The Industrialization and Economic Development of Russia through the Lens of a Neoclassical Growth Model*

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Abstract

This paper studies the structural transformation of Russia in 1885-1940 from an agrarian to an industrial economy through the lens of a two-sector neoclassical growth model. We construct a dataset that covers Tsarist Russia during 1885-1913 and Soviet Russia during 1928-1940. We use the growth model to develop a procedure that allows us to identify the types of frictions and economic mechanisms that had the largest quantitative impact on Russian economic development, as well as those that are inconsistent with the data. Our methodology identifies frictions that lead to large markups in the non-agricultural sector as the most important reason for Tsarist Russia's failure to industrialize before WWI. Soviet industrial transformation after 1928 was achieved primarily by reducing such frictions, albeit at a significant cost of lower TFP. We find no evidence that Tsarist agricultural institutions were a significant barrier to labor transition to manufacturing, or that "Big Push" mechanisms contributed to Soviet growth.

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1 Introduction

The focus of our paper is on the impediments to and mechanisms of structural transformation from agriculture to industry. Traditionally, the mechanisms of structural transformation are based on non-homothetic preferences and uneven technical progress across sectors.[1] These models, however, have difficulty accounting for both a high fraction of labor force employed in agriculture in many poor countries and for rapid industrialization in a number of countries. One explanation is that there are frictions that prevent reallocation of resources across sectors.[2]

In this paper, we analyze frictions in a model of structural transformation to study the predominance of agriculture in Tsarist Russia and rapid industrialization in Soviet Russia. This experience is important for several reasons. Tsarist Russia remained an agricultural economy during the late 19th and early 20th century. In Soviet Russia during the period of only twelve years (1928-1940), about 30 percent of the labor force moved from agricultural to non-agricultural occupations coinciding with a rapid growth in manufacturing production. This experience was one of the first episodes of rapid structural change and it had a profound impact on economic theory and policy. The Soviet experience influenced development economics thinking many decades later.

We focus on two main questions. First, we aim to understand why Tsarist Russia failed to industrialize. The Tsarist economy was heavily agrarian, with a small modern manufacturing sector and over 80 percent of labor force working in agriculture. The structure of the economy resembled that of many other traditional economies. Identifying frictions to industrialization that existed in Russia is a useful step to understanding barriers in other agrarian economies. Second, we aim to understand which policies and economic mechanisms were the primary drivers of industrialization in the Soviet Union in 1928-40.[3]

We use a standard neoclassical growth model to systematically analyze frictions in the Russian economy both qualitatively and quantitatively. Our first contribution is to develop a methodology that allows to use macroeconomic data and the growth model to identify the likely sources of frictions that exist in an economy. Our approach is related to the general

[1] For example, see reviews by Acemoglu (2008) and Herrendorf, Rogerson and Valentinyi (2013).

[2] See Caselli (2005) and Gollin, Lagakos and Waugh (2014) for a review of the evidence on cross-country income differences and Caselli and Coleman (2001), Restuccia, Yang and Zhu (2008), and Lagakos and Waugh (2013) for models with sector-specific distortions.

[3] Very little data exists for 1914-27, and we omit this period in our analysis. The structure of the Russian economy in 1928 looked very similar to its structure in 1913.

wedge methodology used in the literature,[4] but unlike those authors we measure distortions both in quantities and in prices.

At the heart of our methodology is the following identity

$$\frac{U_M}{U_A}\frac{F_N^M}{F_N^A} = \frac{U_M/p_M}{U_A/p_A} \times \frac{p_M F_N^M/w_M}{p_A F_N^A/w_A} \times \frac{w_M}{w_A},$$

where U_M and U_A are the marginal utilities of consumption of non-agricultural and agricultural goods, F_N^M and F_N^A are the marginal products of labor in the two sectors, p_M/p_A and w_M/w_A are relative prices and wages.[5] In a competitive equilibrium of a frictionless growth model, each of the three components on the right hand side of this decomposition are equal to one. We show that many mechanisms frequently discussed in the context of Russian economic experience represent themselves as deviations of some of these components from the frictionless optimality condition. The models that emphasize frictions in consumer markets (for example, rationing of consumer goods or poor integration of different regional markets) map into a distortion to the first, consumption, term of the decomposition. Frictions in the production process (for example, due to the existence of monopoly power or barriers to entry) appear as a distortion to the second, production, component. Frictions in the labor market (for example, due to costly human capital acquisition or legal barriers to mobility) appear as a distortion to the third component. By using the data to identify which component is quantitatively most important, we can narrow down the set of possible mechanisms that hinder realloation of resources from agriculture to non-agriculture. Although we developed this methodology in the context of policies that existed in the Russian economy, it can be applied to study structural transformation in other historical episodes.

When we use this decomposition for the Russian economy before 1913, we find that the Tsarist economy was severely distorted. A conventional parametrization of the neoclassical growth model implies that the distortions to the inter-sectoral allocation of labor are equivalent to a 1050 percent ad valorem tax. Most importantly, we determine that this distortion is primarily driven by the production component of our decomposition. The marginal product of labor in manufacturing was substantially higher than the wages paid to workers which suggests significant markups in the manufacturing sector. This mechanism is consistent with

[4] See, e.g. Chari, Kehoe, and McGrattan (2007) and Mulligan (2002).

[5] We also analyze an analogous equation for capital.

the prevalence of monopolies in the non-agricultural sector,[6] that restrict output, relative to a competitive environment, to maximize profits.

The labor mobility component, w_M/w_A, plays a relatively small role in the overall labor wedge. While wages in manufacturing are higher than wages in agriculture in the Tsarist economy, the gap is only a small fraction of the overall distortion. This evidence casts doubt on a popular view that the archaic agricultural institutions in Tsarist Russia were an important impediment to structural transformation.[7]

Two main patterns emerge when we study the Soviet experience of 1928-40. First, productivity performs poorly in both sectors. In almost all years the TFP in both agriculture and non-agriculture is significantly below their pre-World War I trends. Second, the inter-sectoral distortion decreases significantly. The overall effect is rapid structural change and GDP growth at the cost of reduced efficiency within each sector. We find that the decrease in the production component plays the most important role in the reduction of distortions. This is consistent with a view that high production targets set by the Soviet government during industrialization helped to reduce frictions caused by monopolies in Tsarist Russia. However, this reduction in the distortion in Soviet Russia coincided with reduced efficiency within each sector.

We further evaluate the significance of the production component by fixing all other distortions at their 1913 levels and reducing the production distortion to zero. Output growth in both sectors significantly outperforms that of Soviet Russia with manufacturing production exceeding Soviet numbers by at least a third and agricultural production outperforming Soviet numbers by a quarter during the famine years, and predicts an even more significant labor transition than the one observed in the Soviet Union in 1928-40. These findings are inconsistent with the mechanisms emphasized in the "Big Push" literature. We show that a well known formalization of the "Big Push" predicts both higher manufacturing TFP and a higher labor distortion. We observe the opposite – lower TFP and a lower labor distortion – in our decomposition. Welfare costs of production distortions are large. Elimination of those distortions in Tsarist Russia keeping all other frictions fixed results in welfare gains equivalent to a 27.4 percent permanent increase in aggregate consumption.

We now discuss in more detail the papers that are most closely related our work. Our wedge

[6] See, for example, Spulber (2003) for historial evidence on the prevalence of monopolies in Tsarist Russia.

[7] See, for example, Gerschenkron (1965).

accounting methodology builds on the work of Chari, Kehoe and McGrattan (2007), but, unlike them, we investigate distortions in both quantities and prices and focus on sectoral reallocation. Our work is also closely related to Caselli and Coleman (2001), who were among the first to argue for the importance of using prices to study frictions in structural transformation; Cole and Ohanian (2002), who used the optimality conditions in the one sector model to discuss slow recoveries of the U.S. and U.K. from Great Depressions; and Restuccia, Yang and Zhu (2008), Buera and Kaboski (2009) and Lagakos and Waugh (2013), who studied frictions in structural transformation in multi-sector growth models. As in Cole and Ohanian (2004), Parente and Prescott (1999), Fernald and Neiman (2011), and Alder, Lagakos and Ohanian (2013) we find that monopoly distortions play a central role. Our work is also broadly related to the recent work on the models of structural transformation such as Stokey (2001), Konsagmut, Rebello and Xie (2001), Gollin, Parente and Rogerson (2002), Ngai and Pissarides (2007), Acemoglu and Guerrieri (2008) and Buera and Kaboski (2012 a,b).

Our analysis of both the Tsarist and Soviet economy is inspired by and builds on the economic history research of Allen (1997, 2003), Gregory (1972, 1982), Harrison (Harrison 1998, Gregory and Harrison, 2005), and Davies (Davies 1990, Davies, Harrison and Wheatcroft, 1994). Among these studies, our work is 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 builds on his historical accounts and data.

2 Historical overview

The purpose of this section is to provide a concise summary of the main features of the Russian economy and the most significant economic polices in Russia from the middle of the 19th century to the beginning of World War II. We also discuss some of the main theories that were proposed to explain the patterns of structural change in Russia during this period.

After the defeat in the Crimean War in 1856, Russia undertook major economic reforms. Their most significant part was the abolition of serfdom in 1861. Russian peasants received freedom and land rights in exchange for redemption payments. The land was given to communal property of villages (*obschina*) rather than transferred to private property of individual households. The rules for exit from communes varied across regions but there were two main types. The hereditary commune allowed for exit – as long as the exiting individual or household could sell land to an individual or household within the commune. In the repartition communes (*peredelnaya obschina*), exit required consent of the commune; there was no right to sell land and receive compensation (see, for example, Chernina, Dower and Markevich, 2014).

A popular view, shared by Tsarist reformers, Bolsheviks and some Western economic historians, is that the institution of obschina was a major impediment to labor mobility and modernization of the Russian economy.[8] Attempts to reform communes were undertaken in the early 20th century by the Imperial government. Russian prime minister Pyotr Stolypin issued a series of decrees in 1906-1910 that allowed individual sales of land and greatly facilitated exit from the repartition communes. Stolypin was assassinated in 1911, and his reforms largely failed to take off. Even by 1914, only 10 percent of households in European Russia lived in farms independent from communes (Davies, Harrison and Wheatcroft, 1994, p. 107). The historical literature often describes peasants as subsistence-oriented, with limited involvement in market activity. While food production significantly increased with the abolition of serfdom, most food was still consumed by the families who produced it or by households within the same village (Davies, Harrison and Wheatcroft, 1994, p. 2).

