Online Appendix

April 20, 2016

1 Robustness

In this Appendix we discuss alternative parametrizations of our model and alternative data series. In each case we recalculate the wedges and compare them to the baseline scenario; we also redo our analysis of contributions of wedges to the structural change and GDP growth.

First, we investigate three sets of parameters: parameters governing the degree of non-homotheticity, γ, parameters governing the elasticity of substitution, σ, and the factor shares in production, α. In each case, we find no qualitative change in our results. This is consistent with our argument that the structural transformation in Russia has been driven by the changes in wedges (in particular, by the change in the production component) rather than by non-homotheticities in the utility function — and that the contributions of wedges are robust to the choice of the parameters of the production function and the utility function.

We also redo our analysis for alternative data series on capital stocks, sectoral employment, wages, demography and also find no major changes in our results.

We start with reporting the baseline results (these are the same as Table 2 and Table 3 in the paper).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	4.9	-19.8	3.2	-6.7
2. Manufacturing TFP, X_M	-0.7	-2.6	2.0	-19.3
3. Labor distortion, τ_W	-6.2	13.2	-18.8	37.4
4. Capital distortion, τ_R	0.3	0.3	0.3	4.2
5. Investment distortion, τ_K	-1.9	3.2	-2.3	3.9
6. Defense spending	-1.3	3.7	-2.1	5.3
7. Foreign trade	-3.0	5.7	-0.6	1.1
8. Population growth	-0.5	1.5	-0.5	1.4
9. Expectations, κ	-2.1	5.6	-2.1	5.5
10. Capital accumulation, K_0	1.3	-4.7	2.4	4.8
Total	-9.2	6.1	-18.5	37.6

Table 1: Baseline Counterfactual Analysis 1928-39.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	6.5	0.0	4.1	5.0
Production components	-15.9	20.6	-25.4	42.1
Mobility component	3.6	-7.0	2.8	-5.5

Table 2: Baseline Counterfactual Analysis 1928-39.

1.1 Non-homotheticities

In our baseline scenario we use non-homothetic preferences assuming that there is a minimum level γ^A of consumption of agricultural goods required for survival. This assumption is realistic; in particular, Herrendorf, Rogerson and Valentinyi (2013) show that such preferences help matching the post-war US data very well. The non-homotheticity assumption is especially important for both Tsarist and Soviet Russia given the famines of 1891 and 1933. Moreover, non-homotheticity has traditionally been considered in the non-balanced growth literature as a key driver of structural transformation (see, for example, Kongsamut, Rebelo and Xie, 2001). Since our main focus is on the role of wedges rather than the non-homotheticity of preferences, we perform the following robustness check. We set $\gamma^A = 0$, we recompute all the wedges, and then redo the wedge accounting exercise with the new parameters and the new wedges. Then we compare the results of wedge accounting with homothetic and non-homothetic preferences. The results are presented in Tables 3 and 4.

The main findings do not change. In most cases, signs and relative importance of contributions of individual wedges are the same as in the baseline. The labor wedge and especially its production component still play the key role.

A lower subsistence level implies a smaller contribution of agricultural TFP and a larger contribution of intersectoral distortions. A higher subsistence level implies a larger contribution of agricultural TFP and a smaller contribution of intersectoral distortions. In our baseline parametrization, we set the non-homotheticity parameter to nearly the highest level consistent with consumption being above subsistence in the end of the 19th century. The per capita output in 1928 was substantially higher than output in the 1880s, and the role of non-homotheticities was greatly diminished. Therefore, our baseline results represent a conservative estimate of the effects of intersectoral distortions. Even fully removing the non-homotheticity by setting γ^A to 0 does not significantly affect the baseline results. In particular, the key role of the production component of the labor wedge for both structural change and growth remains unchanged.

In Figure 1 we show the values of the labor wedge, capital wedge, and their consumption component. Here—as well as in all subsequent robustness checks—we do not show the wedges that have not been affected by an alternative parameterization. Figure 1 implies that setting

γ^A to 0 only affects the magnitudes of the wedges but now the qualitative nature of their change over time.

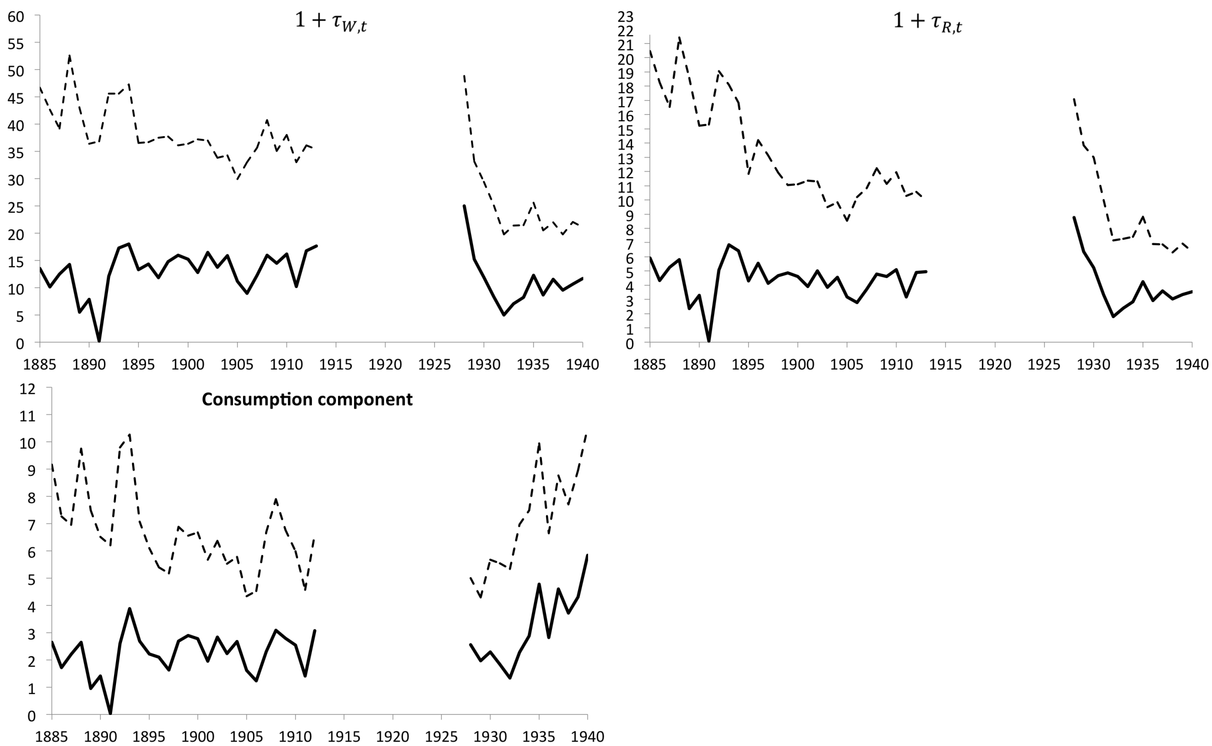


Figure 1: Baseline (solid line) and robustness check $\gamma = 0$ (dashed line).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	0.4	-9.2	0.7	0.4
2. Manufacturing TFP, X_M	-1.9	-0.3	2.4	-20.5
3. Labor distortion, τ_W	-9.0	18.3	-19.2	39.0
4. Capital distortion, τ_R	1.0	-2.3	-0.4	4.6
5. Investment distortion, τ_K	-1.7	2.6	-2.4	4.0
6. Defense spending	-1.3	3.6	-2.2	5.5
7. Foreign trade	-2.3	4.5	-0.6	1.3
8. Population growth	-0.5	1.5	-0.4	1.3
9. Expectations, κ	-1.8	5.1	-1.8	5.0
10. Capital accumulation, K_0	0.7	-2.8	4.0	1.6
Total	-16.3	21.0	-20.1	42.1

Table 3: Robustness checks: $\gamma = 0$.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	4.6	1.1	8.8	-7.4
Production components	-16.4	22.8	-31.4	57.5
Mobility component	3.6	-7.8	3.0	-6.5

Table 4: Robustness checks: $\gamma = 0$.

1.2 Elasticity of substitution between consumption goods

In this section we evaluate the role that substitutability between agricultural and non-agricultural goods in consumption plays for our main result.

While our baseline Stone-Geary utility function (with unit elasticity of substitution $\sigma = 1$) is common in the studies of structural transformation, there is also a growing literature that suggests significantly lower values for the elasticity of substitution. Baumol (1967) suggests values between 0.1 and 0.8. Ngai and Pissarides (2006) use the parameter in the 0.1-0.3 range. Herrendorf, Rogerson and Valentinyi (2013) estimate the elasticity to be either 0.002 or 0.85 depending on the estimation strategy. Buera-Kaboski (2009) argue that the elasticity is very close to 0. To understand the effects of complementarity between consumption of agricultural and non-agricultural goods on our results we choose $\sigma = 0.5$ which is in the middle of the range of existing estimates. We recompute all the wedges and then redo the wedge accounting exercise with the new parameter and the new wedges. The results are presented in Figure 2 and Tables 5 and 6.

A decrease in the degree of substitutability between agricultural and manufacturing goods makes economic outcomes more sensitive to developments in the agricultural (subsistence) sector, and, hence, attributes more of the changes in GDP and labor share to agricultural TFP and to the consumption components of the intersectoral wedge. The contributions of other factors are diminished. Nevertheless, our main results still hold: the production component of the labor wedge remains the key factor explaining both structural change and growth. The two production components together (production component of the labor wage and production component of the capital wedge) still jointly account for most of structural change.

