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Abortion and infant mortality change driven by socioeconomic conditions in Russia

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Abstract

Increasing fertility and decreasing mortality are major response strategies in Russian demographic reform, which has led to significant decreases in both abortion rate (AR) and infant mortality. This study explores mechanisms influencing the socioeconomic conditions leading to abortion and infant mortality. Spatial panel economic analysis using data from the 83 regions of the country covering four time periods was applied. Every 1000 USD increase in per capita gross regional product (GRP) can lead to a decrease of the AR by 0.075, while one year life expectancy increase would lower it by 0.441. For infant mortality rate (IMR), GRP also shows a positive impact, particularly in recent years, while the population size of the region has a negative impact. Every 1000 USD increase in per capita GRP would result in a rate decrease of 0.064 in IMR, and every increase of 1000 added population would lead to an increased IMR by 2.05. The *harvest effect* between AR and infant mortality that was evident earlier, but not in the recent years, implies that the health care system in Russia is effective. A comprehensive improvement in wellbeing, income, *etc.* can contribute to mitigation of abortion and infant mortality. Theoretically, this study extends current research by comprehensively displaying the spatio-temporal patterns of abortion and infant mortality in Russia and qualifies the impact of regional socioeconomic disparities with regard to these two issues.

Introduction

Russia has been experiencing a nationwide population decline in the past decades, mainly attributable to extremely low fertility, extremely high abortion rate (AR) and a generally high mortality, including infant mortality and labour mortality. This demographical transition has significantly constrained the economic development, as president Putin said in a speech to the Russian parliament in 2006. He emphasized that the demographical issue is the most acute problem for contemporary Russia, for the first time mentioning that it concerns security as well as the rise and fall of the nation (Rosenberg *et al.*, 2018). In order to promote population growth, the government has introduced a series of policies covering taxation, economic incentive, subsidy, *etc.* to improve fertility and health care (Ministry of Labour of Russia, 2013; Miljkovic and Glazyrina, 2015; National Healthcare Project, 2018; Luneva *et al.*, 2019). In general, these strategies have achieved some progress with two milestones in 2007: for the first time during the observation period, the annual number of births exceeded the number of terminated pregnancies (ratio of abortion against live birth = 918.6 per 1000); and in 2012, the birth rate outpaced the total mortality rate for the first time since the collapse of Soviet Union. However, despite favourable dynamics, the AR is still

higher than that of developed countries, and the infant mortality rate (IMR) is much higher than the average level reported in developed countries (OECD, 2020). Russia aims to reach a net population growth by 2024, even though Mr Putin considered this an overly optimistic goal in his speech to the Russian parliament in 2019 (Russian government, 2019).

Russia legalized abortion in 1920, which partly remains as a legacy of the Soviet times when it was the primary form of birth control. It was the first country to do so and despite a significant decline of the AR recently (Sakevich and Denisov, 2014; Denisov and Sakevich, 2015), it still has one of the highest ARs in the world. The reason is a combination of social and economic conditions (Miljkovic and Glazyrina, 2015; Popov and Tcherenev, 2018; Zhukov, 2018). Denisov and Sakevich (2015) found a declining abortion dynamic in Russia, particularly among the youngest women, and at the national level, they did not find any obvious difference between abortion risks and social characteristics, such as income or education. At the individual level in the period 1900-1924, women with higher education in Russia might have had higher AR (Gens, 1926). However, based on a recent cross-sectional study in St. Petersburg, Panova *et al*. (2016) found that low education, excessive drinking, low age at the sexual debut and a fragmented family structure are the key factors for unwanted pregnancies that lead to abortion.