The size of Russian industry at the end of the 19th century was relatively small with significant barriers to entry and widespread monopolies. Russian tsars traditionally distrusted capitalist institutions seeing them as a threat to their absolute power (Pipes, 1997). Significant barriers remained even after attempts by the Tsarist government to modernize industry in the second half of the 19th century. Under the Russian corporate law, the registration of any joint stock company required a special concession from the tsar. Many Russian industrialists received a significant part of their income through state subsidies, tariffs, and preferential state orders (Gregory and Stuart, 1986, p. 31). Following the economic reforms of the 1890s, the importance of cartels significantly increased, and they started to dominate most capital industries such as iron, steel, oil, coal, and railway engineering. These cartels decided on sales quotas for their members and determined wholesale prices (Davies, Harrison and Wheatcroft, 1994, p. 2). The traditional Soviet historical narrative describes this period as *"monopoly capitalism"*.[9] Many

[8]For example, the leader of the Bolsheviks, Vladimir Lenin, argued that obschina's imposed restrictions on free labor mobility was a serious constraint on the industrial development of Russia (Lenin, 1972, p. 455). A prominent American economic historian Alexander Gerschenkron asserted that "the obschina restrictions on labour ... mobility were an obstacle to industrial progress" (Gerschenkron, 1965, p. 767).

[9]In his authoritative study of Russian corporate law, Owen (1991, p. 19) observes that "Both the concession system and the issuing of special favors [monopoly rights] figured prominently in the policies of the European

historians, both in the West and in Russia, argued that distortions of monopoly capitalism were a serious impediment to Russia's economic development at the turn of the 19th century.[10]

The Tsarist government weakened during World War I, and the Bolsheviks came to power in 1917. They signed a peace treaty with Germany ending Russia's participation in WWI, nationalized banks and large companies, abolished private land property, and restored peasant communes. This led to a brutal civil war with the anti-Bolshevik forces. The conflict was further exacerbated by the decision of the newly formed Soviet government to use the military for requisitioning of food from peasants. The policies of this period, known as the War Communism, led to a virtual collapse of the economy.

Lenin re-introduced significant elements of a market economy by announcing the New Economic Policy (NEP) in 1921. One of the central features of the NEP was the right of peasants to sell their products freely to either private traders or state companies. The state refrained from use of coercion against agricultural producers. Both state and private markets were required to offer prices at which peasants were willing to trade voluntarily. The state maintained control of banking and large-scale industry, while small-scale private industry was allowed to exist freely.

Economic growth was significant during the NEP, with agricultural production rebounding faster than industrial production and leading to a fall in relative prices of agricultural goods. This created the *"price scissors"* crisis that started in 1923. Peasants, facing worse terms of trade during the NEP than in 1913, responded by reducing marketing of foodstuff and retaining a larger portion of output for their own consumption. Initially, the Soviet government responded by attempting to lower the costs of production of manufacturing goods and by decreasing their prices. In 1927, Stalin reversed these policies and resorted to coercion to procure food. Villages received quotas for grain procurement at state-determined prices, with a higher burden falling

states in the 1820s and 1830s, but nowhere did these principles persist with such force into the twentieth century as in the Russian empire".

[10] For example, Russian historians Vladimir Mau and Tatyana Drobyshevskaya in their overview of the Tsarist economy write "The new state economic structures that emerged at the turn of the 19th and 20th centuries assumed a particular form because of certain peculiarities in the development of productive forces in Russia: the rate of concentration of production was very rapid; powerful monopolies were formed and these trends in economic organization in turn had a significant, if not decisive impact upon the direction and tempo of development" (Mau and Drobyshevskaya, 2013). They also provide several illustrations of the prevalence of cartels and monopolies. An alliance of distillery companies was responsible for 80 percent of marketed output, the Society of Cotton Cloth Manufacturers and the Special Office for Allocating Orders in the match industry were responsible for 95 percent of output.

disproportionately on the more prosperous peasants, the *kulaks*. By the early 1930s, the Soviet government had attempted to socialize all agricultural livestock and ban private agricultural markets. Peasants were forced to join newly formed collectives.[11] Peasants responded with widespread slaughtering of livestock; agricultural production plummeted, and the severe famine of 1932-1933 followed.

Simultaneously with the collectivization policies in agriculture, Stalin pursued industrialization policies by greatly expanding manufacturing production. In 1928, a system of economy-wide five year plans was introduced. The plans were ambitious, especially for industrial production. One of the main goals of the economic strategy of the Soviet government was to overtake advanced capitalist economies in industrial output per head as quickly as possible. As a result, large-scale industry expanded rapidly (Davies, Harrison and Wheatcroft, 1994, p. 137-140).[12]

The industrial expansion was financed by printing a large quantity of money leading to inflation. The Soviet government responded by nationalizing trade, by eliminating the remaining private industry,[13] by introducing price controls, and by rationing consumer goods. The multi-tier retail price system emerged in 1929-1934 (Malafeev, 1964, p. 146). The lowest retail prices were available to urban dwellers on rations. The inhabitants of cities used rations to make most of their purchases. The peasants had to purchase manufacturing goods at substantially higher "commercial" prices. Since peasants had to sell their produced foodstuff at the lower wholesale prices, their terms of trade sharply deteriorated (Allen, 1997).

The precipitous drop of agricultural output and widespread famine in 1932-1933 forced Stalin to curb his economic policies.[14] Compulsory delivery quotas in agriculture were reduced, and free peasant markets, on which peasants were allowed to sell their remaining surplus, were legalized. A limited ownership of small plots of land and livestock was allowed. By 1935, all rations had been abolished, and consumers could freely spend their income in state shops or free farm markets. By 1937, there were no apparent shortages of consumption goods, and free

[11]The *dekulakization* campaign of 1929-1931 affected five to six million peasants, one million out of 25 million peasant households (Davies, Harrison and Wheatcroft, 1994, p. 68). These most successful and knowledgeable peasants were in the best case exiled, and in the worst case executed.

[12]To give a few examples of the most visible changes in the industry, the Gorky car plant GAZ, the giant Magnitogorsk iron and steel combine, and the Norilsk mining and metal complex were established during this time.

[13]By 1929 virtually all small scale private industry had been eliminated (Davies, Harrison and Wheatcroft, 1994, p. 137).

[14]The discussion here is closely based on Davies, Harrison and Wheatcroft (1994, pp. 14-20).

market prices equalized with those in state stores (Allen, 1997). Workers could generally freely move across occupations within cities, although a passport system was introduced in 1933 to stem the flow of peasants from villages who were escaping collectivization and famine that ravaged the countryside.[15] Industrial wages were frequently modified in response to supply and demand.

The role of money, prices, and production plans in the Soviet economy became better understood in recent years with the opening of secret Soviet archives to academic research. A popular stereotype that all prices were fixed by the government and producers received specific output figures to be delivered at those prices turned out to be a great oversimplification. The central government set overarching general plans. To implement those plans state Ministries and individual enterprises engaged in a decentralized system of negotiationgs, and final transaction prices and quantities emerged as an outcome of those negotiations.[16]

Just as there is little agreement about the causes of the low level of industrial development in Russia, there is substantial disagreement among economists and historians as to which mechanisms caused rapid industrialization of the Soviet Union in 1928-40. Some view the Tsarist economy as being trapped in a low income equilibrium and the "Big Push" policies of economy-wide investment pursued by the Soviet government as lifting the Russian economy out of that equilibrium.[17] Others emphasized the ambitious production targets that Soviet enterprises were directed to achieve and "soft budget constraints" that incentivized state companies to expand demand for labor and capital, or violent collectivization policies that drove labor away from agriculture. Still others emphasized additional factors, such as a large increase in military expenditures by Stalin or the collapse of Russian agricultural exports due to trade restrictions and low international prices for Russia's main export commodity at the time, wheat.

[15] Davies and Wheatcroft (2004, p. 407) 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”.

[16] According to Gregory and Harrison, who provide an extensive overview of this research, “Most allocation plans were in rubles rather than in physical units... The general quantity goals set by the Politburo, such as steel tonnage targets, were too aggregated to be tied to individual enterprises... Final allocations were achieved through a decentralized system of negotiations and contracting between state ministries responsible for achieving the overall output goals and enterprises... Actual transaction prices were negotiated between buyers and sellers in a process that was only loosely managed from above.... Official prices were supposed to be used in more important transactions but even those were incomplete, lagged behind new products, or were simply ignored.” (Gregory and Harrison, 2005, pp 744-747).

[17] Rosenstein-Rodan (1943) is one of the first expositions of this idea. Murphy, Schleifer and Vishny (1989) is a well known formalization of the "Big Push" policies.

3 Theoretical Framework

We build on the insights of Chari, Kehoe, and McGrattan (2007) and Cole and Ohanian (2004) that many models of economic policies and frictions can be mapped as distortions, or wedges, in a prototype neoclassical growth model. These wedges can then be measured in the data. Policies and frictions that lead to similar economic outcomes often have distinct predictions about wedges that they affect. By studying the measured wedges one can distinguish among the types of policies that may account for the observed behavior in the data and rule out some alternative explanations.

We analyze a two sector growth model that is used extensively in the growth literature to study structural transformations. We develop a novel wedge decomposition in that model. Our key innovation is to measure distortions not only in the observed quantities but also in prices. Introducing prices is important for several reasons. First, different explanations of structural change or the lack thereof have sharply different implications for price behavior.[18] By using prices in our wedge decomposition we identify the most promising explanations. Second, economists have long been skeptical about the ability of central planning authorities to set prices that clear markets. Our decomposition enables the use of observed Soviet inter-sectoral quantities and prices to evaluate how different those prices are from the predictions of the neoclassical growth model.

3.1 A prototype growth model

We build on a version of the Herrendorf, Rogerson, and Valentinyi (2013) neoclassical growth model which nests several specifications frequently used in the literature. There are two sectors in the economy, agricultural (A) and non-agricultural (M).[19]

The economy is populated by a continuum of agents with preferences

$$\sum_{t=0}^{\infty} \beta^t \frac{U\left(C_t^A, C_t^M\right)^{1-\rho} - 1}{1-\rho}, \tag{1}$$

where

$$U\left(c_t^A, c_t^M\right) = \left[\eta^{\frac{1}{\sigma}}\left(C_t^A - \gamma^A\right)^{\frac{\sigma-1}{\sigma}} + (1-\eta)^{\frac{1}{\sigma}}\left(C_t^M\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}},$$

[18] See Caselli and Coleman (2001) who were among the first to stress this point in the context of the U.S. experience in the 19th century.

[19] In the model, we use terms "non-agriculture" and "manufacturing" interchangeably. In the data, sector M corresponds to all sectors in the economy which are not agriculture.

C_t^A is per capita consumption of agricultural goods, and C_t^M is per capita consumption of non-agricultural goods. The subsistence level of consumption of agricultural goods is denoted by $\gamma^A \geq 0$. The discount factor is $\beta \in (0,1)$, and σ is the elasticity of substitution between the two consumption goods. Each agent is endowed with one unit of labor services that he supplies inelastically. We use notation $U_{i,t}$ to denote the marginal utility with respect to consumption of good i in period t. This preference specification nests two traditional mechanisms used to explain structural change (see, e.g. Chapter 20 in Acemoglu, 2008). The demand-side mechanism explains structural change through preference non-homotheticity and relies on the income elasticity of demand for agricultural goods being less than one. This effect is captured by our preferences when $\gamma^A > 0$. The supply-side theories explain structural change through uneven productivity growth in different sectors and low substitutability between goods. Our preferences capture this effect when $\sigma < 1$.