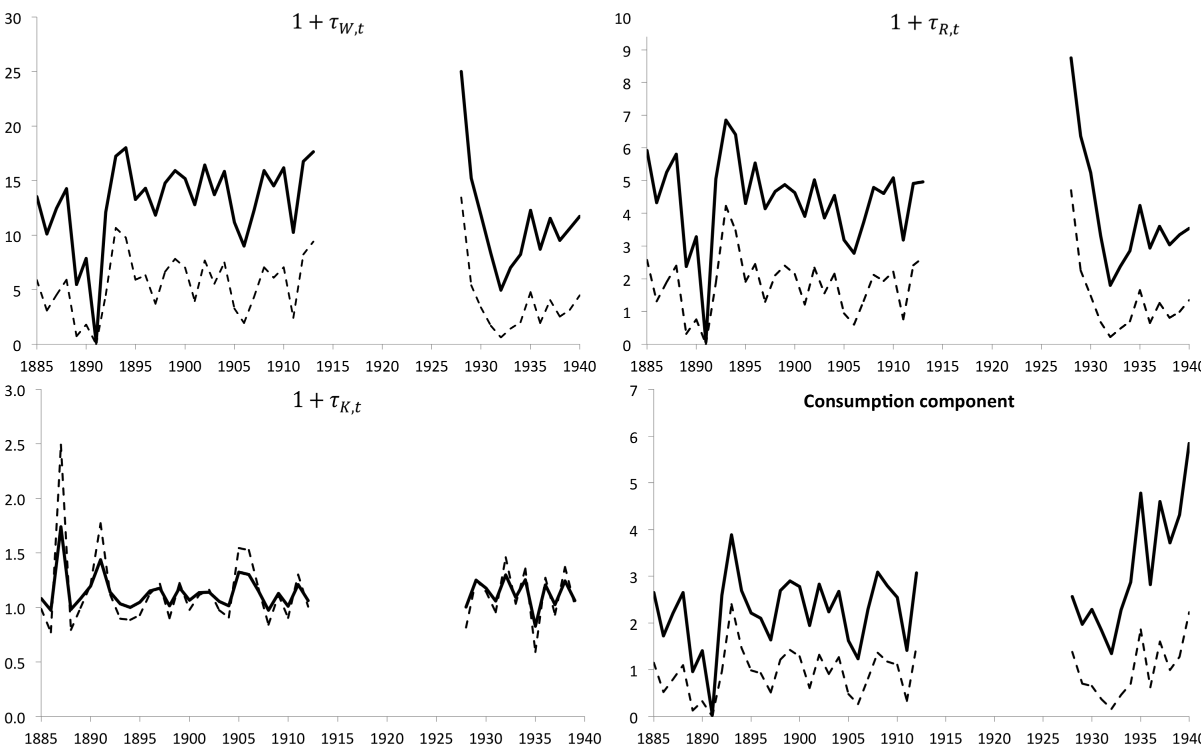


Figure 2: Baseline (solid line) and robustness check $\sigma = 0.5$ (dashed line).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	9.3	-31.5	6.7	-16.5
2. Manufacturing TFP, X_M	-1.0	-1.4	0.3	-15.0
3. Labor distortion, τ_W	-8.3	18.6	-22.9	45.1
4. Capital distortion, τ_R	0.3	0.2	1.9	0.9
5. Investment distortion, τ_K	-4.1	10.7	-2.3	7.7
6. Defense spending	-2.0	6.2	-2.7	7.6
7. Foreign trade	-4.2	8.6	-1.6	3.6
8. Population growth	-0.9	2.5	-0.8	2.4
9. Expectations, κ	-0.4	1.2	-0.4	1.1
10. Capital accumulation, K_0	3.7	-13.5	3.7	-2.1
Total	-7.6	1.5	-18.0	34.9

Table 5: Robustness checks: $\sigma = 0.5$.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	0.1	9.6	-6.4	23.3
Production components	-10.7	14.0	-16.6	26.6
Mobility component	2.6	-4.8	2.1	-3.9

Table 6: Robustness checks: $\sigma = 0.5$.

1.3 Relative value of consumption goods

In this section we check the robustness of our results to changes in the key parameter of the utility function, the preference for agricultural consumption η. In the baseline specification, it is set to $\eta = 0.15$. This parameter only affects the level of the consumption component of the intersectoral wedges. However, it does not have any affect on the path of relative changes in this wedge. For this reason it does not affect any of the numbers in the analysis of contribution of the wedges to the structural change and GDP growth.

The literature uses a broad range of values for η. Caselli and Coleman (2001) set $\eta = 0.01$, Kongsamut et al. (2001) use $\eta = 0.1$, Herrendorf et al. (2013) use $\eta \in [0.01, 0.11]$. If we set the value of η above 0.15, the labor wedge, the capital wedge and the consumption component would be below their baseline values, if we chose the value of η below our baseline value of 0.15, these wedges would be above their respective counterparts in the baseline scenario.

Figure 3 presents the labor wedge, the capital wedge and the consumption component for $\eta = 0.25$; this is the value that sets the average value of the consumption component in 1885-1913 to 1. If we chose the value of η below our baseline value of 0.15, these wedges would be above their respective counterparts in the basedline scenario.

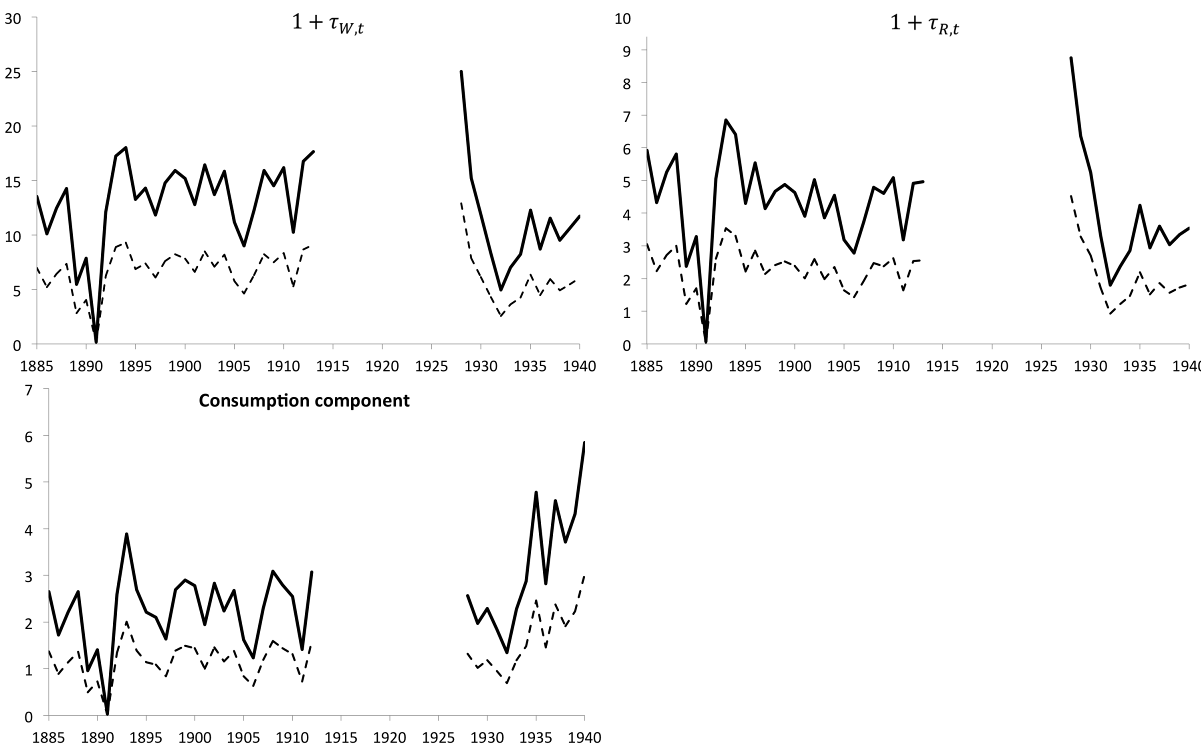


Figure 3: Baseline (solid line) and robustness check $\eta = 0.25$ (dashed line).

1.4 Factor shares

In this section we check the robustness of our results to the change in factor shares. There is a broad range of parameter values used in the literature both at the aggregate and at the sectoral level. Davies (1994, Table 41) summarizes the estimates by Bergson and Kuznets (1963), Moorsteen and Powell (1966), Ofer (1987). The labor share in these estimates varies from 0.54 to 0.81. For simplicity's sake, we set $\alpha_{N,M} = \alpha_{N,A} = \alpha_{K,M} = 0.5$ and keep the returns to scale in agriculture unchanged by setting $\alpha_{K,A} = 0.31$ (which is tantamount to assuming that land share in agriculture remains the same at 0.19). The results are reported in Figure 4, Tables 7 and 8. Notice that as the sectoral TFPs are not directly comparable between baseline and robustness scenarios, we normalize TFPs to zero in 1885 in each case.

The results are very similar to the baseline, especially in the experiment for the 1928-39 change. This is not surprising. 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 shares 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 driver of the labor wedge.

