies on the non-agricultural TFP during those years. We already discussed the fall in the number of horses and the urgent need to produce tractors. This led to inefficient and rush diversion of resources to industries producing mechanized equipment for agriculture. Davies (p.153) argues that in 1932 half of the high quality steel produced in the country was used in production of tractors. The capacity of iron and steel plants diverted to tractors could be used to finish the overambitious construction projects started earlier. The food crisis of 1932-1933 also forced a reduction in the number of workers in construction. In other words, both the price scissors and the fall in agricultural TFP also presented themselves in the fall of non-agricultural TFP. This initial period of industrialization did indeed bring importation of the foreign technology and practices, but it was still quite limited (we expand on this in the next section) and unlikely to affect the

[25]We closely follow the discussion of the chapter "Industry" by Davies in Davies, et. al. 1994. All pages refer to that chapter unless otherwise noted.

non-agricultural TFP significantly at the aggregate level.

An important factor was the overall poor quality of the workers moving from agriculture. Nove (1992, p. 198-199) details the issue and argues that outside of the machinery and the metal-working sectors, productivity gains were very low and possibly negative. The massive move of the peasants to industry required massive acquisition of the new skills. It was difficult or impossible to retrain such large numbers in such a short period, and this was exacerbated by the shortage of qualified engineers and technicians. An interesting fact reported by Nove is that to achieve this objective, the whole system of secondary education was disrupted. The number of students in secondary schools drops from about 1 million in 1928-30, to 300,000 in 1930-31, to merely 4,234 students in 1931-32 before increasing to 1.2 million in 1932-33. These "missing" students were converted to "emergency" technicians going through crash courses. Yet, even those emergency measures "could barely touch the millions who were recruited, or fled, from the country-side" (Nove 1992, p.199). The vast unfinished construction projects, massive influx of unskilled labor, diversion of the resources to fight agricultural crises, exacerbated by repression against skilled personnel not surprisingly led to a large drop in the industrial TFP.

The simplest argument, however, to see why there is a drop in manufacturing TFP is to consider the labor and capital inputs in manufacturing. From 1928 to 1933 (the trough of the manufacturing TFP), capital grew by a factor of 1.88, labor grew by a factor of 2.4, while output grew only by a factor of 1.45. From 1928 to 1935, capital grew by a factor of 2.3, labor grew by a factor of 2.6, while output grew only by a factor of 1.8. We further comment on this issue in the next section.

5.3 Wedges 1936-1940

By 1936, the dramatic changes in the wedges subsided, and the economy entered a more stable period. By 1940, the level of TFP in agriculture is 22 percent higher than in the Tsarist economy in 1913 and 37 percent higher than in 1928. The TFP in manufacturing is slightly below that in the Tsarist economy in 1913 and 25 percent lower than in 1928. The average value of the normalized labor wedge is about 40 percent lower than the average value of that wedge in the Tsarist economy (3.8 vs. 5.9). The average value of the intrasector capital wedge is about 35 percent lower than the average value of that wedge in the Tsarist economy (1.8 vs. 2.4). There is a significant (by 60 percent) decrease in the average investment wedge compared

with the average value of that wedge in the Tsarist economy (0.038 vs. 0.085). Overall, there is strong evidence that the barriers both intratemporal and the intertemporal were significantly reduced in this period. This provides strong support to the view of Allen (2003) or Acemoglu and Robinson (2012) that Stalin's policies removed barriers within the Soviet economy – at least, in the late 1930s. However, the TFP in agriculture increased only insignificantly while TFP in manufacturing is lower.

Connecting wedges to the policies.

Manufacturing TFP. We now continue our discussion in the previous section of why the TFP estimates for the non-agricultural sector that we obtain are lower in 1940 than in 1928. The key force is the significant expansion of inputs. From 1928 to 1940, capital in non-agriculture grew by a factor of 4.4, labor in non-agriculture grew by a factor of 3.7, while output grew only by a factor of 2.75. We proceed with further discussion of changes in Soviet technology that is based on Lewis (Chapter "Industry" in Davies, et al. 1994). Our estimates of the slow growth of TFP are consistent and are directly supported with the summary of the data by Moorsteen and Powell, by Bergson, by Khanin, and by Seton (Lewis, p 195-196 and Figure 15, Table 41 therein). The main conclusion of these studies is that TFP growth had an insignificant impact on growth of GDP relative to the growth in inputs. Moreover, Moorsteen and Powell also point out that the TFP growth in non-agriculture was lower than in the economy as a whole.

On one hand, there were two main positive factors that led to an increase in productivity. First, there certainly were important technological advances. The scale and efficiency in many industries significantly increased (for example, the new and larger blast-furnaces in the iron and steel industry or use of explosions and pneumatic picks in coal mining). Soviet Russia was one of technological leaders in airframe manufacturing and design of tanks. Imported technology was introduced and became operational such as at the Gorky car plant GAZ (based on a Ford plant) and the giant Magnitogorsk iron and steel combine (modeled on U.S. Steel in Gary, Indiana). By 1940, Soviet Russia caught up with Western Europe in high energy transmission. The second positive factor was improvement in the quality of the labor force. By 1940, the peasants who joined industry in 1928 had become quite seasoned and trained workers; some became managers with years of experience in rapid industrialization. Moreover, there was a marked increase in incentives with campaigns on "socialist competition" and Stakhanovite movement of rewarding overachievers and production stars (see an extensive discussion on

these improvements in labor force in Nove 1992, p. 234-235)

On the other hand, Lewis (p. 196) lists five key factors that support his conclusion that "the role of technology in Soviet growth during the years after 1928 was not as great as might be assumed from a listing of the technological developments of the period". First, the most modern technology was concentrated only in some sectors while the rest of the economy lagged significantly behind (for example: construction overwhelmingly used brick and timber rather than concrete; steam power was still the main source of power in railways). Second, the vertical integration developed to overcome poor cross-industry planning led to most industries and large plants operating as self-contained empires. Many of the inputs, related materials and spare parts were produced "in house," often inefficiently and with technology lagging behind the flagship product of those industries. Third, overmanning of industry was a norm. Fourth, after the first wave of foreign technology was put in operation, there was a slowdown of importation of technology and, importantly, the use of the foreign specialists. Finally, *gigantomania* (the unrestrained empire-building preferences of planners for giant factories and production sites) often led to inefficient application of the foreign technology designed for much smaller operations as well as presented often insurmountable organizational and business practice challenges.

Agricultural TFP. Most of the negative TFP effects of the first wave of collectivization were still present in this period: removal and destruction of the most productive class of peasants, poor incentive structure for production in the collective farms and poor management. However, the scale effects of the large collective farms and an increase in mechanization (e.g., tractors increased to 10.3 million horsepower by 1940) had an impact in growing productivity.

The Great Purge and Gulag prison labor. Another factor that certainly had a negative effect on TFP (both in agriculture and manufacturing) was the terror of Great Purges.[26] The peak of the repressions was the 1937-38 wave of mass arrests of members of the party and the professional elite. Nove (1992, p. 239) argues that not only the direct effect of arrests, incarcerations and executions of managers, specialists, and civil servants were important, but also significant was the terror imposed on the rest of the workforce for whom the slightest mistake or initiative could be claimed to be act of sabotage or treason punished by death.

An important question to ask is whether forced labor was important for Stalin's economy

[26] A variety of repressions and purges were a fact of life under Stalin throughout the whole period that we study (1928-1940), and also during WWII and up to Stalin's death. We already talked about the effects of the purges of the specialists at the beginning of industrialization and of dekulakization.

and whether we should consider this separately. Recent studies (e.g., Wheatcroft and Davis in Davies at. al. 1994 and Allen 2003, p.107-108) place the consensus number of Gulag prisoners (including exiles) at close to 3 million people in 1937-39. Allen (p. 108) cites Jasny (1951, p. 418) that "somewhat more than two concentration-camp inmates were needed to do the work of one free laborer". He then concludes that the convicts comprised only 1.5 million "free men equivalents" (about 2 percent of labor in the whole economy, 5 percent of civilian, non-farm labor) and thus, "these fractions were not large enough to be decisive". As most of these prisoners were employed in the non-skilled labor, we concur with this assessment and conclude that the main effect of the Great Purge was on TFP.

Intersector labor and capital barriers. The collectivization drive succeeded in that it mostly destroyed the commune as an institution that we argued was an important factor precluding labor mobility in Tsarist Russia. Nove (1992, p. 243) concludes that by 1935 the shape of kolkhoz as an institution was "more or less settled ... and ... remained [the same] well into sixties".

Price scissors. As argued above, the state learned the cost of excessive price scissors and reduced them in 1933. Through legalizing collective farm markets, government also de facto increased both marginal and average prices for grain that farmers obtained. Furthermore, instead of setting the below-market procurement prices for grain, the government introduced a sales tax on food that drove a wedge between what workers paid for food and what farmers received (Allen, 2003, p. 101). Therefore the price scissors remained in place but were was much lower than in the early 1930s.

