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Innovation and Regional Economic Growth in Russia: Roles of Trade Integration, Sanctions and Investment Potential

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Abstract. Innovation plays a vital role for economic growth as it introduces new ideas and processes, fosters competitiveness, creates jobs, and triggers technological advancements, increasing productivity and efficiency. Russia's transition from a command to market economy requires the country to stress on innovation for sustainable regional economic growth. This study delves into the reciprocal relationship between innovation and economic progress in various Russian regions, emphasizing the significance of trade integration (Russia's admission to the WTO), the 2014 sanctions, and the investment potential within Russia's territories. Owing to the significant inconsistencies in data across different regions and over time, this research utilizes the Method of Moments Quantile Regression (MMQR) for data interpretation. The main findings reveal that regional innovation is a key driver of economic advancement in the Russian Federation, particularly in the lower and middle quantiles. Additionally, this research indicates that the effect of innovation on regional economic growth is amplified following Russia's WTO membership. In addition, this study observes that during sanctions, innovation promoted economic growth in the Russian regions. However, sanctions in general negatively affected the economic growth of the more developed regions of Russia. Furthermore, this research notes a robust correlation between innovation and economic growth in Russian territories with substantial investment potential. The study also identifies that factors like financial development, fixed capital accumulation, and exports significantly enhance economic growth through innovation in the Russian regions. This study significantly contributes to literature from both theoretical and practical standpoints by offering several fresh insights regarding regional economic growth of Russia.

Key words: innovation; economic growth; trade integration; WTO; sanctions; investment potential; MMQR; Russian regions.

JEL F13, R11, O11, O31

1. Introduction

Innovation serves as a key driver of economic growth in a market economy. It stands as the nucleus of industrial advancement, fostering long-term economic development. However, Russia primarily depends on its abundant mineral resources for economic competitiveness, due to its limited innovation capacity [1]. This dependence leaves the Russian economy susceptible to external shocks, such as sanctions and oil price fluctuations. Given this scenario, Russia needs to enhance its innovation to diversify its economy and ensure long-term economic sustainability [2].

Numerous studies emphasize the importance of innovation in improving various economic indicators [3–4]. For example, Viardot et al. [5] regard innovation as a potential catalyst for expediting recovery from economic downturns by facilitating the adoption of innovative techno-

logical advancements. Nieto & Mateo [6] argue that the fundamental principle of a robust economy is shaped by the dynamic imbalance created by innovative entrepreneurs. Considering the crucial role of innovation in reducing reliance on natural resource revenues and in establishing a non-resource-based economy through economic modernization, these have become key items on the Russian government's national agenda [7]. This study, therefore, aims to examine the impact of innovation on economic development in Russian regions, considering factors such as sanctions, trade integration, and regional investment potential.

The impulse for this study to probe the impact of innovation on the regional economic growth of the Russian Federation under several macro-economic conditions is spurred by several theoretical and empirical propositions.

Firstly, this study aligns with the supposition that innovation serves as a vital accelerator for economic development, conferring benefits to consumers, businesses, and the economy as a whole. Innovation exerts substantial effects on the macroeconomic landscape, leading to enhanced productivity where the same input produces a larger output. This, in turn, facilitates the creation of more goods and services, ultimately propelling economic growth.

Schumpeter's [8] seminal work on the theory of economic development postulates that innovation stimulates economic growth. Following Schumpeter, numerous studies have examined the role of innovation in economic development, concluding that innovation revolutionizes industrial production and contributes to significant economic progress [9–10]. Contemporary literature also highlights the role of innovative entrepreneurship in driving innovation-led economic growth.

Shakib [11] empirically examines whether innovation can augment export diversification of Russia's regions, substantiating the significance of factors such as trade globalization through Russia's WTO accession, regional-level business potential, and the economic ramifications of the 2014 sanctions.

As the global landscape is ceaselessly molded and remolded by technological advancements, the importance of innovation in powering economic growth has become irrefutable. Russia, a country with a rich heritage of scientific and technological excellence, is no exception. Hence, this research intends to delve into the intricacies of how innovation is catalyzing economic growth across Russian regions, substantiating its assertions with cutting-edge literature.

Secondly, previous research indicates that a country's involvement with the World Trade Organization (WTO) plays a crucial role in bolstering its economic growth through trade openness and attracting investments [12–13]. Beverelli et al. [14] suggest that the WTO's trade integration mechanism mitigates the unsystematic risks faced by export-oriented countries, aiding them in conducting international trade more easily. Golub [15] asserts that the enhancement of trade integration played a key role in stimulating growth in both emerging and advanced economies during the latter half of the 20th century. Gnangnon [16] finds that the WTO's specialized trade schemes reduce several trade barriers for emerging countries. The Russian economy usually relies on foreign earnings from natural resources, with statistics showing that mineral resources account for 68 % of total exports, and 54 % of export revenue comes from oil and gas sector [17].

However, WTO membership has opened up opportunities for attracting foreign investments through global collaboration, which could potentially aid the country in diversifying its trade through innovation. Batsaikhan & Dabrowski [18] argue that WTO accession could help the Russian economy enhance its global eco-

nomic competitiveness through innovation and economic diversity. Kuznetsov [19] suggests that WTO membership has had a positive impact on Russia's non-energy-based export performance. However, the intensified competition from foreign firms has pressured Russian high-tech sectors to innovate and improve their competitiveness, thereby necessitating increased investment in R&D and human capital. In this context, understanding the role of WTO membership in the innovation-economic growth nexus in Russia is critical. This study plans to explore these vital relationship dynamics.

Thirdly, the current geopolitical position of Russia and the sanctions imposed by various international actors necessitate a critical understanding of the role of sanctions in Russia's regional innovation-economic growth dynamic. Sanctions, as an external economic stressor, can have profound effects on a country's economic growth and innovation. Previous studies confirm that sanctions hinder the normal progression of economic operations and pose a significant obstacle to economic growth [20–21]. The sanctions imposed on Russia following the Russia-Ukraine tension of 2014 had adverse effects on Russia's regional economy [22–23].

The financial sanctions primarily affected Russian enterprises as they limited their ability to secure international funding, which is necessary for undertaking innovative ventures [24]. However, sanctions can also stimulate domestic innovation as countries strive to mitigate the impact of economic restrictions [25]. This 'forced' innovation can potentially spur economic growth by fostering self-reliance and promoting the development of local industries [26]. Russian regions with a strong industrial base and higher investment in R&D have been more successful in leveraging this potential benefit of sanctions [27].

However, sanctions can also hinder economic growth by creating trade disruptions, limiting foreign investment, and causing economic instability [28]. These negative effects of sanctions can be particularly pronounced in regions with less diversified economies and lower investment potential, leading to decreased innovation capacity and stunted economic growth [29].

Moreover, the reduction in international cooperation and knowledge exchange due to sanctions can limit exposure to advanced technologies, thereby affecting the quality and scope of innovation. Motivated by this argument, this study aims to investigate the role of sanctions in terms of regional economic development through innovation in the Russian Federation.

Fourthly, given the vast geographical expanse and regional diversity of Russia, understanding the role of regional investment potential could provide critical insights into opportunities for sustainable economic growth. Regional potential encompasses the maintenance of public debt, a sound macroeconomic scenario, flexible access to collateral, institutional quality, and relationship management [30].

Additionally, the predominant socio-economic and political ambiance in a region comprises a business environment where several businesses can attract investment [31]. Recent research shows that regional investment potential can significantly influence the rate and quality of innovation, and consequently, economic growth [32]. Investment in technology development can stimulate innovation by providing the necessary resources for the development and implementation of new ideas.