Output in sector $i \in \{A, M\}$ is produced using the Cobb-Douglas technology

$$Y_t^i = F_t^i\left(K_t^i, N_t^i\right) = X_t^i \left(K_t^i\right)^{\alpha_{K,i}} \left(N_t^i\right)^{\alpha_{N,i}}, \tag{2}$$

where X_t^i, K_t^i, and N_t^i are, respectively, total factor productivity, capital stock, and labor in sector i. The capital and labor shares $\alpha_{K,i}$ and $\alpha_{N,i}$ satisfy $\alpha_{K,i} + \alpha_{N,i} \leq 1$. Land is available in fixed supply, and its share in production in sector i is $1 - \alpha_{K,i} - \alpha_{N,i}$. 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.

Population growth is exogenous. The total population in period t is denoted by N_t. The amount of labor allocated to the agricultural and the non-agricultural sector in period t is denoted, respectively, by N_t^A and N_t^M. The feasibility constraint for labor is

$$N_t^A + N_t^M = \chi_t N_t, \tag{3}$$

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

We assume that new capital I_t can be produced only in the non-agricultural sector. The aggregate capital stock satisfies the law of motion

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

where δ is the depreciation rate. Denoting by K_t^A and K_t^M the capital stock in agriculture and manufacturing, the feasibility condition for inter-sectoral capital allocation is

$$K_t^A + K_t^M = K_t. \tag{5}$$

We treat net exports of agricultural and manufacturing goods, E_t^M and E_t^A, and government expenditures on manufacturing goods, G_t^M, as exogenous. The feasibility conditions in the two sectors are

$$N_t C_t^A + E_t^A = Y_t^A, \tag{6}$$

and

$$N_t C_t^M + I_t + G_t^M + E_t^M = Y_t^M. \tag{7}$$

The efficient allocations in this economy satisfy three first order conditions: the intra-temporal labor allocation condition across sectors is given by

$$1 = \frac{U_{M,t}}{U_{A,t}} \frac{F_{N,t}^M}{F_{N,t}^A}, \tag{8}$$

the intra-temporal capital allocation condition across sectors is given by

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

and the inter-temporal condition is given by

$$1 = \left(1 + F_{K,t+1}^M - \delta\right) \beta \frac{U_{M,t+1}}{U_{M,t}}. \tag{10}$$

The efficient allocations can be decentralized as a competitive equilibrium. Let $p_{i,t}$ and $w_{i,t}$ denote the prices of goods and wages in the competitive equilibrium. The right hand side of the intra-temporal optimality condition for labor (8) can be re-written as a product of three terms, to which we refer as *consumption*, *production,* and *labor mobility components*:

$$\frac{U_{M,t}}{U_{A,t}} \frac{F_{N,t}^M}{F_{N,t}^A} = \underbrace{\frac{U_{M,t}/p_{M,t}}{U_{A,t}/p_{A,t}}}_{\text{consumption component}} \times \underbrace{\frac{p_{M,t}F_{N,t}^M/w_{M,t}}{p_{A,t}F_{N,t}^A/w_{A,t}}}_{\text{production component}} \times \underbrace{\frac{w_{M,t}}{w_{A,t}}}_{\text{labor mobility component}}. \tag{11}$$

In the competitive equilibrium, all three components are equal to one. Each of these components is an optimality condition in one of the three markets. The first, consumption, component is the optimality condition of consumers. The second, production, component is the optimality condition of competitive, price-taking firms. The third, mobility, component is equalized to one when workers can freely choose in which sector to work. An analogous decomposition can be done for the inter-sectoral capital wedge (9).

3.2 Mapping of frictions into wedges in the prototype economy

The key insight of Chari, Kehoe and McGrattan (2007) is that many models and policies can be mapped into the prototype growth model with additional "wedge" distortions. In the spirit of their work, we define three wedges $1+\tau_{W,t}$, $1+\tau_{R,t}$, and $1+\tau_{K,t}$ as the right hand sides of expressions (8), (9), and (10). While in the frictionless economy all these wedges are equal to one, richer models of economic policies and institutions usually have specific implications regarding the behavior of these wedges as well as sectoral productivities X_t^A and X_t^M.

We focus on the components of the wedges, because they allow for a finer distinction between different economic mechanisms. For example, as we show shortly, both a policy that makes it costly to move to the city and a policy that encourages monopoly formation in industry appear as a positive labor wedge, τ_W. The two policies, however, have sharply different implications for the components of τ_W – the first policy maps into the distortion in the labor mobility component of the wedge while the second policy maps into the distortion in the production component. More generally, the consumption component typically measures frictions in consumer goods markets, the production component measures frictions in the production process, and the mobility component measures frictions in factor allocation (labor and capital) between sectors. By construction, the product of the three components of any wedge is always equal to that wedge.

We now present several models of economic policies and frictions that are commonly discussed by economic historians in the context of the Russian economic experience of 1885-1940 and show their mapping into wedges and their components. To simplify the exposition, we focus on an economy without capital, with capital shares in both sectors set to zero. This allows us to illustrate most mechanisms in a static model. We further set to zero exports and government expenditures, normalize total population to 1 and assume that all of it is of working age, set $\gamma^A = 0$, $\sigma = \alpha_{N,M} = 1$ and $\alpha_{N,A} \leq 1$. These assumptions simplify notation but are not essential to our arguments.

Baseline frictionless economy. In a baseline frictionless competitive equilibrium, firms and consumers are price takers. If $\alpha_{N,A} < 1$, firms in agriculture earn profits (land rents) which are distributed back to the households. The distribution of property rights over those profits is irrelevant for the wedge decomposition. The optimality condition for consumption of household

j,

$$\frac{1-\eta}{\eta}\frac{1/\left(c^{M}\left(j\right)p_{M}\right)}{1/\left(c^{A}\left(j\right)p_{A}\right)}=1, \tag{12}$$

and the aggregate feasibility constraint, $C^{i}=\int c^{i}\left(j\right)dj$, for $i\in\{A,M\}$, imply that

$$\frac{1-\eta}{\eta}\frac{1/\left(C^{M}p_{M}\right)}{1/\left(C^{A}p_{A}\right)}=1,$$

so that the consumption component of the labor wedge is equal to one independently of the distribution of income. The optimality condition (8) implies that the labor allocation in the competitive equilibrium satisfies

$$\frac{1-\eta}{\eta}\frac{1}{\alpha_{N,A}}\frac{N_{A}}{1-N_{A}}=1.$$

In the rest of this section, we consider models of economic frictions that are discussed in the context of the Russian economy of 1885-1940 and show the implications of those frictions for our wedge decomposition.

Peasant communes. In Section 2, we described the particular land ownership institutions that emerged in Tsarist Russia after the abolishment of serfdom in 1861 and a popular theory that communal land ownership was a major barrier to rural-urban labor migration. We model those arguments formally as follows. Consider a variant of our baseline model in which all workers are initially in agriculture and have equal ownership of land rents. We assume that due to communal land ownership those rents are not transferable. If a peasant decides to work in manufacturing, he loses his rights to land rents, which are then redistributed equally among the remaining agricultural workers. All other assumptions of the baseline model are unchanged.

The land rent per agricultural worker is $p_{A}F^{A}\left(N_{A}\right)/N_{A}$, which is strictly positive if $\alpha_{N,A}<1$. In equilibrium, a peasant must be indifferent between receiving the sum of land rents and the agricultural wage, w_{A}, and foregoing the land rents and earning the manufacturing wage, w_{M}. The labor mobility component of the labor wedge is then

$$\frac{w_{M}}{w_{A}}=1+\frac{p_{A}F^{A}\left(N_{A}\right)}{w_{A}N_{A}}>1,$$

while the other two components are equal to one.

Communes are not the only mechanisms that map into the mobility component being greater than one. Costly accumulation of human capital required by the manufacturing sector, as in

Caselli and Coleman (2001), higher urban living expenses and other costs of being separated from traditional family networks all result in a wage premium in the manufacturing sector.

Limited competition (monopoly capitalism). As we discussed in Section 2, the manufacturing sector in the Russian economy was small, faced severe legal barriers to creation of corporations, and was dominated by cartels and monopolies. The simplest way to illustrate the effect of monopolies on our decomposition is to assume that each manufacturing firm in the baseline economy is a monopsonist in a local labor market, and a price-taker in the goods market.[20] Then the equilibrium labor supply, $N(w)$, that a monopsonist faces when charging wage w, is determined by the free labor mobility condition between manufacturing and agriculture and decreasing returns to scale in agriculture,

$$w = w_A = p_A \alpha_{N,A} (1 - N)^{\alpha_{N,A}-1}.$$

A monopsonist chooses the wage rate w to maximize its profit, $p_M N(w) - wN(w)$, taking the labor supply equation as given. This implies that in equilibrium, the production component of the labor wedge is

$$\frac{p_M F_N^M / w_M}{p_A F_N^A / w_A} = 1 + (1 - \alpha_{N,A}) \frac{N_M}{1 - N_M} > 1,$$

which is a measure of markup over the monopsonist's marginal cost. Therefore, monopoly power maps into the production component of the inter-sectoral labor wedge.

Segmented consumer goods markets, rationing, stock outs. Various frictions in consumer markets map into the consumption component of the labor wedge. Consider, for example, the implications of a high cost of accessing markets for some peasants due to a poor transportation network, as discussed in Section 2. We augment our baseline model by assuming that only a fraction of all households can trade at prices p_A and p_M, while the remaining households are located far from city markets and consume only the agricultural goods produced in their village. Therefore, the optimality condition (12) applies only to the households in the first group. Let x be the fraction of total agricultural consumption, C^A, consumed by the households in the first group. Then (12) implies that

$$\frac{1-\eta}{\eta} \frac{1/\left(C^M p_M\right)}{1/\left(x C^A p_A\right)} = 1,$$

[20] Monopolies in product markets can be modeled along the lines of our analysis of the *"Big Push"* model. As we show in that model, monopoly power in product markets implies distortions in the production component similar to the model of a monopsonist.

and the consumption component of the labor wedge is

$$\frac{U_{M,t}/p_{M,t}}{U_{A,t}/p_{A,t}} = \frac{1-\eta}{\eta} \frac{xC^A p_A + (1-x)\, C^A p_A}{C^M p_M} = 1 + \frac{1-\eta}{\eta} \frac{(1-x)\, C^A p_A}{C^M p_M} > 1.$$

Other frictions in consumer markets have similar effects. For example, if demand for any good, given prices p_A and p_M, exceeds supply, and the goods are rationed (as occurred, for example, in Soviet Russia in 1929-34), the ratio of marginal utilities of the two consumption goods may systematically depart from the ratio of relative prices. The consumption component may be greater or smaller than one depending on the relative prices set by the government.