Big Push or Removal of Barriers. We conclude this section by stating that one of our important results is that we find no evidence supporting theories of the Big Push. Stalin's policies of industrialization and collectivization are often thought of as the first and the quintessential example of so called Big Push – a coordinated investment across interlinked sectors undertaken by a central planner. While Allen (2003) tracks the idea of the Big Push to Soviet economists Preobrazhensky (1965, first published in 1926 in Russian) and Feldman (published in Russian in 1928), the modern concept of the Big Push was conceptualized by Rosenstein-Rodan (1943) and formalized by Murphy, Shleifer, and Vishny (1989). The main idea of the Big Push model is as follows: While industrialization raises aggregate output and income, it requires coordinated decision making across producers; in a decentralized market equilibrium, the in-

dividually optimal choice for each firm or household is to stick to the agrarian technology so that industrialization does not occur. The modern, industrial technology is characterized by scale economies; thus the switch to the modern technology only takes place whenever there is a substantial aggregate demand. On the other hand, once the investment in industrial technology is forced by the central planner, everybody is better-off. In terms of our model, the Big Push should have shown in a significant increase in TFP. However, we extensively argued above that even 12 years after the start of the big push, in 1940, there is no evidence of the significantly increased TFP within either sector (although reallocation from rural to urban sector did contribute to growth). If anything, Stalin's Big Push led to a drastic drop in TFP in the first years of this policy, and led to lower manufacturing TFP by 1940.

6 Russia without communist revolution: benchmark scenario

This section develops our benchmark counterfactual of how Russia would develop under alternative history scenarios. In the next section, we consider other scenarios.

Our counterfactual on comparison with the Tsarist economy consists of two parts. First, we use average Tsarist wedges from 1885 to 1913 and extrapolate them until 1940. We then compare economic outcomes in that simulation to the actual performance of the economy under Stalin in 1928-1940. Conceptually we view this exercise as how Russian economy would have developed if all Tsarist distortions remained unchanged.[27] Second, we study the question how Russia would have developed under both Stalin and Tsarist distortions after 1940 in the absence of the WWII. One of the common arguments is that Stalin's reforms improve economic efficiency to successfully fight in the WWII and project economic and political dominance after the WWII. Comparing the economic outcomes under Stalin's and Tsarist distortions allows us to assess this argument.

[27]This analysis ignores a potentially destructive effect of WWI which Tsarist Russia would have experienced. Data on labor and output by sector for 1914-1917 shows no signs of decline in TFP due to WWI. To the extent that we can think of war damage as a destruction of physical capital, this is not a substantial issue. We simulated an economy with an exogenously introduced reasonable drop in capital stock in 1918. This economy converges back to its pre-war path by 1928.

The analysis also assumes that Tsarist wedges will remain unchanged until 1930s. An alternative scenario that assumes lowering wedges along the capitalist development path uses Japan as a benchmark, which we do in the next section.

6.1 "Tsarist" economy versus Stalin economy

For our analysis we need to specify how fast population in Tsarist Russia would grow. Since we have a decreasing returns to scale technology (as the land is an important – and scarce – production factor), faster population growth leads to lower per capita output and welfare. As Figure 3 indicates, there was a very substantial slowdown in population growth in Russia after the communist revolution of 1917, a large part of which was caused by wars, famines and repression. In order to not count these towards welfare gains for Stalin, we assume that the actual population in Russia under Tsarist distortions would be the same as the population in the data.

Another issue is how to treat the initial capital stock for Stalin. As we see from Figure 3, the capital to output ratio in 1928 was substantially below its pre-WWI trajectory. We report how our results would change if we take the economy with Tsarist wedges and endow it with Stalin's 1928 initial capital stock.

Finally, we discuss how to treat projection of Stalin's wedges past 1940. As we have seen from our wedge decomposition in the previous sections, Stalin's distortions mostly stabilize at their new levels around 1936-37. For $\tau_{W,t}, \tau_{R,t}$, $\tau_{C,t}$ we take the average values of these variables for 1937-1940 and extrapolate them into the future. We similarly extrapolate trade (ex_t, im_t) and government expenditures G_t. We use a different strategy for A_t^A and A_t^M. The growth rates of these variables ultimately drive welfare and output in the long run. From Figure 4 one can see that it is difficult to say whether there was a shift in the growth rates in Soviet Russia in 1936-1940 compared with the Tsarist economy. The TFP levels in both sectors are lower than Tsarist trend. The somewhat faster growth rate of TFP in agriculture under Stalin could simply be a result of a catch up to the Tsarist trend. For this reason, we assume that both A_t^A and A_t^M grow with the Tsarist trend after 1940 (the next section provides calculations for two alternative scenarios for the projected growth rates of TFP). We take, as a starting point for 1941, the average detrended level of A_t^A and A_t^M from 1937-1940. Finally, we chose the level of $\tau_{K,t}$ after 1940 to ensure that the simulated model with Stalin's wedges matches the data exactly for 1928-1940. The resulting value of $\tau_{K,t}$ is very similar to the average pre-WWII level