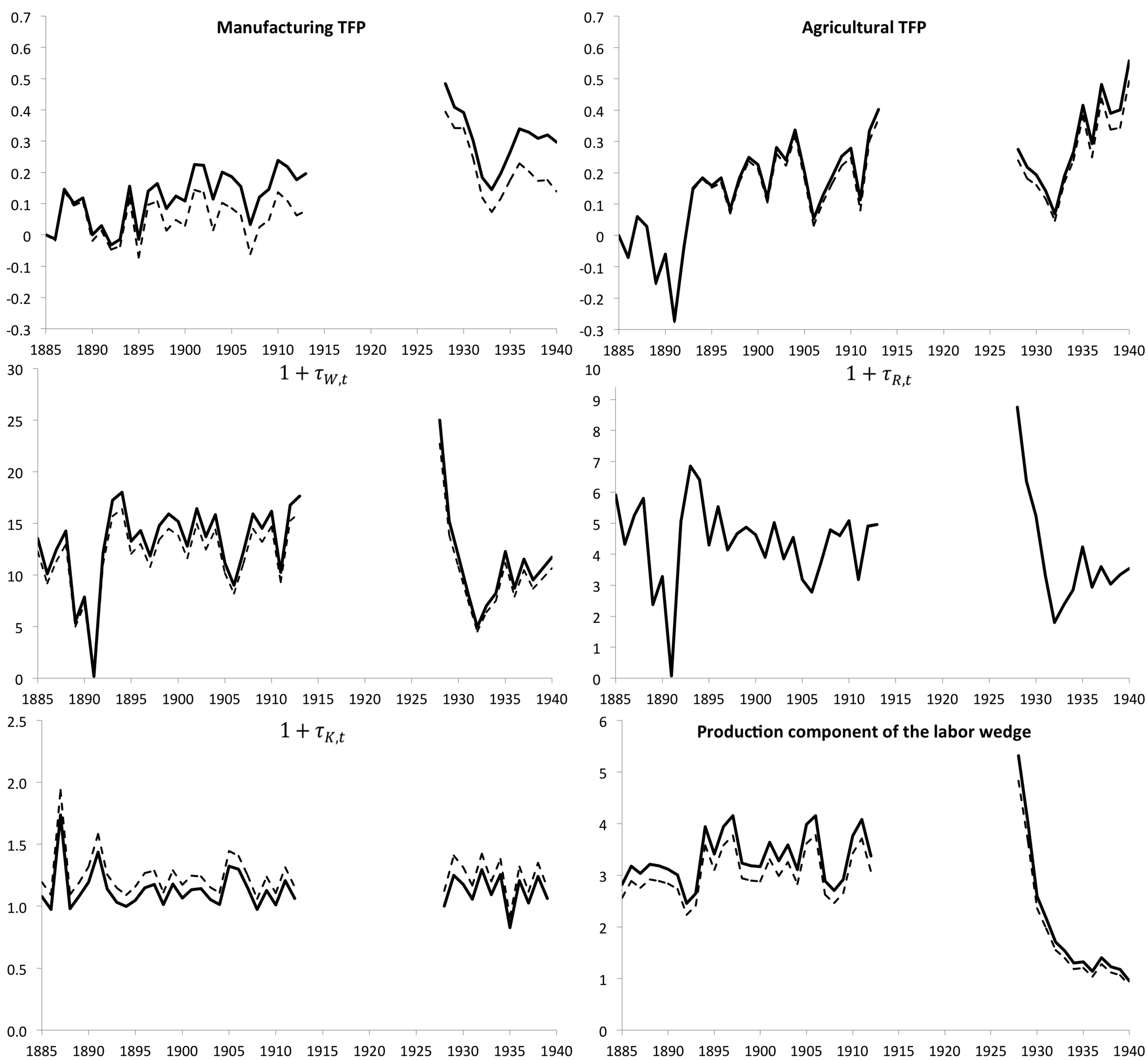


Figure 4: Baseline (solid line) and robustness check $\alpha_{N,M} = \alpha_{N,A} = \alpha_{K,M} = 0.5$, $\alpha_{K,A} = 0.31$ (dashed line).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	4.9	-21.1	3.3	-8.6
2. Manufacturing TFP, X_M	-2.3	-17.2	0.6	-4.7
3. Labor distortion, τ_W	-5.3	10.0	-15.7	25.6
4. Capital distortion, τ_R	-0.8	4.0	-0.8	9.4
5. Investment distortion, τ_K	-3.5	6.1	-5.0	8.1
6. Defense spending	-1.8	5.5	-2.6	6.7
7. Foreign trade	-4.2	8.8	-2.1	5.3
8. Population growth	-1.0	2.6	-0.9	2.5
9. Expectations, κ	-0.2	0.6	-0.2	0.5
10. Capital accumulation, K_0	4.2	-14.6	4.7	1.1
Total	-10.1	19.2	-18.6	46.0

Table 7: Robustness checks: $\alpha_{N,M} = \alpha_{N,A} = \alpha_{K,M} = 0.5$, $\alpha_{K,A} = 0.31$.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	7.0	2.4	4.8	6.2
Production components	-17.7	19.6	-24.4	35.5
Mobility component	4.0	-8.0	3.1	-6.6

Table 8: Robustness checks: $\alpha_{N,M} = \alpha_{N,A} = \alpha_{K,M} = 0.5$, $\alpha_{K,A} = 0.31$.

1.5 CES production functions

In this Section we evaluate the quantitative role of changes in factor shares in the production functions over time. One natural way to introduce changes in factor shares during the process of development and structural change is to assume a non-unit elasticity of substitution between capital and labor in the production function.

While our baseline Cobb-Douglas production function (with unit elasticity of substitution $\lambda_i = 1$) is a standard baseline assumption in the studies of structural transformation, detailed estimates of production functions for developed countries indicate that the elasticities of substitution between capital and labor may differ noticeably from unity both in the agricultural and the non-agricultural sectors. Herrendorf, Herrington and Valentinyi (2015) estimate the

CES parameter at around 0.8 in the non-agricultural sector, and at 1.58 in the agricultural sector from postwar U.S. data. To understand the effects of productive complementarities on our results, we extend the specification for the production functions as follows:

$$Y_t^i = F_i(K_t^i, N_t^i) = X_t^i \left(\left(\frac{\alpha_{K,i}}{\alpha_{K,i}+\alpha_{N,i}} \right)^{\frac{1}{\lambda_i}} \left(K_t^i\right)^{\frac{\lambda_i - 1}{\lambda_i}} + \left(\frac{\alpha_{N,i}}{\alpha_{K,i}+\alpha_{N,i}} \right)^{\frac{1}{\lambda_i}} \left(N_t^i\right)^{\frac{\lambda_i - 1}{\lambda_i}} \right)^{\frac{\lambda_i}{\lambda_i - 1}(\alpha_{K,i}+\alpha_{N,i})}.$$

We preserve the factor shares $\alpha_{K,i}$ and $\alpha_{N,i}$ from the baseline specification, but set $\lambda_A = 1.58$ and $\lambda_M = 0.8$. We recompute all the variables affected by these changes (i.e. the TFPs in the two sectors, and the production components of the labor and capital wedges). We then compare them with the baseline estimates. The results are shown in Figure 5. We do not redo the wedge accounting exercise with the new parameters and the new wedges since the paths are not substantially different, and redoing the exercise for this case is particularly computationally challenging. The changes in the degree of substitutability between capital and labor have a minimal effect on all the TFPs and wedges. Therefore, our assumption that factor shares are constant over time is unlikely to play an important role in our baseline results.

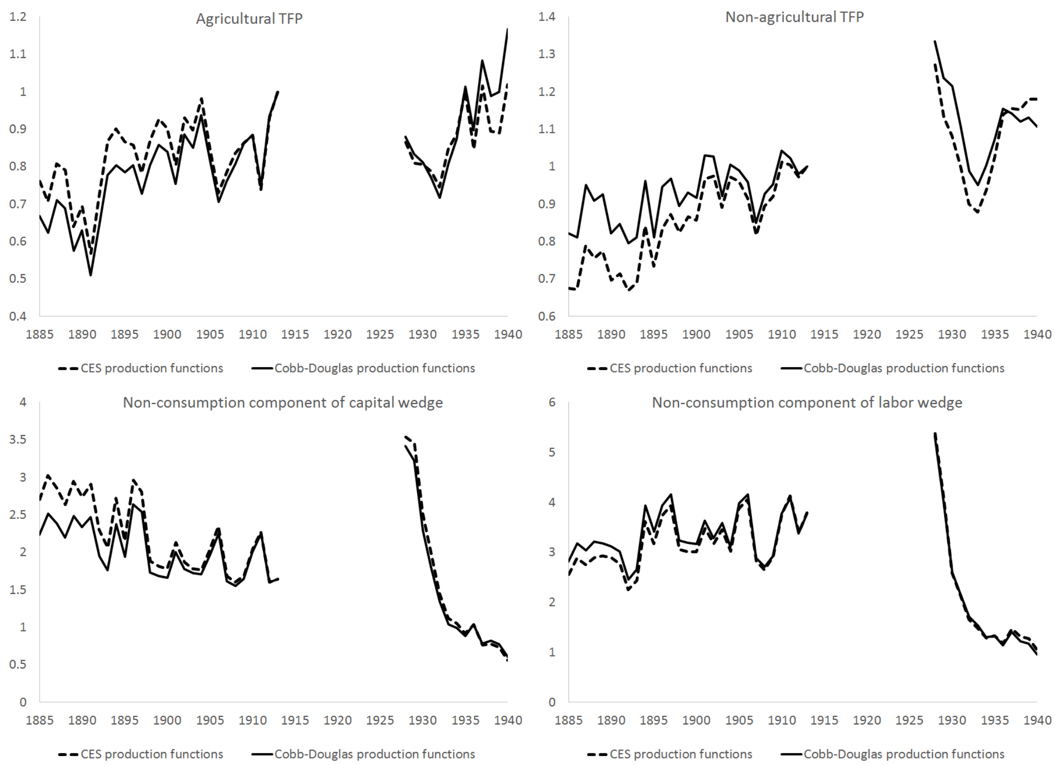


Figure 5: Effect of CES production function on wedges and TFPs.

1.6 Capital stock data

In this Section we consider the alternative series for the sectoral composition of the capital stock. While the data on the total capital stock seem to be reasonably reliable, the attribution of capital to agricultural and non-agricultural activities may be more arbitrary. We perform the following robustness check. Instead of $K^M_{1928} = 0.4K_{1928}$ observed in the data (Moorsteen and Powell (1966)) we assume that both agricultural and non-agricultural capital stocks were equal to the half of the total capital stock K_{1928} (without changing the latter). Then we apply sectoral investment time series for 1928-1940 from Moorsteen and Powell to reconstruct the K^A_t and K^M_t series for 1928-40.

The results are similar to those in the baseline. The magnitudes of contributions of individual wedges change but their signs and relative importance remain the same.