Industrialization and collectivization. The U.S.S.R. pursued a range of policies in industry and agriculture often referred to as industrialization and collectivization. We briefly comment on the implications of some of those policies for the markup (production) component of the labor wedge. If the Soviet government starts with the Tsarist economy, distorted by monopolies in manufacturing, and channels resources into that sector ignoring a monopolist's optimality condition, the markup in manufacturing, all other things being equal, should decrease. Specific examples of such policies are explicit directions for state enterprises to meet ambitious output targets or the "soft budget constraints" that subsidized state enterprises to expand employment and investments.

The production component is a function of the relative markups in manufacturing and agriculture, and it can be reduced both by decreasing markups in manufacturing and increasing them in agriculture. As we discussed in Section 2, one popular view is that the movement of labor into manufacturing was caused by the brutal collectivization campaign that reduced the standards of living of agricultural workers. A range of policies, such as the expropriation of agricultural output and the creation of monopsonist-employers, the collective farms, in the countryside would lead to an increase in the wedge between the marginal product of labor in agriculture and the income of agricultural workers, that maps into a higher markup in agriculture.

The "Big Push". The apparent success of the Soviet Union in rapidly increasing industrial production led many economists to re-think mechanisms of industrial development. One idea that quickly gained prominence both in academia and in policymaking was that a *laissez-faire* economy can get stuck in a bad equilibrium with low manufacturing productivity and output, and a concentrated state effort may be needed to industrialize. The modern formalization of this idea is laid out in well known work by Murphy, Shleifer and Vishny (1989). Here we discuss the mapping of a version of their model into our framework.

The model of Murphy, Shleifer and Vishny (1989) has three main ingredients: increasing returns to scale, monopoly power, and a wage premium in the "modern" sector. To model increasing returns to scale, the authors assume that there is a continuum of manufacturing goods, and that each good can be produced either with a "traditional" constant returns to scale technology with productivity 1 or with a "modern" technology with productivity $X_M > 1$. To adopt the modern technology for good i, a firm must hire D units of labor to pay a fixed cost of adoption. If the firm chooses to do so, it becomes a monopolist in production of that good. The demand spillover is generated by assuming that workers in the modern sector get disutility $\Delta > 0$. The utility from consumption is given by $\int \ln c_M(i)\, di$.

Murphy, Shleifer and Vishny (1989) show that for a range of parameters (D, Δ) this model has two equilibria. In one equilibrium, all firms adopt modern technologies. In the other equilibrium, none of the modern technologies are adopted. The latter equilibrium is Pareto inferior, but the economy may be trapped in it due to increasing returns to scale in production and demand spillovers driven by a combination of monopoly power and the wage premium. The "Big Push" can be interpreted as a government policy of financing the fixed cost of adopting the modern technology when the economy is trapped in the equilibrium with a traditional technology.

In Appendix B, we incorporate this model into our two sector framework by assuming that there also exists an agricultural sector. In the equilibrium with a traditional technology, all the components of the labor wedge are equal to 1 and the total factor productivity in the manufacturing sector is also equal to 1. The "Big Push" equilibrium has three implications: the total factor productivity in manufacturing increases, the production and labor components of the labor wedge become greater than one (and thus the labor wedge increases) and the fraction of labor employed in agriculture increases. The first implication follows from the assumption of increasing returns and the higher efficiency of the modern technology. The second implication is driven by the demand spillovers in manufacturing. Higher income of consumers increases demand for agricultural goods leading to the third implication.

The example of the "Big Push" shows that government policies may affect not only wedges but also sectoral total factor productivities. Other examples of policies that may affect TFP are the pay schemes that reduce incentives to exert effort or policies that change the skill composition within a sector (for example, political prosecution of high-skill workers or the encouragement of an inflow of low-skilled workers into manufacturing).

4 Measurement of wedges in the data

In this section we discuss the choice of data sources and the parameters that we use to measure sectoral productivities, wedges (8), (9) and (10), and their components.

4.1 Parametrization

We draw on a large body of literature that used the prototype two sector growth model of Section 3.1 to study growth and structural transformation in various historical contexts.[21] This literature has a broad consensus regarding the values for some of the key parameters. The parameter η, that determines the long run share of agricultural expenditures in the total consumption basket is believed to be small; the elasticity of substitution between consumption goods, σ, to be no greater than 1; and the labor shares in production, $\alpha_{A,N}$ and $\alpha_{M,N}$, to be quite large, at least 0.5 and possibly as high as 0.7 in manufacturing.

For our baseline preference specification we chose a commonly used Stone-Geary specification which sets $\sigma = 1$. Parameter η measures the long run share of agricultural consumption and we set it to 0.15. We set the subsistence parameter γ^A to maximize the effect of non-homotheticities. Specifically, we set it so that in 1885 the per capita agricultural consumption is 25 percent above the subsistence level. We cannot choose a larger subsistence level since in that case agricultural consumption in the data drops below the subsistence level during the bad harvest of 1891. We base our technology specification on Caselli and Coleman (2001), with the exception that we set the land share in manufacturing to 0 rather than 0.06. For the fraction of the labor force in the population, we set $\chi_t = 0.53$ for all t based on the Russian census of 1897. This number is slightly higher than the fraction of labor force in the 1926 and 1939 censuses, but fitting those numbers introduces only small differences to our analysis. All our parameters are given in Table 1.

[21] For example, Caselli and Coleman (2001), Buera and Kaboski (2009, 2012a,b), Herrendorf, Rogerson and Valentinyi (2013) applied this model to the economic experience of the U.S. in the 19th and 20th centuries, Stokey (2001) to the industrial revolution in England, Hayashi and Prescott (2008) to Japan in the 20th century.

Parameter	Description	Value
$\alpha_{K,A}$	Factor shares	0.21
$\alpha_{N,A}$	of the	0.60
$\alpha_{K,M}$	production	0.34
$\alpha_{N,M}$	functions	0.66
γ_A	Subsistence level	29
η	Asymptotic share	0.15
β	Discount factor	0.96
σ	Elasticity of substitution	1.0
ρ	Intertemporal elasticity	0.0
δ	Depreciation	0.05

Table 1: Parameters

Before we proceed, we want to discuss the implications of parameter choices for our main results. Our quantitative section focuses on two main sets of experiments. The first set of experiments measures the wedges in the Tsarist economy to study the main sources of frictions during that period. Our preference specification is chosen to produce a conservative estimate of those wedges. Both σ and η are on the high ends of the ranges of parameters used in the literature, and γ^A takes almost the maximum possible value. Alternative values of these parameters used in the literature imply larger distortions.

The second set of experiments investigates how the wedges change in 1928-40 and the contributions of those changes to Soviet economic performance. The *qualitative* dynamics of those wedges are essentially independent of the specific assumptions. The dynamics of wedges defined in (8), (9) and (10) and their components depend on the behavior of the sectoral output/labor and output/capital ratios as well as relative prices, wages and consumption of the two goods. The behavior of those variables can be computed directly from the data. The *quantitative* contribution of wedges to the economic performance of Soviet Russia depends primarily on the magnitudes of changes in wedge components during 1928-40. Many parameters drop out of the expressions for changes in wedges, and the contribution of each component is primarily affected by the elasticity of substitution σ. In Section 5.4 we show that our main quantitative insights continue to hold for a wide range of values of σ used in the literature.

Finally, we specifically emphasize the role played in our exercise by price and wage data for the Soviet period. In our analysis, we use prices at which Soviet enterprises conducted their transactions and measures of relative income for urban and rural workers. Our analysis does *not* require an assumption that the economic agents can freely make decisions given those prices, for example freely decide whether to move into urban manufacturing or stay in rural agriculture. As we emphasized in Section 3.2, the additional distortions that the command economy introduces given those prices are captured by the components of the wedges that we measure.

4.2 Data

We discuss the construction of the data in great detail in Appendix A. Here we highlight the main issues. The principal source of economic data for output, consumption, and investment 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 are sufficiently disaggregated and allow us to construct series for consumption and investment in the agricultural and non-agricultural sectors and to use a perpetual inventory method to impute capital stock. Gregory provides data on the sectoral composition of value added for select years, and we extrapolate between them. Employment is constructed using the census of 1897 and Gregory's estimates of sectoral employment growth rates over different sub-periods of 1885-1913.

For relative prices we use the price deflator implied by Gregory's series. Our wage data are from Strumilin (1960, 1982), which in turn is based on administrative records of the Tsarist period. For agricultural wages we take the average annual wages of a male employee (*batrak*) hired on a year-long contract. For manufacturing wages we take the average annual wages of male factory workers.

Our main source of Soviet economic data on quantities is from the comprehensive work of Moorsteen and Powell (1966), which is widely used by Western economic historians. Moorsteen and Powell use official Soviet data to construct sectoral outputs, capital stocks, and value added according to Western definitions. To construct sectoral employment shares, we use the 1926 census and Soviet employment records.

We use two versions of price series to construct relative prices. For our baseline specification, we use wholesale prices at which Soviet companies conducted transactions. We also use indexes of retail prices in private markets. The implications of the two sets of indexes for the behavior of *relative* prices are similar, even though private market prices indicate a higher overall inflation rate in some years. Both price indices are from Allen (1997). We do not utilize the wage data directly as a large fraction of agricultural income was in-kind. Instead, we use Allen's (2003) estimates of farm and nonfarm consumption per head in 1928-1939. For this, he measures the in-kind income in private market prices, adds cash income and subtracts taxes. He assumes that all income is spent on consumption, which is essentially equivalent to our notion of wages.

One natural concern is whether the official Soviet series, on which Moorsteeen and Powell base their analysis, and on which most subsequent research builds, are reliable. This question has been the focus of much historical research. It has been long known that grain production figures were systematically inflated. The opening of archives allowed historians to re-estimate production data using internal documents (Davies, Harrison and Wheatcroft, 1994, pp. 115-117) but these updated numbers are broadly consistent with the estimates of agricultural production done by Moorsteen and Powell. No similar problem was detected for other goods and services. According to Allen (2003, p. 212), "Did the Soviets really produce as many tons of steel or pairs of shoes as they claimed? Many Western scholars have investigated this question, however, and the consensus is that the published Soviet figures for output were basically reliable". The recent archival work and the analysis of Soviet production data using contemporary American input-output relationships did not uncover any significant inconsistencies.

Since the role of government changed dramatically between 1913 and 1928, we define government purchases narrowly as military spending. This definition also allows us to calculate the contribution of military buildup before WWII to structural change. We count all other government expenditures as non-agricultural consumption.

Figure 1 presents sectoral data for the Tsarist and the Soviet period.

Figure 1: Aggregate economic indicators in Russia in 1885-1940.

