Looking for Multiple Equilibria in Russian Urban System

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Abstract

This paper studies the effect of the shock to spatial population distribution in the USSR brought by the WWII and Stalinist policies. Using a unique data set on the number of WWII evacuees at the level of city or rural *raion* and the data on locations and size of Gulag labor camps I measure the impact on city growth during Stalin's time. I test whether these shocks were reversed after Stalin's death, when Gulag system was abolished and many restriction on population mobility were lifted, and find no evidence of mean-reversion on average. The city growth dynamics is consistent with multiple equilibria hypothesis: cities that received a lot of investment (as measured by the Gulag population) and many wartime evacuees in the 1930s-1950s, get a permanent growth spurt, while cities that received a smaller shock are more likely to revert to their original growth trajectory. I estimate the elasticity of the threshold shock to location fundamentals as measured by longitude and latitude, and find that it is harder to overcome inertia and make a city grow if it's located further to the north.

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1 Introduction

Models of New Economic Geography starting with Krugman (1991) predict the possibility of multiple stable equilibria in the distribution of economic activity across geographical space. When transport costs are sufficiently low and increasing returns are sufficiently strong, it is beneficial for firms and people to concentrate. But where this concentration will occur? What location will become center, and which would remain periphery? If we start with the common theoretical setting with *a priori* symmetric locations, then either of them can eventually become an agglomeration, i.e. the model produces multiple equilibria.

What makes a location more likely to host an agglomeration in real life? History knows many examples where natural advantage or historical accident determined the future of a city, a region, and therefore, the overall spatial pattern of economic activity in a country. Theoretically, temporary advantage can tilt the distribution of economic activity toward a particular place. Then, capital ana labor would migrate to this location to take advantage of increasing returns. Thus, agglomeration locks itself in, outlives the very factors that created it, and remains a permanent point of attraction for economic activity. The same argument can be applied to switching between equilibria: if we believe in agglomeration externalities, then a temporary intervention can make a peripheral location more attractive, firms and people would come in, then increasing returns would attract more and more capital and labor. This way, it is possible to jump-start the development of a peripheral region with a temporary policy.

How applicable is this simple theoretical story to reality is a question of extreme practical importance. Indeed, if switching between potential spatial equilibria is relatively easy, this means that temporary shocks can permanently alter the spatial economy. In this case, regional policy, in principle, is capable of implementing permanent changes to economic geography landscape with temporary measures. If the opposite is true, i.e the multiple equilibria are rare or the transition from one to another is rather difficult, then we have to accept that regional policy is potent only in short run, only as long as the particular measures are in effect.

Since the famous work by Davis & Weinstein (2002) researchers have tried to find evidence of multiplicity of equilibria using historical events as natural experiments. The examples of Japanese cities (Davis & Weinstein (2002)) and industries (Davis & Weinstein (2008)) suggest that even drastic negative shocks such as WWII destruction in Japan do not trigger the switch to a different equilibrium. Populations and industry shares of the cities exhibit mean-reversion to their prewar trajectories, and there appears to be only one spatial equilibrium. Bosker, Brakman, Garretsen & Schramm (2007) came to the same conclusion in the case of Western German cities - because of the division of Germany they do not exhibit reversion to their pre-war trajectories, but partial mean-reversion is observed, and cities seem to converge to a new (single) equilibrium.[1] On the other hand, the work of Redding, Sturm & Wolf (2011) on airline industry in Germany showed that the main air hub had shifted from Berlin to Frankfurt after the WWII, but did not shift back to Berlin after German reunification, even though hub in Berlin could have been a stable equilibrium. This is a piece of evidence in favor of multiplicity of equilibria.

Why did we not observe multiple equilibria in the data more often? The explanation may be that fundamental characteristics of locations play much bigger role in attracting economic activity than agglomeration externalities (increasing returns). However, the examples of WWII destruction in Germany and, especially, in Japan cannot be used to conclusively test for this. Bombing during the war, severe as it was, destroys neither location fundamentals nor agglomeration externalities associated with a location. In most cases, transportation infrastructure remains in place,

[1] Interestingly enough, cities in socialist Eastern Germany did not exhibit mean-reversion, presumably due to heavy influence of central planning in regional economics, this influence being orthogonal to what market incentives would have produced.

as well as attachment of people and firms to the city/region - so the destroyed capital is restored and people return. Maybe the shock to the infrastructure has to be more severe to trigger the switch of equilibrium?

It is also possible that the reactions to the positive shock and to the negative shock differ. People's reaction to the negative shock (destruction) would be to rebuild all that was lost. But what if a shock were positive? Imagine that, as an experiment, a city is arbitrarily built, infrastructure is created, people are moved in, capital is accumulated - would this new city be eventually destroyed or abandoned? Or would it persist?

In this paper I study the dynamics of city growth in the Soviet Union and Russia throughout 20th century in order to evaluate the existence of multiple spatial equilibria. Russian history throughout XXth and the beginning of XXIst centuries presents a unique case. The big experiment of central planning in spatial economy gives an opportunity to observe, after the breakup of the Soviet system, the adjustment toward a market-based spatial equilibrium. The uniqueness of Russia is twofold. First, Russia is large territorially, while Japan or Germany are relatively small countries. In fact, one of the criticisms of Davis & Weinstein (2002) was that Japan is not suited to be an example of an economy where multiple spatial equilibria are likely. Japanese terrain does not provide for a variety of alternative locations for cities and concentrated economic activity. Most of its territory is mountainous and difficult to settle. Moving from one place to another is easier in Japan because of relatively short distances, and this helps speedy recovery of population shares after the war. Russia, on the other hand, spans 11 time zones, and presents a vast variety of alternative locations, highly heterogeneous by physical geography. Transportation costs between alternative locations is much higher in Russia, on average. In theory, these factors work to make mean-reversion of any shock more difficult in Russia, therefore, we have a better chance to see multiple equilibria.