However, Gimpelson & Kapeliushnikov [33] state that the levels of investment vary significantly across Russian regions, leading to marked disparities in innovation and economic growth. Some regions, particularly those with strong investment climates, have been able to foster innovation and achieve robust economic growth, while

others have lagged [34]. It has been suggested that effective capital allocation at the regional level can significantly enhance innovation capacity and economic growth. This underscores the importance of not just the quantity, but also the quality of regional investments in driving the innovation-economic growth nexus. A conducive investment climate is crucial in attracting foreign direct investment (FDI), which can stimulate innovation and economic growth. Kolmykova et al. [35] state that Russian regions with a better investment climate have attracted more FDI, leading to increased innovation activities and economic growth.

Motivated by the proposition generated from the extant literature, this study intends to investigate the role of innovation in the economic growth of Russian regions amidst their concurrent investment potentials.

This research observes from the above motivational review that previous studies have extensively explored the innovation-growth nexus from various macroeconomic perspectives, yet it highlights a notable gap: few investigations have specifically analyzed how regional economies in Russia have responded to innovation promotion.

To fill this knowledge gap, the current study seeks to provide a comprehensive examination of innovation as a vital driver for economic growth across the diverse regions of Russia. Moreover, it investigates the intricate relationships between sanctions, regional investment potential, and trade integration, assessing how these factors influence the innovation-economic growth nexus in different parts of the country.

Based on the research objectives, this study formulates the following *hypotheses*:

H1: Innovation promotes economic growth in Russian Regions.

H2: Innovation promotes economic growth in the presence of trade integration.

H3: High Investment potential matters for innovation driven growth in Russian regions.

H4: Sanctions enforce innovation for economic growth in Russian Regions.

By leveraging a robust dataset, that captures total innovation and economic growth across all 66 regions of Russia from 2009 to 2019, this research aims to shed light on the significant variations that exist among these regions. To analyze the dataset and account for the regional heterogeneity present, the study employs Machado and Silva's [36] method of moments quantile regression (MMQR).

This robust econometric approach not only enables a thorough exploration of the data but also provides insights into how various factors may uniquely affect economic growth in the context of innovation, thereby contributing to a deeper understanding of the regional economic landscape in Russia. Ultimately, this study aspires to inform policymakers and stakeholders about the potential pathways through which innovation can foster sustainable economic development in the Russian regions.

This research presents the novel argument that the economic development in Russia's regions is directly stimulated by the progression of innovative activities. It also emphasizes the academic necessity to generate new credible evidence on the impact of factors like trade integration, sanctions, and regional investment potential on the relationship between innovation and economic growth in emerging markets.

This investigation contributes a novel perspective to the dialogue on innovation and economic growth dynamics, being the pioneer in exploring the influence of innovation on economic growth within the context of Russian regions, considering various macroeconomic conditions such as trade integration, sanctions, and regional investment potential.

The primary scientific finding indicates a more substantial role of innovation in driving the economic growth of Russian

regions, particularly in the presence of regional economic disparities. The study also underlines a stronger impact of innovation on regional economic growth following Russia's entry into the WTO. It acknowledges that the 2014 Western sanctions on Russia had a significant negative effect on the economic growth of its economically stronger regions, but an insignificant negative impact on the least developed regions.

The research further discloses that innovation is more successful in Russian regions with a high investment potential and confirms that factors like financial development, gross fixed capital formation, and exports enhance economic growth in Regional Russia via innovation. The empirical evidence gathered by this study could potentially guide policymakers in forming effective strategies to foster innovation, quicken trade integration, and build an investment-conducive environment to ensure sustainable growth in the Russian regions.

The rest of the paper is organized as follows. In Section 2, the dynamics of innovation and economic growth are discussed from theoretical and empirical standpoints to derive the hypotheses. In Section 3, details on variable selection, data collection and selection of research methods have been presented. Section 4 presents the analysis and the econometric investigations of this study. The convergence and divergence of the research outcomes with relevant literature are discussed Section 5. Section 6 concludes the study by presenting some policy indications, limitations of this research and future research potential.

2. Literature Review

This section presents an in-depth review of the theoretical as well as empirical aspects of how innovation contributes to economic growth, as viewed from several macroeconomic viewpoints. In the first sub-section, the innovation-growth nexus is discussed. Then, the role of trade integration in innovation-growth dynamics is portrayed. After that, the role of innovation in economic growth in the context of sanctions is discussed. Finally, the role of regional investment potential within the purview of the innovation-growth relationship is discussed.

2.1. Innovation — Economic Growth: theory and empirical evidence

The importance of innovation in driving economic growth is well-documented in influential studies [37–38]. For example, Schumpeter [8] proposed the theory of creative destruction, explaining how capitalism fosters economic growth through innovation and entrepreneurship. Subsequent literature, building on Schumpeter's theory, suggests that market-oriented institutions are well suited to stimulate growth.

The role of innovation in economic growth gains further clarity from the perspective of endogenous growth theory, as Lucas [39] in his seminal work emphasizes the value of knowledge as a productive element.

Romer [10] posits that innovation, especially technological advancements, forms an essential endogenous factor contributing to long-term economic growth. This idea is expanded upon by Hasan et al. [40], who contend that both the volume and quality of innovation are crucial for economic growth, and that the impact of innovation on growth depends on a country's economic framework and development stage. They demonstrate a direct connection between patent activity levels and economic growth rates.

However, Maradana et al. [41] and Pradhan et al. [42] argue that innovation and economic growth share a bi-directional relationship, with growth stimulating innovation in certain countries.

Conversely, Ulku [43] finds scant evidence that investment in research and de-

velopment (R&D) consistently yields innovation gains, suggesting that innovation may not necessarily result in long-term economic growth.

In a separate study, Chernyshev [44] asserts that economic growth is primarily driven by productivity, especially in the realm of innovation, with competition among innovative companies, business cycles, and enterprise interdependence as key drivers of innovation and technical advancement. This is mirrored in Russia's context by Gokhberg & Roud [45], who highlight the direct correlation between innovation and economic growth in the country, evidenced by the role of technology and knowledge-intensive sectors.

Gershman et al. [46] further show a robust link between innovative activity levels and economic development in various Russian regions, suggesting that innovation-led development can significantly reduce regional disparities in Russia.

Domnina et al. [47] find that digital innovation fuels productivity and growth in several Russian regions. As the complexities of the 21st century unfold, the role of innovation in spurring economic growth is increasingly recognized, especially in Russia, prompting a comprehensive exploration of this dynamic in the present study.

2.2. Innovation and Economic growth: role of trade integration

The World Trade Organization (WTO), established in the 1990s, advocates for international trade by reducing regional trade barriers [48]. Numerous studies posit that a country's accession to the WTO attracts investment and diversifies trade, thereby stimulating their economies [49–50].

Hughes [51] suggests that the WTO enhances trade integration by mitigating trade barriers arising from idiosyncratic risks. The WTO's Regional Trade Agreements (RTAs) have been instrumental in lowering trade barriers, encouraging countries to pursue trade-oriented economic growth strategies [52].

Russia's 2012 accession to the WTO has significantly affected its economic growth and innovation. Shepotylo & Tarr [53] propose that this move has improved market access, thereby fostering innovation. Russia's entry into the WTO opened new opportunities for innovation by enabling access to advanced global market technologies and promoting growth in regional economies [54]. Furthermore, WTO membership has encouraged new regional investments, particularly in manufacturing and digital technology industries, which in turn has spurred innovation and economic growth in these regions [55].

However, the influence of WTO membership on innovation and economic growth varies across Russian regions, with some regions benefiting more from trade opportunities and access to new technologies due to the competitive challenges and regulatory compliance requirements of the WTO [56]. Felbermayr et al. [57] argue that the full potential of WTO membership remains unrealized due to structural disparities in the Russian economy.