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 occupation for about 85 percent of the working-age Russian population was agriculture in 1885, and this fraction declined 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. Figure 1 measures the share of value added in agriculture in 1913 prices to isolate the effect of changes in quantities.

The level of GDP per capita and the structural composition of the Russian economy in 1928 were approximately the same as they were in 1913.[22] Growth in real GDP (measured in 1913 rubles) is very rapid, but it starts from a low base and by 1940 GDP per capita is just above the pre-1913 trend. GDP per capita should also be interpreted with caution due to the so-called "Gerschenkron effect". We report GDP per capita in 1913 prices, at which point the manufacturing sector was relatively small and its relative prices were high. Since manufacturing output grew faster than agricultural output after 1928, the baseline prices of early years are

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

particularly favorable to show high rates of GDP growth. There is little doubt that structural transformation was very rapid in 1928-1940. The labor force in manufacturing almost tripled during this time period and the expansion of this sector was much more rapid.

5 Wedge decomposition

Figure 2 presents the total factor productivities X_t^M, X_t^A and the wedges $1+\tau_{W,t}$, $1+\tau_{R,t}$ and $1+\tau_{K,t}$. The dashed lines are the Tsarist trend growth rates for X_t^M and X_t^A and the average values of quantity wedges in 1885-1913 (with the exclusion of the famine years in the early 1890s) for a comparison with the frictions in the Soviet economy.

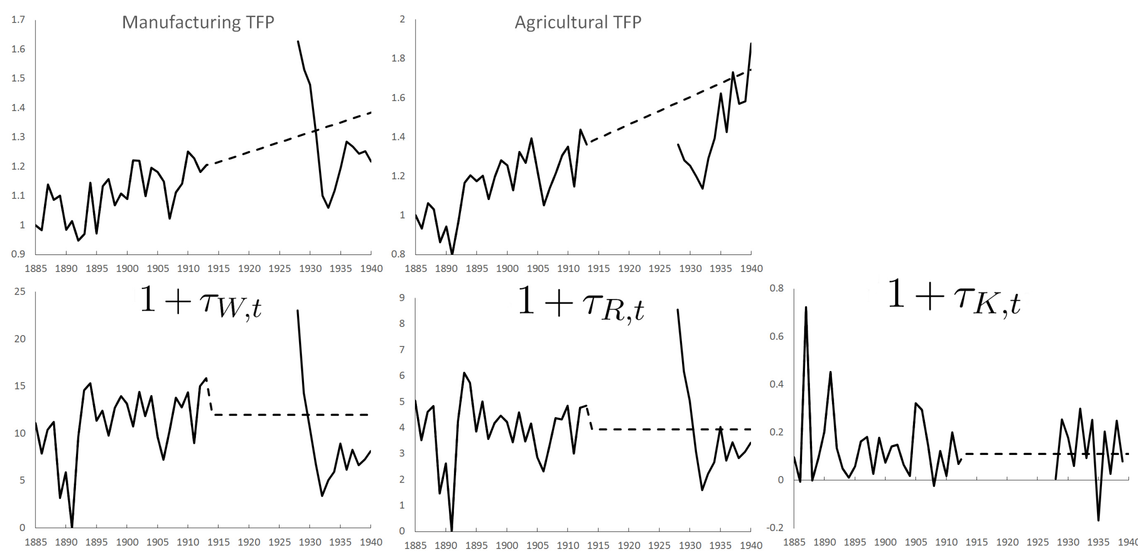

Figure 2: Aggregate distortions in Russia in 1885-1940.

Figure 3 shows the decomposition of the wedges $1+\tau_{W,t}$ and $1+\tau_{R,t}$ into their components. Since there are no data on the sectoral capital rental rates, the decomposition is done under the assumption that the mobility component of the inter-sector capital wedge is zero. In our discussion of the results we mainly focus on the labor wedge decomposition since we can measure its components more precisely.

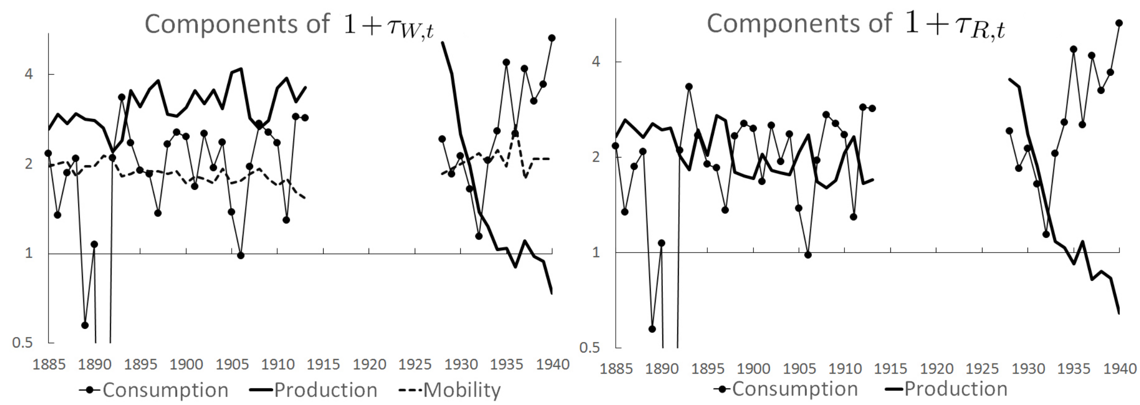

Figure 3: Components of labor and capital distortions in Russia in 1885-1940.

5.1 Wedges in 1885-1913 (Tsarist Russia)

The most important observation regarding the wedges in this period is that the distortions to the inter-sectoral allocation of factors of production in Tsarist Russia are large. The average value of the labor wedge during 1885-1913 is 11.5, which is equivalent to an ad valorem tax of 1,050 percent on moving labor from the agricultural to the manufacturing sector. From the standpoint of the neoclassical growth model, there are large efficiency gains that could be achieved by reallocating labor away from agriculture. All three components of the labor wedge are sizable but their relative importance is quite different.

The production component of the labor wedge is the most significant, accounting for half of the overall wedge. It suggests that frictions in the production process that cause under-utilization of labor in manufacturing were particularly severe in Tsarist Russia. Recall from our discussion in Section 3.2 that high values of the production component are consistent with monopoly power in goods or labor markets. Therefore, our decomposition is consistent with the view that cartels, monopolies, and various administrative barriers to creating and running corporations were an important reason for the low share of manufacturing production in Russia before WWI.[23]

Why is the production component large? Our decomposition suggests that markups in non-agricultural production were significant. To check this hypothesis more directly, we calculated the total labor bill in a subset of the non-agricultural sector for which the best data are available

[23]For example, Spulber (2003, p. 143) cites a well-known Soviet historian Liashcenko who concludes that Russian monopolies were characterized by "wide prevalence, great proportions and high degree of concentration".

– factories. Gregory (1982) reports that the value added in factories was 3 bln rubles in 1913, and employment records show that factories employed 2.3 mln people (Gregory, 1972). Factory surveys during the Tsarist period show that the average annual wage in factories was 257 rubles in that year (Allen, 2001, Strumilin, 1960), which implies that the total wage bill was less than 20 percent of the total factory value added. Standard estimates of the labor share in production are in the range of 60-70 percent, which implies a markup of 3-3.5, remarkably close to the average markup of 3.14 that we obtain through our decomposition.[24]

The labor mobility component is sizable but it is the smallest out of the three components, and its relative significance further falls after 1895. Its average value of 1.85 implies that manufacturing wages are 85 percent higher than agricultural wages. Higher wages in manufacturing are a common historical phenomenon, and such factors as costly skill acquisition or higher urban living expenses can partially account for that.[25] The agricultural policies in Tsarist Russia that discouraged labor mobility (see our discussion of communes in Sections 2 and 3.2) are the residual of this component, once wages are adjusted for those factors. Therefore, policies that discourage labor mobility are unlikely to play a significant quantitative role in the low labor share in manufacturing. Contrary to the views of Lenin, Gerschenkron and many others, Russian communes do not appear to be among the main barriers to structural transformation.[26]

The consumption component of the labor wedge is sizable. This is consistent with the evidence that different regional markets were poorly integrated and that many Russian farmers were "subsistence-oriented" producing only a small fraction of their income for commercial sale. As we showed in Section 3.2, costly access to centralized markets maps into a positive price component in our decomposition.[27]

[24]The importance of the production component decreases if a country adopts less labor intensive technologies, that is, chooses technologies for which $\alpha_{M,N}$ is lower. This choice would be optimal for countries which are relatively abundant in capital and scarce in labor which is contrary to the evidence on relative factor abundance in Russia at the beginning of the 20th century.

[25]See Caselli and Coleman (2001) for the emphasis on skill composition and its implications for the behavior of prices and wages in the neoclassical growth model. Allen (2003) discusses the importance of skill acquisition in the Russian economy. The only wage series we have for manufacturing workers that contains information about skills is the time series for construction workers in St Petersburg from Strumilin (1960). The wages for an unskilled construction worker (*chernorabochij*) in that data set are about 50% higher than the average agricultural wages in the European provinces of the Russian empire.

[26]This finding is consistent with the recent work by economic historians who used the available micro-data to study the causal effect of communal land holdings on rural-urban migration. Gregory (1994) argues that communal restrictions on rural-urban migration were not significant. Borodkin, Granville, and Leonard (2008) use time series evidence for the St Petersburg region and Nafziger (2010) analyzes a household-level dataset of villages in the Moscow province to reach similar conclusions.

[27]See also Spulber (2003, p. 101) for various administrative measures that hampered domestic trade. Spulber

5.2 Wedges 1928-1940 (Soviet Russia)

The analysis of Figures 2 and 3 reveals two broad patterns during 1928-40. The total factor productivity performs poorly in both sectors (it is significantly below Tsarist trends for most of the sample), and all the wedges fall relative to their average Tsarist levels. The drop in the labor wedge is fully accounted for by the drop in its production component. By 1935, this component reaches the level predicted by the neoclassical growth model. The other two components of the labor wedge increase, especially after 1935.

To quantify the contribution of each component of our wedge decomposition to growth and to changes in the agricultural labor share we perform the following procedure. We first compute the path of the economy holding all wedges fixed at their 1928 levels.[28] Even with all the wedges fixed, GDP still grows at 1.2 percent per year, and the labor share decreases by 0.9 percent. This is due to the fact that the initial capital in 1928 is lower than the steady state, hence, convergence to the steady state generates some growth and structural transformation (row 9, Capital Accumulation K_0). We then re-compute the path of the economy when all exogenous variables (including wedges and productivities) are set to values that we observe in the data. When all those series are set to the values observed in the data, the model matches the observed quantities and prices in the data exactly. We compare the simulated path with fixed wedges with the actual historical path by computing the difference between the rates of growth of annual GDP and the difference between the changes in the agricultural labor share from 1928 to 1939. Finally, we compute the contributions of wedges and TFPs by adding exogenous variables subsequently one by one and computing the relative changes in GDP and the labor share at each step.