Second, Russia experienced not only destruction-type shocks, but also, due to the impact of Stalinism and central planning, relocation-type shocks (effectively, positive shocks to some regions). Similarly to Japan and Germany, Soviet Union also experienced negative WWII consequences - the eastern parts of the country suffered heavy losses, both in infrastructure and population. In addition to that, in several periods of Soviet history previously undeveloped territories were aggressively populated, people were resettled (by force or via wage incentives), and infrastructure was built. A number of cities, towns, and industries in the remote and inhospitable parts of the country were built literally from nothing. All of this was done without regard to the true economic rationale - to consider economic cost and benefits would be nearly impossible in the absence of market prices, even if Soviet planning authorities wanted to. Thus, we have a chance to observe how the market system (Russia after transition) reacts to the shock that had *created* agglomeration externalities in places where location fundamentals are lacking. In Russian case we have a hope to empirically separate the impact of location fundamentals and agglomeration externalities on regional growth.

I apply the methodology of Davis & Weinstein (2002), Davis & Weinstein (2008), and Bosker et al. (2007) to the data on growth or decline of Russian cities after transition. The main research questions are whether we observe mean reversion comparing the growth of cities during several historical periods: both under Soviet Union and after transition, and whether the spatial process is best described by the model with a single or multiple equilibria. I also extend the methodology of Davis & Weinstein (2008) allowing for the observed heterogeneity in the dynamics of city growth in a following way. I let the critical values of the shock that trigger a change of an equilibrium - the breakpoints - depend on a set of observable characteristics of a location, parameterize it and estimate the parameters. These parameters essentially quantify the trade-off between the long-run effect of (observed) location fundamentals and agglomeration externalities. In general, the results will add to our understanding of the effectiveness of regional policies, long-term and short-term. In particular, it is interesting to know whether any of the Soviet regional policies appear to have a permanent impact on the long-run spatial equilibrium in Russia.

2 Methodology

Following Davis & Weinstein (2002) consider a simple law of motion for the log of city sizes s_i:

$$s_{it} = \Omega_{it} + \epsilon_{it}, \tag{1}$$

where Ω_{it} - target size (for now, assume it is stable over time, $\Omega_{it} = \Omega_{it+1} = \Omega_i$), ϵ_{it} - a random shock, possibly persistent over time. Let

$$\epsilon_{it+1} = \rho\epsilon_{it} + \nu_{it+1}, \tag{2}$$

where $0 < \rho < 1$, ν_{it+1} are iid. Davis & Weinstein (2002) estimate the following equation:

$$s_{it+1} - s_{it} = (\rho - 1)\nu_{it} + [\nu_{it+1} + \rho(1-\rho)\epsilon_{it-1}], \tag{3}$$

where ν_{it} is a past period innovation, not directly observable.

Equations (1)-(3) describe the case of a single equilibrium. After an exogenous shock a system of cities (or regions) returns to the long-run trajectory. Parameter ρ describes the speed of convergence when time period length is given.

Davis & Weinstein (2008) propose the methodology for looking for multiple equilibria in this setting. Modify equation (3) to allow for critical values of ν_{it} (breakpoints) b_h and b_l. When ν_{it} exceeds a corresponding breakpoint by absolute value, a transition to a new equilibrium is triggered:

$$s_{it+1} - s_{it} = (\rho - 1)(\nu_{it} - \Delta_l) + [\nu_{it+1} + \rho(1-\rho)\epsilon_{it-1}], \text{if } \nu_{it} < b_l$$

$$s_{it+1} - s_{it} = (\rho - 1)\nu_{it} + [\nu_{it+1} + \rho(1-\rho)\epsilon_{it-1}], \text{if } b_l < \nu_{it} < b_h$$

$$s_{it+1} - s_{it} = (\rho - 1)(\nu_{it} - \Delta_h) + [\nu_{it+1} + \rho(1-\rho)\epsilon_{it-1}], \text{if } b_h < \nu_{it}.$$

In case if location i is affected by a significant negative shock, its long-run target share of population changes to a lower level $\Omega_{it+1} = \Omega_{it} + \Delta_l$ ($\Delta_l < 0$). After a significant positive shock - to a higher level $\Omega_{it+1} = \Omega_{it} + \Delta_h$, correspondingly.

An equation 4 can be rewritten in the following way:

$$s_{it+1} - s_{it} = (\rho-1)\nu_{it} + (1-\rho)I_l(b_l, \nu_{it})\Delta_l + (1-\rho)I_h(b_h, \nu_{it})\Delta_h + [\nu_{it+1} + \rho(1-\rho)\epsilon_{it-1}], \tag{4}$$

where I_h, I_l - indicator variables that are equal to 1 if $\nu_{it} > b_h$ or $\nu_{it} < b_l$, correspondingly, and 0 otherwise.

Pure innovation ν_{it} is not observed in the data. Davis & Weinstein (2002) construct a proxy for it by extracting an exogenous part of last period change in log-sizes $s_{it} - s_{it-1}$. Essentially, they employ an instrumental variables procedure: first an endogenous variable $s_{it} - s_{it-1}$ is regressed on instruments, then the fitted values are used in the second stage in place of ν_{it}.