IMR is one of the main health indicators as it reflects healthcare priorities and performance of social insurance programmes (Baranov *et al*., 2016). In Russia, approximately 55%-65% of all deaths in the age group 0-14 years occur among children aged less than one year (Ivanov *et al*., 2017). Based on a country-level study, Schell *et al*. (2007) found that, in low-income countries, women's education level is strongly negatively related to infant mortality; the less income, the stronger the negative correlation. An individual-level study based on odds ratio (OR) evaluations in north-western Russia indicates that education is the most significant factor associated with poor infant outcome (OR=1.9, 95%); this was discovered by Grjibovski *et al*. (2002) when comparing secondary or less education with 3 years or more of university studies. At the regional level, Grigoriev *et al*. (2016) found that the educational quotients positively contributed to mitigation of infant mortality. According to Ivanov *et al*. (2017), the correlation between income and IMR in Russia has become more significant since 2011 indicating that personal economy plays a more and more important role in infant mortality, while the increasing health expenditure seems to have a very small influence on infant mortality in Russia (Schell *et al*., 2007; Rosenberg *et al*., 2018).

The role played by the socioeconomic conditions with regard to abortion and infant mortality in Russia is still controversial. The hypothesis of this study is that the spatial variations of infant mortality and AR are related to socioeconomic status and wellbeing, and that the impact might have both spillover and lag effects. The objectives were to explore the spatial and temporal pattern of abortion and infant mortality by investigating how socioeconomic conditions and wellbeing affect these two demographical indicators.

Materials and methods

Areas covered and data collected

This study was conducted using data covering Russia's 83 regions, including first-level administrative divisions (oblasts), republics, autonomous governorates, lower-level administrative divisions (krais), and the cities Moscow and St. Petersburg. Provincial-level socioeconomic data, including unemployment rate, per capita gross regional product (GRP), urbanization rate, total population as well as health data including life expectancy, IMR and AR, were all obtained from the Russia Federal State Statistic Service for the annual periods 2000, 2004 (alternatively 2005), 2010 and 2016 (alternatively 2015 or 2017). The number of abortions per 100 live births, including both induced abortions and miscarriages, was taken as the AR, while that used for infant mortality was the number of deaths per 1000 live births of children less than one year old. The urbanization rate was calculated as the percentage urban population of the total population. The education index was obtained from the National Human Development Report for the Russian Federation for 2000, 2004, 2010 and 2015. Life expectancy was used as an independent variable representing the general health-related well-being of the region. Covariates included in the study are listed in Table S1.

Analysis methods

AR and IMR were set as dependent variables. First, we conducted Pearson's correlation and spatial autocorrelation analysis to give a general picture of the variables. Spatial econometric analysis was then used to explore the driving mechanism for AR and IMRs. Pearson correlation between health indicators and variables was conducted using SPSS (IBM, Chicago, IL, USA) and ArcGIS10.2 (ESRI, Redlands, CA, USA) was applied for global autocorrelation and regional agglomeration analysis, including Global Moran's I, which varies between $-1\sim1$. The local indicators of spatial association statistics indicates clustering pattern between one region and surrounding ones, where the Z value threshold is usually set at 1.65; thus, the chance that a dataset is spatially clustered increases with Z-values above this value together with a P-value lower than 0.05 (or 0.01). The detailed methodology for spatial econometric analysis and the latter two approaches have been described by Anselin (1995) and Wang *et al*. (2019).

Traditional regression analysis does not include spatial correlation but spatial econometric analysis compensates for this deficiency (Anselin, 1990; Wong and Lee, 2005) through dealing with the lag effect of the dependent variable, which is called spatial lag model (SLM) or the spatial autoregressive model. SLM can be used to explore the *space overflow effect* of the factors and was used in this study to investigate whether the AR, alternatively the IMR (as dependent variables), in one region is influenced by the factors (the independent variables) from this region and/or is also related to factors from neighbourhood regions. The spatial error model (SEM) (Lesage and Pace, 2009) explains correlations through the spatial lag of the deviations and this approach was used to measure the impact of the AR and IMR deviations on neighbourhoods at the regional level. When considering the correlation between the spatial lag of independent variables and dependent variables, spatial auto-correlation shows a lag effect from both independent variables and dependent variables. In this case, the model is spatial Durbin model (SDM) (Lesage and Pace, 2009), which uses both endogenous and exogenous interaction. When there is no lag effect from the independent variables (exogenous interaction), SDM becomes SLM; when there is no lag effect from the dependent variables (endogenous interaction), SDM becomes SEM.