Conversely, some studies argue that WTO accession does not necessarily enhance bilateral trade, thus contributing insignificantly to trade-led growth [58]. For instance, Rose [59] contends that the WTO does not play a significant role in promoting bilateral trade. Esteve-Pérez et al. [60], following Rose [59], finds that WTO accession does not affect trade growth. Subramanian & Wei [61] also suggest that WTO membership primarily benefits advanced countries.

However, Tomz et al. [62] challenged Rose [57], noting that Rose omitted several economies that, while not officially recognized, were de facto WTO members and enjoyed similar benefits. The existing studies stress that WTO accession of the countries promote countries trade activities and augment aggregate economic growth.

2.3. Innovation-Economic growth nexus and the role of sanctions

Economic sanctions serve as policy instruments wielded by countries or international organizations to apply pressure on a targeted nation, its officials, or its citizens [63]. These sanctions can manifest in various ways, including travel restrictions, export limitations, trade embargoes, and asset freezes. Although their goal is to discourage specific policies or actions, they often yield broad economic impacts [64].

Previous research indicates that the enforcement of sanctions can hinder a nation's capacity to export or import goods and services, resulting in reduced trade volumes [65–68]. This can substantially affect the economy of the targeted nation, especially if it heavily depends on international trade [69].

For example, Splinter & Klomp [70] argue that export restrictions can result in job losses in the export sector and discourage foreign investment, adversely affecting the economic growth and development of the targeted country.

Neuenkirch & Neumeier [71] found that sanctions imposed by the United States and the United Nations from 1976 to 2012 had significant effects on the economic growth of the targeted countries.

Evenett [72] demonstrated that the implementation of the "US Anti-Apartheid Act" in the mid-1980s severely affected South Africa's export growth. According to Hufbauer et al. [73], economic sanctions reduce the volume of bilateral trade between the sanctioning countries and those under sanctions.

Gurvich & Prilepskiy [74] discovered that the financial sanctions placed on Russia in 2014 significantly restricted foreign capital for state-owned banks, oil and gas companies, and arms industries, also impacting non-sanctioned businesses by limiting foreign direct investment.

However, Kholodilin & Netšunajev [23] did not find strong evidence that the 2014 Western sanctions had a significant effect on the Russian economy. Lektzian & Biglaiser [75] suggest that while sanctions initially affect the economy of the targeted country, they can also stimulate the creation of new markets or promote local businesses to boost import substitutions. Sanctioned nations may react by shifting their trade focus to neighboring countries that maintain stable economic and political relationships with the sanctioning governments [76].

Moreover, countries with diverse economies can effectively navigate the repercussions of geopolitical conflicts and other economic disruptions in the long term [77]. For instance, Iran, an oil-rich country, managed to diversify its economy amid the oil price fluctuations of the 1970s [78]. This study observes inconsistent evidence regarding how economies typically react to economic sanctions imposed by powerful nations.

2.4. Innovation and Economic growth dynamics: The role of regional investment potential

In an intensely competitive economy, high investment levels are crucial for modernizing the private sector and enhancing innovation-driven economic growth [79]. Funding innovative businesses is regarded as a critical factor in propelling economic growth [80].

King & Levine [81] suggest that a country's financial sector provides the necessary capital for private companies to undertake innovative initiatives. Shakib et al. [32] argue that the banking sector delivers the vital capital needed for innovation and boosts economic growth.

However, Baños-Caballero et al. [82] observe that innovative projects often face capital constraints when making investment decisions for new ventures. Campello et

al. [83] posits that innovative firms struggle to secure external credit due to return volatility, asymmetrical information, and a lack of collateral.

Rehman et al. [84] explains that banks typically Issue loans to businesses based on their past and potential financial stability, especially their cash flows adjusted for risk and transaction costs.

Bigsten et al. [85] note that startups and financially vulnerable businesses often face more credit constraints than their established and larger counterparts do. Angilella & Mazzù [86] suggest that firms with innovation-intensive business models encounter several constraints that reduce their chances of receiving external capital.

Wellalage & Fernandez [87] argue that regional authorities can support innovative businesses with efficient fundraising by ensuring attractive investment potential, which can contribute to economic growth.

Panzera & Postiglione [88] state that regions often compete to attract more investments to provide businesses with new opportunities. Tagoe et al. [89] note that while small businesses are more inclined towards innovation, they are the ones that struggle most for finances, concluding that a favorable investment climate is critical for attracting external financing for innovative firms to sustain economic growth.

In the Russian context, Chernyavskaya et al. [90] suggest that regional investment potential is significant for attracting substantial foreign investment for innovation, but note that the state of innovation finance is inconsistent across Russian regions.

Smith & Thomas [91] found that Russian regions with a more favorable investment climate have attracted more Foreign Direct Investment (FDI), leading to increased innovation activities and economic growth. Given this backdrop, this study finds that regional investment potential plays a significant role in loan disbursement decisions by banks.

The existing literature concludes that innovation functions as a crucial factor for economic growth of the nations. Besides, the literature review presents an inclusive proposition about the role of WTO in augmenting economic growth. Moreover, this review finds that sanctions play contrasting roles in the context of economic growth of the sanctioned countries.

Nevertheless, the existing research shows that regional investment potential is critical to economic success of nations. Amidst these scholastic arguments with regard to innovation-growth nexus of countries, this study aims to investigate the role of innovation in economic growth of the Russian regions under several economic and geopolitical circumstances.

3. 3. Data, models and method of research

3.1. Data

This study seeks to ascertain whether innovation can foster regional economic growth within the Russian Federation. It also aims to examine the role of trade integration, regional investment potential, and sanctions within the context of the innovation-growth nexus in Russian regions.

To verify the research hypotheses empirically, this study employs real Gross Regional Product (GRP) as a representation of regional economic growth, following the examples of Panzera & Postiglione [88], Hasan et al. [92], and Cherodian & Thirlwall [93] who utilized gross regional product as a surrogate for economic growth.

In alignment with the studies of Autor et al. [94], Hsu et al. [95], and Zemtsov et al. [96], total patents are used in this study as an indicator of innovation.

Furthermore, this study considers the volume of bank loans disbursed to entrepreneurs and legal entities within Russian regions as a measure of financial development, drawing upon the arguments of

Sohag et al. [97], Al Mamun et al. [98], and Shakib et al. [99] that bank credits had better represent financial development, particularly in developing countries.

For proxies of trade integration and sanctions, this study refers to Russia's accession to the WTO platform (examples: Hughes [48], Shepotylo and Tarr [50], Tomz et al. [60]) and the 2014 sanctions (examples: Splinter & Klomp [71], Evenett [73], Hufbauer et al. [73]), respectively. Furthermore, the regional investment potential index of Russia, introduced by "Expert RA", a leading Russian Credit rating agency, is used as a proxy for regional investment potential, following Sugak & Brazgovka [100] and Bratukhina et al. [101].

This study also incorporates several control variables to examine the primary hypothesis from various angles. Accordingly, following Handa & Khan [102], Petkovski & Kjosevski [103], and Li, & Wei [104], this study includes gross fixed capital formation, total export, and the total population of the Russian regions as control variables in the proposed econometric model.

Data for 66 Russian regions were sourced from the Russian government's official website and the country's federal statistics repository for this research. Some regions were omitted from the study's dataset due to a lack of adequate data. Additionally, data for Moscow city were excluded to avoid the outlier effect. The study encompasses data from 2009 to 2019, with the timeline capped in 2019 to exclude any structural shifts that transpired following the advent of the Covid-19 pandemic and the subsequent military action in Ukraine.

The details of all the variables and sources of data collection are stated in Table 1.