Data on the city growth during the period when shock occurred reflects the compound effect of the shock and the "natural" trends of the city growth that are driven by pre-existing historical circumstances, development, and changes in the economic environment. To deal with these issues, Davis & Weinstein (2002) use additional control variables in equation 4 to capture preexisting growth trends.

Davis & Weinstein (2008) reduce the model to a standard switching regression by assuming that ρ is close to zero, so that a shock of period t is completely reversed by the end of the period $t+1$. The assumption was natural in their case, since they considered a relatively short-term impact of bombing during the war years versus two decades of post-war reconstruction. It was possible for Japanese cities to fully mitigate the WWII destruction before 1969. In contrast, I am exploring the long-lasting impact of Soviet planning system. It's influence on population migration was profound, and it would be naive to expect that its results can be undone in merely 13 post-transition years.[2] Of course, we could expect some degree of reversion of Soviet policies during the late Soviet years. However, even in the late Soviet period the role of the state in managing migration flows was significant. Migration to the largest cities was restricted by administrative controls, migration to the remote territories was encouraged via economic stimulae. Therefore, neither in post-transitional Russia, nor in the USSR of 1970s-1980s we cannot expect to see such strong and prompt mean-reversion of the shock as in post-war Japan, and there is no ex ante expectation that ρ is close to zero. I do not impose $\rho = 0$ constraint, the value of ρ is estimated via ML-procedure together with the rest of the parameters.

Additionally, I allow the thresholds b_l and b_h to vary between observations according to observable characteristics. Consider two locations with inherently different attractiveness to people (economic agents). A city in a good location (warm climate, in proximity to other populated areas, easy access to natural transportation roots, ports, etc) should be more stable in an event of a negative shock and easier to "jump-start" by a positive shock than a city in an unfavorable location (bad climate, far away, etc). The better is the location, the lower should be the both thresholds. Thus, if x - is a vector of location characteristics, let thresholds be linear functions of these characteristics: $b_l = \beta_{l0} + x\beta$, $b_h = \beta_{h0} + x\beta$, where β - parameter vector, and equation 4 becomes:

[2] My data covers the time period till the last Russian Population Census in 2002.

$$s_{it+1}-s_{it}=(\rho-1)\nu_{it}+(1-\rho)I_l(\beta_{l0}+x\beta,\nu_{it})\Delta_l+(1-\rho)I_h(\beta_{h0}+x\beta,\nu_{it})\Delta_h+[\nu_{it+1}+\rho(1-\rho)\epsilon_{it-1}], \quad (5)$$

The parameters $\rho, \Delta_l, \Delta_h, \beta_l, \beta_h$ of the equation 5 are determined via likelihood maximization procedure. The vector of threshold parameters β is of the main interest here: it describes the trade-off between location fundamentals (vector of characteristics x) and the shock to the agglomeration externalities.

Instruments

In our context, the Soviet system influenced the spatial economy profoundly. However, the behavior of individual households was rational given the constraints, circumstances and incentives of that time. Therefore, the growth or decline of cities and regions under Soviet Union was (apart from the facts of involuntary resettlement) a product of people's decisions made under a mixed set of incentives. Some factors, relevant in both planned and market environment (climate, historical amenities, etc), worked to influence migration decisions in the same manner as they do today. And some factors(wage and housing incentives, investments, man-built infrastructure) were created by the central planning system to induce migration, and are largely orthogonal to the present-day market stimuli. Instruments should proxy for these additional distortions brought by the Soviet system. The main source of identification comes from the various documented policies of labor migration during the Soviet times.

There were several major waves of cross-country population migration in USSR, both forced and coerced through state-sponsored economic incentives. First GULAG camps appeared in 1920s and the system of camps was used with varying intensity for economic development of remote places all through 1930 to 1950s. The first mass wave of relocation dates from the beginning of 1930s, with the onset of collectivization campain. Rich and middle-class farmers and their families were arrested and forcibly moved, mainly to Siberia, either to labor camps or to specified settlements, without a right to return. Second mass wave was due to intensified repressions at the end of the 1930s. The number of GULAG prisoners continued to grow up until the beginning of the 1950s. It is a widely known fact that the prison labor in 1930s - 1950s was used strategically in the sectors and regions deemed critical for the industrial development of the country, and where free labor would be too expensive (Applebaum (2003)), i.e. it could be viewed as an external shock to the geographical location of labor.

Third migration wave happened during WWII, when Western parts of the country lost population due to deaths, destruction, and evacuation. Industrial enterprizes were evacuated to Siberia and Central Asia. Many of them never returned to the west. One of the consequences of WWII was an unprecedented shift in population, which was not reversed when the war was over.

Fourth migration wave in 1970 was voluntary, workers were recruited to the major infrastructure and industrial projects in Siberia and the Far East with (promise of) the economic incentives.

In addition to the forced relocations and direct migration incentives, Soviet governments practiced various restrictions on population mobility, trying not only induce migration to some specific areas, but also discourage population inflow in the other places. One example of such policy were residential restrictions in large cities, that were meant to curb the number of incomers and usually prohibited free in-migration except for the closed relatives of the residents and a set a "quote" for the recruitment of non-residents to the industrial enterprizes.

3 Data sources and dataset construction

Population

Population and basic demographic data come from population censuses in Russian Empire (1897), USSR (1926 - 1989), and Russian Federation (2002). Most detailed data for up to 3500 settlements exist for the censuses of 1989 and 2002. Included are all urban population centers (cities and urban-type settlements), rural population centers of 10 000 people or more and all *raion* centers regardless of size. I exclude from the sample several regions of North Caucasus: Chechnya, Ingushetiya, Dagestan, since population dynamics during 1989 - 2002 was driven by two wars and constant military conflicts. Mass inflows and outflows of refugees changed the size of population cities drastically, and in war zones population accounting is clearly inaccurate.