Model selection

The statistical test method introduced by Lesage and Pace (2009) was used to choose the best-fit model. For the AR calculations, four steps were conducted.

i) First, the simple ordinary least squares technique is run on panel data with fixed estimates for space, time and spatio-temporal outcomes. In time-fixed and space-fixed lag models (LM_{lag}), significantly (P=1%, 5%) rejects the hypothesis of absence of a spatial effect of the variables on AR, indicating spatial effect should be included. When R_LM_{lag} and R_LM_{error} significantly reject this hypothesis, it is necessary to use the SDM model applying the Wald and likely-ration (LR) tests to see if SDM can be simplified to SLM or SEM. However, if none of the four parameters in the space-time fixed models, (LM_{lag}, R_LM_{lag}, LM_{error} and R_LM_{error}) reached significance, the hypothesis is allowed (Table S2). Thus, it is necessary to combine LR_{space} and LR_{time} together to see which fixed model to choose.

ii) If the P-values from both space fixed effects and the time fixed effects are significant in the LR test (P<0.001), the null hypothesis of no space or time fixed effects is rejected (Table S3) and the next step requires inclusion of both time and space effect in the space panel model.

iii) If the LR and Wald tests reject SDM to be simplified to SEM or SLM at the 5% level significance in the three different fixed models, it will be necessary to conduct space-fixed SLM, SEM and SDM as well as time-fixed SLM and SDM, compare the result and select the best-fit model.

iv) Comparing the results from space-fixed SLM, SEM and SDM with those emanating from time-fixed SLM and SDM, the significance of the estimation coefficients of the explanatory variables, *i.e.* the corrected R2, and Log-likelihood (Table S5) indicate the space-fixed SDM model as the best-fit model. Using a similar procedure for IMR, chooses the space-fixed SDM model as the best-fit model for IMR (Tables S6-S9).

Model result interpretation

Tables 1 and 2 represent the model results of the independent variables' impact on dependent variables AR and IMR. The direct

Table 1. Direct and indirect effects of different factors on abortion rate in Russia.

Factors	Coefficient	Direct	Indirect	Total
Unemployment rate	0.067345	0.105188**	0.627109***	0.732297***
GRP	−0.000071***	−0.000075***	−0.000069*	−0.000145***
Education index	6.726972	11.015764	66.954659***	77.970423***
Urbanization rate	0.082401	0.037454	−0.699091**	−0.661637*
Life expectancy	−0.433857***	−0.441723***	−0.180049	−0.621772***
Total population	0.003394***	0.003825***	0.006718***	0.010543***
W*Unemployment rate	0.392554***			
W*GRP	−0.000021			
W*Education index	42.203621***			
W*Urbanization rate	−0.493688**	Hausman test		
W*Life_expectancy	0.042921	129.3381***		
W*Total population	0.003261*		W*dep.var z-probability	
W*dep.var.	0.372977***	<0.001	-	-

***Significance at the 1% confidence level; **significance at the 5% confidence level; *significance at the 10% confidence level. GRP, gross regional product.

Table 2. Direct and indirect effects of different factors on infant mortality rate in Russia.