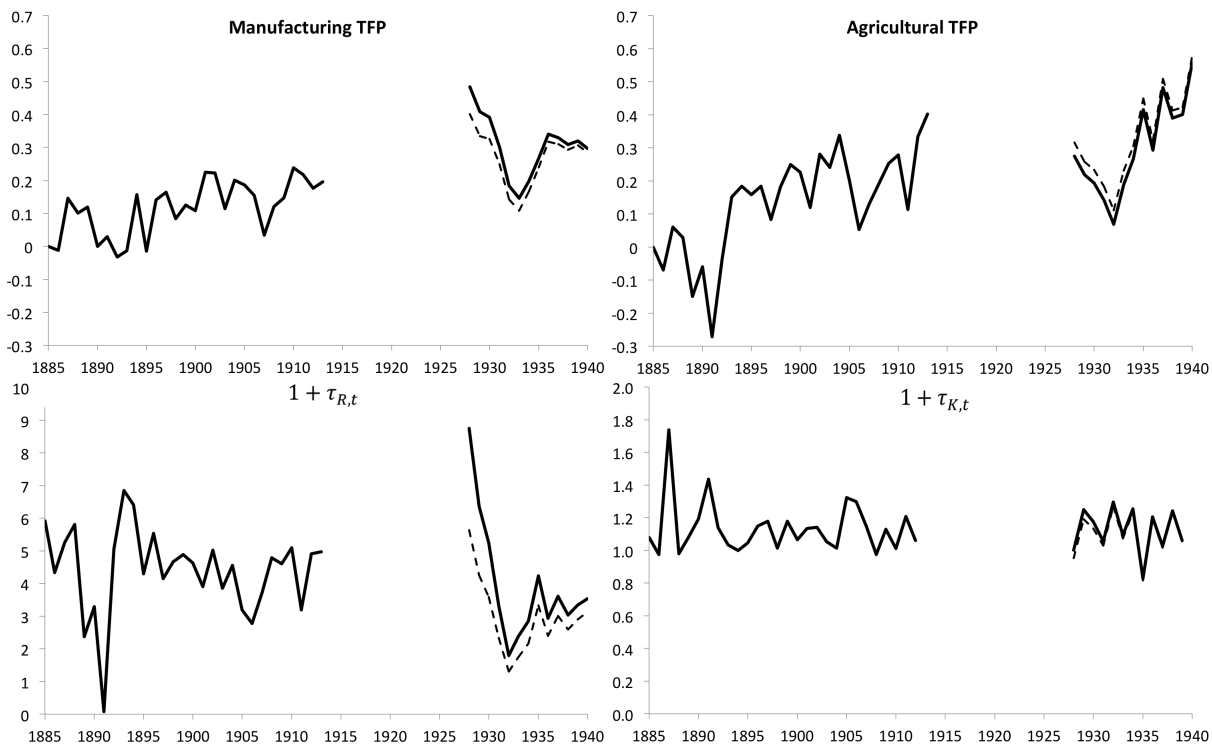


Figure 6: Baseline (solid line) and robustness check with alternative estimates of sectoral capital stock in 1928 (dashed line).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	4.3	-17.2	2.9	-7.0
2. Manufacturing TFP, X_M	-0.3	-6.3	1.6	-16.3
3. Labor distortion, τ_W	-6.2	13.0	-19.4	36.0
4. Capital distortion, τ_R	1.1	-2.2	-0.3	2.3
5. Investment distortion, τ_K	-2.4	7.3	-0.2	3.9
6. Defense spending	-1.3	4.0	-2.2	5.5
7. Foreign trade	-3.0	5.7	-0.5	1.4
8. Population growth	-0.5	1.4	-0.5	1.3
9. Expectations, κ	-2.1	5.6	-2.0	5.5
10. Capital accumulation, K_0	1.4	-5.2	2.2	5.1
Total	-9.2	6.1	-18.5	37.6

Table 9: Alternative sectoral capital stock series.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	6.3	0.9	4.1	5.1
Production components	-15.0	16.7	-26.6	38.6
Mobility component	3.6	-6.8	2.7	-5.4

Table 10: Alternative sectoral capital stock series.

1.7 Adjustment for rural housing

In this Section, we check the sensitivity of our results to excluding rural housing from the agricultural capital stock. The data for rural housing before 1913 are not available, so we use Moorsteen and Powell's estimates of the share of rural housing in the agricultural capital stock for 1928-40 and extrapolate it for tsarist Russia.

Once again, the results are qualitatively the same — neither the signs nor the relative importance of contributions change.

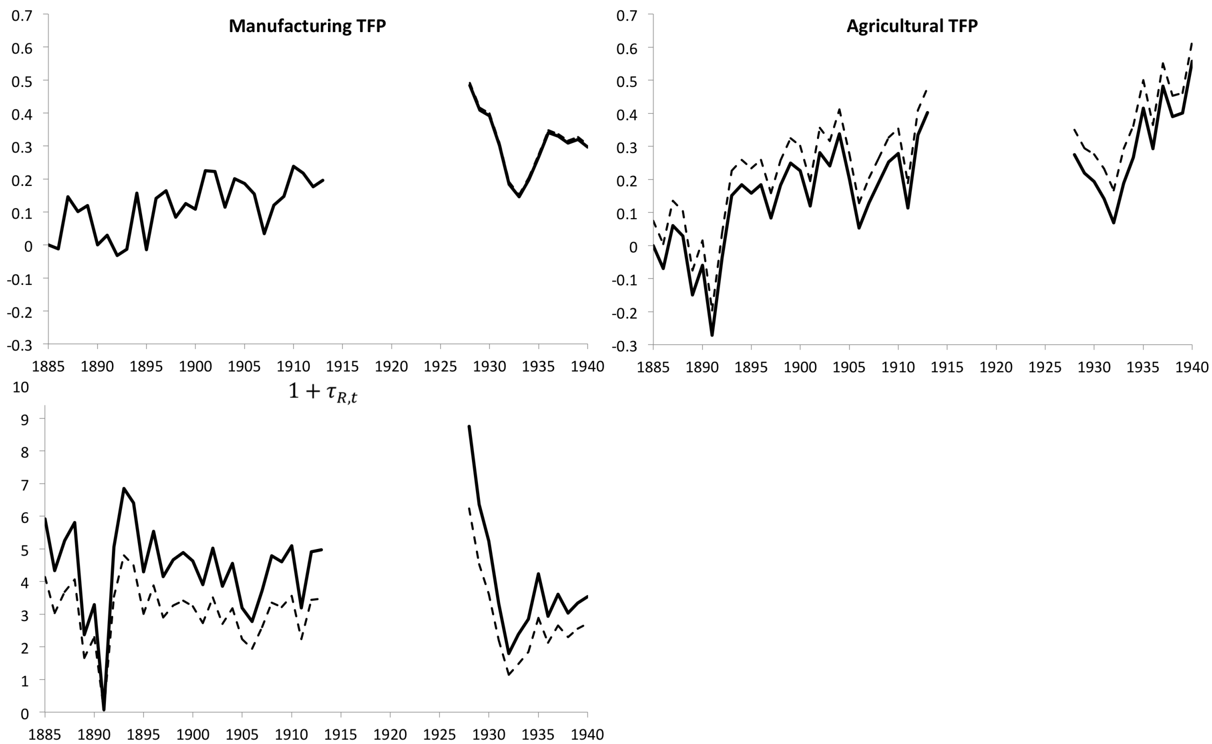


Figure 7: Baseline (solid line) and robustness check with exclusion fo rural housing from the agricultural capital stock (dashed line).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	4.9	-19.8	3.1	-6.3
2. Manufacturing TFP, X_M	-0.6	-3.1	2.0	-19.2
3. Labor distortion, τ_W	-5.8	12.1	-18.3	36.1
4. Capital distortion, τ_R	-0.2	1.4	0.6	1.4
5. Investment distortion, τ_K	-2.0	3.5	-3.3	5.4
6. Defense spending	-1.2	3.7	-2.1	5.2
7. Foreign trade	-3.0	5.6	-0.7	1.5
8. Population growth	-0.5	1.5	-0.5	1.3
9. Expectations, κ	-1.9	5.2	-1.9	5.1
10. Capital accumulation, K_0	1.3	-4.7	2.4	4.8
Total	-9.1	5.3	-18.6	35.3

Table 11: Rural housing excluded from agricultural capital stock.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	7.3	-2.1	5.1	2.3
Production components	-16.9	22.9	-25.7	40.9
Mobility component	3.6	-7.2	2.8	-5.7

Table 12: Rural housing excluded from agricultural capital stock.

1.8 Off-farm employment of rural workers

In this robustness check we allow for off-farm employment of rural workers. We assume that 10 percent of agricultural labor force work in the non-agricultural sector (the estimate of 10% comes from Moorsteen-Powell, 1966, p. 645, Table Q-2). We therefore decrease N_t^A by 10 percent and increase N_t^M by $0.1N_t^A$ in each year.

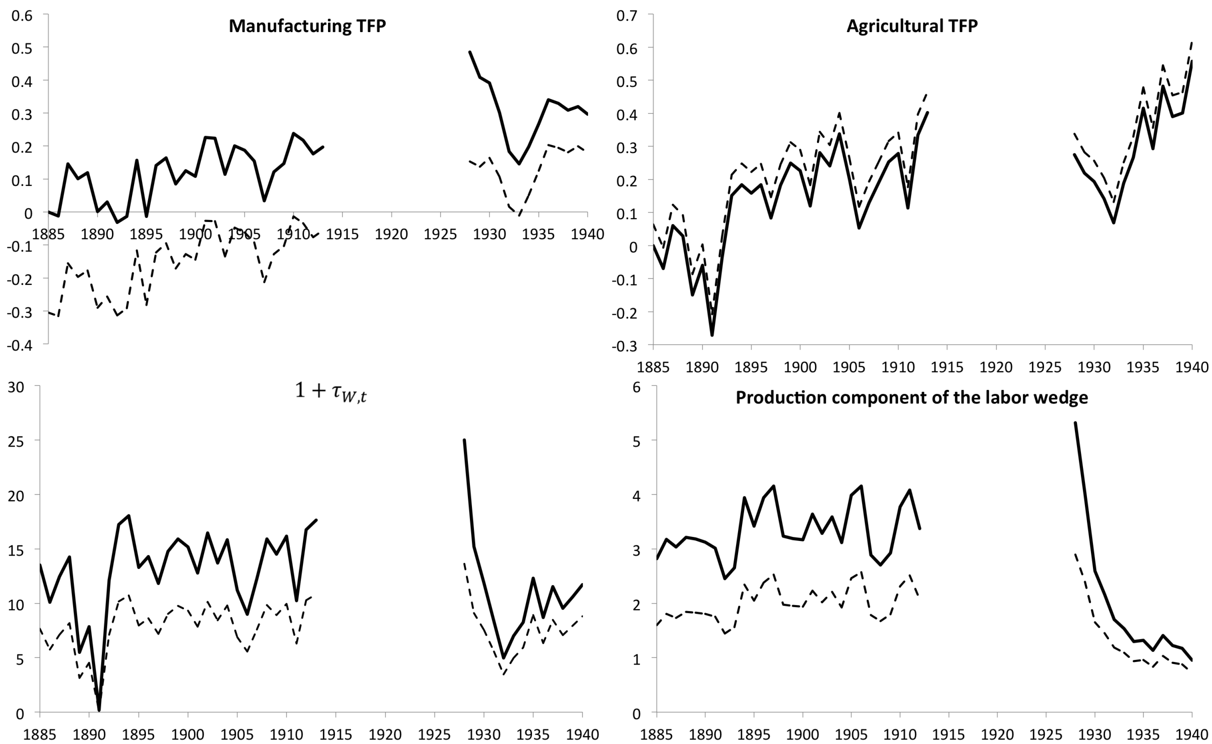


Figure 8: Baseline (solid line) and robustness check with 10% off-farm employment of rural workers (dashed line).