The remaining sample is not representative of Russian settlement structure, since the data on the vast majority of small rural settlements are missing. Data on population centers of more than 10 000 is quite accurate and complete for most of the census years, so a population of 10 000 seems a natural sampling cutoff.

The earlier years normally have information for all the settlements that had a status of a city. The smallest sample is for the year 1897 with 500 cities and towns (*uezdnye goroda*). For the years 1959 and 1939 data for the settlements that had at least 15000 inhabitants in 1959 are collected in C.D. Harris, "Population of cities of the Soviet Union, 1897, 1926, 1939, 1959 and 1967 : with tables, maps, and gazetteer", 1970.

GULAG camps

Data on GULAG system is collected in Smirnov (1998). The database of GULAG prisons and labor camps, created by the *Memorial* society (Smirnov (1998)), documents geographical location, number of prisoners through time and the type of production activity for every camp.

As a proxy for the economic impact of a camp I calculate the total number of prisoner-years in each location. This way, a camp with the same number of prisoners has twice as much weight if it existed twice as long. I also split the camps into categories according to the specialization. Camps were designated for different types of economic activity: construction, logging and mining, services, etc. I expect to see stronger long-run economic impact from the infrastructure and industrial construction as opposed to natural resource extraction.

To match the data on population centers (cities, towns, villages, settlements) with the data on GULAG camps, I use the geographical coordinates to calculate the total number of prisoner-years inside a 20 km, 50 km and 100 km radius from the population center.

Mobility restrictions

Gang & Stuart (1999) studied the effect of migration restrictions on the growth of the Soviet cities. Following their classification, I construct dummy variables for two types of restrictions: total and expansion restrictions. Total restrictions supposedly presented a stronger barrier to the city growth, as they were meant to prohibit all in-migration except for the cases of family reunion. Expansion restrictions set targets for new labor from the outside of the city that can be attracted by resident enterprizes, and supposedly presented a weaker barrier for city growth. I break the cities under the total restrictions into two groups: those restricted since 1939 and since 1959.

WWII

Unfortunately, the detailed data on wartime destruction and deaths of residents are not available for the Soviet Union. Therefore, I cannot repeat the investigation of Davis & Weinstein (2002) for Russian case. The only variable I am able to construct to proxy for the WWII destruction is the dummy whether city or town was occupied by German forces or was located near the front lines.

The "positive" impact on the cities untouched by fighting is much better documented. The mini-census of evacuated population was conducted in the late 1942 - early 1943 in all territories of the USSR still under control of Soviet Army. The archival sources (SNK RSFSR (1943)) hold the reports on the number of evacuees by the subregional administrative units. Thus, we know how many people were evacuated via government efforts or came on their own as refugees to each of the cities and to each of the rural districts in all reporting *oblasts*.

I construct two variables: people evacuated to a city, and people evacuated to nearby The evacuees in rural areas were matched to the closest city, if there is a city in 200 kilometers or less. This procedure matches all rural evacuees, except the residents of two distant *raions* in the south of Chita Oblast.

Information on evacuated enterprises was extracted from the database of Soviet defence industrial establishments (Dexter & Rodionov (2012)). For each city I recorded the number of enterprises that were moved to it during 1941-1943. Unfortunately, there is no information on the size of enterprize, so using simple count data was the only option.

4 Estimation procedure and the results

4.1 Preview of the data and the first stage

The first step is to explore the sample to get a feel for the general patterns in city growth in Russia from 1897 to 2002. To illustrate historical trends in Soviet population geography I start with performing via OLS a series of linear growth regressions with the explanatory variables capturing geography and prior history of city development. Geographical controls are a quadratic form of latitude and longitude. I also include prior growth, prior size of cities and spatial lags of population. Administrative status of the settlement should also be a factor, however over such a long run and with many administrative changes and reforms during the history of the Soviet Union, it is likely endogenous to population growth. I include the status of oblast center only, since most of the Soviet oblast centers used to be province centers in Imperial Russia.

The estimates are presented in table 1. The estimated effect of geographical location is presented on Figures 2 and 3 in appendix A. Several robust empirical regularities are evident. During the first half of the century smaller cities had a growth advantage, while in the second half this effect disappeared. Spatial lags become significant in the late USSR: in 1979-89 isolated cities grew faster. The shape of latitude-longitude quadratic form replicates well-known historical waves of migration in Russia and USSR: spatial expansion to the east up until the mid XXth century, and the return migration to the south-western parts of the country that started in 1970s-1980s and intensified during the first years after transition. Interestingly enough, growth of cities is highly persistent, but only starting from 1939. In fact, growth from 1939 on is orthogonal to that of 1897-1926. This is an expected result, since heavy influence on spatial patterns of development by the Soviet planning system takes off precisely in the beginning of 1930s. Oblast center dummy is highly significant, which is consistent both with ongoing process of urbanization and concentration of population in large cities, and with the oblast centers being favored by the central planning system.

The spatial patterns of city growth evidently reverse in 1959. The period of 1939-1959 is characterized by faster growth of the middle-part of the country (Volga region, Urals and Western Siberia). From 1959 to 1979 we see quite the opposite: Far East and westernmost regions grow faster *ceteris paribus*. Apparently, on the interregional scale, the partial reversal of Stalinist policies began practically immediately, at least, as the data allows to observe, in 1960s.