Factors	Coefficient	Direct	Indirect	Total
Unemployment rate	0.05688	0.066989	0.413575***	0.480564***
GRP	−0.000063***	−0.000064***	−0.00003	−0.000094**
Education index	7.203508	8.058719	41.269559***	49.328277***
Urbanization rate	0.087084	0.078229	−0.277519	−0.199289
Abortions rate	0.013003*	0.013734*	0.040801***	0.054535***
Total_population	0.002072**	0.002051**	−0.001377	0.000674
W*Unemployment rate	0.368495***			
W*GRP	−0.000018			
W*Education index	36.097399***			
W*Urbanization rate	−0.25294	Hausman test		
W*Abortions rate	0.035208***	161.7182***		
W*Total population	−0.00153		W*dep.var z-probability	
W*dep.var.	0.11899**	0.07913	-	-

***Significance at the 1% confidence level; **significance at the 5% confidence level; *significance at the 10% confidence level. GRP, gross regional product.

effect with significance indicates that the factor can affect the dependent variables. The indirect effect with significance indicates that the factor of the neighbouring area can affect the dependent variables, which is a spillover effect. The level of direct or indirect effect shows the extent of the impact, for example, the direct effect of GRP on AR (Table 1) is –0.000075***, which means every one-unit GRP increase makes the AR decrease by 0.000075. The estimated value of spatial autocorrelation coefficient (W*dep.var.) being significant at the 1% level indicates that the dependent values (AR and IMR) are spatially correlated. The Hausman test hypothesis is that there is no difference between a random-effect model and fixed model, but when it is significant at the 1% confidence level (Tables 1 and 2), it rejects the random-effect model favouring the fixed-effect model, which indicates that the space-fixed SDM passed the test.

Results

Statistical description

The AR decreased significantly in the past decades from 202.4 per 100 live births in 2001 to 43.7 in 2015, though the level is still high in comparison to the level of the European Union (EU) in 2015 (20.3). At the Russian regional level, the ARs have experienced a general, significant decline since 2000 (Figure 1). In 2000, the highest AR was in Khabarovsk Kray with 239 abortions per 100 live births; in 2005 it was in Vologda Oblast with 206 abortions per 100 live births; and in 2010 in Magadan Oblast with 129 abortions per 100 live births. In the nation as a whole, the ARs in 2015 ranged from a minimum of 12 in Dagestan Republic to the maximum of 105 in Magadan Oblast with an average of 54.38 abortions per 100 live births. The border regions in the South had mainly low ARs, while the eastern coastal and north-western regions showed considerably higher ones.

The IMR has shown a distinguished regional difference by longitude in the earlier years (2000, 2005 and 2010), and the regions with higher infant mortality were mainly located in the East. The highest IMR was found in the Chechen-Ingush Republic, with 33.0 and 25.7 both in 2000 and 2005, respectively, and Tyva Republic, with 16.1 in 2010. More recently, the IMR ranged from 2.5 in Nenets Oblast to 16.1 in Chukchi Republic with a national wide average of 6.3 per 1,000 live births (Figure 2).