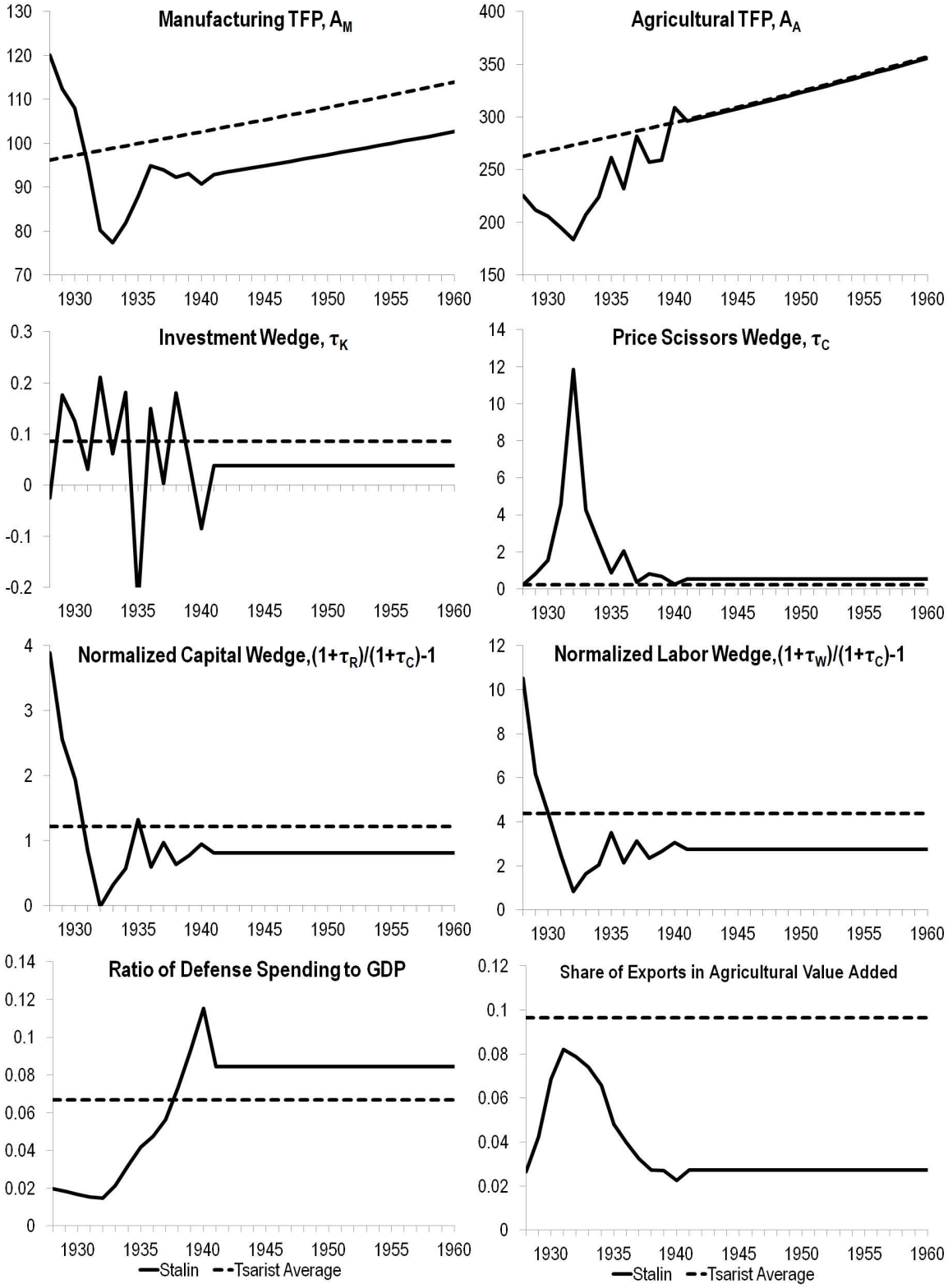

Figure 5: Extrapolated Wedges for Stalin and Tsar

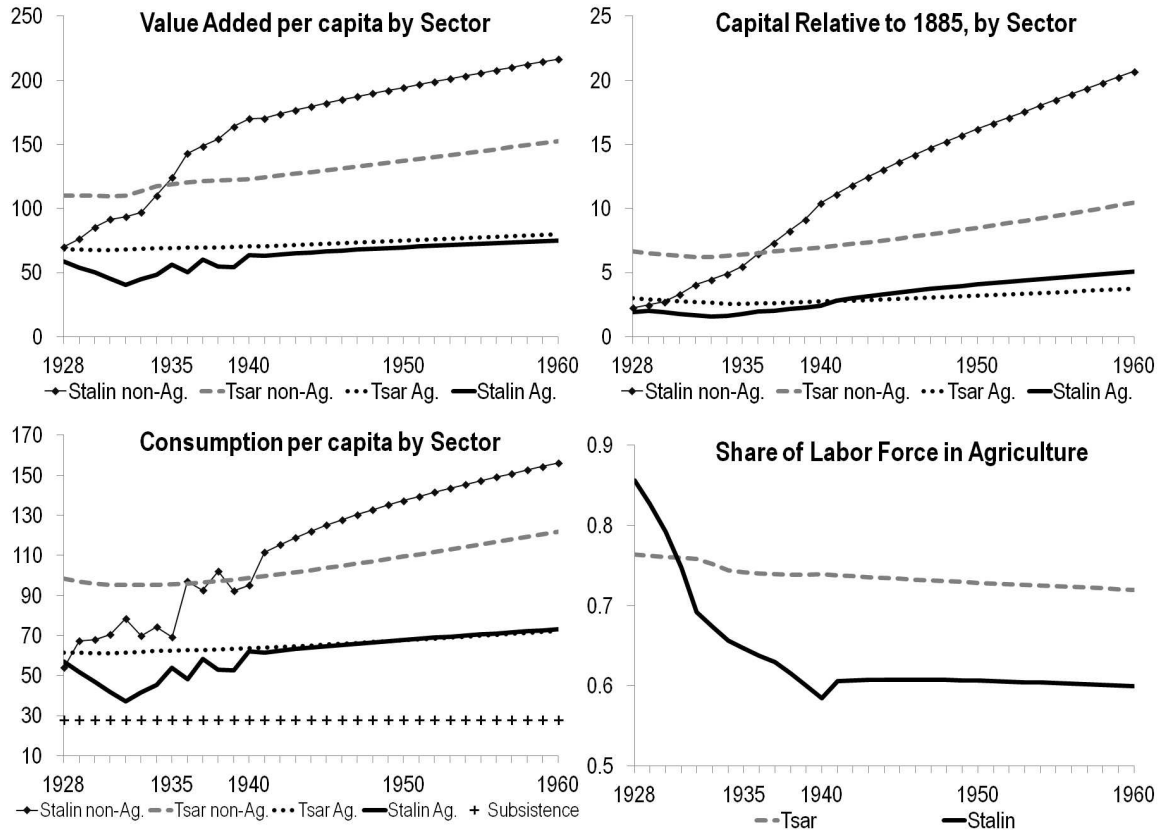

Figure 6: Predicted Economic Indicators for Stalin and Tsar

of this distortion.[28]The specifics of the projection are in Table 5 in the Appendix.[29]

Figure 5 plots actual and projected wedges from 1928 to 1960. Figure 6 plots actual and simulated sectoral value added, consumption, the capital stock and the labor composition for 1928-1960. We now briefly make several observations. Consumption of agricultural goods is significantly lower under Stalin than under the Tsarist distortions in 1928-1940. Consumption of non-agricultural goods is also significantly lower except for the last several years when non-agricultural consumption in the data is slightly higher. Since consumption is a sufficient statistic for the welfare in our economy, these graphs clearly indicate that the welfare under the Soviet

[28]We project all the wedges and simulate the economy for the period 1941-2000. We choose the terminal condition for expected consumption in the year 2000, which implies stable rates of investment throughout the projected period. We allow the wedges in the Tsarist projection to converge to Stalin's values between 1990 and 2000. This allows us to keep the terminal condition fixed across all counterfactual exercises.

[29]We estimate linear trends for sectoral TFPs of the Tsar and extrapolate these trends post 1913. Because the base for the later period is higher, the implied growth rate is lower. If we estimated a log-linear rather than a linear trend for TFP, we would get unreasonably high values of GDP per capita by extrapolating the economy of the Tsar.

distortions is significantly lower than under the Tsarist distortions during the 1928-1940 period.

The situation reverses after 1940. We assume that Stalin's economy manages to grow TFP at Tsarist economy rates; however, the lower wedges in the Stalin's economy contribute to a larger accumulation of capital. As a result, output and consumption in both sectors under Stalin's distortions overtake output and consumption under Tsarist distortions soon after 1940. Therefore, the welfare becomes higher after 1940.

To formally measure the welfare gains (losses) we find a fraction of consumption that needs to be added (or subtracted) to make the household indifferent between the simulated consumption stream and the observed consumption stream. Thus, the welfare gain in units of consumption, ϕ, solves

$$\sum_{t=T_0}^{T_1} \beta^t U\left(c_t^A, c_t^M\right) = \sum_{t=T_0}^{T_1} \beta^t U\left(\left(1+\phi\right)\hat{c}_t^A, \left(1+\phi\right)\hat{c}_t^M\right),$$

where $\hat{c}_t^i$ denotes the observed consumption streams and c_t^i represents the simulated consumption stream obtained from the counter-factual exercise.

Table 1 shows decomposition of the contribution of various wedges to welfare. Specifically, we start with the projected Tsarist economy and replace one-by-one each Tsarist wedge with the corresponding Stalin wedge in the order given in the table.[30] A negative number shows by how much welfare decreases with Stalin wedges, a positive number indicates an increase. When we replace all Tsarist wedges with their Stalin counterparts, we replicate data for 1928-1940, and provide the total welfare gains. The second from the bottom line (*Total*) reports the welfare numbers net of the effects of population. The last line (*Total net of* K_{1928}) reports the welfare numbers if, in addition, we assume that the Tsarist economy starts with the Soviet capital stock in 1928.

The first three columns correspond to welfare from 1928 to 1940 (measured as discounted utility over those periods), to welfare from 1928 to infinity (which represents a lifetime utility of an infinitely lived representative consumer born in 1928); and welfare from 1940 to infinity (which represents a lifetime utility of a representative consumer born in 1940). The fourth column isolates the contribution of the wedges after 1940 to welfare after 1940. The wedges in 1928-1940 affect welfare and output after 1940 by affecting the level of capital, K_{1940}. To

[30] We computed a variety of alternative decompositions, and they give similar results.

	Gain from policy for			
Policy	[28-40]	[28-∞]	[40-∞]	[40-∞], K_{1940}
τ_K	-2.2%	4.7%	9.9%	7.6%
τ_C	11.4%	13.0%	9.9%	7.3%
τ_W	-10.1%	-4.6%	3.6%	5.4%
G_M and τ_R	2.6%	0.9%	-0.3%	-1.0%
A_M	-1.9%	-6.6%	-10.2%	-9.2%
A_A	-15.4%	-7.4%	-1.3%	-0.1%
ex and q	5.5%	5.4%	5.3%	5.0%
Total	-24.1%	-1.0%	16.5%	14.9%
Total net of K_{1928}	-10.1%	5.3%	16.9%	14.9%

Table 1: Welfare Decomposition: Stalin vs Tsar

abstract from the effect of those policies, the fourth column compares welfare under Tsarist and Soviet wedges after 1940, keeping the capital stock K_{1940} the same for both economies.

Our main findings for welfare are as follows:

Consider the effects of wedges on the welfare of the generation born in 1928 (the second column of the table). The largest wedges affecting welfare are, in order of decreasing importance: the fall of TFP, price scissors, and in about equal measures, the effects of trade and reduction of the capital wedge. The decline in TFP in both sectors resulted in welfare losses subtracting approximately 14 percent (the sum of -6.6 percent and -7.4 percent). The drop in foreign trade partially compensated for this decline by pushing people from the villages to the cities, and accounted for 5.4 percent. The reduction in the capital wedge sped up capital accumulation and led to faster long-run growth that accounted for another 4.7 percent welfare gain. The effects of government spending and the intersector rate distortion jointly account for only the 0.9 percent welfare gain.

Now consider the effects of the wedges on the welfare of the generation born in 1928 during the period 1928-1940 (the first column of the table). The effects of the TFP fall are slightly larger: -17.3 percent with the bulk of the TFP losses coming from the drop in the agricultural TFP. The effects of price scissors and the wage distortions largely canceled each other out in the short run (1928-1940). In this period, the policy of price scissors was perhaps too "successful" in moving people from agriculture so that the labor wedge had to increase to negate it. The effect of trade remains about the same (5.5 percent).

For the generation born in 1940, the three key factors of the welfare gain are the combined

Policy	$\Delta\left(\frac{N_A}{N}\right)$ in 1945	Contribution
τ_K	-0.027	23 %
τ_C	-0.031	24 %
τ_W	-0.040	31 %
G_M and τ_R	-0.003	3 %
A_M	0.004	-4 %
A_A	-0.002	2 %
ex	-0.026	21 %
Total	-0.126	100 %

Table 2: Contributions of Wedges to the Long-Run Change in Labor Share in Agriculture

effect of the price scissors and the labor wedge (15.5 percent), reduction in manufacturing TFP (-10.2 percent), and the reduction of the capital wedge (9.9 percent). The effect of trade remains about the same (5.3 percent). In short, Stalin's policies of breaking the labor barriers and reducing the intertemporal investment frictions did succeed in the long run. The main negative effect both in the short and in the long run was the fall of TFP.

The total effect of Stalin's policies for the 1928 generation adds up to a 1.0 percent loss of consumption (net of population effects). However, the short run costs (1928-1940) amounted to 24.1 percent of consumption. The generation born in 1940 reaps the benefits of the reduction of frictions and yields a 16.5 percent lifetime gain.