Next, Table 2 shows the results of the first stage of IV estimation. The population growth between 1939 (the last census before the war) and 1959 (the first census after the war) is fitted on the observed measures of evacuation and presence of Gulag. In column (1) all cities were included, column (2) presents the results for the sub-sample of cities that were not occupied. As suggested by the exploratory analysis, I control for the administrative status. In columns (3) and (4) I add geographical controls: quadratic form of longitude and latitude and region fixed effects. The estimated coefficients practically do not change between columns, thus my evacuation and Gulag variables primarily explain intra-regional variation in city growth.

To check if on the intra-regional scale the effects of evacuation and Gulag are persistent I estimate the specification from column (3) for the longer time periods. If the shock of war and Stalinism were transitory, there would be no correlation of city growth with my evacuation and Gulag variables for the longer time lags. Table 3 shows that this not the case. Rather than dissipate, the effect of evacuation grows with time. Thus, on average there is no reversion to the mean, unlike in Davis & Weinstein (2002)'s Japan.

Dependent variable is Ln(Population$_t$)-Ln(Population$_{t-1}$)

Date$_t$ - Date$_{t-1}$	1926 - 1897 (1)	1939 - 1926 (2)	1959 - 1939 (3)	1970 - 1959 (4)	1979 - 1970 (5)	1989 - 1979 (6)	2002 - 1989 (7)
Ln population$_{t-1}$	-.18	-.16	-.11	-.015	-.018	-.006	-.012
	(.064)	(.050)	(.035)	(0.11)	(.016)	(.007)	(.010)
Ln urban population$_{t-1}$ inside 20 km radius	.075	.031	.044	-.019	-.010	-.017	.010
	(.061)	(.047)	(.029)	(.01)	(.009)	(.006)	(.008)
Ln urban population$_{t-1}$ inside 100 km radius	.027	.060	.00	-.008	-.005	.002	.001
	(.019)	(.021)	(.011)	(.007)	(.008)	(.003)	(.004)
Growth$_{t-1}$		.097	.14	.089	.26	.32	.19
		(.070)	(.027)	(.023)	(.032)	(.028)	.027)
Oblast center dummy	.43	.50	.29	.25	.13	.07	.043
	(.068)	(.088)	(.051)	(.028)	(.031)	(.021)	(.021)
Geography controls	yes	yes	yes	yes	yes	yes	yes
N of obs	500	459	624	756	902	946	955
R^2	0.19	0.25	0.20	0.18	0.25	0.35	0.31

Robust SE in parentheses

Table 1: History of city growth in Russia and USSR, XXth century

4.2 Model with multiple equilibria

This section presents the results of the multiple-equilibria search procedure. First exercise is to consider a shock period to be 1939-1959, so that the composite measure would include war and GULAG variables with estimated coefficients form column (3) in table 2. Recovery period is set to be 1959-1970. I estimate equation (5) via iterative procedure.

First step is to estimate the equation with the constructed measure of shock plugged instead of innovation ν_t and setting I_l and I_h to zero. Just as Davis & Weinstein (2002), I also include control variables, appropriate for the period under consideration.

During 1959-1970, migration restrictions were set in place in USSR, which might affect reverse migration dynamics. I include them into the set of control variables. In short, equation 5 becomes:

$$Ln(Pop_{it+1}) - Ln(Pop_{it}) = \alpha_0 + (\rho - 1)\hat{\nu_{it}} + \alpha_1 * Geography\ Controls$$
$$+\alpha_2 * Population_{it} + \alpha_3 * Population\ Growth_{it} + \alpha_4 * Spatial\ Population\ Lag$$
$$+\alpha_5 * Migration\ Restrictions_t + (1 - \rho)I_h + (1 - \rho)I_l + e_{it+1}, \quad (6)$$

I estimate this equation to receive residuals e_{it} to be used in second step.

Second step is very similar to the procedure of Davis & Weinstein (2008). I do a grid search over all parameter values to find the first-iteration values of ρ, Δ_h, Δ_l, b_{l0}, b_{h0}, β. Knowing the thresholds, we can now split the sample of observations into groups according to the equilibrium selected by each city, define dummy variables I_h and I_l, and re-estimate (6) to obtain a new set of residuals. This step is repeated during a full grid search until parameter values are found.

Table 4 presents the results of two runs. First run (second column in table 4

Dependent variable is Ln Pop1959 - Ln Pop 1939

Independent varaibes	(1)	(2)	(3)	(4)
People evacuated	1.104***	1.139***	1.016***	.986**
to city (per capita)	(.288)	(.307)	(.336)	(.396)
People evacuated				
to raion (per capita)				
*urals and siberia	.502***	.502***	.415**	.467*
	(.097)	(.108)	(.195)	(.266)
*center and volga	-.022	-.071	-.043	-.007
	(.060)	(.048)	(.053)	(.067)
Enterprises evacuated	.714***	.517***	.484***	.375*
(per 1000 people)	(.230)	(.188)	(.179)	(.198)
Gulag in 50 km,	.095***	.065***	.053**	.051**
Ln(person-years p.c. +1)	(.023)	(.019)	(.022)	(.022)
Oblast center	.099**	.097*	.096**	.128**
	(.040)	(.051)	(.046)	(.056)
Geography	-	-	latitude, longitude,	Region
			quad. form	dummies
Errors	clustered	clustered	Het. robust	Het. robust
	at region level	at region level		
R^2	0.12	0.16	0.17	0.28
Sample	All cities	Evacuation	Evacuation	Evacuation
Partial F-stat	20.77	15.81	8.90	5.34
on instruments (p-value)	(0.00)	(0.00)	(0.00)	(0.00)
Number of obs	758	417	417	417

Table 2: Effect of the evacuation and Stalinism, short-run.