Correlation analysis

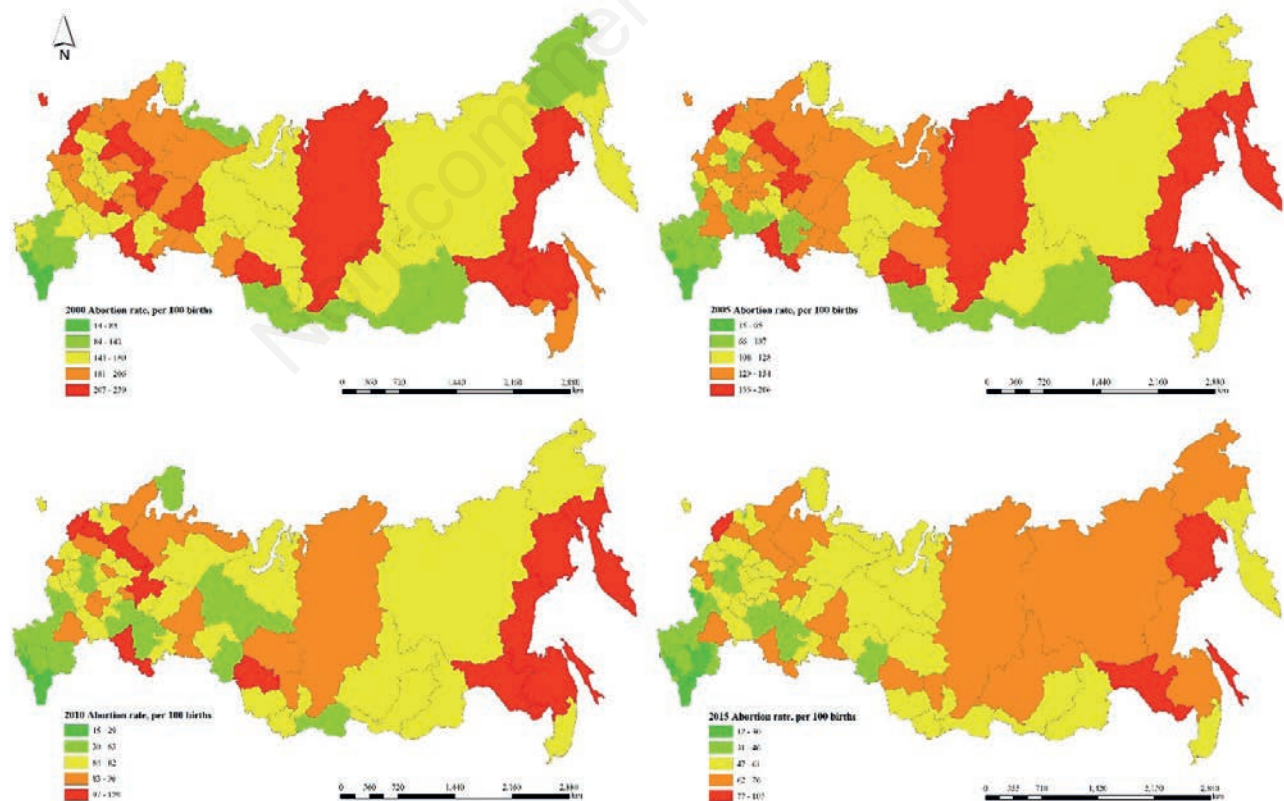The Pearson correlations between AR and IMR with indepen-

Figure 1. The spatial distribution of the abortion rate in Russia.

dent variables are listed in Table 3. For AR, negative correlations (at P<0.05) were found for unemployment and life expectancy, while positive correlation was found for urbanization in the four time periods investigated indicating that these confounders play significant roles for AR. For education, no correlation was found in the earlier years, while a positive correlation showed up in the more recent years indicating that regions with a higher education level also have a higher tendency to utilize abortion. Although this is counterintuitive, it is in concordance with research showing that women with higher education tend to have low fertility due to a high AR (Sakevich and Denisov, 2014).

Unemployment rate and urbanization rate were positively associated with IMR in the four periods, while AR was negatively correlated with IMR in 2000, but not so in recent years.

Spatial clustering

Global Moran's *I* indicated a spatial autocorrelation for AR and IMR (Table 4). For AR, spatial autocorrelations showed up in the four years selected (at P<0.001) and also for IMR, but only in 2010 (at P<0.001) and in 2016 (P<0.05). For AR, the aggregation patterns were mainly the same in the four periods studied, with low-low areas clustering in the south-eastern regions, neighbouring Ukraine and Georgia, while they were high-high in areas mainly located in western and north-eastern regions (Figure S2). For IMR

(Figure S3), the aggregation pattern in 2000 and 2010 were almost the same with low-low areas clustering in the Northwest and high-high areas clustering in central and eastern Russia. In 2005 the low-low spots were found to be scattered in the Northeast, with the high-high spots clustered in central Russia, while in 2016, the low-low spots were mainly located in areas surrounding Yamalo-Nenets and the high-high spots in regions bordering Mongolia.

