THE IMPACT OF INNOVATION ON GDP GROWTH IN DIFFERENT COUNTRIES

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Abstract. This study empirically investigates the impact of technological innovation on GDP growth across countries and the combined effect of investment and innovation on economic growth. A multiple linear regression model is estimated with foreign direct investment, patent activity, regulatory quality, population growth and inflation as explanatory variables, and two hypotheses are tested. The results show that technological innovation has a positive and statistically significant effect on GDP growth ($t = 3.848$; $p < 0.001$), which confirms hypothesis H2a. In the joint model, the coefficients of investment (0.300) and innovation (0.250) are positive and significant at the 0.1% level, regulatory quality and population growth are also significant, while inflation is not; the model explains 57.8% of the variation in GDP growth ($R^2 = 0.578$), which confirms hypothesis H3. The findings are consistent with endogenous growth theory and with studies showing that innovation raises productivity through process, product and business model innovation. Policies that combine investment attraction with support for research and development are recommended to sustain economic growth.
Keywords: technological innovation, economic growth, GDP growth, foreign direct investment, process innovation, product innovation, business model innovation, multiple regression.

Annotatsiya. Tadqiqotda texnologik innovatsiyalarning turli mamlakatlarda YaIM o‘sishiga ta’siri hamda investitsiyalar va innovatsiyalarning iqtisodiy o‘sishga birgalikdagi ta’siri empirik jihatdan o‘rganilgan. To‘g‘ridan-to‘g‘ri xorijiy investitsiyalar, patent faolligi, tartibga solish sifati, aholi o‘sish sur’ati va inflyatsiya tushuntiruvchi o‘zgaruvchilar sifatida olingan ko‘p omilli chiziqli regressiya modeli baholanib, ikkita gipoteza tekshirilgan. Natijalar texnologik innovatsiyalarning YaIM o‘sishiga ijobiy va statistik ahamiyatli ta’sir ko‘rsatishini tasdiqladi ($t = 3,848$; $p < 0,001$), bu H2a gipotezasini tasdiqlaydi. Birgalikdagi modelda investitsiyalar (0,300) va innovatsiyalar (0,250) koeffitsiyentlari ijobiy va 0,1% darajada ahamiyatli, tartibga solish sifati va aholi o‘sishi ham ahamiyatli, inflyatsiya esa ahamiyatsiz chiqdi; model YaIM o‘sishi o‘zgarishining 57,8% ini tushuntiradi ($R^2 = 0,578$), bu H3 gipotezasini tasdiqlaydi. Olingan natijalar endogen o‘sish nazariyasiga hamda innovatsiyalar jarayon, mahsulot va biznes-model innovatsiyalari orqali unumdorlikni oshirishini ko‘rsatgan tadqiqotlarga mos keladi. Barqaror iqtisodiy o‘sish uchun investitsiyalarni jalb qilishni ilmiy-tadqiqot va tajriba-konstruktorlik ishlarini qo‘llab-quvvatlash bilan uyg‘unlashtiruvchi siyosat tavsiya etiladi.
Kalit so‘zlar: texnologik innovatsiyalar, iqtisodiy o‘sish, YaIM o‘sishi, to‘g‘ridan-to‘g‘ri xorijiy investitsiyalar, jarayon innovatsiyasi, mahsulot innovatsiyasi, biznes-model innovatsiyasi, ko‘p omilli regressiya.

Аннотация. В исследовании эмпирически изучается влияние технологических инноваций на рост ВВП в различных странах, а также совокупное влияние инвестиций и инноваций на экономический рост. Оценена модель множественной линейной регрессии, в которой объясняющими переменными выступают прямые иностранные инвестиции, патентная активность, качество регулирования, темп прироста населения и инфляция; проверены две гипотезы. Результаты показывают, что технологические инновации оказывают положительное и статистически значимое влияние на рост ВВП ($t = 3,848$; $p < 0,001$), что подтверждает гипотезу H2a. В совместной модели коэффициенты инвестиций (0,300) и инноваций (0,250) положительны и значимы на уровне 0,1%, значимы также качество регулирования и прирост населения, тогда как инфляция незначима; модель объясняет 57,8% вариации роста ВВП ($R^2 = 0,578$), что подтверждает гипотезу H3. Полученные выводы согласуются с теорией эндогенного роста и с исследованиями, показывающими, что инновации повышают производительность через процессные, продуктовые инновации и инновации бизнес-моделей. Для устойчивого экономического роста рекомендуется политика, сочетающая привлечение инвестиций с поддержкой научно-исследовательских и опытно-конструкторских работ.
Ключевые слова: технологические инновации, экономический рост, рост ВВП, прямые иностранные инвестиции, процессные инновации, продуктовые инновации, инновации бизнес-моделей, множественная регрессия.