Dependent variable is Ln Pop_{t+1} - Ln Pop_t

Independent varaibes	1970-1939	1979-1939	1989-1939	2002-1939	2010 1939
People evacuated	1.527***	1.813***	1.811***	1.889**	2.006***
to city (per capita)	(.420)	(.468)	(.498)	(.519)	(.544)
People evacuated					
to raion (per capita)					
*urals and siberia	.413*	.471**	.443**	.435*	.412*
	(.217)	(.229)	(.234)	(.245)	(.249)
*center and volga	.021	.049	.030	.065	.064
	(.071)	(.077)	(.078)	(.083)	(.085)
Enterprises evacuated	.623***	.696***	.771***	.716***	.772***
(per 1000 people)	(.219)	(.240)	(.264)	(.272)	(.287)
Gulag in 50 km,	.051*	.052*	.072**	.071**	.065
Ln(person-years p.c. +1)	(.027)	(.030)	(.034)	(.035)	(.085)
Oblast center	.268**	.378*	.427***	.468***	.530***
	(.065)	(.075)	(.082)	(.088)	(.093)
Geography	latitude, longitude, quad. form				
Errors	Het. robust				
R^2	0.15	0.18	0.18	0.19	0.21
Sample	Evacuation				
Number of obs	417	417	418	420	420

Table 3: Effect of the evacuation and Stalinism, long-run.

takes Stalinist and post-Stalinist periods as described above to see if Stalinist policies were (partially) reversed during 1960s. Third column presents the same procedure, defining a shock for the whole Soviet period 1926-1989, and looking for a reversal in post-Soviet years 1989-2002.

I found 2 equilibria in 1960s. Essentially, there was a group of leading cities (about 12%) that were favored in Stalin's time, and continued on growing faster than average in the 60s. About 88% of locations experienced modest impact of GULAG in 1930-1950s, and continued to grow modestly. Values of β coefficients were found to be reasonable and expected. I took two observable characteristics in vector x: longitude and latitude. The results show that for a city located further to the north a stronger positive (and weaker negative) shock is required to to pass the threshold to a new equilibrium.

Third column in table 4 presents results of the procedure for post-transitional

Dependent variable is Ln(Population$_{t+1}$)-Ln(Population$_t$) standardized

Response period Date$_{t+1}$ - Date$_t$	1970 - 1959	2002 - 1989
Innovation period Date$_t$ - Date$_{t-1}$	1959-1939	1989-1926
$\rho - 1$	-1	-1
no mean-reversion threshold	.16 (12% observations)	(outliers only)
β:		
Latitude	.04	
Longitude	0.00	
Controls $\Delta\Omega$	macro-regional dummy	

Table 4: Maximum likelihood estimators, models with multiple equilibria. (To be appended with more combinations of time periods)

change in city population. Here, the results are much more modest. I did not find any evidence of either clustering of the residuals according to multiple equilibria pattern, nor even any sign of mean-reversion of Soviet policies at all. We have to remember that my instruments for the Soviet shock rely heavily on the information from 1930-1950s. There is evidence that the partial reversal of Stalinist policies indeed happened already in 1960s and 1970s, and it is more recent policies of 1980s that would be relevant for the post-transitional dynamics.

Of course, it is not possible to completely rule out the possibility that the faster growth of the group of "high-equilibrium" cities was not due to the events of the Stalinist period, but due to some new or ongoing Soviet policies that persisted through 1960s, 1970s, and 1980s. There is definitely a lot of room for further research into the nature and the mechanisms of the Soviet spatial policies in all the periods of USSR history, and their long-run consequences.

5 Conclusions and discussion

This paper makes another attempt to obtain the evidence of multiple equilibria by investigating the dynamics of city growth after a natural experiment. In contrast with the previous work by Davis & Weinstein (2002), Davis & Weinstein (2008), Bosker et al. (2007), who studied the episodes of severe destruction during WWII, I consider a different type of experiment - when infrastructure, capital, and even labor were not destroyed, but brought to previously underdeveloped locations. The results are strikingly different. Mean-reversion after such type on impact is weak if exists at all. There is evidence that indeed, multiple equilibria might be present in the growth of Soviet cities in 1960s.

However, this conclusion hardy gives an optimistic view on the effectiveness of regional policy. Even is multiple equilibria exist, and, therefore, temporary regional policy can indeed "jump-start" a region or a city into growth, is is crucial to consider costs of such successful policy against its benefits. To achieve high-growth (or high-population) equilibrium, a location might require substantial investment. In the example of remote locations of USSR - enormous amount of resources and numerous slave labor. Results also suggest that there is a trade-off between fundamental characteristics of the location and the size of the positive impact that is required. Unfavorable locations require substantially more investment *ceteris paribus*.