Spatial panel analysis

The direct and indirect effects of the different factors favouring AR and IMR can be found in Tables 1 and 2, respectively. The estimations show that the per capita GRP and life expectancy had a negative effect for AR (at the 1% level), while the total populations in the various regions were found to have a positive effect for AR (at the 1% level). This means that a higher per capita GRP and wellbeing, *e.g.*, better health and decreasing AR; however, the larger the population size, the higher the AR. Per capita GRP and total population also showed spillover effects (indirect effects), confirming that better wellbeing and a smaller size of the population contributes to AR mitigation.

Specifically, every 1000 USD increase in the per capita GRP would lead to a decrease of 0.075 AR in the region, and every one year increase in life expectancy would lead to a decrease of 44.1
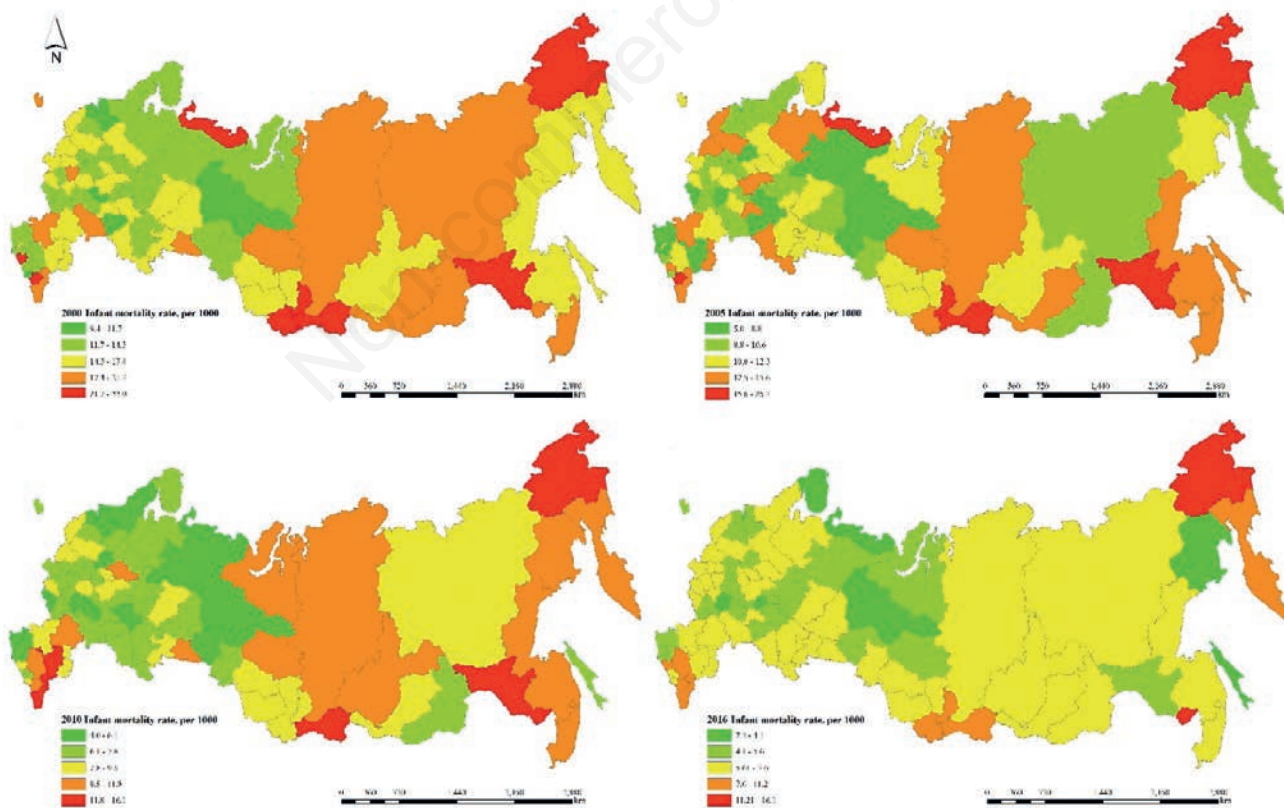