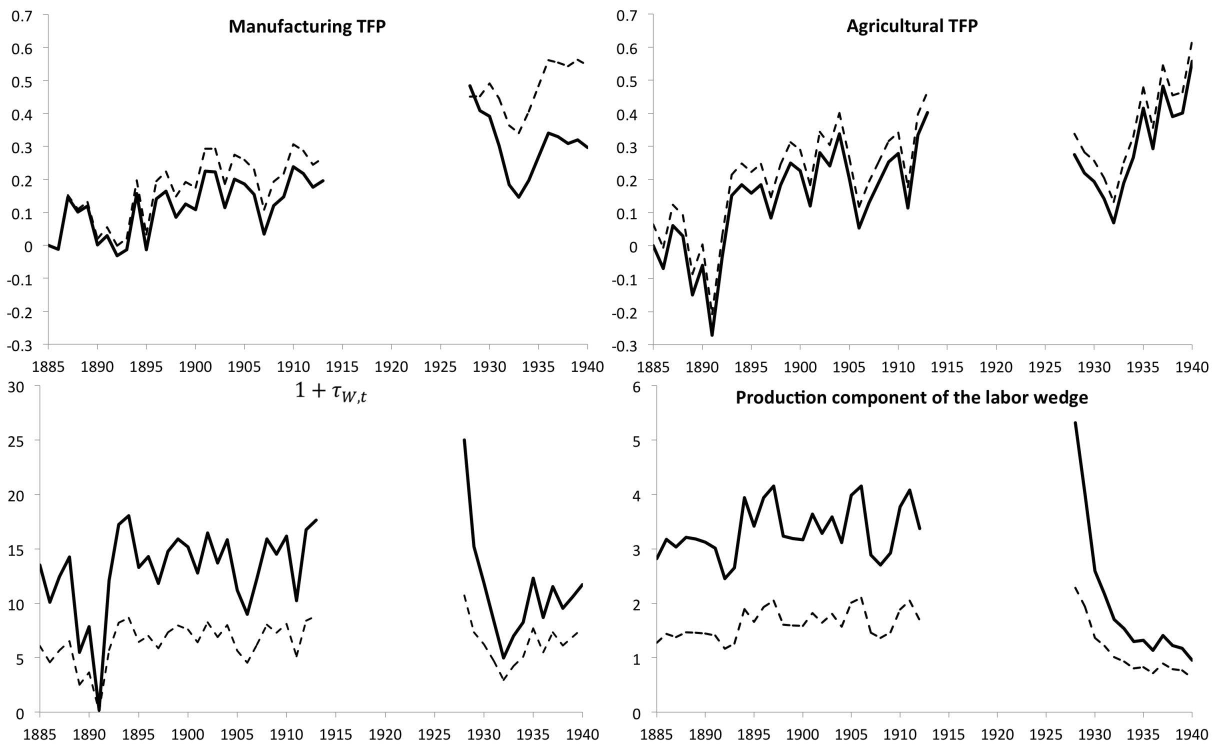


Figure 9: Baseline (solid line) and robustness check with 15% off-farm employment of rural workers (dashed line).

Nafziger (2010, 2012) provides a different estimate: 40% for men and 10% for women (thus about 25% on average). However, his data come from the Moscow region (more specifically, from the Central Industrial Region) which was more industrialized and offered more opportunities for non-agricultural employment. Crisp (1978, p. 331) argues that this ratio is about 1.5 times as low in European provinces – and probably even lower in non-European provinces. This implies the average rate of off-farm non-agricultural employment was somewhere in the 10-15% range. In addition to the test with 10% off-farm employment we have also carried out a test with 15% employment and found similar results. Given the discussion above, however, the 15% off-farm employment rate should be treated as an upper bound.

The results for both 10% and 15% are presented in Figures 8-9 and Tables 13-16. Overall, the results are similar to those in the baseline specification. The production component of the labor wedge is still the major driver of the structural change.

The only important difference is that in the Figure 8 the non-agricultural productivity does not fall in 1928-1940 and in the Figure 9 it even increases in this period. This is driven by the fact that these scenarios result in a much slower growth of non-agricultural employment relative to the baseline scenario. While in our baseline data the non-agricultural employment triples in 1928-1940 (from 10.5 to 30.2 million people), the assumption of 15% off-farm employment actually implies only doubling it (from 20.8 to 39.0 million workers).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	5.1	-17.7	2.9	-5.2
2. Manufacturing TFP, X_M	-0.8	1.8	0.2	-3.2
3. Labor distortion, τ_W	-2.6	6.9	-14.2	19.8
4. Capital distortion, τ_R	0.5	-0.5	0.3	3.5
5. Investment distortion, τ_K	-1.9	2.1	-2.2	2.5
6. Defense spending	-1.5	3.7	-2.4	4.9
7. Foreign trade	-2.7	3.3	0.1	-0.1
8. Population growth	-0.5	1.1	-0.4	1.0
9. Expectations, κ	-2.7	5.6	-2.6	5.5
10. Capital accumulation, K_0	1.1	-3.7	2.3	6.4
Total	-6.0	2.6	-16.0	35.2

Table 13: Robustness checks: 10% off-farm employment.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	7.3	-0.1	4.7	3.3
Production components	-13.1	11.6	-21.0	24.0
Mobility component	3.6	-5.2	2.4	-4.0

Table 14: Robustness checks: 10% off-farm employment.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	5.0	-16.8	2.4	-3.8
2. Manufacturing TFP, X_M	-0.8	3.8	0.2	1.6
3. Labor distortion, τ_W	-0.8	4.2	-12.8	14.4
4. Capital distortion, τ_R	1.2	-2.2	1.0	2.2
5. Investment distortion, τ_K	-1.4	0.6	-1.6	1.0
6. Defense spending	-1.8	4.0	-2.8	5.0
7. Foreign trade	-3.6	4.6	-0.6	1.6
8. Population growth	-0.4	0.8	-0.4	0.8
9. Expectations, κ	-3.2	6.4	-3.2	6.2
10. Capital accumulation, K_0	1.2	-3.8	2.4	7.2
Total	-4.6	2.0	-15.6	35.2

Table 15: Robustness checks: 15% off-farm employment.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	8.6	-0.6	5.8	2.4
Production components	-12.2	7.8	-20.6	18.6
Mobility component	4.0	-5.4	2.6	-4.2

Table 16: Robustness checks: 15% off-farm employment.

1.9 Alternative wage series

In this Section we check robustness of our results to using alternative wage series for the tsarist period. We use Strumilin's data for the wages in the largest industrial enterprises (Strumilin 1982, p. 291). These data are only available for 1900-1913; we merge these series with our baseline data for 1885-1900 assuming proportional changes over time.

The results shown in Tables 17-18 are virtually the same as in the baseline specification. By definition, only production component of the labor wedge and the labor wedge's mobility component are affected. In Figure 10 we only show the production component (the impact on the mobility component is a mirror image).

We also check whether our results are robust to the changes in wages in 1928-1940. Our baseline data on relative wages come from Allen (2003, Table 7.4), who shows a modest decline of relative standard of living in agriculture. We check what the wedges would be in the absences of this decline: we fix the relative wages at the 1928 level for the whole 1928-40 period. The results presented in Tables 19-20 are also very similar to the baseline. The contribution of the mobility distortion falls, and contributions of other labor wedges adjust accordingly. The production component still plays a dominant role.

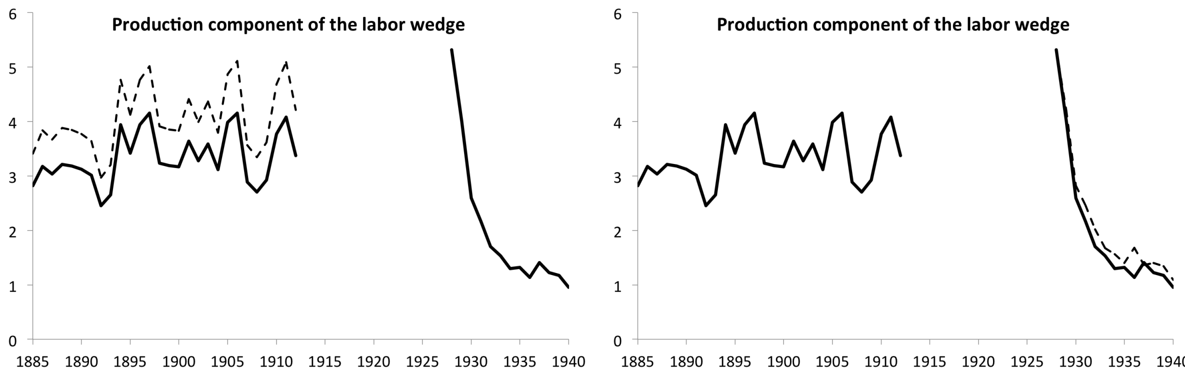


Figure 10: Baseline (solid line) and robustness check (dashed line). The left-hand side graph presents the production component of the labor wedge for the alternative time series of wages for 1885-193, the right-hand side one - for the alternative time series of wages for 1928-1940.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	4.8	-20.2	3.2	-7.0
2. Manufacturing TFP, X_M	-0.7	-2.6	2.0	-19.3
3. Labor distortion, τ_W	-6.2	13.3	-18.9	37.6
4. Capital distortion, τ_R	0.4	0.4	0.3	4.3
5. Investment distortion, τ_K	-1.9	3.2	-2.3	3.9
6. Defense spending	-1.3	3.7	-2.1	5.3
7. Foreign trade	-3.0	5.7	-0.6	1.2
8. Population growth	-0.5	1.5	-0.5	1.4
9. Expectations, κ	-2.1	5.6	-2.1	5.5
10. Capital accumulation, K_0	1.3	-4.7	2.4	4.8
Total	-9.2	6.1	-18.5	37.6