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A Tables and figures

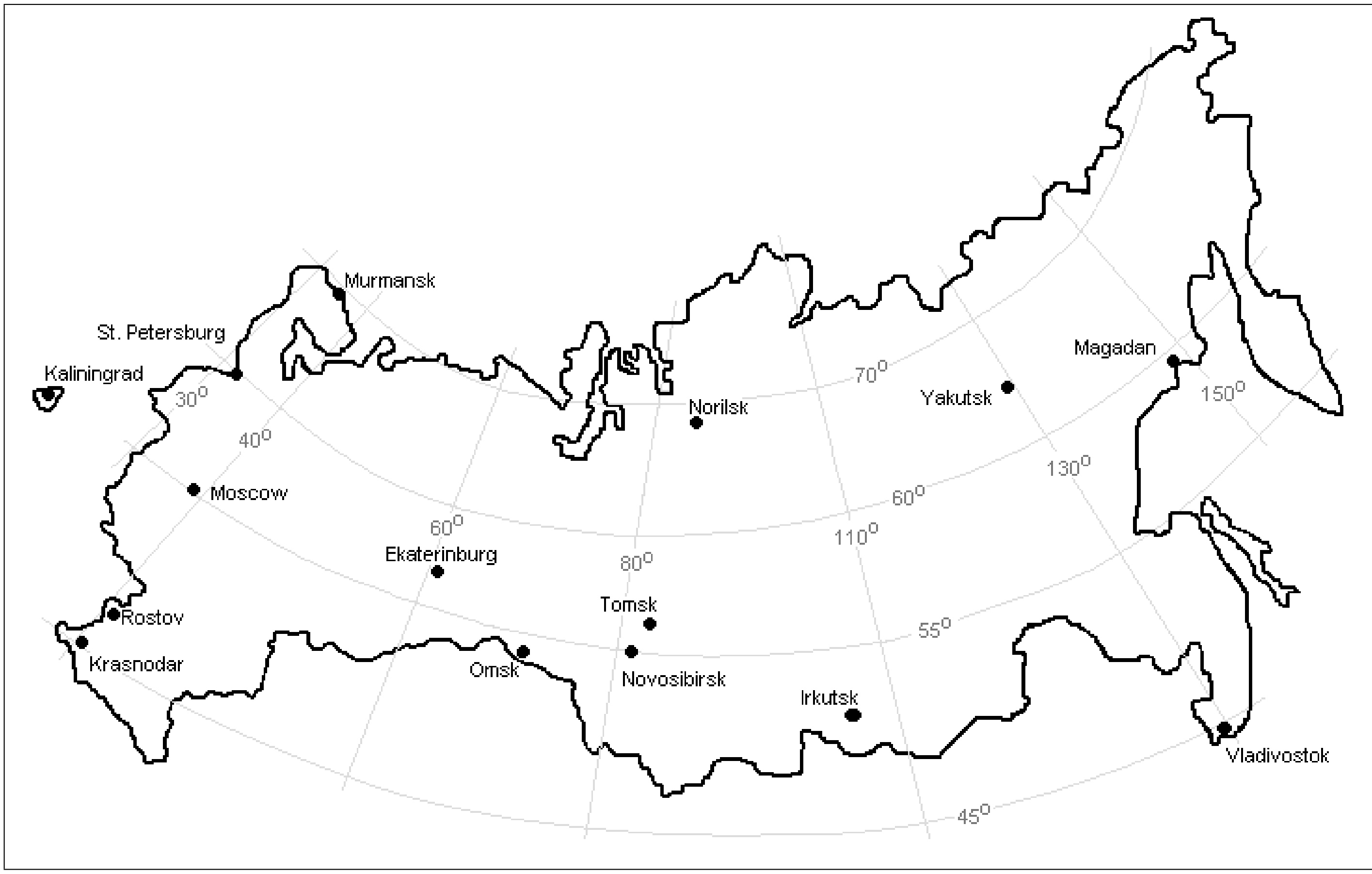

Figure 1: Several major cities in Russian Federation, geographical location.