The numbered rows in Table 2 report the marginal contribution of each factor. The exact numbers slightly depend on the order in which we add wedges and other series, and we report the average values after taking 1000 random draws of the order in which we add exogenous

(p. 111) gives the statistics on how inefficient and limited the Russian railroad system was. For example, at the end of 1913, Russia had only 1/12th of railroad coverage in terms of kilometers of railway per 100 square kilometers of territory, compared to Great Britain, Ireland and Germany. Spulber (p. 76) concludes that "the major part of the peasant farms constituted a subsistence sector, and the limited rest, a commercialized sector".

[28] The system of feasibility conditions (6), (7) and market clearing conditions (8)-(10) for 1928-1940 consists of Z unknown variables and $Z-1$ equations. An additional assumption is needed to either determine the level of investment I_{1940} or expected consumption in manufacturing C^M_{1941}. We experimented with different assumptions to pin down the last expression all producing similar results (see the working paper Cheremukhin et al (2013) and especially its computational appendix). The experiments in our baseline specification assume that after 1941 the TFPs continue to grow with their trend rates, and the wedges remain at their levels of the late 1930s.

variables.

Policy	Change in labor share	GDP per capita growth rate
1. Agricultural TFP, X_A	-1.3%	0.4%
2. Manufacturing TFP, X_M	2.0%	-2.9%
3. Labor distortion, τ_W	-26.5%	5.3%
a. consumption	2.7%	-0.7%
b. production	-31.4%	6.5%
c. mobility	2.1%	-0.5%
4. Capital distortion, τ_R	7.4%	-1.5%
a. consumption	-0.5%	0.8%
b. production	7.9%	-2.2%
5. Investment distortion, τ_K	-3.8%	1.7%
6. Defense	-1.2%	0.3%
7. Foreign trade	-0.2%	-0.1%
8. Population growth	-0.5%	0.1%
9. Capital accumulation, K_0	-0.9%	1.2%
Total	-24.7%	4.4%

Table 2: Wedge Accounting 1928-39.

Note that the table above presents the effects of each factor individually. For example, a removal of the production component of the capital wedge keeping fixed the labor wedge leads to a negative effect on growth (row 4). If labor and capital production distortions are caused by the same underlying friction, a better exercise to understand the effect of the production (markup) components of the distortions is to simultaneously change these components for both the labor and the capital distortion. Our results are in Table 3.[29]

	Change in Labor Share	GDP per capita growth rate
Data	-24.7%	4.4%
Explained by production components	-23.5%	4.2%

Table 3: The contribution of the production component in 1928-39.

[29]Since we do not have the data on rental rates of capital to estimate the capital mobility barrier, in this exercise we assume that the capital mobility component is zero.

Our decomposition shows that the policies that reduced the relative production distortions between the two sectors led to a reallocation of labor towards manufacturing and to higher growth rates in per capita GDP in 1928-39. Recall that the high level of the production component in the Tsarist economy is consistent with monopolists in the manufacturing sector optimally deciding to reduce their output in order to increase profit. In such circumstances any policy that encourages manufacturing producers to expand output should on the margin reduce the markup in the manufacturing sector, reduce the production component of the labor distortion, and reallocate labor from agriculture to manufacturing. Removal of entry barriers and encouragement of competition are examples of such policies in competitive economies. In the Soviet economy, the central government incentivized enterprise managers to achieve ambitious production targets rather than to maximize profit, and channeled resources into industry, which also led to an expansion of industrial output, to reallocation of labor, and to a reduction in the production component of the inter-sectoral labor wedge. Soviet agricultural policies may have also contributed to the reduction of the production component. As we discussed in Section 3.2, the allocation of resources between sectors depends on the relative markups in the two sectors. An increase in monopsony power of agricultural producers, due to the policy of collectivization and a ban on private commercial farming, allows them to influence wages paid in the agricultural sector and to increase markups there. Such policies also reduce the production component of the labor wedge and push labor out of agriculture.

Our findings are inconsistent with the predictions of "Big Push" theories that sweeping state investments should increase productivity in the manufacturing sector and increase the labor wedge (see Section 3.2). We observe exactly the opposite. The labor wedge significantly decreased. TFP fell in both sectors during the main phases of industrialization and collectivization and remained significantly below Tsarist trends in most years.

The behavior of sectoral TFPs is consistent with a view that the Soviet economy, although successful in reallocating resources towards manufacturing, failed to provide the right conditions for efficient utilization of those resources within each sector. While part of the productivity drop can be accounted for by other factors, such as the large inflow of relatively inexperienced, low-skill workers into manufacturing, the poor performance of agricultural productivity and output are particularly illustrative. Davies, Harrison and Wheatcroft (1994) trace the drop in agricultural output to several factors. They argue that the state exaction of grain from peasants on its own created dramatic disruptions to agricultural production by reducing incentives to work on collectivized land, by disrupting the system of crop rotation, and by a drastic fall in the number of draught animals. Moreover, the dekulakization campaign led to exile and execution of the most successful and knowledgeable peasants. All these factors are consistent with an inefficiently managed transition process.

The effect of the reduction in agricultural output on population is another glaring example of the inefficiencies of Soviet policies. Although agricultural production dropped in 1931-33 relative to its 1928 level, in per capita terms it was still above the levels of production in the late 19th century. Since total agricultural output exceeded subsistence needs, any increase in mortality could be avoided. Instead, Soviet policies of food collection and distribution led to the most severe famine in Russian history, resulting in millions of deaths.[30,31]

Our decomposition in Table 2 also shows that such factors as the increase in military expenditures in the late 1930s and the reduction in international trade played some role in the reallocation of labor towards manufacturing, but the effect of these factors is relatively small. Similarly, the contributions of sectoral total factor productivities are relatively small, which illustrates that the channels of structural change typically emphasized in the literature (see, e.g. Chapter 20 in Acemoglu, 2008), played a minor role in the structural transition of the Soviet Union.

5.3 The role of the production component of the distortions

Our analysis suggests that distortions in manufacturing, consistent with monopolistic behavior, were among the main factors hindering structural change in Tsarist Russia, and that the removal of such distortions was the main mechanism through which labor re-allocation occurred in the Soviet economy. This finding is consistent with a number of recent papers that emphasize the

[30]Davies, Harrison and Wheatcroft (1994) review different available estimates and conclude (p. 77) that "the total number of the excess deaths may have amounted to 8.5 million in 1927-36 ... most of the deaths took place during the 1933 famine."

[31]Meng, Qian and Yared (2014) provide important evidence on the causes of famine in another centrally-planned economy, China, in 1959-61. They identify poor information flows within the government as the main reason for high mortality. Many features of the two famines are very similar. In both cases, although there was sufficient food production to avoid malnutrition, government policies led to relative scarcity of food in the countryside compared with the cities, and the most fertile regions experienced some of the most severe famines. The similarity of institutions and outcomes in the two economies suggests that similar mechanisms are likely to have led to high mortality rates in Soviet Russia in 1931-33.

negative effect of monopolies on growth.[32] This literature typically emphasizes that monopolies may lower productivity in a given sector. Our findings also indicate that monopolies further lower welfare by creating a barrier to efficient allocation of resources between sectors.

In this section, we investigate the effect of monopoly distortions on Tsarist Russia.[33] We conduct the following experiment. We fix all the wedges, exports, and government expenditures at their 1913 levels and extrapolate the economy forward using trend TFP growth rates from 1885-1913. We compare this simulation with an alternative extrapolation in which all production distortions are reduced to zero, while the remaining components are kept at their 1913 levels. This experiment allows us to evaluate welfare losses due to deviations from efficient choices of competitive firms in both sectors.

Figure 4 shows these two extrapolations. We also show the data for the Tsarist and Soviet periods as a reference point.

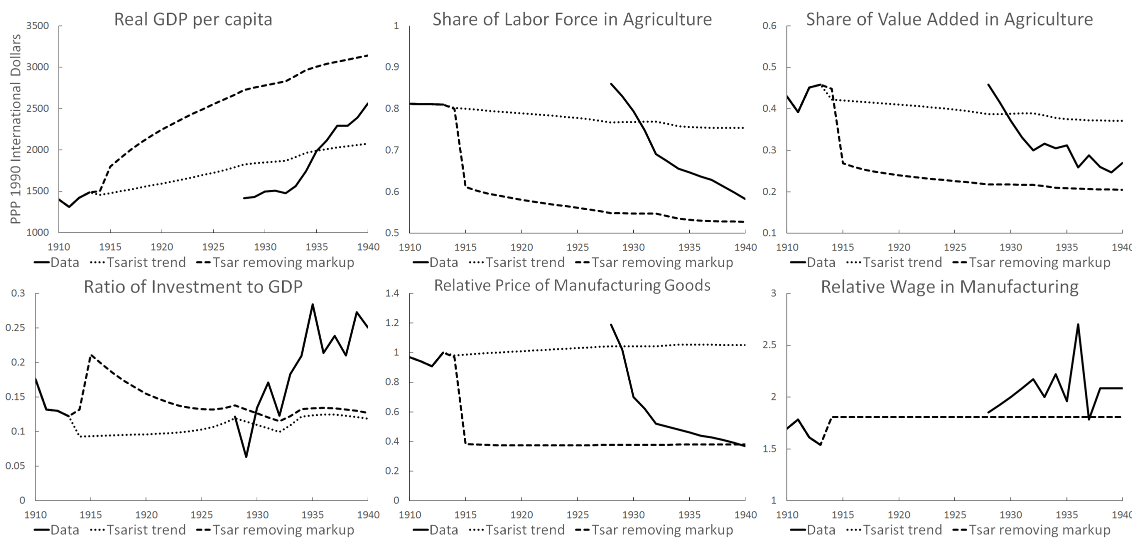

Figure 4: Effects of the reduction of the monopoly component

The monopoly distortions have a sizable effect on real GDP and on the labor share. In 1940, real GDP in the absence of Tsarist monopoly distortions is 50 percent higher than in their presence. Since productivity growth is the same in the two simulations by construction,

[32] See Parente and Prescott (1999), (2002), Cole and Ohanian (2004), Fernald and Neiman (2011), Alder, Lagakos, and Ohanian (2013).

[33] As we emphasized earlier, several different mechanisms can map into production distortions and resemble the distortion introduced by a monopolist. In this section we refer to them as monopoly distortions for simplicity.

all additional GDP growth is achieved through reallocation of labor and accumulation of capital. Because the manufacturing sector is more capital intensive, the elimination of monopoly distortions generates an initial investment boom. It also leads to a reallocation of about 30 percent of the labor force towards manufacturing and a drop in the relatives prices of manufacturing goods by about 60 percent. The permanent removal of monopoly distortions leads to a welfare gain equivalent to a 27.4 percent permanent increase in aggregate consumption.