Table 1. **Variables, definitions, and sources**

Variable	Definition	Source
LGRP	Natural log of Gross Regional Product (in million rubles)	https://rosstat.gov.ru/statistics/accounts
LINOV	Natural log of region wise total patents in Russia (in units)	https://rosstat.gov.ru/statistics/science
LCRDT	Natural log of bank credit disbursed to sole proprietors and legal business organizations (in million rubles)	https://rosstat.gov.ru/statistics/finance
LGFC	Natural log of Gross Fixed Capital (total investment in the fixed assets) of the Russian Regions	https://www.fedstat.ru/indicator/40562#
LPOPL	Natural log of region wise total population in Russia	https://rosstat.gov.ru/folder/12781
LEXPT	Natural log of the region wise total export in Russia (in million rubles)	https://rosstat.gov.ru/folder/11193
INVPO	Regional Investment Potential Index of Russia (Calculated annually)	https://www.raexpert.ru/
WTOD	Russia's accession to WTO (dummy)	
SANCD	sanctions imposed on Russia in 2014 (dummy)	

3.2. Research Method and Econometric Models

This study employs the "Method of Moments Quantile Regression" (MMQR), as recommended by Machado & Silva [36], to investigate both heterogeneous and distributional effects across the quantiles in relation to innovation, real gross regional product (GRP), financial development, population, trade integration (accession to the WTO platform), investment potential, and sanctions in regional Russia.

Koenker & Bassett [105] assert that standard quantile regressions provide reliable estimates in addressing outliers and are appropriate methods when the conditional means of two variables are not significantly related. However, Inuwa et al. [106] argue that standard quantile regression methods do not account for the potential unobserved heterogeneity within the cross-sections.

Furthermore, Koenker [107] suggests that MMQR enables the estimation of covariance effects between the factors of regional economic growth and their respective conditional heterogeneity, thereby defining their exact relationships.

Khan et al. [108] indicates that the MMQR approach addresses the possible heterogeneity within the explanatory variables. This method is suitable in scenarios where a specific effect aims to absorb panel dataset variations. Moreover, the MMQR approach considers asymmetrical locations and provides insights into non-crossing quantile regressions.

Machado & Silva [36] argue that fixed-effect approaches do not handle heterogeneity, while MMQR does due to its capability to perform heterogeneous estimation for the entire panel. Furthermore, the heterogeneity of the coefficients confirms that the MMQR method successfully addresses cross-section heterogeneity.

Consequently, this study follows the MMQR approach to operationalizing the research. The conditional quantile $Q_y(\tau \mid X)$ estimations of the proposed econometric models under different locations and scales are defined with the following equation:

$$Y_{it} = \alpha_i + X'_{it}\beta + (\delta_i + Z'_{it}\gamma)U_{it}. \quad (1)$$

Here, probability $P\{\delta_i + Z'_{it}\gamma > 0\} = 1$, and $(\alpha, \beta', \delta, \gamma')'$ are the constraints which are to be predicted. The discrete fixed effects (i) are quantified as (α_i, δ_i), $I = 1, \ldots, n$ and k vector of known components of (X) is signified by Z, which are divergent modifications with component l presented below:

$$Z_l = Z_l(X) \quad l = 1, ..., k. \quad (2)$$

Here, X_{it} is distributed independently and evenly for any fixed i and over time t. U_{it} is also distributed independently and evenly among individuals i through time t and is superfluous to. It is also uniformed to accomplish the moment conditions. Equation (3) derives the following:

$$Q_y(\tau \mid X) = \\ = (\alpha_i + \delta_i(\tau) + X'_{it}\beta + Z'_{it}\gamma q(\tau)). \quad (3)$$

Here, X_{it} is a vector for all explanatory variables and $Q_y(\tau \mid X)$ consider that the operational quantiles are dispersed to the dependent variable Y_{it} (Gross regional product) depending on the distribution (location) of explanatory variables X_{it}. The discrete (i) quantile (τ) fixed effect is established by the scalar coefficient indicated as $\alpha_i(\tau) = \alpha_i + \delta_i q(\tau)$.

The modification in the intercept does not accurately represent the individual impact when compared to the overall least-squares fixed-effects. The above constraints fail to account for the temporal variability and heterogeneity that are suitable for varying throughout the conditional quantile distribution of the en-

dogenous parameters. The τ-the model quantile shown by $q(\tau)$ can be assessed by adopting the result of the following optimization:

$$\min_q \sum\sum \rho\tau\left(R_{it} - Z'_{it}\gamma\right)q. \qquad (4)$$

Here, $\rho\tau(A) = (\tau - 1)\,AI\{A \le 0\}\,TAI \times \times\{A > 0\}$ signifies the check function.

By adopting the conventional conditional regression approach, this study formulates the following MMQR model:

$$\begin{aligned} Q_{LGRP_{it}}(\tau \mid X_{it}) &= (\alpha_i(\tau) + \delta_i q(\tau)) + \\ &+ \beta_{1i}(\tau) LINOV_{it} + \beta_{2i}(\tau) LCRDT_{it} + \\ &+ \beta_{3i}(\tau) LGFC_{it} + \beta_{4i}(\tau) LPOPL_{it} + \\ &+ \beta_{5i}(\tau) LEXPT_{it} + Z'_{it}\gamma q(\tau) + \varepsilon. \end{aligned} \qquad (5)$$

In the model, natural log of Gross Regional Product (*LGRP*) is used as the dependent variable and natural log of total innovation (*LINOV*) as the explanatory variables. For control variables, the natural log of total bank credit disbursed regionally (*LCRDT*), natural log of Gross fixed capital (*LGFC*), natural log of region based total export (*LEXPO*), and natural log of total region-based population (*LPOP*) are considered. In the equation, "*i*" stands for of region and "*t*" stands for time. "α" is denoted as intercept and "β" is signifies the parameters. Besides, "ε" signifies the error term.

This study additionally explores the impact of trade integration, regional investment potential and western sanctions in the context of innovation-growth nexus of the Russian regions by establishing the following equations:

$$\begin{aligned} Q_{LGRP_{it}}(\tau \mid X_{it}) &= (\alpha_i(\tau) + \delta_i q(\tau)) + \\ &+ \beta_{1i}(\tau) LINOV_{it} + \beta_{2i}(\tau) LCRDT_{it} + \\ &+ \beta_{3i}(\tau) LGFC_{it} + \beta_{4i}(\tau) LPOPL_{it} + \\ &+ \beta_{5i}(\tau) LEXPT_{it} + \beta_{6i}(\tau) WTOD_t + \\ &+ Z'_{it}\gamma q(\tau) + \varepsilon. \end{aligned} \qquad (6)$$

$$\begin{aligned} Q_{LGRP_{it}}(\tau \mid X_{it}) &= (\alpha_i(\tau) + \delta_i q(\tau)) + \\ &+ \beta_{1i}(\tau) LINOV_{it} + \beta_{2i}(\tau) LCRDT_{it} + \\ &+ \beta_{3i}(\tau) LGFC_{it} + \beta_{4i}(\tau) LPOPL_{it} + \\ &+ \beta_{5i}(\tau) LEXPT_{it} + \beta_{6i}(\tau) INVPO_t + \\ &+ Z'_{it}\gamma q(\tau) + \varepsilon. \end{aligned} \qquad (7)$$

$$\begin{aligned} Q_{LGRP_{it}}(\tau \mid X_{it}) &= (\alpha_i(\tau) + \delta_i q(\tau)) + \\ &+ \beta_{1i}(\tau) LINOV_{it} + \beta_{2i}(\tau) LCRDT_{it} + \\ &+ \beta_{3i}(\tau) LGFC_{it} + \beta_{4i}(\tau) LPOPL_{it} + \\ &+ \beta_{5i}(\tau) LEXPT_{it} + \beta_{6i}(\tau) \mathrm{SANCD}_t + \\ &+ Z'_{it}\gamma q(\tau) + \varepsilon. \end{aligned} \qquad (8)$$

In equation (6), the primary regression model is extended by including WTO dummy as the proxy for trade integration. Accordingly, in equations (7) and (8), annual investment potential index of the Russian regions and Sanction of 2014 as the dummy are included as the proxy for investment potential and sanctions to investigate their influence on innovation and regional economic growth nexus of the Russian federation.