Table 2 provides a similar decomposition of the role of the wedges on the difference between the share of agricultural labor force under Stalin and under the Tsarist policies for 1945.[31] The share of the labor force in agriculture is 12.6 percentage points lower under Soviet wedges than under the Tsars. This table shows that about 7.1 percentage points are explained by the reduction in the normalized labor wedge $(1+\tau_{W,t})/(1+\tau_{C,t})$, which is represented as the sum of $\tau_{C,t}$ and $\tau_{W,t}$. The difference in this wedge explains more than half (55 percent) of the difference. The reduction in the capital wedge contributes 2.7 percentage points of the change. These two results are consistent with the view (e.g., Acemoglu and Robinson 2012) that Stalin's policies broke barriers on labor mobility between villages and cities and resulted in reduction of investment friction.

Table 6 in the Appendix provides a further decomposition of the effects of wedges on the labor share, capital, and output for 1928-36, 1937-40, and for 1945.

[31] These are the same scenarios for which the welfare decomposition was computed. We chose 1945 for this comparison to capture the long-run change in the labor share in agriculture.

7 Alternative counterfactuals

In this section, we consider two alternative counterfactuals. First, we compare Stalin's policies with those in Japan, excluding the effects of trade and population. We find this comparison to be informative for several reasons. Both countries undertook major economic reforms in the 19th century around the same time (abolishment of serfdom, reforms of Witte and Stolypin in Russia and Meiji restoration in Japan) and had similar levels and growth rates of per capita GDP before WWI. We also show that many distortions and TFP growth rates were similar in Tsarist Russia and in Japan. The economic transformation of Japan provides an alternative to both our assumption that all Tsarist distortions remain unchanged and to the radical economic reforms of the U.S.S.R.

Second, we consider an alternative scenario where the New Economic Policy (NEP) would have continued after 1928. Third, we consider two alternative scenarios for the growth rates of Stalin's economy if the WWII did not happen.

7.1 Stalin's policies versus Japanese policies

For the data on Japan we mainly rely on Hayashi and Prescott (2008) and their original data sources from the *Long Term Economic Statistics (LTES)* publications edited by Ohkawa and Rosovsky (1973). We re-construct all series so that they are all measured in the same way as the corresponding series for Russia. Hayashi and Prescott cover the same 1885-1940 period for Japan as we do for Russia.

Figure 7 shows that while both the growth rate and the level of real GDP per capita is roughly the same in Russia and in Japan in 1885-1913, the structural composition of the two economies is quite different. The fraction of the labor force employed in non-agricultural sector in Japan is significantly smaller than in Russia and declines steadily throughout the sample period. The role of agriculture in the economy is also much less important than in Russia, with only about 25 percent of value added being produced in agriculture. A part of this difference can be explained by the international specialization; Japan imports agricultural goods. After WWI, Japan mostly follows its pre-war pattern of development, with some acceleration in the GDP per capita growth rate after 1933. Finally, our analysis shows a large intrasectoral capital wedge τ_R in Japan that falls over time. It is mainly driven by the value of residential

Figure 7: Comparison of Economic Indicators for Russia and Japan

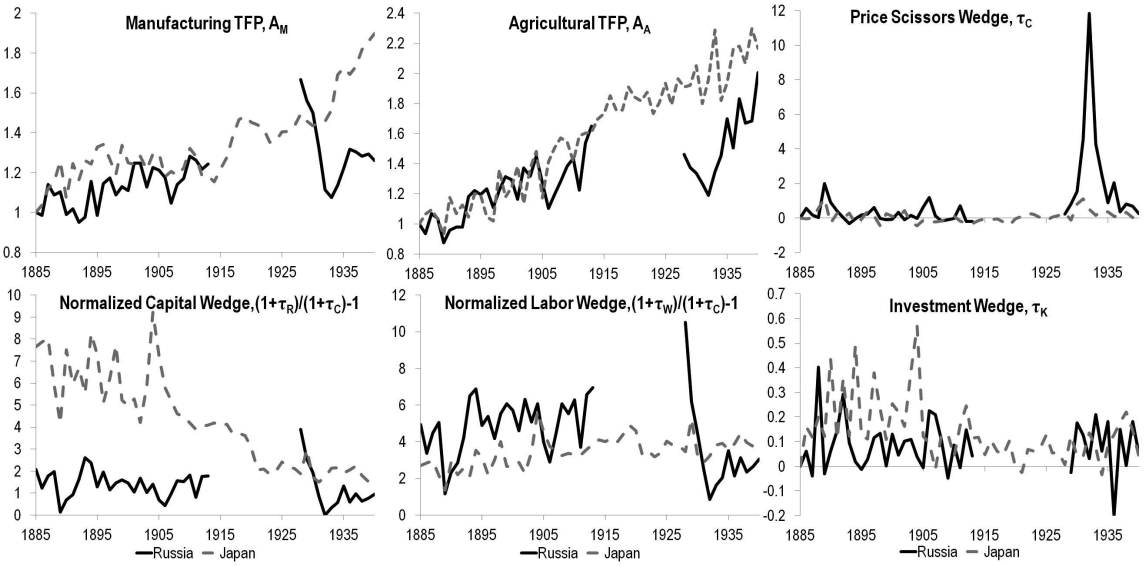

Figure 8: Wedges and sectoral TFPs in Russia and Japan.

farm structures. According to the LTES, the value of those structures to agricultural output is greater than the value of all (residential and non-residential) agricultural capital stock to agricultural output in Russia in 1885. Ideally, we would like to exclude residential structures from our measures of capital, but we do not have the necessary data for Tsarist Russia.

We start by comparing the wedges for Russia, both under the Tsars and under Stalin, with those in Japan. This comparison is presented in Figure 8. The Tsarist economy and the economy of Japan were quite similar before 1913. Russia lagged Japan in terms of manufacturing TFP in the 1890s but then caught up in the first decade of 1900s. The average manufacturing TFP growth for the pre-1913 period was 0.66 percent for Russia and 0.86 percent for Japan. Russia and Japan had essentially equal agricultural TFP. The intersectoral capital distortion was

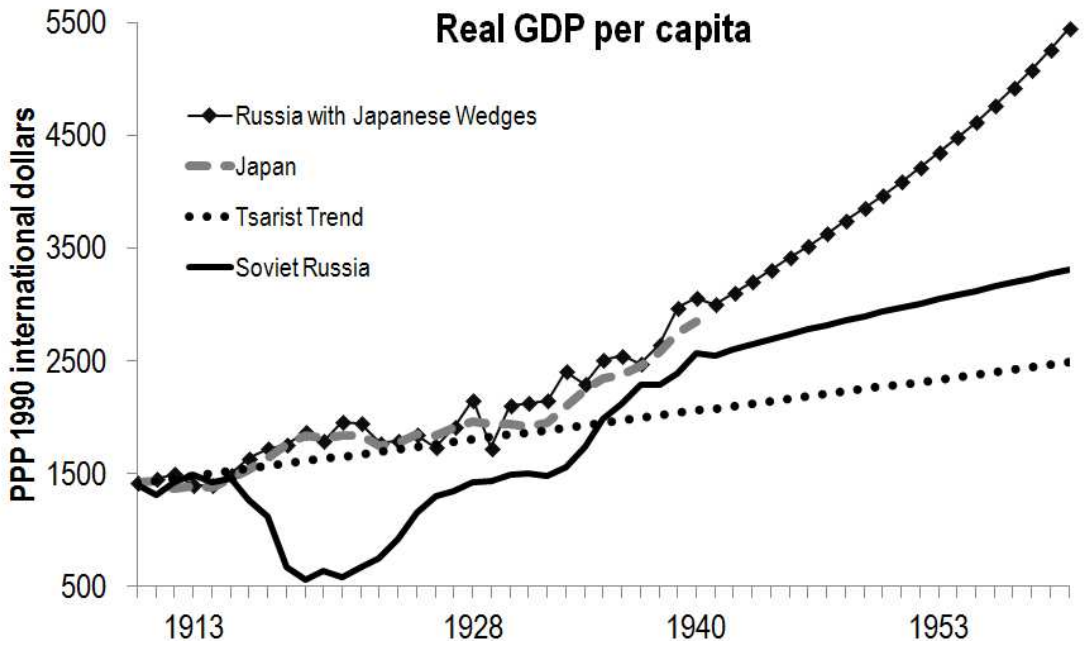

Figure 9: Real GDP per capita in Soviet Russia, Japan and Russia with Japanese wedges

significantly higher in Japan before 1913 but declined significantly throughout the period. The intersectoral labor distortion was lower in Japan – this likely reflects the fact that the institution of *obschina* in Russia was much more distortionary than the barriers for labor mobility in Japan that Hayashi and Prescott (2008) focused on. There is no significant difference in the pattern of the intertemporal wedge.

After WWI, the path of Japanese wedges and TFP growth rates changes albeit less significantly than it did in Soviet Russia. Most notably the TFP growth rate in non-agriculture, and to a lesser extent agriculture, accelerates.