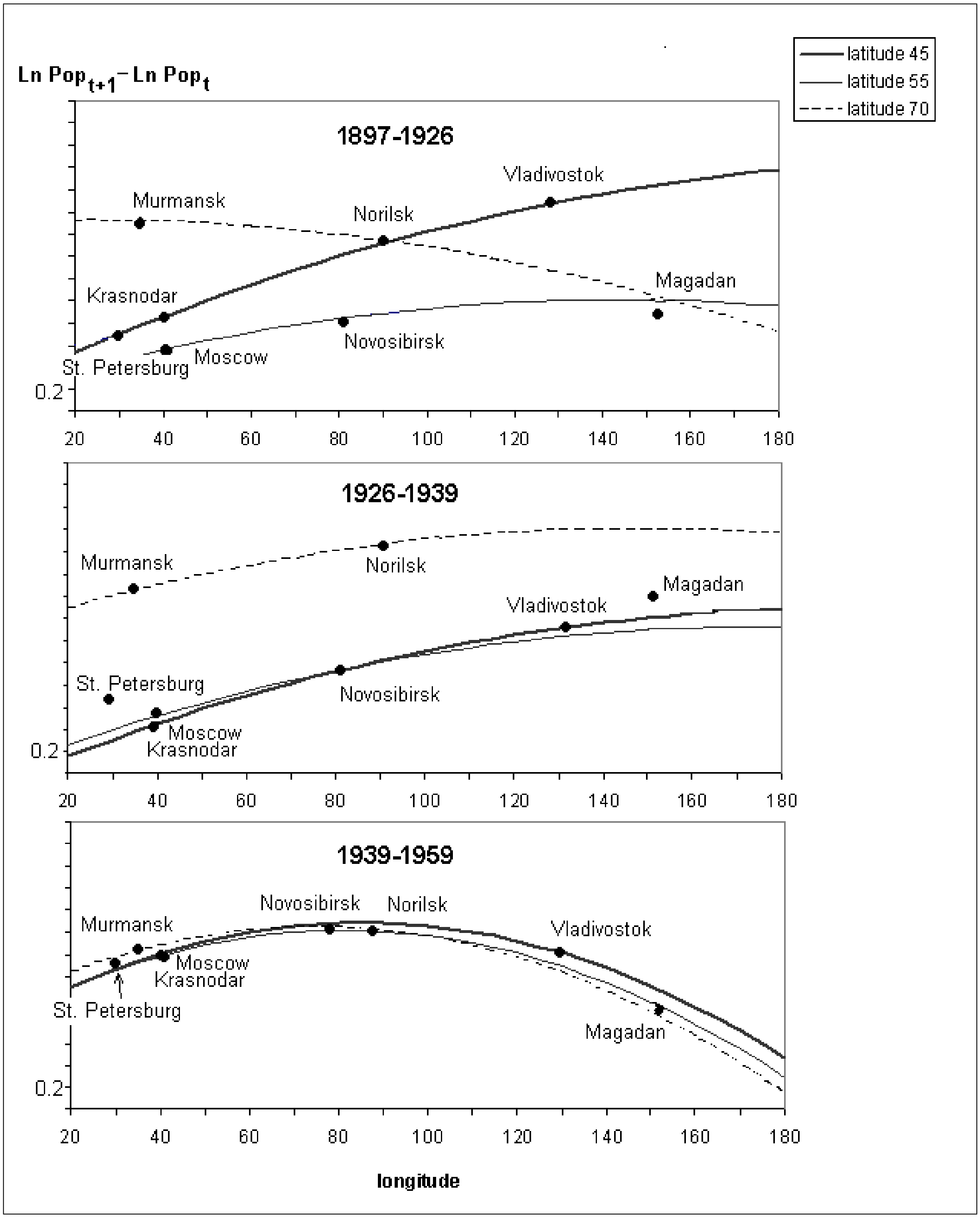

Figure 2: Urban population growth as a function of geographical location, 1897-1959.

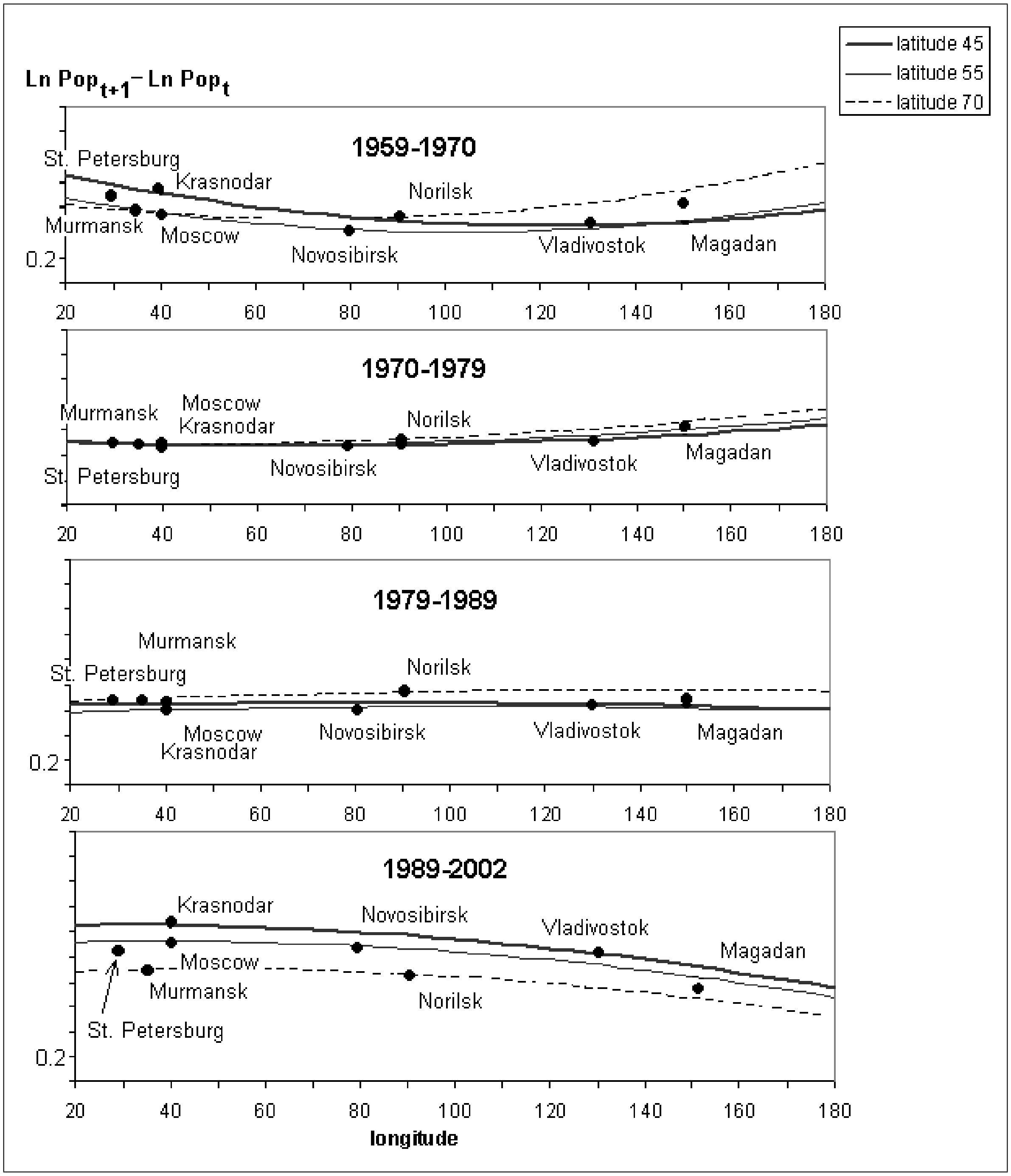

Figure 3: Urban population growth as a function of geographical location, 1959-2002.