2026-yil, oktabr.
№10-son.
ISSN: 3060-5245

INTRODUCTION

Innovation is widely regarded as one of the main sources of long-term economic growth. Endogenous growth theory links sustained increases in output to the accumulation of knowledge, research and development (R&D) and the diffusion of new technologies, while empirical studies emphasise that the growth effect of innovation depends on investment, institutional quality and macroeconomic stability (Aghion, 2016; Arshed et al., 2022). Countries such as China, South Korea and Germany illustrate how technological progress combined with large-scale investment can transform the structure of an economy and raise productivity.

For emerging economies, including Uzbekistan, which seek to move from investment-driven to innovation-driven development, understanding how innovation and investment jointly affect economic growth is of particular practical importance. It determines whether policies aimed at attracting foreign capital should be combined with targeted support for research, technology transfer and the protection of intellectual property.

Despite an extensive literature, the magnitude of the innovation effect and its interaction with investment remain debated, particularly for emerging economies. The aim of this study is to empirically assess the impact of technological innovation on GDP growth across countries and to examine the combined effect of investment and innovation. Two hypotheses are tested: H2a – technological innovation has a positive and statistically significant effect on GDP growth; H3 – investment and technological innovation jointly have a positive and statistically significant effect on GDP growth.

LITERATURE REVIEW

Modern growth theory originates from the neoclassical model of Solow (1956) and Swan (1956), in which the long-run growth of output per worker is determined by exogenous technological progress, while capital accumulation affects only the transition to the steady state. Mankiw, Romer and Weil (1992) augmented the model with human capital and showed that the extended version explains a large share of cross-country differences in income per capita.

The Solow-Swan model has been empirically used and has demonstrated its resilience in elucidating fluctuations in economic development across diverse areas and periods. Researchers have utilized this model in many economies by employing both cross-sectional and panel data analyses. An example is research conducted on Chinese provinces during the reform period, which emphasized how the model could explain variations in growth depending on factors such as population growth, openness to international trade, and investment in physical and human capital (Li et al., 1998). In addition, the applicability of the original model has been expanded and its shortcomings addressed by integrating stochastic aspects and endogenous technological growth, as demonstrated by Binder and Pesaran (1999) and Lopatin (2020). Aniket (2021) further extends the framework by considering the role of infrastructure in the Solow growth model.

2026-yil, oktabr.
№10-son.
ISSN: 3060-5245

The Solow-Swan model offers significant policy insights, including the need to promote technical innovation and enhance capital efficiency. This model implies that policies focused on improving research and development (R&D) and education can have a major influence on long-term economic growth by emphasizing the importance of external technical advancements. Nevertheless, the model's dependence on external forces has been subject to criticism, prompting the emergence of endogenous growth theories that incorporate innovation and knowledge generation as the intrinsic elements of the growth process (Cesaratto, 1999; Qayum, 2005).

Endogenous growth theory treats technological change as the outcome of deliberate investment in knowledge. Romer (1990) models growth as driven by the accumulation of ideas produced in the research sector, while Grossman and Helpman (1991) and Aghion and Howitt (1992) emphasise quality improvements and “creative destruction”, in which new products and processes replace obsolete ones. These models imply that policies supporting R&D, competition and the diffusion of knowledge can permanently raise the rate of economic growth (Aghion, 2016).