Our counterfactual exercise envisions the path of the Russian economy under the assumption that after 1913 the changes in the Tsarist economy would be similar to those in Japan. In particular, for all wedges and TFPs we construct new series for Russia using the law of motion $\tau_t^{Russia} = \tau_{1913}^{Russia} \frac{\tau_t^{Japan}}{\tau_{1913}^{Japan}}$ for $t = 1914, ..., 1940$ where $\tau_t \in \{\tau_{C,t}, \tau_{K,t}, \tau_{W,t}, \tau_{R,t}, A_{M,t}, A_{A,t}, G_{M,t}\}$. To control for Russia's population and comparative advantage we keep the actual realizations of population growth and trade as occurred in the data. After 1940, we extrapolated the average growth rates of all wedges between 1928 and 1940.[32]

[32]Since $G_{M,t}$ significantly increased in Japan before WWII, we set $G_{M,t} = \Sigma G_{M,1928-40}/13$ for $t > 1940$.

	Gain from policy for			
Policy	[28-40]	[28-∞]	[40-∞]	[40-∞], K_{1940}
τ_K	-4.5%	1.6%	6.4%	4.3%
τ_C	3.2%	9.7%	9.4%	7.4%
τ_W	3.5%	4.5%	12.4%	13.7%
G_M and τ_R	4.6%	3.6%	2.9%	2.4%
A_M	-17.4%	-36.6%	-53.1%	-52.6%
A_A	-12.9%	-5.7%	-0.1%	1.1%
ex and q	-	-	-	-
Total	-41.3%	-31.0%	-22.7%	-24.2%
Total net of K_{1928}	-23.4%	-22.7%	-22.2%	-24.0%

Table 3: Welfare Decomposition: Stalin vs. Japan

Figure 9 compares implied real GDP per capita with actual real GDP per capita in Japan and in the USSR, as well as with our projection of real GDP in the Soviet Union and in Tsarist Russia under the assumption of no changes in wedges. Before 1940, the constructed path of Russia's GDP per capita is very similar to that of Japan. The gap between projected GDP per capita in Russia and the USSR increases after 1940, mainly due to higher productivity growth. Even though by construction these series do not take into account the drop in GDP during the WWII, these projections understate the eventual level of GDP achieved by Japan after 1960.

Table 3 shows welfare decomposition for this economy. It is evident that imposing the Japanese wedges substantially improves the Tsarist counterfactual simulation. The large welfare gain comes from the improvements in productivity. While distortions in Stalin's policies decrease and are generally lower than those in Japan, lower productivity wipes out those gains and leads to significant welfare losses.

7.2 Stalin's policies versus NEP

In this section, we compare the outcome of Stalin's policies to an outcome of a counterfactual excercise where the New Economic Policy (NEP), which was in place in the U.S.S.R between 1921 and 1928, remains in place after 1928. The lack of high quality data for 1921-1927 limits what we can say about this period, and our discussion here is more tentative.

As it is evident from Figure 1, the Soviet economy experienced rapid growth in GDP per capita during the NEP years. However, economic growth did not coincide with structural change. A larger fraction of the labor force was employed in agriculture in 1928 compared with

1913, and the share of investment in GDP remained at 12%. This implies that distortions, measured as wedges in our accounting excercise, must have remained large in 1928. Therefore, TFP in both sectors must have been growing fast during 1921-1928 to reconcile high distortions and rapid growth of GDP. If we assume that wedges measured in 1928 remained in place through the whole 1921-1928 period and impute the implied capital stock and TFP, we obtain that manufacturing TFP grew on average 10% annually during this period. Such rapid TFP growth is clearly not sustainable in the long run and would have to slow down.[33]

The lack of available data makes it impossible to determine with certainty how much of that growth would have continued in the medium run in the absence of Stalin's "Great Turn". For this reason, we explore what we view as the lower bound on the potential outcome of the NEP. In our simulations, we assume that the average wedges from 1928-1929 remain in place indefinitely, and that the growth rate of TFP in manufacturing is reduced to the average Tsarist rate of 0.5% after 1928. We view this number as a lower bound since the actual reduction in the growth rate of TFP is unlikely to be as sharp, and the level of distortions is likely to reduce over time.

Figures 10 and 11 and Table 4 present our findings. The key observation is that the welfare outcome of this counterfactual is almost the same as the one achieved under Stalin's policies. The big welfare gains from Stalin's reduction in wedges after 1928 are nearly fully offset by productivity losses during that period, so that the net welfare gain for an infinitely lived representative consumer from industrialization and collectivization is just 0.2 percent.

Even small departures from our baseline assumptions for this counterfactual produce net welfare gains for NEP, very substaintial in some cases. For example, if we assume that some of the high growth rate of TFP could be maintained after 1928, and assume that it reduces to 2% (the average TFP growth in Japan in the interwar period) rather than 0.5%, the welfare gains of the representative consumer exceed 20 percent, as shown in the last line of Table 4 (see the online appendix for more details). Similarly, following Allen (1993), if we assume that some industrialization would take place after 1928, which we interpret as a reduction of τ^K to the levels achieved under Stalin, additional welfare gains of more than 4 percent are realized.

[33]Rapid TFP growth during NEP is consistent with the view of Davies in Davies et. al. (1994) that rapid growth was caused by the exploitation of spare capacity unused during the Civil War.