Table 17: Robustness checks: Alternative wage series for the tsarist period.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	6.5	0.0	4.1	5.0
Production components	-20.3	30.2	-26.1	44.8
Mobility component	8.0	-16.5	3.4	-8.0

Table 18: Robustness checks: Alternative wage series for the tsarist period.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	4.9	-19.8	3.3	-6.6
2. Manufacturing TFP, X_M	-0.7	-2.6	2.0	-19.4
3. Labor distortion, τ_W	-6.2	13.2	-18.8	37.4
4. Capital distortion, τ_R	0.3	0.2	0.2	4.2
5. Investment distortion, τ_K	-1.9	3.2	-2.3	3.9
6. Defense spending	-1.3	3.7	-2.1	5.3
7. Foreign trade	-3.0	5.7	-0.6	1.1
8. Population growth	-0.6	1.5	-0.5	1.4
9. Expectations, κ	-2.1	5.6	-2.1	5.5
10. Capital accumulation, K_0	1.3	-4.7	2.4	4.8
Total	-9.2	6.1	-18.5	37.6

Table 19: Robustness checks: Fixed wages in 1928-40.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	6.5	-0.1	4.1	4.9
Production components	-13.3	15.4	-22.7	36.8
Mobility component	1.0	-1.9	0.1	-0.3

Table 20: Robustness checks: Fixed wages in 1928-40.

1.10 Demographics

Finally, we check the robustness to our definition of labor force. In the baseline scenario, we have removed all invididuals reported as out-of-labor-force in the censuses. We ended up with the ratio of total employment to population χ_t around 0.51. In this robustness check, we count all able-bodied population as labor force and therefore use $\chi_t = 0.53$. There only very minor quantitative changes in the results but no qualitative changes.

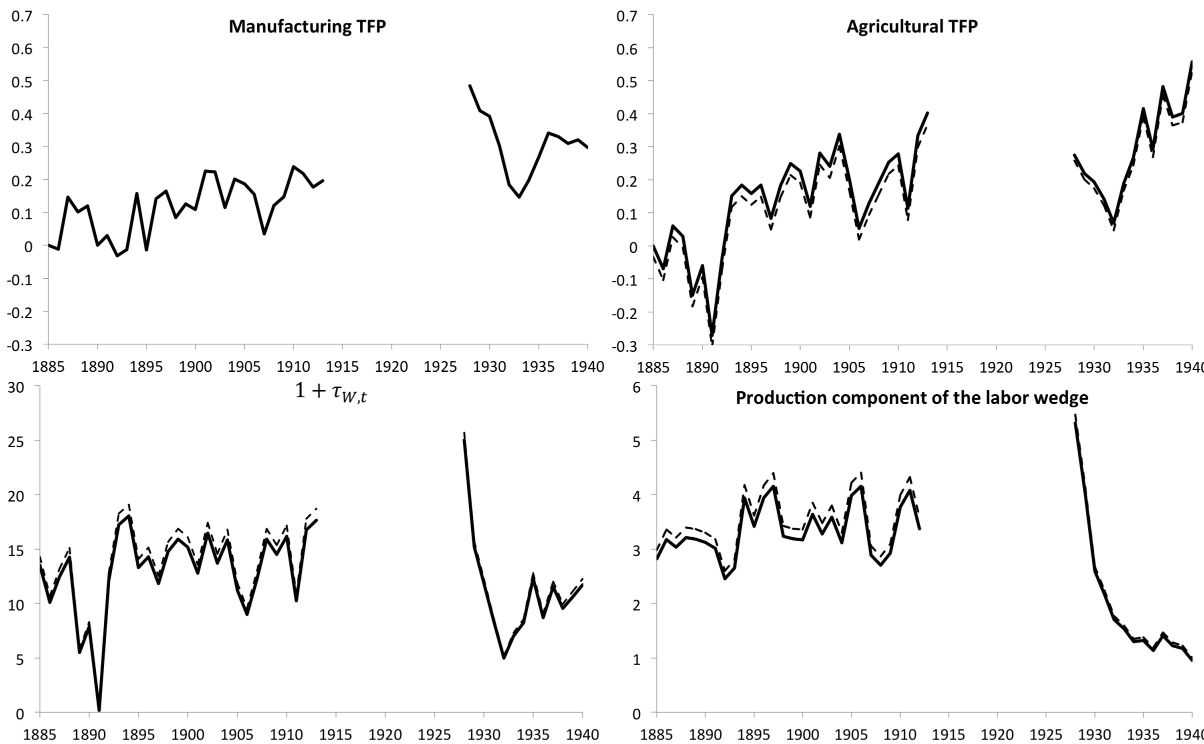


Figure 11: Baseline (solid line) and robustness check with alternative assumptions on the composition of the labor force (dashed line).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	4.7	-19.5	3.3	-7.6
2. Manufacturing TFP, X_M	-0.7	-2.5	1.9	-19.4
3. Labor distortion, τ_W	-6.4	14.4	-18.3	38.2
4. Capital distortion, τ_R	0.4	0.2	0.3	4.2
5. Investment distortion, τ_K	-1.8	3.2	-2.3	4.0
6. Defense spending	-1.2	3.8	-2.0	5.4
7. Foreign trade	-3.0	6.0	-0.6	1.3
8. Population growth	-0.6	1.6	-0.5	1.5
9. Expectations, κ	-2.1	5.7	-2.0	5.6
10. Capital accumulation, K_0	1.3	-4.9	2.4	4.5
Total	-9.4	8.0	-17.7	37.6

Table 21: Robustness checks: demography.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	6.3	0.0	4.0	5.2
Production components	-15.9	21.8	-24.7	42.9
Mobility component	3.5	-7.2	2.7	-5.7

Table 22: Robustness checks: demography.

1.11 Human capital

In this Section, we discuss the role of human capital. In our framework, costly acquisition of human capital can contribute to the mobility component of the labor wedge. Indeed, if the non-agricultural sector has higher returns to skills than the agricultural one, the ratio of wages in non-agricultural and agricultural sector will be different from unity.[1]

In order to quantify the contribution of human capital to wedges, we need the data on the returns to skills and on the stock of human capital in each sector. The data on skills distribution between agricultural and non-agricultural sectors in Russia are very limited. We have used data from 1897, 1926, and 1939 censuses to calculate the literacy separately in rural

[1]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 and Allen (2003) for a discussion of the role of skill acquisition in the Russian economy.

and urban areas. For the population 9-49 years of age, the average literacy in 1897 was 24.6 percent in rural areas and 60.9 percent in urban areas. In 1926 these rates were 55.0 and 85.0 percent, respectively. In 1939 these were 86.7 and 94.9 percent. We assume that in 1885-1913 the literacy rates were the same as in 1897 census. In 1928-1939 we have interpolated the literacy rates using 1926 and 1939 data points.

In order to estimate the returns to literacy, we have used the cross-sectional studies of Moscow region (1909) and Vladimir region (1897) by Kozminykh-Lanin (1912a,b). Kozminykh-Lanin shows that the difference between the wages of literate and illiterate urban workers was 11-13%. We use the upper bound of 13% in the non-agricultural sector; we assume zero returns to literacy in the agricultural sector.

Given these returns to skills and allocation of skills across sectors, we re-calculate all the wedges in model with human capital. As the manufacturing TFP is not directly comparable between the baseline and robustness exercises, we normalize the TFP to zero in 1885 in each case. The difference is very small (results are available upon request). It is not surprising: the change in non-agricultural productivity growth rate due to increased literacy was only 0.1% per year in both 1897-1926 and 1926-1939.

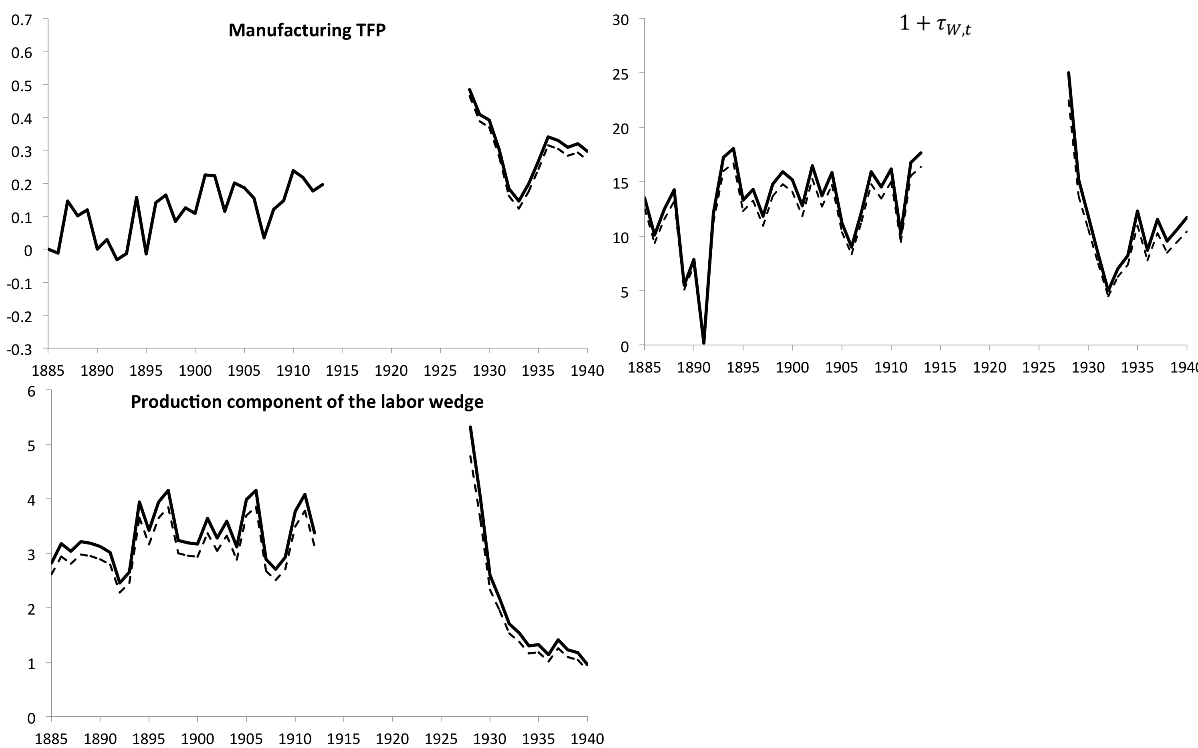


Figure 12: Baseline (solid line) and robustness check (dashed line).