4. Results and analysis

4.1. Descriptive Statistics

This study performs empirical investigation by analyzing the descriptive statistics of the dataset used in this research. Table 2 shows the meaning and standard deviation of the dependent, independent and control variables. Given the proxies for economic growth, this study observes higher disparities among the sample Russian regions. The empirical investigation also evidences that the sample regions experience wide disparity in terms of innovation, financial development, gross capital formation, export, and population. The presence of such heterogeneity provides strong ground for adopting the MMQR technique to derive robust regression outcome.

Table 2. **Descriptive statistics**

Variable		Mean	Std. Dev.	Min	Max	Observations
LGRP	overall	26.15494	0.921036	23.49687	28.38334	N = 726
	between		0.919758	23.73311	28.17106	n = 66
	within		0.118409	25.75953	26.50099	T = 11
LINOV	overall	1.532061	0.319405	–0.36651	2.096038	N = 726
	between		0.310171	0.58447	2.023644	n = 66
	within		0.084499	0.510016	1.994958	T = 11
LCRDT	overall	2.597211	0.089741	2.255727	2.827307	N = 726
	between		0.085105	2.408245	2.792411	n = 66
	within		0.030172	2.444694	2.724436	T = 11
LGFC	overall	4.239005	1.033971	1.474099	6.817789	N = 726
	between		0.999952	2.033435	6.517589	n = 66
	within		0.28807	3.288436	5.292952	T = 11
LPOPL	overall	14.15189	0.698729	12.23645	15.82016	N = 726
	between		0.107099	13.9916	14.36711	n = 66
	within		0.690587	12.39123	15.71356	T = 11
LEXPT	overall	7.062916	1.662063	2.079442	10.22803	N = 726
	between		1.634951	2.825604	9.878933	n = 66
	within		0.355329	5.85013	9.152767	T = 11
INVPO	overall	1.136329	0.97262	0.164	6.249	N = 726
	between		0.974842	0.190455	5.903727	n = 66
	within		0.093702	0.20942	1.539693	T = 11
WTOD	overall	0.727273	0.445669	0	1	N = 726
	between		0	0.727273	0.727273	n = 66
	within		0.445669	0	1	T = 11
SANCD	overall	0.545455	0.498273	0	1	N = 726
	between		0	0.545455	0.545455	n = 66
	within		0.498273	0	1	T = 11

4.2. Main Results

The quantile regression this study considers distinguishes the quantiles based on the dependent variable (Gross regional product). The lower quantiles (Q1–Q3) refer to the regions with the least economically developed regions, while the highest quantiles (Q7–Q9) refer to the most economically developed regions. This study also distinguishes the regions with a me-

dium degree of economic development, which are included in the medium quantiles (Q4–Q6).

4.2.1 Innovation and economic growth relationship in Russian regions

In table 3, this study reports estimation of the main econometric model (Eq. 5). The table shows that the coefficient of innovation is positive and significant for all quantiles (Q1–Q9). This indicates that an increase in the number of innovations increases the gross regional products in all regions. The spatial fixed effect of gross regional product confirms that innovation promotes regional economic growth in Russian Federation.

However, the time fixed-effect shows a negative and insignificant effect, meaning that innovation during the time has a negative and insignificant effect on the regional economic development, which this study explain with the lower variation of the indicator over time. This study further observes that the magnitude of the relationship between innovation and regional economic growth is higher in the lower quantiles (least developed regions) indicating that innovation is crucial for augmenting growth in these regions.

This study further observes that the control variables representing financial development, gross capital formation, export, and population are found to be promoting regional growth through innovation in the Russian Federation. However, this study reports that the population size negatively but insignificantly affects economic development in lower quantiles (Q10–Q50) but population has negative and significant in the upper quantiles (Q60–Q90).

4.2.2 Innovation-economic growth nexus in Russian regions: role of trade integration

In table 4, this study presents the result of Equation 6 which takes into account the role of trade integration (Russia's accession to WTO) on innovation-economic growth nexus of Russian regions. Table 4 reports that reports that before Russia's joining into the WTO platform, the coefficient of innovation with regard to regional economic growth is positive and significant only in the least developed regions but in major regions (Q6-Q9) the impact is not tangible. This indicates that innovation did not contribute to economic growth in the highly developed Russian regions before Russia's accession to the WTO. However, following Russia's entry into the WTO, innovation significantly promoted economic growth in all the Russian regions.

This finding concludes that Russia's accession to WTO platform enhanced innovation activities in all the Russian regions which eventually propelled regional growth. Meanwhile, this study report that the spatial fixed effect of gross regional product confirms that innovation promotes economic growth in Russian regions both in the event of Russia's accession to the global trade network and lack thereof.

However, the time fixed effect shows a negative and insignificant effect, meaning that innovation during the time has a negative and insignificant effect on the economic development in those regions indicating less variation within the variables over time.

This study further report that financial development, gross capital formation and export positively affect the innovation-growth dynamics of the Russian regions from the perspective of trade integration.

Contrarily, this study find that population size negatively and insignificantly affects innovation and growth nexus in the upper quantiles before the WTO accession but in all quantiles after the WTO entry of the Russian Federation.

Table 3. **Estimation result of the innovation-economic growth nexus of the Russian region**

VARIABLES	location	scale	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
LINOV	0.322***	−0.129***	0.511***	0.448***	0.408***	0.367***	0.324***	0.282***	0.231***	0.173**	0.109
	(0.0581)	(0.0364)	(0.0830)	(0.0707)	(0.0648)	(0.0607)	(0.0583)	(0.0585)	(0.0619)	(0.0684)	(0.0795)
LCRDT	1.901***	−0.149	2.121***	2.048***	2.002***	1.953***	1.903***	1.855***	1.796***	1.729***	1.654***
	(0.234)	(0.146)	(0.332)	(0.285)	(0.261)	(0.244)	(0.234)	(0.234)	(0.247)	(0.275)	(0.320)
LGFC	0.571***	0.0685***	0.470***	0.503***	0.525***	0.547***	0.570***	0.592***	0.619***	0.650***	0.684***
	(0.0198)	(0.0124)	(0.0285)	(0.0241)	(0.0220)	(0.0207)	(0.0200)	(0.0202)	(0.0214)	(0.0234)	(0.0271)
LPOPL	−0.0226	−0.00680	−0.0126	−0.0159	−0.0180	−0.0202	−0.0225	−0.0247*	−0.0274*	−0.0305*	−0.0338*
	(0.0139)	(0.00868)	(0.0197)	(0.0169)	(0.0155)	(0.0145)	(0.0139)	(0.0139)	(0.0146)	(0.0163)	(0.0190)
LEXPT	0.0762***	−0.0182***	0.103***	0.0940***	0.0884***	0.0825***	0.0764***	0.0706***	0.0634***	0.0552***	0.0461***
	(0.0102)	(0.00637)	(0.0145)	(0.0124)	(0.0114)	(0.0106)	(0.0102)	(0.0102)	(0.0108)	(0.0120)	(0.0139)
Constant	18.09***	0.715**	17.03***	17.39***	17.61***	17.84***	18.08***	18.31***	18.59***	18.91***	19.27***
	(0.530)	(0.331)	(0.754)	(0.646)	(0.592)	(0.553)	(0.531)	(0.531)	(0.560)	(0.624)	(0.725)
Observations	726	726	726	726	726	726	726	726	726	726	726