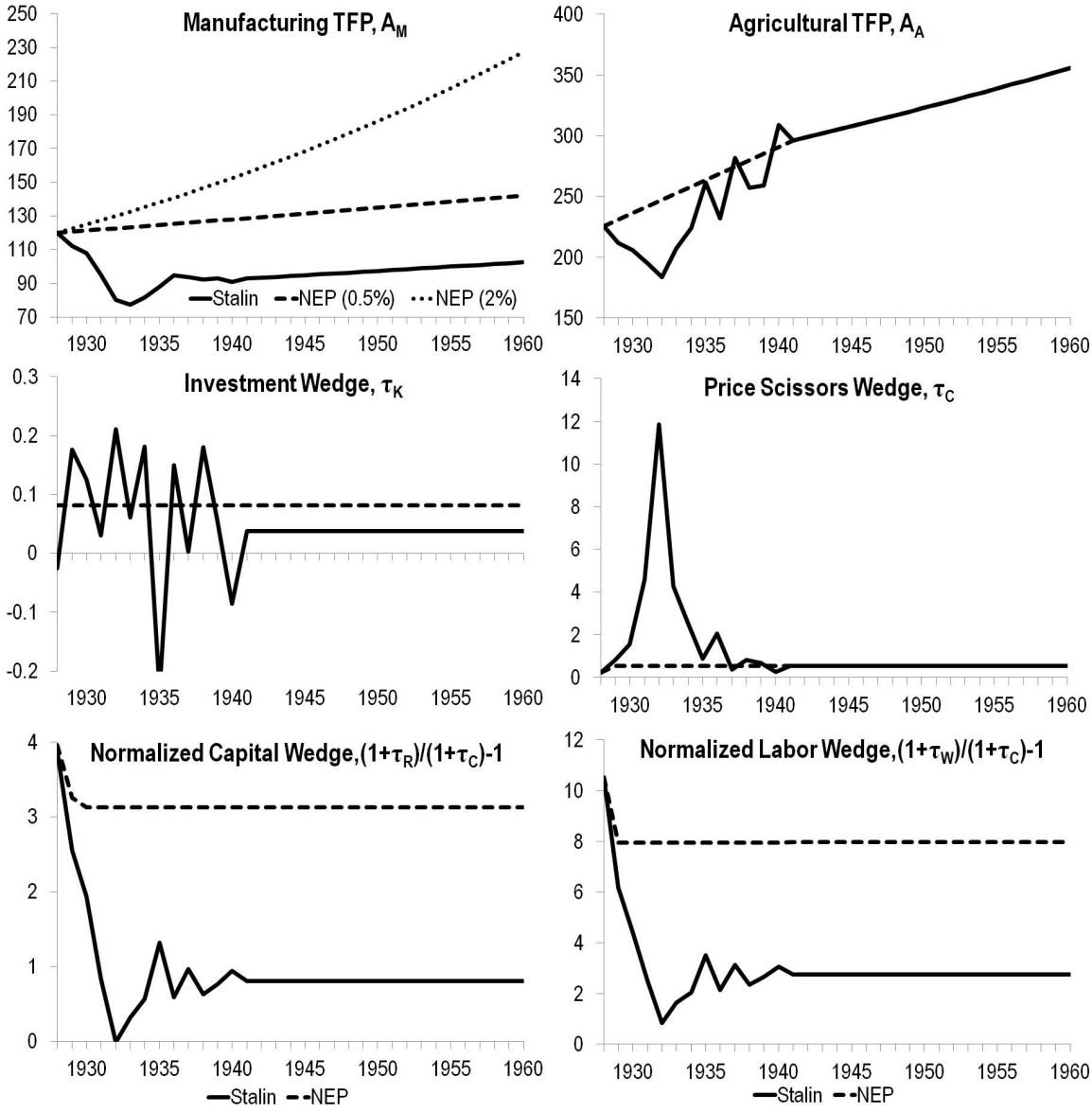

Figure 10: Wedges: NEP vs Stalin

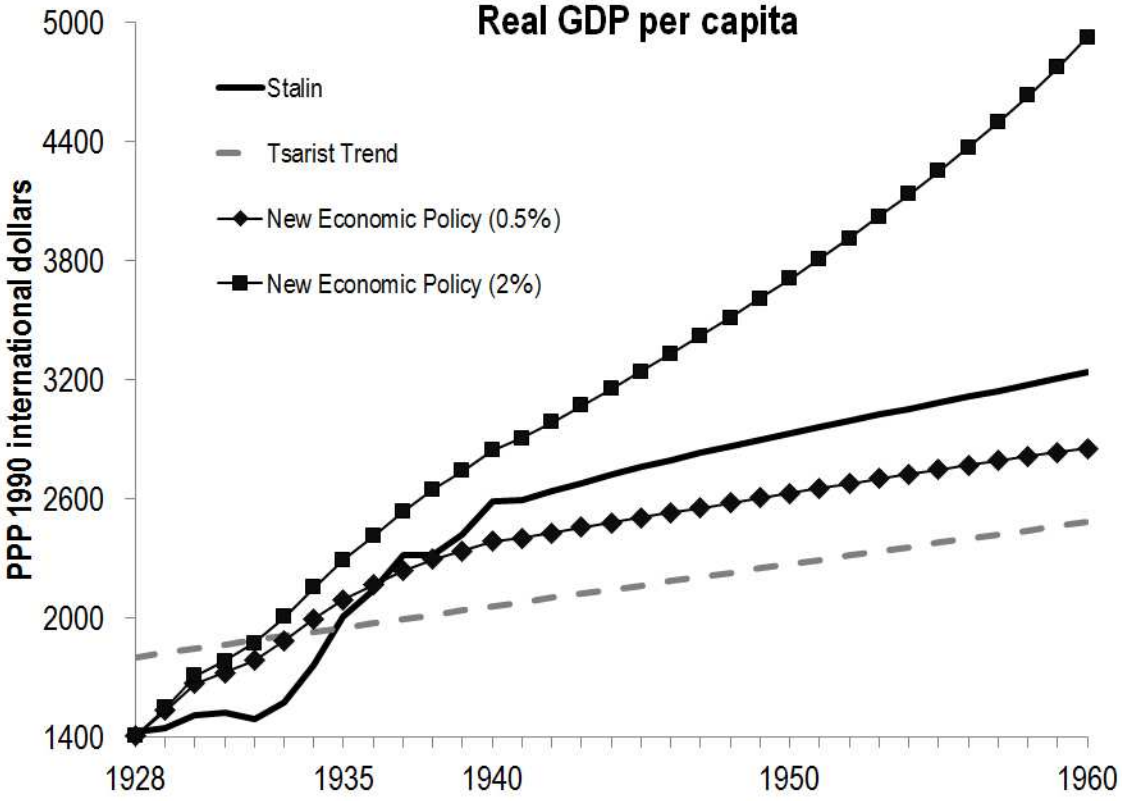

Figure 11: Real GDP per capita: Tsar vs NEP vs Stalin

	Gain from policy for		
Policy	[28-40]	[28-∞]	[40-∞]
τ_K	-2.6%	3.0%	7.3%
τ_C	6.5%	6.0%	1.6%
τ_W	20.7%	26.5%	34.8%
G_M and τ_R	4.0%	-0.5%	-3.9%
A_M (0.5%)	-23.6%	-29.9%	-34.6%
A_M (2%)	-30.1%	-50.8%	-66.0%
A_A	-8.4%	-4.1%	-0.8%
ex and q	-0.3%	-0.8%	-1.2%
Total (0.5%)	-3.7%	0.2%	3.2%
Total (2%)	-9.8%	-20.1%	-27.7%

Table 4: Welfare Decomposition: Stalin vs. NEP

7.3 Alternative post-1940 growth scenarios

One set of projections for which long-term values are of particular interest are the growth rates of TFP in the two sectors. Recall that the benchmark counterfactual assumed that the sectoral TFP growth rates post-1940 for the Stalin's economy are equal to those for the Tsarist economy. We now provide a calculation for two additional alternative scenarios.

For our benchmark simulations for Table 1 we assumed that the TFP in agriculture and non-agriculture in the Soviet economy continues to grow with Tsarist trends after 1940. It is possible to make plausible claims that this assumption either understates or overstates the productivity growth in Soviet Russia had it not joined WWII. On the one hand, actual productivity growth in non-agriculture is significantly lower in 1935-1940 than Tsarist trend. On the other hand, one could argue that the low productivity is a temporary result of rapid reallocation and adjustment costs and would have increased in the medium term. To address these concerns we consider two scenarios.

The first scenario uses the trend of sectoral TFP growth in 1937-40 (that is, the regression line drawn through these values) to project sectoral TFP growth under Stalin for the post-1940 period. This approach implies a continued decline in manufacturing TFP but a speed-up in agricultural TFP growth. Table 29 in the online appendix shows that the adverse effect on manufacturing TFP far outweighs the favorable effect on agricultural TFP. The net effect of this alternative path comes at an additional welfare cost of around -4.5 percent of consumption for the generation born in 1928, and an additional cost of -7.8 percent for the generation born in 1940.[34]

The second scenario uses the realized levels of TFP and wedges under Stalin post WWII. We use data produced by Moorsteen and Powell (1966) to compute estimates of all the wedges for Stalin's economy for the period 1945-1953[35] and compare it to our simulations. Figure 12 compares the actual realization of wedges after WWII to our projections. After a recovery period following WWII, the wedges in the Soviet economy stabilized around their pre-WWII levels by 1950. The exception is TFP in manufacturing, which reaches higher levels than our projections but is still below the Tsarist trend.

[34]Generation 1928 discounts the effects of changes to sectoral TFP growth after 1940 more than generation 1940, as they are in the more distant future.

[35]Stalin died in 1953 and significant changes took place in the aftermath of his death. The study of those reforms is outside of the scope of this paper.

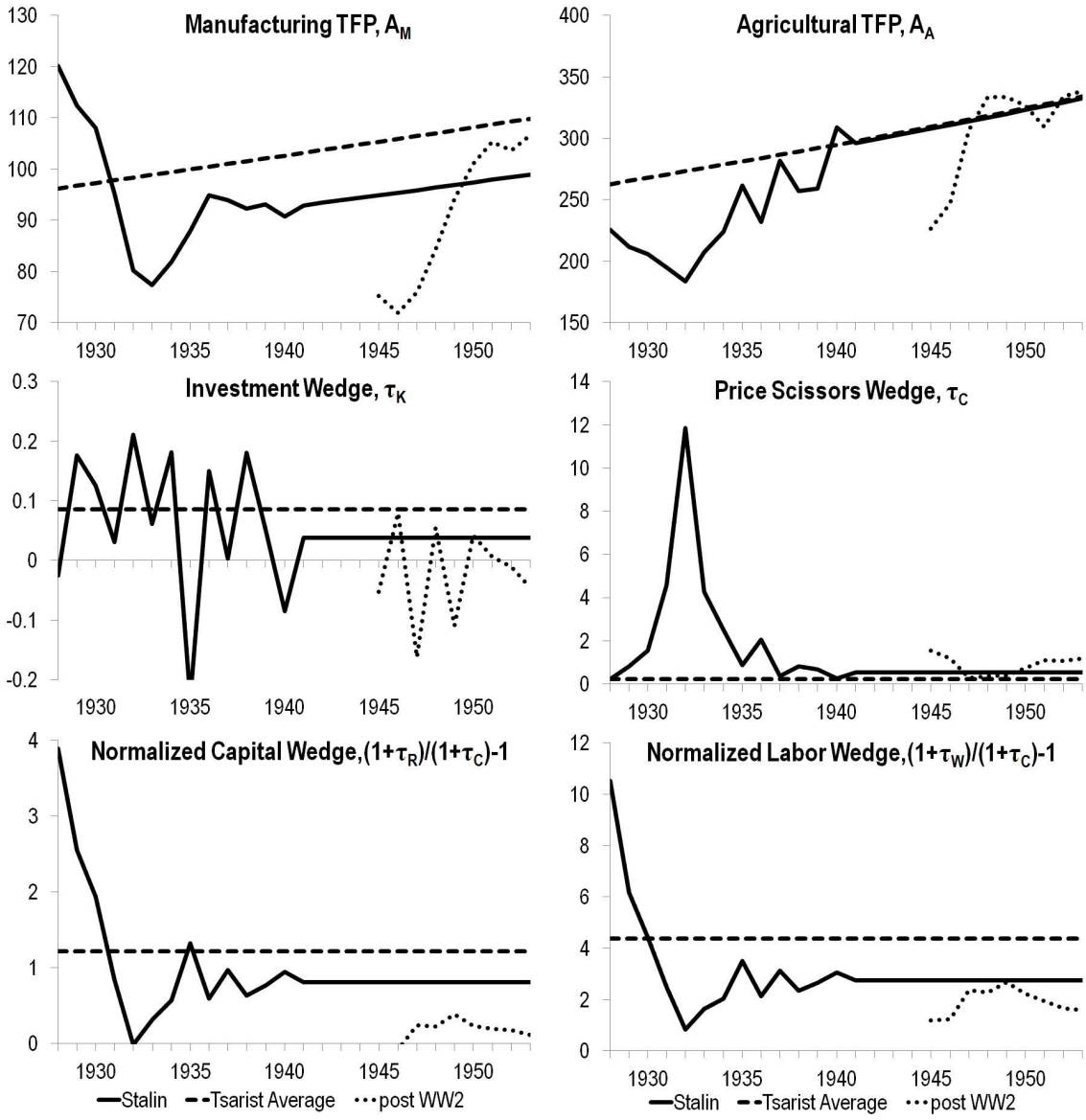

Figure 12: Wedges and sectoral TFPs under Tsar and Stalin.