1.12 Alternative definition of Tsarist trend

In this robustness check we change the assumptions about the way tsarist trend is computed. In the baseline we assumed that TFPs in both sectors grow at a constant pre-1913 from 1913 to 1940. We fixed the levels of wedges at their average pre-1913 levels for the post-1913 period. In this robustness check we instead allow the wedges also to have trends. In particular, we assume that the wedges, like TFP, follow their pre-1913 log-trends from 1913 to 1940. We show the baseline and alternative paths of wedges and their components in Figure 13. We recompute the decompositions from the main text and show them in Tables 23-24. The differences with the baseline simulation mainly stem from the differences in trends in the productio and mobility component. As production component trends up and mobility component trends down, the positive contribution of the reduction of the production component is larger, and the mobility component contributes negatively. The overall magnitudes and signs of the main effects are the same. Our main results are somewhat strengthened.

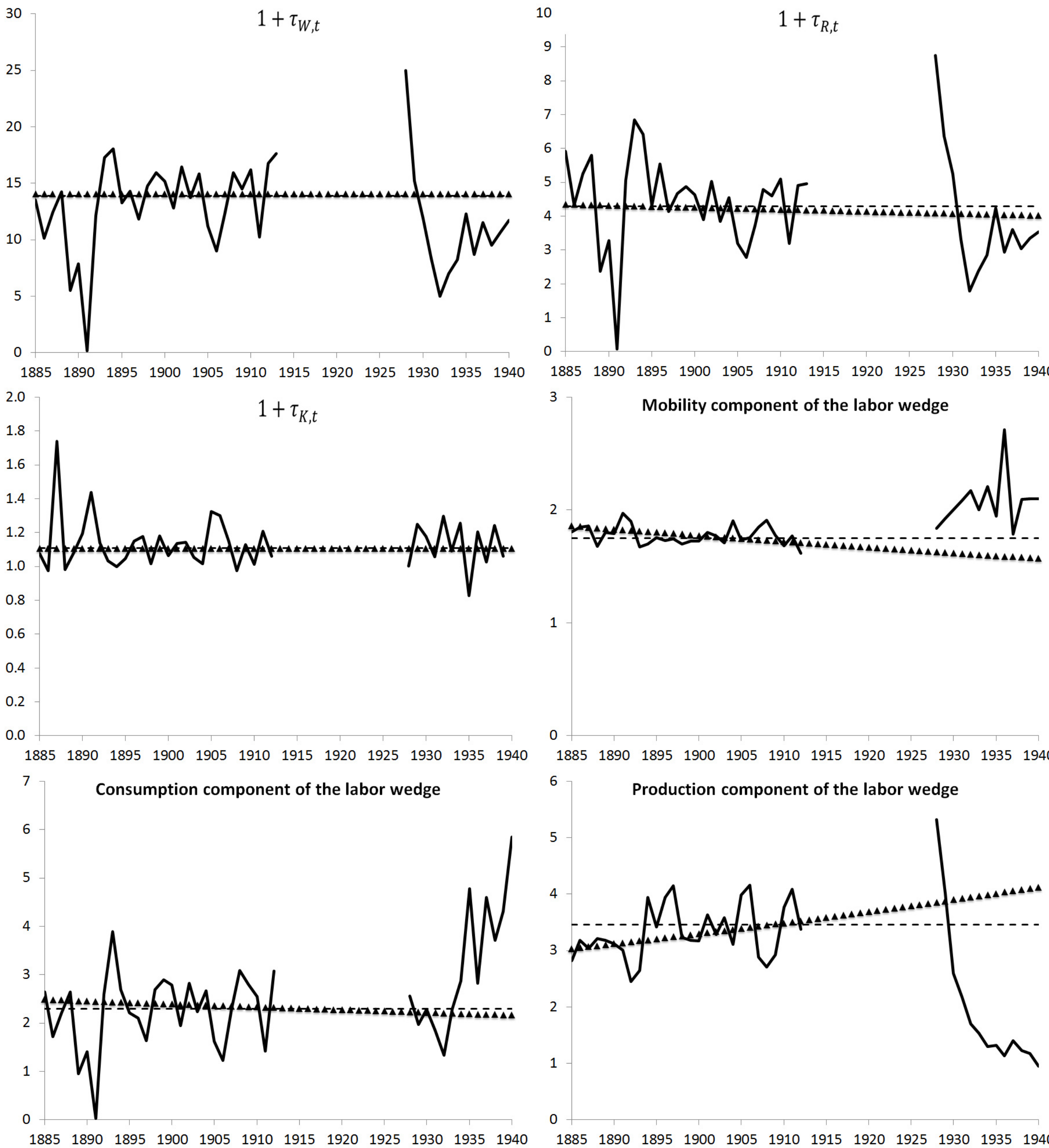


Figure 13: Data (solid line), baseline Tsarist trend (dotted line), and alternative Tsarist trend (triangles).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	5.0	-17.8	3.6	-4.4
2. Manufacturing TFP, X_M	-0.6	-3.3	2.1	-19.7
3. Labor distortion, τ_W	-6.5	12.9	-19.0	36.5
4. Capital distortion, τ_R	-0.1	0.7	0.1	4.2
5. Investment distortion, τ_K	-1.9	3.7	-2.2	4.1
6. Defense spending	-1.3	3.8	-2.1	5.3
7. Foreign trade	-2.9	5.3	-0.6	0.7
8. Population growth	-0.5	1.3	-0.4	1.2
9. Expectations, κ	-2.2	6.0	-2.2	5.9
10. Capital accumulation, K_0	1.1	-4.2	2.1	4.2
Total	-9.8	8.4	-18.5	38.0

Table 23: Robustness check: alternative wedge trends.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	7.7	-2.1	5.1	3.8
Production components	-20.4	25.8	-28.1	42.6
Mobility component	6.1	-10.1	4.0	-5.7

Table 24: Robustness check: alternative wedge trends.

2 Sensitivity to individual wedges

In all the experiments above, we calculate the contribution of change in each wedge in the following way. We start with the counterfactual values of wedges and sequentially change each wedge to the its value observed in the data. Eventually, we end up with all wedges set to their actual values from the data. We average out the different sequences of adding individual wedges through calculating the Shapley value for each wedge's contribution.

In Table 25 and 26 we use an alternative approach. For each individual wedge, we calculate its marginal contribution by changing its value from actual to counterfactual value holding all other wedges at their actual values. The results are qualitatively similar to those in the baseline (Tables 1 and 2).

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
1. Agricultural TFP, X_A	5.5	-19.8	4.8	-6.4
2. Manufacturing TFP, X_M	-0.1	-4.3	2.8	-21.8
3. Labor distortion, τ_W	-1.0	14.4	-13.8	42.8
4. Capital distortion, τ_R	1.9	-4.8	1.2	1.5
5. Investment distortion, τ_K	-0.6	-0.1	-0.7	0.3
6. Defense spending	-1.2	3.8	-1.9	5.9
7. Foreign trade	-3.0	5.6	-0.9	-0.9
8. Population growth	-0.1	0.4	0.0	0.1
9. Expectations, κ	-3.4	9.4	-3.3	9.2
10. Capital accumulation, K_0	0.3	-2.4	2.1	3.1
Total	-1.7	2.2	-10.0	33.8

Table 25: Marginal contributions of individual wedges in the neighborhood of the actual data series.

	Share of employment in agriculture	GDP per capita	Share of employment in agriculture	GDP per capita
	1939 level		1928-39 change	
	p.p.	percent	p.p	percent
Consumption component	9.1	-7.2	6.0	1.4
Production components	-12.2	25.2	-21.9	49.2
Mobility component	4.1	-8.5	3.2	-6.3

Table 26: Marginal contributions of components wedges in the neighborhood of actual data series.

3 Comparison of Russian economy in 1913 and 1928

We showed that non-agricultural productivity was higher in 1928 than in 1913, while agricultural productivity was lower. We also find that the intersectoral distortions were higher in 1928 than in 1913. In this section we review the available evidence about the structure of Russian economy in 1913 and 1928. Our overall conclusion is that the evidence supports our qualitative findings, while there remains uncertainty about their quantitative magnitude.

We start with non-agricultural productivity. Assuming that non-agriculture has constant returns to scale in capital and labor, we can decompose the rate of change in manufacturing

TFP as

$$\Delta \ln X^M = \Delta \ln \frac{Y}{N} + \Delta \ln \frac{Y^M}{Y} - \Delta \ln \frac{N^M}{N} - \alpha_{K,M} \Delta \ln \frac{K^M}{N^M},$$

where N is the total labor force. In our data non-agricultral productivity changes between 1913 and 1928 primarily because the share of non-agricultural labor force $\frac{N^M}{N}$ decreased; all other components show little change between 1913 and 1928. Next, we review available data on the behavior of components on the right hand side of the equation above.

There is general agreement in the literature that the structure of Russian economy in 1928 was similar to 1913. Markevich and Harrisson (2011) discuss various estimates of real output per capita $\frac{Y}{N}$ in 1928 vs. 1913 in Soviet interwar borders and show that the consensus is around 100 percent. Their own estimate is 97.3 percent. Maddison's estimate is 96.4 percent, Davies et al. (1994, p.42) argue in favor of 100 percent and Gregory estimates are within the 90-100 percent range (Gregory 1990 p. 247). There is less work on the structural composition of Russian economy but a recent comprehensive study by Markevich and Harrisson (2011) finds that $\frac{Y^M}{Y}$ was also essentially the same in 1913 and 1928.