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

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Table 4. **Estimation results of innovation and economic growth in Russian regions accounting for trade integration**

Variables (Before WTO)	location	scale	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
LINOV	0.247*	–0.206**	0.579**	0.472**	0.379**	0.286**	0.220*	0.164	0.105	0.0321	–0.0786
	(0.130)	(0.0880)	(0.227)	(0.190)	(0.162)	(0.139)	(0.127)	(0.119)	(0.118)	(0.125)	(0.142)
LCRDT	2.622***	0.139	2.398**	2.470***	2.533***	2.596***	2.640***	2.678***	2.717***	2.767***	2.841***
	(0.631)	(0.428)	(1.116)	(0.932)	(0.788)	(0.669)	(0.609)	(0.578)	(0.571)	(0.597)	(0.700)
LGFC	0.535***	0.0714**	0.420***	0.457***	0.489***	0.522***	0.544***	0.564***	0.584***	0.609***	0.648***
	(0.0455)	(0.0309)	(0.0801)	(0.0667)	(0.0568)	(0.0488)	(0.0444)	(0.0419)	(0.0416)	(0.0438)	(0.0501)
LPOPL	0.00390	–0.0287	0.0501	0.0352	0.0223	0.00934	0.000138	–0.00766	–0.0157	–0.0259	–0.0413
	(0.0299)	(0.0203)	(0.0527)	(0.0440)	(0.0373)	(0.0318)	(0.0290)	(0.0274)	(0.0271)	(0.0285)	(0.0331)
LEXPT	0.0773***	–0.0250*	0.118***	0.105***	0.0934***	0.0821***	0.0741***	0.0673***	0.0602***	0.0514**	0.0380
	(0.0220)	(0.0149)	(0.0387)	(0.0323)	(0.0274)	(0.0234)	(0.0213)	(0.0202)	(0.0200)	(0.0210)	(0.0243)
Constant	16.16***	0.445	15.45***	15.68***	15.88***	16.08***	16.22***	16.34***	16.47***	16.63***	16.86***
	(1.441)	(0.978)	(2.549)	(2.129)	(1.800)	(1.529)	(1.391)	(1.322)	(1.305)	(1.365)	(1.600)

End of table 4

VARIABLES (after WTO)	location	scale	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
LINOV	0.318***	−0.0961*	0.462***	0.410***	0.381***	0.354***	0.321***	0.293***	0.255***	0.208**	0.160*
	(0.0756)	(0.0529)	(0.125)	(0.102)	(0.0919)	(0.0834)	(0.0760)	(0.0726)	(0.0732)	(0.0812)	(0.0962)
LCRDT	1.743***	−0.362*	2.285***	2.086***	1.980***	1.876***	1.753***	1.649***	1.504***	1.326***	1.146***
	(0.292)	(0.205)	(0.484)	(0.396)	(0.356)	(0.323)	(0.294)	(0.281)	(0.283)	(0.314)	(0.372)
LGFC	0.597***	0.0860***	0.468***	0.515***	0.540***	0.565***	0.594***	0.619***	0.653***	0.696***	0.739***
	(0.0269)	(0.0188)	(0.0444)	(0.0354)	(0.0317)	(0.0291)	(0.0268)	(0.0260)	(0.0267)	(0.0291)	(0.0344)
LPOPL	−0.0197	0.0109	−0.0360	−0.0301	−0.0269	−0.0237	−0.0200	−0.0169	−0.0125	−0.00717	−0.00174
	(0.0190)	(0.0133)	(0.0316)	(0.0259)	(0.0232)	(0.0211)	(0.0192)	(0.0183)	(0.0183)	(0.0204)	(0.0242)
LEXPT	0.0713***	−0.0224**	0.105***	0.0925***	0.0859***	0.0795***	0.0719***	0.0654***	0.0565***	0.0454***	0.0342**
	(0.0136)	(0.00951)	(0.0225)	(0.0184)	(0.0165)	(0.0150)	(0.0137)	(0.0131)	(0.0132)	(0.0146)	(0.0173)
Constant	18.36***	0.906*	17.00***	17.50***	17.77***	18.03***	18.34***	18.60***	18.96***	19.41***	19.86***
	(0.665)	(0.465)	(1.102)	(0.901)	(0.809)	(0.734)	(0.668)	(0.639)	(0.644)	(0.714)	(0.847)
Observations	528	528	528	528	528	528	528	528	528	528	528

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

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4.2.3 Innovation-economic growth nexus in Russian regions: role of regional investment potential

In Table 5 This study report that the coefficient of innovation is positive and significant for all quantiles (Q1–Q9) both for regions with high low investment potentials. It indicates that an increase in regional innovation in general propels regional GRP irrespective of the extent of investment potential.

However, from critical observation, this study finds that the coefficients of innovation concerning regional development tend to be higher in the regions with better investment potential. This emphasizes the need for ensuring a better investment attractiveness for promoting innovation-driven growth in Russian Regions. Meanwhile, this study report that as it happens for our main model, the spatial fixed effect of gross regional product confirms that innovation promotes economic growth in Russian regions with both high and low business potential. However, the time fixed effect shows a negative and insignificant effect, meaning that innovation during the time has a negative and insignificant effect on the economic development in those regions indicating less variation within the variables over time.

This study also observes that the overall magnitude of the relationship between innovation and regional economic development is higher in the lower quantiles (q10–Q30), indicating that innovation promotion is crucial for augmenting economic development in the least developed regions irrespective of favorable and unfavorable business atmosphere. From the control variable perspective, this study report that the financial development, gross capital formation, and export, in Russian regions contribute to the economic development of these regions through innovation.

On the other hand, this study finds that population size negatively affects the innovation-growth nexus of the regions with high investment potential in almost all quantiles other than the lowest (Q10) and highest (Q90) quantiles. Meanwhile, such an effect on the population is negative but insignificant in regions with low investment potential.

4.2.4 Innovation and economic growth in Russian regions: role of sanctions of 2014

In Table 6, this study reports that the coefficient of innovation is positive and significant for all quantiles (Q1–Q9), indicating that innovation tangibly augments GRP per capita amidst sanctions. Meanwhile, this study report that the spatial fixed effect of gross regional product confirms that innovation promotes economic growth in Russian regions.

However, the time fixed effect shows a negative and insignificant effect, meaning that innovation during the time has a negative and insignificant effect on the economic development in those regions indicating less variation within the variables over time. From the sanction's perspective, this study find that western sanctions negatively but insignificantly affect economic growth through innovation in the lower quantiles (least developed Russian Regions). However, these sanctions negatively and significantly influence the innovation and economic growth nexus in the middle and upper quantiles (medium and developed regions).

From the control variable perspective, this study report that the gross financial development, capital formation, and export contribute to the economic development of the Russian regions. Besides, this study find that population size negatively and insignificantly affects regional growth through innovation in the Russian Federation.