Figure 2. The spatial distribution of the infant mortality rate in Russia.

abortions per 100 live births, while an increase of 1000 population in the region would relate to an increase of 3.8 AR. For spillover effects, every 100 USD increase in the per capita GRP would influence a decrease of 0.0069 AR on average in the neighbouring regions, while every increase of 1000 people in one region could result in an increase of 6.78 AR in the neighbouring regions. For IMR (Table 2), the estimations indicate that per capita GRP has a negative influence (at the 1% level), while AR and the total population measure have a considerably weaker but still positive influence (at the 10% and 5% levels, respectively). For the per capita GRP and the total population, the influence only exists as a direct force as no spillover effect was found, while for the AR, the influence was even larger in the neighbouring regions.

In detail, every 1000 USD increase in per capita GRP was associated with a decrease of 0.064 IMR in the region, while an increase of 1000 people in the region would relate to an increase of 2.05 IMR. AR shows a week positive influence on IMR, which means every one abortion decrease would relate to a decrease probability of 0.013 infant mortality.

Discussion

This paper should be seen against the background of the Russian demographic policy, which is defined by a number of statutory acts, most of which based on the *Concept of Demographic Policy* of the Russian Federation, which came into force in 2007 with the second (now current) stage of the Concept implemented from 2015 (Arkhangelsky *et al*., 2015). The act named *On Additional Measures of State Support of Families with Children* that was adopted in 2007 is regarded as a successful innovation promoting fertility and decreasing mortality. Among the demographic goals planned to be reached by 2025, IMR is supposed to decrease from 10.2 per 1000 in 2006 and to 7.5 in 2010 followed by 5.1 in 2025. Although this rate has experienced an

obvious decline, the decent from 16.6 in 2000 to 6.5 in 2017 need to fall another 1.4 in the next four years to reach the goal. It is still high compared to that of the EU countries' average (3.4) and that of the US (5.7), but lower than some developing countries, such as China (8.0) and Ukraine (7.5).

With respect to the confounders favouring demographic and health growth, Miljkovic and Glazyrina (2015) found that the provision of job opportunities plays an important role in terms of willingness to give birth comparing to merely subsidies. Arkhangelsky *et al*. (2015) conclude that the introduction of maternity capital (benefits and tax refunds for families with children) through this policy raised the fertility rate in 2007-2008, while Kuklin and Vasilyeva (2015) feel that the implementation of some measures, including the President's Mother and Child Initiative for 2007-2011, have substantially contributed to abortion control. The prevention of abortion increase after the economic crisis in 2008 is emphasized by both publications cited above. Indeed, these measures might strongly contribute to the mitigation of IMR in less affluent countries, although the impact has been much less obvious in Russia. The eastern part of the country has a generally much higher AR compared to the western part, and the spatial distribution pattern has not changed for many years. The government attributes this situation partly to the region's high unemployment, while some scientists relate it to religion as the region has had more atheism than religious worship (Ferris-Rotman, 2018; Wang *et al*., 2019). The results from our study shows that there is direct influence of unemployment rate to AR as a good job market is important for an abortion decision. Other studies have implied that public health financing might play a small role on mitigation of abortion and mortality (Schell *et al*., 2007), however, our findings suggest that wellbeing of the society has a very strong impact. This disparity might be attributable to the increased ratio of the medical expenditure in Russia compared to previous years. Still, spending is still far behind, in fact 5~6 times less than that of developed countries. Soboleva (2015) attribute the positive demographic dynamic in recent years in Russia, particularly in Siberia, to the

Table 3. Pearson correlation.