There is more uncertainty about the composition of the labor force and the capital-labor ratio. The primary source for the data on occupational choice is the censuses that were conducted in 1897, 1926, 1939 (and an unpublished one in 1937). The labor force in the other years is extrapolated using available administrative employment and birth and death data. There seems to be a consensus from different sources that the labor share in non-agriculture was lower in 1928 then in 1913. The census data shows that the share of non-agricultural employment was higher in 1897 than it was in 1926 (0.18 vs 0.15-0.17 depending on the exact definition of working age population, Gukhman 1926 p. 250, Davies et al., Table 10). Moreover, there is little doubt that this share increased further by 1913 (Gukhman 1926, Gregory 1982). This evidence strongly suggests that $\frac{N^M}{N}$ was lower in 1928 than in 1913. It is also consistent with the fact that Russia lost its industrial territories of Poland, Western Ukraine and Belarus and acquired agricultural territories in Central Asia after WWI.

The estimates of capital stock in 1928 are less reliable. Soviet statistical agencies started to systematically collect data on investment rates only in 1928. The main source of data for the level of capital stock is Gosplan's survey conducted in 1927-28, which was subsequently used by Moorsteen and Powell in their construction of the estimates of Soviet capital stock. This data, combined with data on occupational choice described above implies that the capital-labor ratio was practically unchanged (to be precise, 6 percent lower) in 1928 than it was in 1913.

The arguments that agricultural productivity was lower is the mirror image of the arguments about non-agricultural productivity. Moorsteen and Powell estimates of capital stock shows that the capital-labor ratio in agriculture was similar in 1913 and 1928. Therefore the decrease in agricultural productivity is primarily driven by the higher share of agricultural employment.[2] Given the fact that the structural composition of the economy was similar in 1913 and 1928, we have

$$\frac{1+\tau_{W,1928}}{1+\tau_{W,1913}} \approx \frac{N_{A,1928}/N_{M,1928}}{N_{A,1913}/N_{M,1913}}, \ \frac{1+\tau_{R,1928}}{1+\tau_{R,1913}} \approx \frac{K_{A,1928}/K_{M,1928}}{K_{A,1913}/K_{M,1913}}.$$

Since agriculture had relatively more capital and labor in 1928 than it had in 1913, the intratemporal wedges must have increased.

[2]Note that since capital-labor did not change, this also implies that the share of capital stock in agriculture was also higher in 1928.

4 Robustness of counterfactual exercise

As a counterfactual exercise we considered the scenario of the Tsarist regime removing the production distortion abruptly in 1914. In this section we consider alternative scenarios in this vein. In particular, we consider what would have happened if Tsarist regime removed the production distortion abruptly in 1890 or gradually from 1890 to 1914. In all three cases, we assume that all TFPs and wedges behave in a way that matches the data until 1913 and follows the baseline Tsarist trend from 1914 to 1940. The only exogenous variable that changes between counterfactuals is the production component of the labor wedge. As shown in Figure 14, the production component: a) drops to 1 in 1914; b) drops to 1 in 1890; c) declines at a constant rate from its 1890 value to 1 in 1914. Figure 15 illustrates the path of the economy in all three cases and compares it with the data. We find that in all three counterfactual exercises the economy quickly converges to the same path after 1914. Thus, there is no accumulated effect that would depend on when and how the distortion was removed.

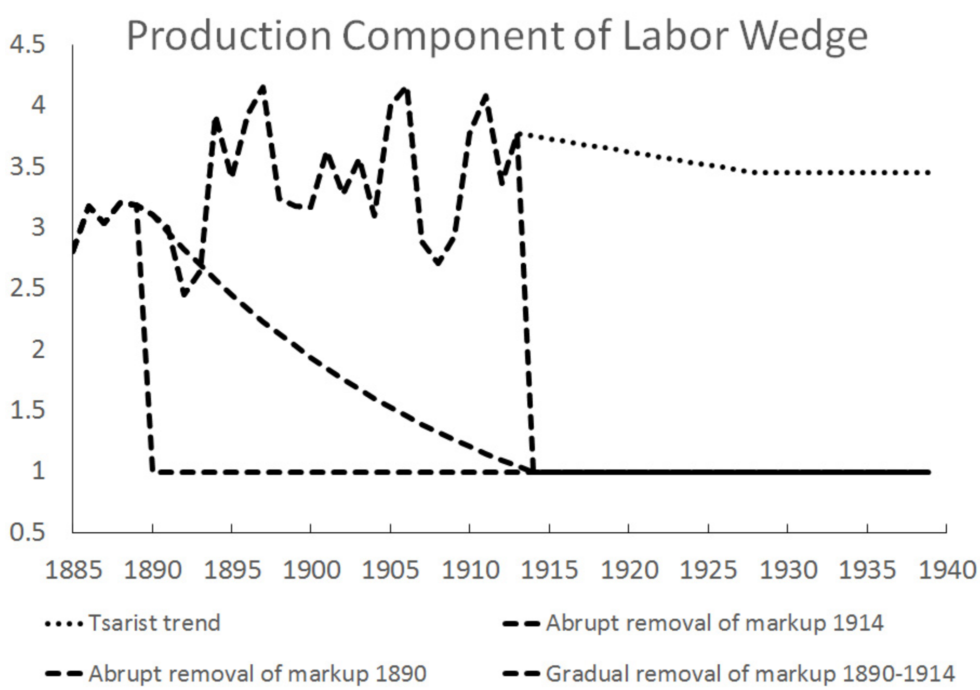
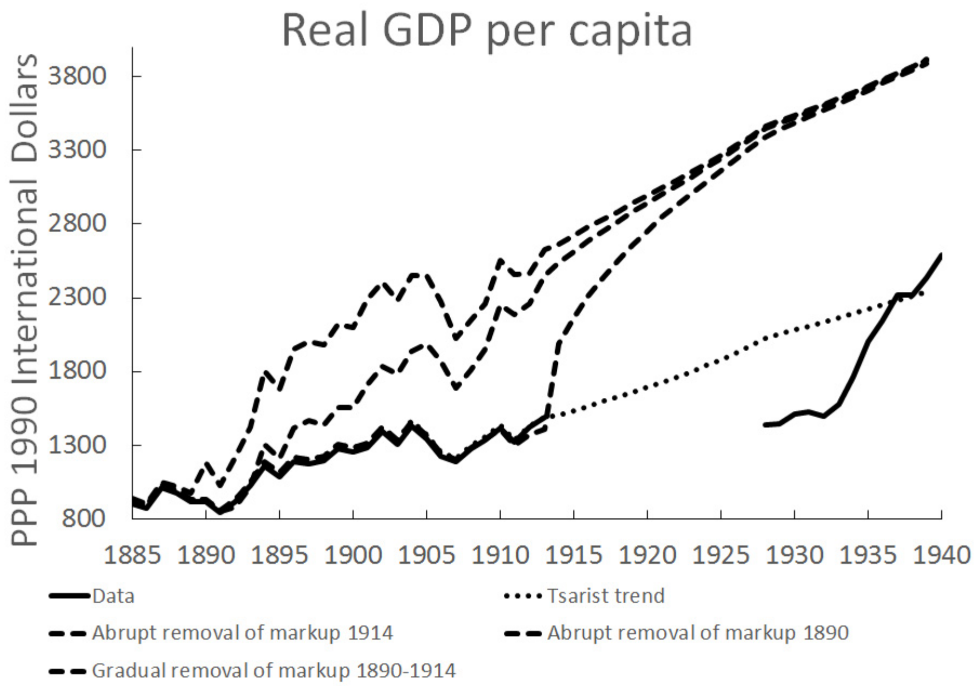


Figure 14: The production component of the labor wedge along Tsarist trend (dotted line) and in three counterfactuals (dashed lines).



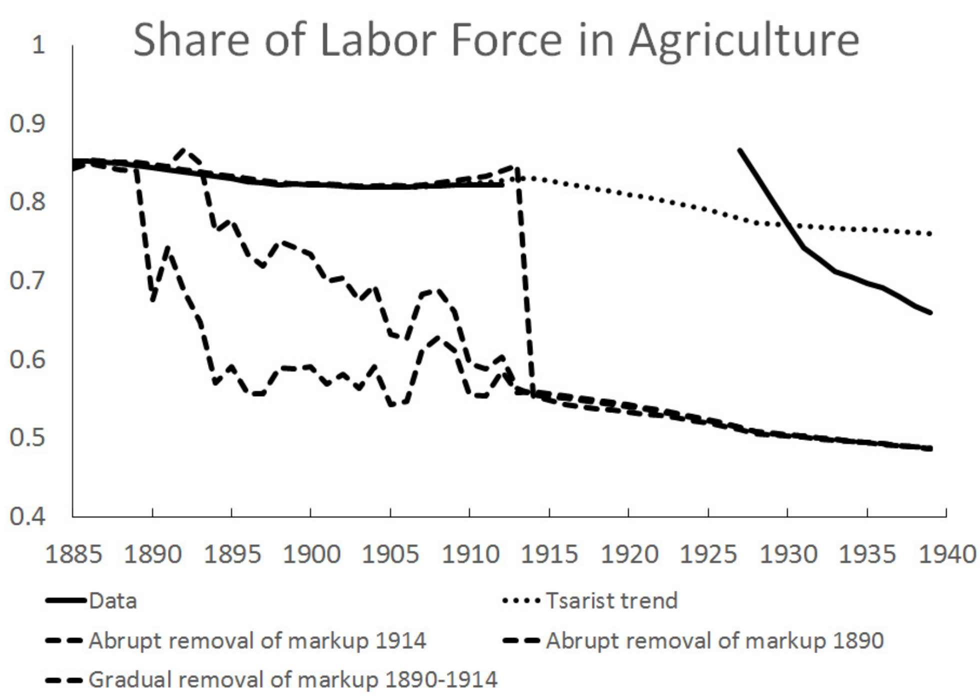


Figure 15: Baseline (solid line) tsarist trend (dotted line) and three counterfactuals (dashed lines). The top graph presents real GDP per capita, and the bottom graph presents the share of labor in agriculture.

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