Table 5. **Estimation results of innovation and regional economic growth nexus accounting for the business potential of the Russian regions (low and high potential)**

Variables (Low potential)	location	scale	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
LINOV	0.175**	−0.0260	0.225*	0.202**	0.189**	0.181**	0.172**	0.161**	0.154**	0.146**	0.138*
	(0.0690)	(0.0418)	(0.124)	(0.0939)	(0.0802)	(0.0728)	(0.0674)	(0.0638)	(0.0642)	(0.0666)	(0.0720)
LCRDT	1.652***	−0.154	1.944***	1.808***	1.733***	1.683***	1.635***	1.569***	1.523***	1.481***	1.429***
	(0.350)	(0.212)	(0.626)	(0.476)	(0.407)	(0.369)	(0.341)	(0.323)	(0.325)	(0.337)	(0.364)
LGFC	0.624***	−0.0189	0.660***	0.643***	0.634***	0.628***	0.622***	0.614***	0.608***	0.603***	0.597***
	(0.0307)	(0.0186)	(0.0550)	(0.0419)	(0.0357)	(0.0324)	(0.0300)	(0.0284)	(0.0286)	(0.0296)	(0.0320)
LPOPL	0.00148	−0.00693	0.0146	0.00848	0.00513	0.00288	0.000689	−0.00227	−0.00434	−0.00625	−0.00857
	(0.0229)	(0.0138)	(0.0409)	(0.0311)	(0.0266)	(0.0241)	(0.0223)	(0.0211)	(0.0212)	(0.0220)	(0.0238)
LEXPT	0.0498***	0.0140	0.0233	0.0357*	0.0424**	0.0469***	0.0514***	0.0573***	0.0615***	0.0653***	0.0700***
	(0.0152)	(0.00919)	(0.0272)	(0.0207)	(0.0177)	(0.0161)	(0.0149)	(0.0141)	(0.0141)	(0.0146)	(0.0158)
Constant	18.58***	0.688	17.28***	17.89***	18.22***	18.44***	18.66***	18.95***	19.16***	19.35***	19.58***
	(0.800)	(0.484)	(1.433)	(1.092)	(0.933)	(0.845)	(0.783)	(0.741)	(0.745)	(0.771)	(0.833)

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End of table 5

Variables (High Potential)	location	scale	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
LINOV	0.451***	–0.159***	0.691***	0.613***	0.560***	0.515***	0.465***	0.409***	0.344***	0.268***	0.176*
	(0.0630)	(0.0386)	(0.0762)	(0.0656)	(0.0620)	(0.0612)	(0.0628)	(0.0671)	(0.0749)	(0.0864)	(0.103)
LCRDT	1.905***	–0.143	2.120***	2.050***	2.003***	1.962***	1.918***	1.867***	1.809***	1.740***	1.658***
	(0.284)	(0.174)	(0.336)	(0.295)	(0.279)	(0.275)	(0.281)	(0.299)	(0.334)	(0.387)	(0.463)
LGFC	0.533***	0.106***	0.373***	0.426***	0.461***	0.490***	0.524***	0.561***	0.605***	0.655***	0.716***
	(0.0271)	(0.0166)	(0.0340)	(0.0284)	(0.0267)	(0.0264)	(0.0274)	(0.0294)	(0.0329)	(0.0377)	(0.0446)
LPOPL	–0.0325**	–0.00430	–0.0260	–0.0281*	–0.0295*	–0.0308**	–0.0321**	–0.0336**	–0.0354*	–0.0374*	–0.0399
	(0.0158)	(0.00969)	(0.0187)	(0.0164)	(0.0155)	(0.0153)	(0.0156)	(0.0166)	(0.0186)	(0.0215)	(0.0257)
LEXPT	0.0992***	–0.0303***	0.145***	0.130***	0.120***	0.111***	0.102***	0.0911***	0.0787***	0.0643***	0.0469**
	(0.0145)	(0.00892)	(0.0175)	(0.0151)	(0.0143)	(0.0141)	(0.0145)	(0.0154)	(0.0172)	(0.0199)	(0.0237)
Constant	18.01***	0.635	17.06***	17.37***	17.58***	17.76***	17.96***	18.18***	18.44***	18.74***	19.11***
	(0.647)	(0.397)	(0.767)	(0.672)	(0.636)	(0.627)	(0.640)	(0.682)	(0.761)	(0.881)	(1.054)
Observations	528	528	528	528	528	528	528	528	528	528	528

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6. **Estimation results for innovation- regional economic growth nexus accounting for sanctions of 2014**

VARIABLES	location	scale	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
LINOV	0.317***	−0.124***	0.504***	0.438***	0.404***	0.362***	0.319***	0.274***	0.231***	0.173**	0.119
	(0.0600)	(0.0389)	(0.0916)	(0.0767)	(0.0701)	(0.0642)	(0.0603)	(0.0590)	(0.0610)	(0.0674)	(0.0770)
LCRDT	1.855***	−0.229	2.198***	2.078***	2.014***	1.937***	1.857***	1.774***	1.696***	1.589***	1.491***
	(0.243)	(0.157)	(0.371)	(0.312)	(0.285)	(0.260)	(0.243)	(0.238)	(0.245)	(0.273)	(0.311)
LGFC	0.580***	0.0781***	0.463***	0.504***	0.526***	0.552***	0.579***	0.607***	0.634***	0.671***	0.704***
	(0.0215)	(0.0139)	(0.0327)	(0.0271)	(0.0248)	(0.0230)	(0.0217)	(0.0213)	(0.0221)	(0.0241)	(0.0276)
LPOPL	−0.0173	−0.00290	−0.0129	−0.0144	−0.0153	−0.0162	−0.0172	−0.0183	−0.0193	−0.0206	−0.0219
	(0.0148)	(0.00958)	(0.0226)	(0.0190)	(0.0174)	(0.0158)	(0.0148)	(0.0145)	(0.0149)	(0.0166)	(0.0189)
LEXPT	0.0741***	−0.0205***	0.105***	0.0940***	0.0883***	0.0814***	0.0743***	0.0669***	0.0599***	0.0503***	0.0415***
	(0.0107)	(0.00696)	(0.0164)	(0.0137)	(0.0126)	(0.0115)	(0.0108)	(0.0105)	(0.0109)	(0.0121)	(0.0138)
SANCD	−0.0464**	−0.0277**	−0.00497	−0.0195	−0.0272	−0.0365	−0.0462**	−0.0562***	−0.0657***	−0.0786***	−0.0905***
	(0.0216)	(0.0140)	(0.0329)	(0.0277)	(0.0253)	(0.0231)	(0.0216)	(0.0212)	(0.0218)	(0.0242)	(0.0277)
Constant	18.14***	0.849**	16.87***	17.31***	17.55***	17.83***	18.13***	18.44***	18.73***	19.13***	19.49***
	(0.547)	(0.355)	(0.836)	(0.701)	(0.642)	(0.586)	(0.549)	(0.537)	(0.554)	(0.615)	(0.702)
Observations	726	726	726	726	726	726	726	726	726	726	726

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

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5. Discussion

The empirical findings reveal that innovation in Russian regions significantly spurs regional economic growth. This study reports that innovation tangibly augments regional economic growth of Russia, with innovation playing ф stronger role for the growth of the least developed regions. The findings of this study shows that Russia's joining of WTO augmented innovation-driven economic growth in the Russian regions.

Furthermore, this study concludes that the economic sanctions imposed in 2014 have had a negative and considerable impact on the economic growth of Russia's advanced regions. However, less prosperous regions were not greatly impacted in this regard. Furthermore, this study identifies a significant magnitude of innovation-growth dynamics in the Russian regions with great investment potential.

This study also finds that gross financial development, fixed capital formation, and exports all have a key role in encouraging economic growth through innovation in the Russian regions.

The empirical findings of this study converge with and diverge from some of the existing studies. For example, the estimation of our main model that innovation propels economic growth supports prior literature like Lucas's [39], Romer [10], Chernyshev [41], Gokhberg & Roud [42], Gershman et al. [43] who argued that economic growth is mainly driven by output, specifically in the field of innovation. They conclude that the major forces behind innovation and technological improvement are the economic cycle, the competition between innovative ventures, and the interconnectedness of production among enterprises in an economy.

However, our study diverges from Maradana et al. [41] and Pradhan et al. [42] who argued that economic growth has the potential to enhance the level of innovation in the development process indicating the possibility of a two-way relationship between innovation and economic growth. Moreover, our study contradicts with Ulku [43] who claim that innovation does not have any tangible relationship with economic growth in some economies.