Year	Abortion				Infant mortality			
	2000	2005	2010	2016	2000	2005	2010	2016
Unemployment	−0.645**	−0.553**	−0.338**	−0.268*	0.522**	0.494**	0.372**	0.384**
GRP	0.017	0.054	0.056	0.123	−0.113	−0.034	−0.16	−0.254*
LE	−0.438**	−0.587**	−0.607**	−0.714**	-	-	-	-
AR	-	-	-	-	−0.379**	−0.076	0.04	−0.037
Population	−0.024	−0.204	−0.305**	−0.320**	−0.329**	−0.319**	−0.241*	−0.195
Urbanization	0.498**	0.344**	0.346**	0.371**	−0.407**	−0.318**	−0.303**	−0.371**
Education	−0.183	0.223*	0.347**	0.334**	−0.230*	−0.466**	−0.173	−0.259*

*Significance at P=0.05; **significance at P=0.01. GRP, gross regional product; LE, life expectancy; AR, abortion rate.

Table 4. Moran's *I* of abortion rate and infant mortality rate in Russia.

Year	Abortion				Infant mortality			
	2000	2005	2010	2016	2000	2005	2010	2016
Moran's *I*	0.467	0.367	0.366	0.391	0.147	0.129	0.313	0.146
Z-value	6.897	5.444	5.385	5.750	2.305	2.069	4.665	2.352
P-value	<0.001	<0.001	<0.001	<0.001	0.021	0.038	<0.001	0.018

general economic improvement, which agrees with our results as GRP growth decrease AR and IMR.

We noted a negative relationship between AR and IMR in 2000 but not later, which indicates that there might be a *harvest effect* between AR and the IMR in earlier years. *i.e.* women with inferior health, low socioeconomic status or less access to prenatal health care, always have higher infant mortality (Biggs *et al.*, 2013; Finer and Zolna, 2014; David and Collins, 2014), and higher abortion rate among these women would lead to (in relative term) lower infant mortality. This result agrees with historical experience, such as that of Nazi Germany, Communist Romania, Stalin's Soviet, present-day Poland, the US in the 1970s-1980s and even in some of its states today. A strict or outlawed abortion control can result in increased maternal mortality and even infanticide (Puffer, 1993; Edwards, 2019). However, the general abortion decline seen in recent years may mainly be attributable to family planning, *i.e.* use of more effective contraception (Denisov and Sakevich, 2015).

The decoupled and even positive influence of AR on IMR in recent years shown by our panel analysis of the years 2005, 2010 and 2016, indicates that regions with lower AR might also have lower infant mortality. This might attribute to the strong policies on abortion control and general improvement on health care system both at the macro (community, public health) and the micro (individual) level. For example, Arkhangelsky *et al.* (2015) suggest that the Healthcare Development part of the State Program of the Russian Federation contains a number of measures which may produce a tangible impact on mortality reduction. This is supported by the failure of the individual states to expand Medicaid under the Affordable Care Act in the US, which shows a higher IMR under abortion restrictions (Edvards, 2019). Indeed, public funding support for abortion is strongly, inversely associated with an increased IMR risk (Krieger *et al.*, 2016). Although the education level, particularly that of the mother, has a positive impact on IMR mitigation (Grjibovski *et al.*, 2002; Schell *et al.*, 2007), we only found a positive impact via Pearson's correlation but not from the panel analysis.

The current study ascertains a favourable employment rate, GRP and wellbeing can contribute to the decrease of AR and IMR. The measures under the nation's demographic policy also provide positive influence on abortion control and infant mortality mitigation. However, one should also be aware that, the near-term demographic reform in Russia would mainly benefit from abortion control and IMR mitigation, and that excess mortality mitigation would reach to a ceiling by 2040 according to prediction (Arkhangelsky *et al.*, 2015), while a long-term demographic growth would rely on a sound fertility support measures covering not just the financial sector, but also general business, private sector and in the end society itself.

Conclusions

By spatial panel econometric analysis at four time instances covering the first two decades of the new millennium, we have shown that abortion and infant mortality in Russia have declined significantly, and that income and wellbeing, represented by per capita GRP and life expectancy, have led to a strong decrease of abortion and infant mortality, while the size of the region where it occurs has a negative impact on infant mortality.

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