The predictions of the neoclassical growth model for the behavior of labor allocations and prices due to the removal of the production component of distortions are notably consistent with the behavior of those variables in the Soviet data. Recall that in the data the production component of distortions reduced almost to one by 1935. The observed drop in relative prices in Soviet Russia and the reallocation of labor are remarkably consistent with the simulated response of the economy. This is consistent with the fact that the production components in Table 2 account for most of the growth and most of the labor transformation. The behavior of prices in the data is also consistent with the view of economic historians that prices played an important allocative role in the Soviet economy and arose as an outcome of a decentralized bargaining process between Soviet enterprises and government ministries rather than from being set in an arbitrary fashion.[34]

Our analysis also gives an insight on a classical debate in development economics on "push" versus "pull" theories of development, whether it is the development of modern industry that attracts ("pulls") workers by a higher wage or it is rapid productivity growth in agriculture that "pushes" workers out of that sector.[35] We find that the "pull" forces played a central role in the growth experience of Russia in 1885-1940. We find that distortions in production, such as barriers to entry and competition, were likely a significant block to a more efficient allocation of resources between sectors in Tsarist Russia. Structural transformation in 1928-40 was mainly

[34] An early comprehensive study of Soviet prices by Harrison (1998) based on the archives of the former Soviet planning commission and the statistical office argues that “The [planned] prices were quite distinct from the prices currently prevailing in the Soviet economy at any given time, wholesale and retail, regulated and free-market. These currently prevailing prices played important roles, even in a planned economy ...” Gregory and Harrison (2005) based on the recently revealed Stalin’s archives argue in favor of rational allocative price setting by Soviet firms: “Final allocations of products were achieved through contracting between ministries, ministry main administrations, and enterprises. Decentralized contracting generated a degree of price flexibility, and this tells us much about the motivations, resources, and constraints of the agents involved ... The archives show that price-setting was one of the most important activities of Soviet firms ...”. See also our discussion of price setting in the Soviet economy in Section 2.

[35] Lewis (1954) and Harris and Todaro (1970) are the seminal papers on labor pull. Nurkse (1953), Schultz (1953), and Rostow (1960) are seminal works on labor push.

achieved through the removal of such blocks. While productivity in Soviet agriculture was at or below the Tsarist trend, the reduction in markups and the increase in demand for labor seems to have played a critical role in Russia's structural transformation.[36]

5.4 Robustness

In this section we discuss the results of alternative parametrizations of our model. We investigate three sets of parameters: parameters governing the factor shares in production, α, parameters governing the degree of non-homotheticity, γ, and the elasticity of substitution, σ. We summarize the implications of these parameters for our decomposition of structural change and growth in 1928-39 in Table 4. In all simulations, the changes in the production components of the labor and capital wedges play the largest quantitative role. We comment on the specific details below.

To compute the results presented in each column of Table 4, we changed the values of some of the parameters and kept the remaining parameters unchanged. In the first robustness exercise, we changed σ from 1 to 0.5; in the second, we changed γ from 29 to 0; in the third, we set $\alpha_{N,M} = \alpha_{N,A} = \alpha_{K,M} = 0.5$ and kept the returns to scale in agriculture unchanged by setting $\alpha_{K,A} = 0.31$. In each of three cases, we re-computed the paths of the wedges and then re-produced the wedge accounting exercise from Section 5.2 for the new set of parameters.

First, we want to make several general observations. The assumptions regarding the degree of non-homotheticity and the factor shares mainly affect the levels of wedges but not their contributions to growth or labor reallocation. The contributions to growth and labor reallocation are primarily driven by changes in the wedges, which, in turn, are determined by changes in the capital-labor ratios and the prices observed in the data. Assuming lower labor shares, $\alpha_{N,i}$, for example, implies a somewhat lower absolute level of the production component in the Tsarist economy and the Soviet economy, but the relative fall of this component is essentially unchanged. For this reason, the contribution of the production component with the labor share set to 0.5 is roughly the same as in our baseline simulation. Although the absolute value of the component is somewhat reduced, it remains the most significant component of the labor wedge before 1913.

[36] We, however, are not claiming that "push" forces are not important. Our model predicts that a large increase in agricultural productivity would also lead to structural change; we do not observe such an increase in the Soviet data.

The homotheticity parameter, γ, also plays a relatively minor role. Recall that in our baseline parametrization, we set it to nearly the highest level consistent with consumption being above subsistence at the end of the 19th century. The per capita output in 1928 was substantially higher that output in the 1880s, and the role of non-homothecities was greatly diminished. Thus, fully removing the non-homotheticity by setting γ to 0 does not significantly change the baseline results.

The elasticity of substitution, σ, measures the responsiveness of economic variables to a given change in each wedge component. With a lower elasticity, a given drop in the production component has a smaller effect. However, even with $\sigma = 0.5$, the production component of distortions accounts for over half of all structural change.

Policy	Change in Labor Share			GDP per capita growth rate		
	$\sigma = 0.5$	$\gamma = 0$	$\alpha_{N,i} = 0.5$	$\sigma = 0.5$	$\gamma = 0$	$\alpha_{N,i} = 0.5$
1. Agricultural TFP, X_A	-1.9%	0.1%	-0.9%	0.1%	0.4%	0.2%
2. Manufacturing TFP, X_M	1.3%	1.9%	3.2%	-2.6%	-2.9%	-3.9%
3. Labor distortion, τ_W	-23.0%	-26.8%	-27.2%	4.7%	-5.0%	5.1%
a. consumption	-2.0%	2.5%	3.7%	0.6%	-0.7%	-1.0%
b. production	-22.8%	-31.8%	-33.2%	4.4%	6.3%	6.6%
c. mobility	1.8%	2.5%	2.4%	-0.4%	-0.6%	-0.5%
4. Capital distortion, τ_R	6.7%	7.1%	8.3%	-1.4%	-1.5%	-1.5%
a. consumption	-3.1%	2.5%	-1.5%	0.7%	0.1%	1.2%
b. production	9.8%	4.6%	9.8%	-2.1%	-1.6%	-2.6%
5. Investment distortion, τ_K	-5.7%	-4.2%	-5.1%	2.3%	2.0%	2.2%
6. Defense	-1.3%	-1.6%	-1.5%	0.4%	0.4%	0.4%
7. Foreign trade	-0.1%	-0.4%	-0.1%	-0.1%	0.0%	-0.1%
8. Population growth	-0.4%	-0.8%	-0.6%	0.1%	0.1%	0.1%
9. Capital accumulation, K_0	-0.4%	0.0%	-1.0%	1.0%	0.9%	1.9%
Total	-24.7%	-24.7%	-24.7%	4.4%	4.4%	4.4%

Table 4: Summary of Robustness Exercises

6 Conclusion

In this paper, we use the neoclassical growth model to qualitatively and quantitatively study the structural transformation of Russia in the late 19th and early 20th century. We extend the wedge accounting methodology by paying special attention to prices in addition to quantities. Decomposing wedges into their price components allows us to differentiate among various mechanisms that map into the same quantity wedge but have sharply different predictions for prices. We find that the high level of the inter-sectoral labor wedge was the main impediment to structural transformation of Tsarist Russia, and its reduction played by far the most significant role during Soviet industrialization. In terms of the analysis of the components of the labor wedge, we find that the distortions to the allocation of resources across sectors, consistent with the evidence on the importance of monopolies in Tsarist Russia, is the key ingredient of the labor wedge. The reduction in the degree of misallocation of production in Soviet Russia explains essentially all of the observed structural transformation. Other components of the labor wedge become more distorted. Thus, our findings on the role of the production component of the labor wedge cast doubt on the most common explanation of slow transformation of Tsarist Russia – that archaic institutions of land ownership precluded labor mobility across sectors. Our findings are also inconsistent with the theory of a "Big Push". Moreover, we find little evidence that the difference in TFP growth across sectors is responsible for structural transformation.

We believe that our analysis of the most important barriers to the development of Tsarist Russia and the factors behind Soviet industrialization is useful beyond the interests of economic history. Our methodology of decomposing wedges into price components is applicable more broadly to a variety of other settings. Our findings on the relative importance of components of the labor wedge gives further support to the idea that frictions and prices play a significant role in structural transformation (e.g., Caselli and Coleman, 2001). The fact that misallocation of resources consistent with effects of monopoly distortions plays a key role supports and further develops the findings in the contexts of barriers to riches (Parente and Prescott, 2002), the U.S. Great Depression (Cole and Ohanian, 2004), and the decline of the U.S. rust belt (Alder, Lagakos, and Ohanian, 2013). Our findings on the limited role of labor mobility restrictions and the absence of evidence for the role of the "Big Push" is of broader interest to the economic development literature.

We now briefly note some other issues that we did not discuss in this paper. First, our working paper version (Cheremukhin et. al., 2013) provides a much more complete description of the historical accounts, robustness exercises, and other counterfactuals. Second, we on purpose avoided the discussion of welfare implications of various policies. Stalin's era was one of the most terrible episodes of Russian history with millions perishing in the famine of the early 1930s. Any welfare calculation must necessarily take a stand on the costs of the lives lost. Thirdly, in this paper we did not discuss two periods of Russian history that are of interest to scholars of Russia. The period of the Civil War and War Communism following the fall of Tsarist Russia is an example of a significant economic disaster. We refer the reader to an impressive reconstruction of some of the economic statistics during that period by Harrison and Markevich (2011a,b). The brief period of the New Economic Policy in the 1920s saw a reintroduction of a limited market economy in Soviet Russia that was cut short by Stalin. We refer an interested reader to a detailed analysis of the New Economic Policy in the working paper version (Cheremukhin et. al., 2013).

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8 Appendix A: Construction of data

8.1 Capital stock

8.1.1 Russia 1885-1913

For Russia in 1885-1913 all data are from Gregory (1982) using 1913 prices. Capital in agriculture is a sum of value of livestock (Table H.1), accumulated agricultural equipment (Table I.1) and net 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 the 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), and 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, 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.

8.1.2 Russia 1928-1940

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

8.2 Exports and international prices

The data for the total volume of exports and imports for Tsarist Russia are from Gregory (1982), Table M-1. We use the data from Davies (1990), Table 56, to find the 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 the volume of exports and imports for the USSR from 1928 to 1938 are from Davies, Harrison and Wheatcroft (1994). They provide an index of exports and imports relative to 1913, and we use the numbers for 1913 trade from Gregory (1982) to obtain the volume of trade in 1913 prices. We impute the values for 1939 and 1940 by assuming that they 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, Harrison and Wheatcroft (1994), table 50. We found no comparable numbers for the Tsarist period. As a proxy for the international prices of Russian exports we take wheat prices in the state of New York. The dollar prices for wheat are from Jacks (2005). The nominal prices deflated by the US CPI are from the NBER Macrohistory Database.

8.3 Output, consumption and investment by sector

8.3.1 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

50.7 percent of value added was produced in agriculture in 1913. 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 defense 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 the 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 subtracting the value of agriculture in current prices we obtain the value of manufacturing in current prices and the price deflator for manufacturing goods. The ratio of the price deflator for agricultural goods to the price deflator of manufacturing goods yields the relative price of agricultural goods.