Meanwhile, in the context of the role of trade integration in promoting economic growth through innovation, this study corroborates with Beverelli et al. [14], Golub [15], Gnangnon [16], Bown [48], Hughes [51], and Shepotylo & Tarr [53] who argues that accession to WTO significantly contributes to economic regional economic development.

However, Siddiqui [58], Rose [59], and Esteve-Pérez et al. [60] Subramanian & Wei [61] contradict our finding claiming a positive association between trade integration and economic growth of nations.

Besides, the empirical finding on the impact of sanctions of 2014 coincides with Lektzian & Mkrtchian [20], Vatansever [21], Chortane, & Pandey [22], Allen [65], and Besedeš et al. [66], who found that sanctions significantly affect the economic activities of the target countries by increasing their business costs, reducing foreign trade and investment, increasing currency devaluation and inflation and blocking financial aids. However, this study diverges with Kholodilin & Netšunajev [23], Lektzian & Biglaiser [75], Early & Peksen [76], Astrov et al. [77] and Ross [78] who argue that sanctions, while deterring economic growth in the short run, create opportunities for growth in the long-run.

They propose that sanctioned countries can achieve resilience amidst such geopolitical turmoil by altering their trade destination, enhancing economic and political ties with neighboring countries and allies to attract new investment and trade, strengthening the financial sector, and most importantly, diversifying their economy.

Moreover, the finding on the role of regional investment potential in augmenting economic growth through innovation goes in line with Shakib et al. [32], Campello et al. [83], Angilella & Mazzù [86], Panzera & Postiglione [88], and Chernyavskaya et al. [90] who argued that finance functions more prominently in extending capital to innovative private sector located in a favorable investment atmosphere. The findings are further supported by Smith & Thomas [91], who find that Russian regions with a better investment climate receive more foreign capital, which help them promote innovation driven growth.

This research offers some valuable insights, but there are certain limitations that need to be acknowledged. Primarily, the data used may not accurately represent the current state of the relationship between innovation and economic growth of Russia's regions, as the most recent information was not available at the time of the study.

Additionally, the significant shift in Russia's economic landscape following the 2022 sanctions is not fully reflected in the study's findings. As such, further research that includes data from the post-sanctions period could provide a more comprehensive understanding of the role of innovation in the context of regional growth, especially considering the mediating effect of geopolitical factors like sanctions.

Furthermore, the impact of the February 2022 sanctions on Russia's financial sector was considerable, yet this study did not explore how the financial sector might influence export diversification through innovation in these transformative circumstances. Future research should consider this research gap. Despite these limitations, the study posits that innovation is a critical driver of economic growth of Russian regions. It further asserts that trade integration and investment potential are integral catalysts for boosting economic growth in transition economies, such as the Russian Federation.

Lastly, the study suggests that geopolitical tensions, such as sanctions, can present opportunities to promote regional innovation to tackle long-run economic adversities.

6. Conclusion and policy implications

Given the critical role that innovation plays in Russia's economic development, this study examines the relationship between innovation and growth in the context of various macroeconomic scenarios as they relate to Russian regions.

This study employed the Quantile via Moment (MMQR) method to account for the regional differences in the panel data. The empirical results demonstrate that innovation in Russian regions has a substantial impact on regional economic growth.

This study demonstrates that innovation significantly enhances the economic growth of different regions in Russia. Furthermore, it reveals that innovation has a more prominent role in driving the growth of the least developed regions. The study's findings indicate that Russia's accession to the World Trade Organization (WTO) has contributed to an increase in innovation-driven economic growth in the regions of Russia.

Moreover, this study asserts that the economic sanctions implemented in 2014 have a detrimental and significant effect on the economic development of Russia's prosperous regions. Nevertheless, economically disadvantaged areas did not experience significant effects in this aspect. Moreover, this study reveals a substantial correlation between innovation and economic growth in Russian regions that have high investment potential.

This study additionally reveals that gross financial development, fixed capital formation, and exports play a crucial role

in promoting economic growth through innovation in the Russian region.

This study offers new empirical insights into the influence of innovation on economic growth in several regions of Russia.

First, this study reveals that innovation in the Russian region significantly boosted the country's economy. The findings also demonstrate that innovation plays a key role in driving the growth of the least developed regions.

Second, this study reveals that Russia's entry into the WTO network had a significant impact on economic expansion in the regions by fostering market competition and facilitating the emergence of opportunities for creative enterprises.

Third, this study reveals that the economic growth of developed Russian regions was considerably impacted by the Western sanctions imposed in 2014. Nevertheless, the impact on the least developed regions was relatively less compared to their developed counterparts.

Fourth, this study demonstrates that the relationship between innovation and economic growth is stronger in regions with significant investment opportunities compared to regions with limited investment potential.

The outcomes of this research emphasize substantial theoretical and practical implications, particularly in leveraging innovation to foster regional economic growth.

Firstly, there is a theoretical underpinning for the Russian government and banking authorities to augment their support for innovation. This could be achieved by bolstering funding for research and development, especially in sectors exhibiting resilience and growth potential amid sanctions, such as applied research and technology and product development.

Secondly, from a practical standpoint, it is crucial to enact proactive measures for fostering inter-regional trade integration, leveraging the trade development schemes of the World Trade Organization (WTO) to their full potential. For the third point, the theoretical perspective suggests that to circumvent the adverse impacts of sanctions, trade integration can serve as an efficient strategy. Policymakers should thus encourage innovation to enhance economic integration and diversity, which could subsequently contribute to the sustainable economic growth of various regions.

Finally, in practical terms, policy experts should pinpoint and invest in regions with high potential for innovation and economic growth. This strategy should extend beyond major cities like Moscow and St. Petersburg to encompass other promising regions, thus ensuring balanced and inclusive economic development.

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Инновации и региональный экономический рост в России: роль торговой интеграции, санкций и инвестиционного потенциала

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Аннотация. Инновации играют жизненно важную роль в экономическом росте, поскольку они внедряют новые идеи и процессы, повышают конкурентоспособность, создают рабочие места и стимулируют технологический прогресс, повышая производительность и эффективность. Переход России от командной к рыночной экономике требует акцента на инновациях для обеспечения устойчивого регионального экономического роста. В исследовании рассматривается взаимосвязь между инновациями и экономическим прогрессом в различных регионах России, при этом особое внимание уделяется значению торговой интеграции (вступление России в ВТО), санкциям 2014 г. и инвестиционному потенциалу территорий России. Из-за значительных несоответствий в данных из разных регионов и разных периодов в исследовании для интерпретации данных используется метод квантильной регрессии моментов (MMQR). Основные выводы показывают, что региональные инновации являются ключевым фактором экономического развития в Российской Федерации, особенно в нижнем и среднем квантилях. Кроме того, данное исследование показывает, что влияние инноваций на региональный экономический рост усиливается после вступления России в ВТО. Также отмечается, что в период санкций инновации способствовали экономическому росту в российских регионах. При этом санкции в целом негативно сказались на экономическом росте более развитых регионов России. В исследовании отмечается устойчивая корреляция между инновациями и экономическим ростом в российских регионах со значительным инвестиционным потенциалом. Также отмечается, что такие аспекты, как комплексное финансовое развитие, накопление основного капитала и экспорт, значительно повышают экономический рост за счет инноваций в российских регионах. Исследование вносит существенный вклад в литературу как с теоретической, так и с практической точек зрения, предлагая несколько свежих идей о региональном экономическом росте России.

Ключевые слова: инновации; экономический рост; торговая интеграция; ВТО; санкции; инвестиционный потенциал; MMQR; регионы России.

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