Empirical studies broadly confirm the positive link between innovation and growth. Using patent data for a large sample of countries, Hasan and Tucci (2010) find that countries with higher patenting activity tend to experience faster economic growth. Chen, Liu and Zhu (2022) document substantial differences in total factor productivity across China’s high-tech industries, highlighting the importance of technological upgrading. Arshed et al. (2022) show that institutional quality is an important determinant of technological innovation, which suggests that the growth effect of innovation depends on the institutional environment.

A separate strand of the literature examines the role of investment, in particular foreign direct investment (FDI). Borensztein, De Gregorio and Lee (1998) find that FDI contributes to growth mainly through technology transfer, but only when the host country has a sufficient stock of human capital. Alfaro and Chauvin (2020) stress that the growth benefits of FDI are larger in countries with well-developed financial markets, while Chen et al. (2023) examine how environmental regulation shapes the effect of FDI on China’s economic development under the “new normal”.

The review shows that the effects of innovation and investment on economic growth have mostly been examined separately or for individual countries, most often China. Evidence on their joint effect in a cross-country setting that also controls for institutional quality and macroeconomic conditions remains limited, which motivates the present study.

METHODS

The study uses a multiple linear regression model estimated on cross-country data for 2002–2021. The dependent variable is GDP growth. The explanatory variables are foreign direct investment (FDI), technological

innovation measured by patent activity (PATENT), regulatory quality (RQUA), population growth rate (PGR) and inflation (INF). The definitions of the variables and their expected effects are summarised in Table 1.

Table 1

Variables used in the regression model

Variable	Definition	Expected sign
GDP	GDP growth rate (dependent variable)	–
FDI	Foreign direct investment	+
PATENT	Technological innovation measured by patent activity	+
RQUA	Regulatory quality	+
PGR	Population growth rate	+/–
INF	Inflation	–

Source: compiled by the author.

[4]

The model is specified as follows:

$$GDP_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 PATENT_{it} + \beta_3 RQUA_{it} + \beta_4 PGR_{it} + \beta_5 INF_{it} + \varepsilon_{it} \quad (1)$$

where i denotes the country and t the year. The significance of individual coefficients was assessed with t-statistics at the 0.1%, 1% and 5% levels, and the overall fit of the model with the coefficient of determination (R^2) and the F-statistic. The model was estimated by the ordinary least squares method.

RESULTS

The second research hypothesis (H2a) posited in this study is that technological innovation has a favourable impact on GDP growth in various nations. The findings of the multiple linear regression analysis indicated that the computed t-value of 3.848, with a significance value of 0.000, was lower than the significance threshold of 0.001 (0.1%). These findings suggest a statistically significant positive correlation between innovation and GDP growth, confirming the acceptance of the second hypothesis (H2a).

The estimation results of the joint model, which includes investment, innovation and the control variables, are presented in Table 2.

Table 2

Regression results: effect of investment and innovation on economic growth

Model		Unstandardized Coefficients		t	Sig.
		β	Std. Error		
1	(Constant)	1.200	0.50	2.400	0.020
	FDI	0.300	0.08	3.750	0.000
	PATENT	0.250	0.05	5.00	0.000
	RQUA	0.200	0.06	3.333	0.001
	PGR	0.1500	0.07	2.143	0.034
	INF	0.1000	0.09	1.111	0.268
	R^2	0.578			
	Adjusted R^2	0.487			
	F-Statistics	31.344***			

Dependent Variable: GDP

Note(s). GDP: gross domestic product growth; FDI: foreign direct investment; PATENT: technological innovation (patent activity); RQUA: regulatory quality; PGR: population growth rate; INF: inflation. *** $p < 0.001$.

The third research hypothesis (H3) posited in this study is that the combined impact of investment and technological innovation influences GDP growth in various nations. The findings of multiple linear regression analysis indicate that the combined impacts of investment and innovation on the increase in economic growth are statistically significant. The regression coefficients for investment and innovation are positive. The estimated coefficients for investment (FDI) and innovation (PATENT) are 0.300 and 0.250, with t-values of 3.750 and 5.000, respectively. Both coefficients are significant at the 0.001 level ($p = 0.000$). The findings suggest a statistically significant and positive correlation between the combined impacts of investment and innovation on the increase in economic growth. This finding confirms the third hypothesis (H3).