8.3.2 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 defense expenditures as our measure of the government sector, and we checked the robustness of our conclusion by added administrative expenditures. Finding appropriate series for relative prices is particularly challenging. We rely on the work of Allen (1997, Table A2) who calculates the ratio of wholesale industrial prices to wholesale agricultural prices based on the previous work of Bergson et al. (1955) and Barsov (1969).

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 capita, 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 the 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.

8.4 Population and labor force

8.4.1 Russia 1885-1913

The data for population is from Gregory (1982), Table 3.1. He reports the data for the territory of Russian empire excluding Finland and we follow his convention. We obtain the composition of the labor force from Davies (1990) and Gregory's estimates. Davies (1990), Table 3, provides an estimate of the composition of the labor force by sector in 1913. Gregory (1982), Table 6.3, reports growth rates for labor force by sector for different time periods during 1885-1913. We use these growth rates to backtrack labor force for years before 1913.

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 the 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 the self-reported primary occupation. This definition seems to be the only way to obtain a consistent definition of the sectoral labor force for Tsarist Russia and the Soviet Union. 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).* 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.

Our data on wages for 1885-1913 come from Allen (2003) and Strumilin (1982). The agricultural wages come from the data on male daily wage (Strumilin, 1982, Table 2B, p. 253) which we then multiply by 205 days per year to obtain the annual wage; according to Table 21, p. 268, agricultural workers worked for 104.2 days in the summer and 100.8 in the winter season. The non-agricultural wages for 1900-1913 are provided in Strumilin (1982, p. 293). Then we use we use the data on wages of day laborers and factory workers (Allen, 2003, Figure 2.2) to calculate the changes in wages in 1885-1900; taking the 1900 level from Strumilin (1982, p. 293) we then calculated the wages in 1885-1899. The data on wages for unskilled construction workers in St Petersburg is from Strumilin (1960, Table 13, p. 113).

8.4.2 Russia 1928-1940

It is difficult to obtain reliable data for the composition of the 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, Harrison and Wheatcroft, 1994, Table 12). Comparing to the Census data, they do not cover all of the non-agricultural labor force but give a reasonably good approximation of the growth rate of the non-agricultural labor force over the entire time period. According to the census data, the 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 use a procedure that follows our estimate of Tsarist labor force as closely as possible.

We use population numbers from Davies, Harrison and Wheatcroft (1994), Table 1. From 1926 census (Davies, Harrison and Wheatcroft, 1994, Table 11) we obtain the composition of the labor force by sector. We assume that each sector covered by the survey data grows 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 residual.

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

Our data on farm and non-farm wages (consumption) in 1928, 1932-39 come from Allen (2003, Table 7.5). We use linear interpolation of the ratio of agricultural to non-agricultural wages for the missing years 1929-31. For the year 1940 we take the ratio of agricultural to non-agricultural wages from 1939.

8.5 Adjustment for border changes, conversion prices

Using the procedure above we obtained two data sets, one for Russia in 1885-1913 in 1913 borders (excluding Finland) and 1913 prices and the other one for the USSR in 1928-1940 in pre-1940 borders and 1937 prices. In this section we discuss the 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, 2011a, 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.[37]

[37] While land endowment remained the same, Russian empire lost richer territories (Finland, Poland, Western Belarus and Ukraine, Caucasus) and gained poorer territories in Central Asia. Tsarist NNP in 1913 measured in the USSR interwar borders would decrease from 22 mln rbl to 16.5 mln rbl (Harrison and Markevich, 2011a,

Harrison and Markevich (2011a) 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 the 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 the fraction of agriculture in GDP is the same in 1913 and 1928. Since all these numbers are given in 1913 prices, they imply that the quantities of agricultural and nonagricultural goods decreased proportionally to the decrease in the NNP. This gives us a relationship

$$p_{1913}^A Y_{1913}^A \frac{Y_{1928}^A}{Y_{1913}^A} = p_{1913}^A Y_{1928}^A = \frac{p_{1913}^A}{p_{1937}^A} p_{1937}^A Y_{1928}^A,$$

which implies that

$$\frac{p_{1937}^A}{p_{1913}^A} = \frac{p_{1937}^A Y_{1928}^A}{p_{1913}^A Y_{1913}^A} \frac{20,266}{16,600}.$$

We find p_{1937}^M / p_{1913}^A analogously.

9 Appendix B: A model of the "Big Push"

In this Section we show how to incorporate a version of the "Big Push" model of Murphy, Shleifer and Vishny (1989) into the two sector growth model and derive its prediction for structural change and components of wedge decomposition.

As in Murphy, Shleifer and Vishny (1989) we assume that manufacturing consists of a continuum of goods with preferences given by $\int_0^1 \ln c_M(i)\, di$. Each manufacturing product $i \in [0, 1]$ can be produced either using "traditional" constant return to scale technology with productivity normalized to one, or using "modern" technology. The "modern" technology in sector i requires initial fixed cost investment of D units of labor; then the firm that made this investment becomes a monopolist in that sector and operates a constant returns to scale technology with productivity $X > 1$.

In addition, there is an agricultural good which can only be produced through a constant returns to scale technology with productivity 1.

Table 1). In the context of our model this differences is reflected in TFPs, and therefore we do not recompute Tsarist output in Soviet borders.

A consumer maximizes his utility of consumption minus disutility of labor

$$\max \left\{ \eta \ln c_A + (1-\eta) \int_0^1 \ln c_M (i)\, di - \Delta \mathbf{1} [\text{modern}] \right\} \tag{13}$$

subject to the budget constraint

$$p_A c_A + \int_0^1 p(i)\, c(i)\, di = \Pi.$$

Here Π is the consumer's income, and $\Delta \mathbf{1}$ [modern] is his disutility of labor which is zero if the consumer works in the traditional sector and is $\Delta > 0$ if he works the modern sector. Like in Murphy, Shleifer and Vishny (1989), each worker inelastically supplies one unit of labor, and the disutility of working in the modern sector results in a wage premium in the modern sector.

Consumer demand is

$$\begin{aligned} c_A &= \frac{\Pi}{p_A} \eta, \\ c(i) &= \frac{\Pi}{p(i)} (1-\eta). \end{aligned} \tag{14}$$

Since agricultural sector has only constant returns to scale technology, prices and wages are always equal to 1: $p_A = w_A = 1$.

Let us now consider incentives to industrialize. If sector i uses the traditional technology, the prices and wages are also equal to 1: $p_M = w_M = 1$. The producers make zero profits.

If a sector moves to the modern technology, it sets the prices using its monopoly power and taking into account the demand function (14). Competition from the traditional sector implies that the profit maximizing price for a monopolist is 1.

The modern producers also have to pay a higher wage $w_M' > 1$ to compensate for the disutility of working in the modern sector. Therefore, if a sector i industrializes, it receives a profit $y_i - w_M' \left(\frac{y_i}{X} + D \right)$, where y_i is the demand for its good (14) at price $p(i) = 1$. Therefore, manufacturing sector has incentives to industrialize if and only if

$$y_i = \Pi(1-\eta) > D \frac{w_M'}{1 - {w_M'}/{X}}.$$

As all manufacturing sectors are symmetric, there can only be two stable equilibria. In one equilibrium ('no-industrialization'), all manufacturing sectors use traditional technology. In the other, 'industrialization', equilibrium, all manufacturing goods are produced through modern technology.

When manufacturing does not industrialize, the equilibrium is analogous to our baseline frictionless economy. In particular, from optimality conditions

$$\frac{1-\eta}{\eta}\frac{c_A}{c_M}\frac{p_A}{p_M}=1,$$

the fact that $p_M = p_A = 1$, and $c_j = N_j$, we get

$$\begin{aligned}\frac{1-\eta}{\eta}\frac{N_A}{N_M} &= 1,\\ N_A+N_M &= 1.\end{aligned}$$

Therefore

$$N_A=\eta;\quad N_M=1-\eta.$$

The consumer's income is $\Pi = 1$. This equilibrium exists if and only if

$$1-\eta<D\frac{w_M'}{1-w_M'/X}, \tag{15}$$

Let us now consider the equilibrium where all manufacturing firms industrialize. We still have $p_M' = p_A' = 1$, but now

$$\begin{aligned}\frac{1-\eta}{\eta}\frac{N_A'}{XN_M'} &= 1,\\ N_A'+N_M'+D &= 1.\end{aligned}$$

This immediately implies

$$N_A'=\frac{(1-D)\,\eta X}{1-\eta+\eta X},\ N_M'=\frac{(1-D)\,(1-\eta)}{1-\eta+\eta X}.$$

The consumer's income is

$$\Pi'=p_Ac_A+p_Mc_M=XN_M'+N_A'=\frac{(1-D)\,X}{1-\eta+\eta X}.$$

The wages in manufacturing are pinned down by $\ln\left(\Pi'-(w_M'-1)\right)=\ln\left(\Pi'\right)-\Delta$ which implies

$$w_M'=1+\frac{(1-D)\,X}{1-\eta+\eta X}\left(1-e^{-\Delta}\right).$$

The industrialization equilibrium exists whenever

$$\Pi'(1-\eta)>D\frac{w_M'}{1-w_M'/X}. \tag{16}$$

If the fixed cost of industrialization D is sufficiently low and the productivity in the modern sector X is sufficiently high then $\Pi' = \frac{(1-D)X}{1-\eta+\eta X} > \Pi = 1$ so that for some range of Δ both (15) and (16) hold. In this case there is a multiplicity of equilibria (and therefore a rationale for the "Big Push").

Let us now compare the two equilibria. In the industrialization equilibrium, TFP in manufacturing is higher:

$$\frac{XN'_M}{N'_M + F} > w'_M > 1.$$

Mark up in manufacturing is also higher:

$$\frac{X}{w'_M} > \frac{N'_M + F}{N'_M} > 1.$$

The ratio of wages in manufacturing and agriculture is also higher:

$$\frac{w'_M}{w'_A} = w'_M > 1 = \frac{w_M}{w_A}.$$

The ratio prices and the ratio of marginal utilities are the same in both equilibria. The normalized labor wedge is $X > 1$ in the industrialization equilibrium and 1 in the no-industrialization equilibrium.

Whenever both equilibria exist, the labor force in agriculture is *higher* in the industrialization equilibrium:

$$N'_A = \frac{(1-D)\,\eta X}{1-\eta+\eta X} > N_A = \eta.$$

The intuition for this result is straightforward. The industrialization equilibrium exists if and only if industrialization results in higher aggregate income $\Pi' > \Pi$. This in turn implies that industrialization results in a higher demand for agricultural products. As the technology in agriculture does not change, increase in agricultural production requires an increase in agricultural employment. The labor moves to agriculture from manufacturing (where higher TFP allows to produce more output with less labor).