In the second scenario, we use average values of the wedges for the period 1950-1953 reported in Table 5 instead of the projected wedges for Stalin's economy. We use levels of sectoral TFP for 1953 to compute growth rates of TFP for the post-1940 period and use these growth rates in the second alternative scenario.

Table 31 in the online appendix reports the impacts of this alternative scenario on the baseline welfare decomposition. We find that most of the wedges take values close enough to our baseline simulation. As a result, their impact is minimal. The largest changes come from faster TFP growth in the manufacturing sector and higher price scissors, which each produce under 3 percent in extra welfare gains over the long run.

8 Robustness

We prepared an extensive online appendix that provides a comprehensive set of robustness exercises. This Appendix also contains the details of a variety of alternative assumptions already mentioned in the paper. We now briefly summarize the main implications of robustness checks.

First, we assess the sensitivity of our estimates of the wedges to measurement error in the data by conducting a Monte-Carlo exercise as follows. We create artificial data series by adding 1 percent log-normal random disturbances to the original data series. We use this artificial data to compute pseudo-series for the wedges. Using 1,000 such pseudo-series for the wedges we compute percentage standard deviations of the pseudo-wedges for the whole period and for its sub-periods. The elasticities of the wedges with respect to the measurement error are computed as the ratios of the percentage standard deviations of the pseudo-wedges to the percentage measurement errors. We find that 1 percent measurement error artificially introduced into the data leads, on average, to 1-5 percent changes in the values of the wedges. We then proceed with finding the standard errors for the decomposition of the welfare (Table 1).

We find that the standard errors are relatively low, as even two standard deviations, in most cases, do not significantly alter our main conclusions. The same is true for the standard errors in the paths of the manufacturing labor share, total capital and total GDP in 1913 prices achieved by Stalin's policies compared with the potential path coming from a continuation of

Tsarist policies.

Second, we provide a sensitivity analysis with respect to calibrated parameters. In each exercise one of the parameters $\{\alpha_{A,K}, \alpha_{A,N}, \alpha_{M,K}, \alpha_{M,N}, \gamma, \eta, \beta,\}$ is changed. For each alternative calibration, new time series for wedges are recovered from the data. These new wedges are used to evaluate the welfare gains of policies and the effects on key variables. Most of these effects are small. Here we discuss the effects of changes in three parameters. First, a 10 percent decrease in the subsistence level γ^A leads to a reduction in welfare losses from Stalin's policies compared with Tsarist (Table 1), in both the short run and the long run by about 2 percent of consumption. Overall, while a 10 percent decrease in the subsistence level leaves the signs and the magnitudes of most of our results intact, a 10 percent increase only reinforces our conclusions. Second, an increase in the discount factor β (from 0.96 to 0.93) puts a greater weight on short-term losses coming from Stalin's policies and discounts more the long-term gains. Third, assuming capital and labor to be complements (replacing the unit elasticity of substitution by an elasticity of 0.8) makes capital accumulation more important for long-run development. As capital is less substitutable by labor, the same set of distortions leads to a lower path of development both for Stalin's economy post-1940 and for the Tsarist economy post-1913. Since the path of Stalin's economy relies more strongly on fast capital accumulation than does the development of the Tsarist economy, the long-run gains from Stalin's policies are reduced in this counter-factual exercise. Although the short-run losses from Stalin's policies are somewhat lower as well, the overall welfare comparison shifts against Stalin's policies. The overall long-run gains from Stalin's policies fall from 16.1% to 5.9% and the welfare loss of generation 1928 increases from 1% to 4.8%. Thus, the adoption of the assumption that capital and labor are complements also reinforces our main results.

Third, we provide a sensitivity analysis with respect to projections of the wedges into the future. In each exercise, one of the projected long-term values for the wedges is changed to its alternative reported value. Each alternative wedge value is used to evaluate welfare gains of policies and the effects on key variables coming from alternative assumptions about future fundamentals. Specifically, we proceed as follows: We first report the effect of a 1 percent change in a fundamental. If we believe that the data has a 2 percent measurement error, and that each 1 percent change in a wedge translated into 2-3 percent standard deviation of the wedge, then we multiply all numbers in the 1 percent change calculation by a factor coming from

the impact of this 2-3 percent standard change. This would give us an approximate standard deviation of the confidence bounds on our main estimates due to potential measurement errors in the data. We find that these confidence bounds are quite narrow.

9 Conclusion

We started this paper with a question: "Was Stalin necessary for Russia's economic development?" In short, our answer is a definitive "no." A Tsarist economy, even in our conservative version assuming that it would not experience any decline in frictions, would have achieved a rather similar structure of the economy and levels of production as Stalin's economy by 1940. The short-run (1928-1940) costs of Stalin's policies are very significant for an economy in a peaceful period. Our comparison with Japan leads to astonishingly larger welfare costs of Stalin's policies.

Our projections post 1940 are more speculative. Our conservative benchmark estimates (giving perhaps undue credit to Stalin's TFP projections) point to a long-term welfare gain coming from the reduction of the frictions that outweigh the lackluster performance of TFP.

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11 Appendix A: Construction of data

11.1 Capital stock

11.1.1 Russia 1885-1913

For Russia in 1885-1913 all data is from Gregory (1982) and is computed in 1913 prices. Capital in agriculture is a sum of value of livestock (table H.1), accumulated agricultural equipment (table I.1) and net capital fixed capital stock in agriculture (table J.1). Agricultural structures include rural residential structures and Gregory does not provide a separate estimate of those. Gregory provides estimates of livestock and net capital stock, but gives investment in agricultural equipment. We derive the stock of agricultural equipment with perpetual inventory method by assuming a 5 percent depreciation.

Capital stock in non-agriculture is defined as the value of accumulated industrial equipment (table I.1), net stock of industrial structures (table J.1), industry inventories (table K.1), railroads (table L.1). The values for the stock of structures, inventory, railroads and urban housing are taken directly from Gregory, while the stock of accumulated industrial equipment is obtained by perpetual inventory method assuming a 5 percent depreciation.

This definition of capital stock includes rural residential housing into agricultural capital stock but does not include urban residential housing in any measure of capital stock. The reason for this is as follows. Ideally, following Hayashi and Prescott (2008) we would like to exclude housing stock from all measures of capital. Gregory does not provide a breakdown of rural capital between residential and nonresidential. We do not include urban residential housing into non-agricultural capital stock since the estimates of urban capital stock differ dramatically for pre 1913 and post 1928 Russia, which we view as unrealistic.

Total capital stock is defined as a sum of capital stock in agriculture and non-agriculture.

We computed investments in each sector from the series of capital stocks assuming a 5 percent depreciation.

11.1.2 Russia 1928-1940

For Russia in 1928-1940 we use data from Moorsteen and Powell (1966). All data is in 1937 prices.

We use the data on the composition of gross residential fixed capital stock (table 3-3) to

find the fraction of urban residential capital stock in gross residential fixed capital stock. We assumed that the same ratio holds for net residential capital stock (table T-15) to find the value of net urban residential capital stock.

We define non-agricultural capital stock as net nonresidential, nonagricultural capital stock (table T-25). This definition includes industrial fixed structures, equipment and inventories.

We define agricultural capital stock as net fixed capital stock minus net nonresidential nonagricultural capital stock and minus the value of urban residential housing.

Total capital stock is defined as a sum of capital stock in agriculture and non-agriculture.

11.2 Exports and international prices

The data for total volume of exports and imports for tsarist Russia is from Gregory (1982), Table M-1. We use the data from Davies (1990), Table 56, to find composition of exports and imports for 1913. We assume that the same composition holds for 1885-1913 and compute net exports of agricultural goods and net imports of non-agriculture goods.

The data for volume of exports and imports for the USSR from 1928 to 1938 is from Davies et al (1993). The provide index of exports and imports relative to 1913 and we use the numbers for 1913 trade from Gregory (1982) to obtain volume of trade in 1913 prices. We impute the values for 1939 and 1940 by assuming that the remain at the 1938 level. We use the data from Davies (1990), Table 58, to find composition of exports and imports for 1927/1928. We assume that the same composition holds for 1928-1940 and compute net exports of agricultural goods and net imports of non-agricultural goods.

We use data on Soviet terms of trade from Davies et al (1993), table 50. Unfortunately we found no comparable numbers for tsarist period.

As a proxy for the international prices of Russian exports we take New York state price of wheat. The dollar prices for wheat are from Jacks (2005). The nominal prices deflated by the US CPI are from the NBER Macrohistory Database.

11.3 Output, consumption and investment by sector

11.3.1 Russia 1885-1913

We computed investments in each sector from the series of capital stocks assuming a 5 percent depreciation. We computed GNP from NNP series in Gregory (1982), Table 3.1 by adding a 5

percent depreciation to the total capital stock.

We did not find reliable data for value added in manufacturing and agriculture for all years. Gregory (1982) in Table 3.6 reports that in 1913 50.7 percent of value added is produced in agriculture. He also provides numbers for retained consumption of agricultural goods which were not marketed by the peasants (Table M.1) for all time period. We assume that fraction of value added of agricultural production to the retained consumption is at the same level as in 1913 to obtain the estimate of the value added in agriculture during 1885-1913. The value added in manufacturing is obtained by subtracting the value added in agriculture from GNP.

Gregory reports breakdown of imperial and local government expenditures for selected years (Tables F.4 and G.4). For the benchmark analysis we took defence expenditures as our measure of government sector and we checked the robustness of our conclusion by added administrative expenditures. The data for the missing years was obtained by linear interpolation.

To obtain relative prices, we computed nominal value added of agriculture following the same steps as we did for the value added in agriculture in 1913 prices. The ratio of the two gives us a price deflator for agriculture. Gregory in Tables 3.1 and 3.2 reports net investments in current prices and 1913 prices, which allow us to compute investment price deflator and depreciation in current prices. Using Gregory's estimates of National income in current prices and our estimates of depreciation in current prices we obtain GNP in current prices. By subtract value of agriculture in current prices we obtain the value of manufacturing in current prices and price deflator for manufacturing goods. The ratio of the price deflator for agricultural goods to the price deflator of manufacturing goods yields relative price of agricultural goods.

11.3.2 Russia 1928-1940

Moorsteen and Powell (1966), Table P.1 provide estimates of GNP and production by sector in 1937 prices. We measure agricultural sector as total output in agriculture, and manufacturing as GNP minus agricultural sector.

Moorsteen and Powell also provide a breakdown of government expenditures in the same table. For the benchmark analysis we took defence expenditures as our measure of government sector and we checked the robustness of our conclusion by added administrative expenditures.

Finding appropriate series for relative prices is particularly challenging. Many official prices are not allocative and they do not necessarily reflect the shadow prices and costs that economic

agents face. We rely on the work of Allen (1997) who constructs transaction prices (Table A2) which he argues are the best measure of the prices that peasant faced. These prices are constructed as a ratio of free retail non-food prices to wholesale agricultural prices.

11.4 Population and labor force

11.4.1 Russia 1885-1913

The data for population is from Gregory (1982), Table 3.1. He reports of the data for the territory of Russian empire excluding Finland and we follow his convention.

We obtain composition of labor force from Davies (1990) and Gregory's estimates. Davies (1990), Table 3 provides estimate of the composition of labor force by sector in 1913. Gregory (1982), Table 6.3 reports growth rates for labor force by sector in for different time periods during 1885-1913. We use these growth rates to backtrack labor force for years before 1913.

11.4.2 Russia 1928-1940

It is difficult to obtain reliable data for the composition of labor force. There have been three censuses in Russia, in 1926, 1937 and 1939, but the results of the 1937 are mostly unpublished and many historians question reliability of 1939 census. There are official numbers for employment in various non-agricultural sectors of the economy for select years (Davies et al (1994), table 12). Comparing to the Census data, they do not cover all of the non-agricultural labor force, but give reasonably good approximation of the growth rate of the non-agricultural labor force over the entire time period. According to the census data, non-agricultural labor force increased by a factor 3.37 between 1926 and 1939, while official survey numbers show an increase of 3.19 between 1928 and 1940. We try to use a procedure that follows our estimate of tsarist labor force as closely as possible.

We use population numbers from Davies et al (1994), Table 1. From 1926 census (Davies et al (1994), Table 11) we obtain composition of labor force by sector. We assume that each sector covered by the survey data growths at the same rate as implied by the surveys. This gives us an estimate of non-agricultural labor force for each year. The implied increase in the labor force is 3.36, which closely matches the implied growth of non-agricultural labor force from 1939 census. To find agricultural labor force we assume that labor force participation in all years is the same as in 1926, and find agricultural labor force as a residual.

This procedure implicitly assumes that fraction of labor force to population did not change between 1926 and 1939. This assumption approximately holds in the data. Ratio of labor force to population is 49 percent in 1926 and 50 percent in 1939.

11.5 Adjustment for border changes, conversion prices

Using procedure above we obtained two data sets, one for Russia in 1885-1913 in 1913 borders (excluding Finland) and 1913 prices and the other on for the USSR in 1928-1940 in pre-1940 borders and 1937 prices. In this section we discuss conversion of all prices and quantities to have comparable units.

The territory of Russian empire excluding Finland is 21,474 sq km, while the territory of the USSR in pre-1940 borders is 21,242 sq km (Harrison and Markevich (2011), Table 2). Thus the areas of the two territories are quite similar and therefore we assume that land endowments are the same in the two periods and do not make any border adjustments.[36]

Harrison and Markevich (2011) also report that NNP in 1913 prices in Russia decreased from 20,266 mln rubles to somewhere between 15,600 and 17,600 mln rubles in 1928. We take the average of the two numbers and assume that NNP in Russia in 1928 is 16,600 mln rubles in 1913 prices. Harrison and Markevich (2011b) report (Table A10) that fraction of agriculture in NNP in Russian Empire excluding Finland was 44.3 percent in 1913 (50.9 percent if forestry, fishing and hunting is included in definition of agriculture) and in USSR interwar borders was 44.4 percent (50.8 percent with forestry, fishing and hunting). Therefore we assume that fraction of agriculture in GDP is the same in 1913 and 1928. Since all these numbers are given in 1913 prices, they imply that quantities of agricultural and nonagricultural goods decreased proportional to the decrease in the NNP. This gives us a relationship

$$p^A_{1913}Y^A_{1913}\frac{Y^A_{1928}}{Y^A_{1913}} = p^A_{1913}Y^A_{1928} = \frac{p^A_{1913}}{p^A_{1937}}p^A_{1937}Y^A_{1928},$$

which implies that

$$\frac{p^A_{1937}}{p^A_{1913}} = \frac{p^A_{1937}Y^A_{1928}}{p^A_{1913}Y^A_{1913}}\frac{20,266}{16,600}.$$

We find p^M_{1937}/p^A_{1913} analogously.

[36] While land endowment remained the same, Russian empire lost richer territories (Finland, Poland, Western Belarus and Ukraine, Causasus) and gained poorer territories in Central Asia. Tsarist NNP in 1913 measured in USSR interwar boarders would decrease from 22 mln rbl to 16.5 mln rbl (Harrison and Markevich (2011), Table 1). In the context of our model this differences will be reflected in TFPs and therefore we do not recompute tsarist output in Soviet borders.

12 Appendix B:Tables

Table 5 shows a variety of values which the wedges take for different periods and in different scenarios. The first three columns of Table 5 show the average values of the wedges measured for three subperiods: 1885-1913, 1928-1936 and 1937-1940. The next two columns show projected values for the wedges used in the two baseline counterfactual simulations: for Stalin and for Tsar. Columns "Japan" and "50-53" show the average values for the wedges inferred from Japanese data for the period 1914-1940 and for the USSR after World War II for the period 1950-1953.

Table 6 is the analogue of Table 2 in the main body of the paper. We measure the effect of different wedges on the behavior of the variables. The third column of the table is exactly the first column of Table 2.

	Period Average			Projection			
Wedge	[85-13]	[28-36]	[37-40]	Stalin	Tsar	Japan	[50-53]
N_t	1.0	0.78	0.78	0.78	1.0	—	—
τ_K	0.085	0.066	0.038	0.038	0.085	0.070	0.045
τ_C	0.24	3.19	0.52	0.52	0.24	0.13	0.89
τ_W	5.66	13.11	4.71	4.71	5.66	4.35	4.61
τ_R	1.75	6.18	1.76	1.76	1.75	2.75	1.29
$(1+\tau_W)/(1+\tau_C)$	5.89	4.76	3.80	3.80	5.89	4.85	3.02
$(1+\tau_R)/(1+\tau_C)$	2.41	2.34	1.83	1.83	2.41	3.50	1.22
G_M	0.067	0.024	0.085	0.085	0.067	0.08	0.090
A_M	1.0	0.97	0.91	0.90	1.0	1.07	0.94
A_A	1.0	0.79	0.95	0.995	1.0	1.05	1.01
A_M growth	0.66%	-2.95%	-1.12%	0.61%	0.61%	0.70%	1.23%
A_A growth	1.45%	0.35%	3.05%	0.97%	0.97%	1.21%	0.70%
ex	0.096	0.058	0.027	0.027	0.096	—	0.033
q	0.66	1.07	1.58	1.58	0.66	—	1.65

Table 5: Average and Projected Wedges

	Labor Share			Capital			Output		
Policy	28-36	37-40	1945	28-36	37-40	1945	28-36	37-40	1945
τ_K	1.2%	4.2%	2.7%	3.7%	26.6%	37.0%	2.3%	11.6%	13.7%
τ_C %	16.1%	1.7%	3.1%	24.0%	38.8%	14.0%	32.2%	12.3%	8.3%
τ_W	-14.2%	5.1%	4.0%	-46.9%	-29.1%	-0.0%	-36.0%	-0.9%	4.8%
G_M and τ_R	2.2%	0.2%	0.3%	14.5%	10.0%	3.1%	5.2%	3.2%	1.3%
A_M	0.3%	-0.4%	-0.4%	3.0%	-14.2%	-15.8%	-3.3%	-11.2%	-12.2%
A_A	-5.9%	-0.8%	0.2%	-11.4%	-14.1%	-4.6%	-20.7%	-6.4%	-1.2%
ex and q	1.5%	2.8%	2.6%	3.2%	2.6%	3.5%	3.7%	4.1%	4.2%
Total	2.8%	13.2%	12.6%	-49.3%	15.3%	36.2%	-23.9%	11.5%	18.7%

Table 6: Effects on Labor Share, Capital and real GDP