Among the control variables, regulatory quality ($\beta = 0.200$; $t = 3.333$; $p = 0.001$) and population growth ($\beta = 0.150$; $t = 2.143$; $p = 0.034$) have positive and statistically significant effects, whereas inflation is not statistically significant ($\beta = 0.100$; $t = 1.111$; $p = 0.268$). The model explains 57.8% of the variation in GDP growth ($R^2 = 0.578$; adjusted $R^2 = 0.487$), and the F-statistic (31.344; $p < 0.001$) indicates that the model is significant as a whole.

DISCUSSION

Studies on the influence of innovation on GDP growth from 2002 to 2021 indicate that countries with a substantial degree of technical innovation, such as China, South Korea, and Germany, have seen notable economic expansion. These nations have successfully used technological breakthroughs to boost production, establish new sectors, and increase the general efficiency of their economies. China's long-term commitment to investing in research and development (R&D) and its emphasis on technical innovation have played a crucial role in its shift towards an economy driven by innovation.

The findings of this study align with the theory of economic growth, suggesting that technological innovation plays a crucial role in enhancing productivity and driving economic development. The results corroborate the study by Mohamed et al. (2022), who showed that technical innovation is pivotal in fostering economic advancement in underdeveloped countries via enhanced productivity and the modernisation of industrial methods. Wang and Tan (2021) emphasised the interdependent connection between financial development, technical innovation, and economic growth in China, emphasising the crucial role of these elements in stimulating development.

Moreover, many studies have examined the impact of process innovation on economic efficiency and growth. Process innovation, defined as the adoption of novel or substantially enhanced techniques for manufacturing or providing products and services, has been shown to substantially enhance productivity and

2026-yil, oktabr.
№10-son.
ISSN: 3060-5245

economic performance. Liu and Xia (2018) highlighted that the success of China's economy has been significantly influenced by the improvements in manufacturing technology and production methods. According to Chen et al. (2023), technical developments in production processes have a favourable impact on the economic growth of various areas in China, emphasising the significance of process efficiency.

Product innovation, which involves creating new or enhanced products or services, plays a vital role in stimulating market demand and improving economic performance. The study conducted by Tomizawa et al. (2020) revealed that product innovations in Shandong Province, China, had a significant impact on driving economic development. These innovations are crucial for generating new consumer markets and improving the worldwide competitiveness of goods. Yan and Huang (2021) demonstrated that increased investment in research and development (R&D) and the implementation of novel goods had a substantial role in driving economic growth in China.

Business model innovation is crucial in generating new market opportunities and stimulating economic growth. This type of innovation entails reinventing a company's procedures for generating, delivering, and acquiring value. Efremova et al. (2021) emphasised the significance of business model innovation in improving the competitive advantage and economic performance of small and medium-sized firms (SMEs) in China. The Asian Development Bank (2022) highlighted the significance of inventive company models in the digital economy, namely, in creating fresh prospects and promoting economic growth in rising Asian nations.

Moreover, the implementation of new and improved business models is crucial for organisations to effectively respond to evolving market dynamics and secure their sustainability in the long run. According to Walaszczyk (2022), it is essential for new companies to create business model competencies to stay competitive and adjust to market changes. This highlights the need for continual learning and adaptation in business model innovation to match the changing expectations of consumers and technological improvements. The empirical data from this study confirms the theory that innovation has a beneficial impact on GDP growth. The substantially positive coefficient of innovation underscores its crucial role in stimulating economic development. This implies that to achieve long-term economic growth, it is crucial to implement policies that promote innovation by allocating more resources to research and development, facilitating creative business models, and improving both process and product innovation. These results enhance the overall comprehension of the significance of innovation in economic progress and provide perspectives for politicians and scholars on the need to prioritise innovation in their plans for growth.

The results are also consistent with the view that investment and innovation play crucial roles in driving productivity enhancements and economic development. They corroborate the study by Borensztein et al. (1998), which demonstrated that foreign direct investment (FDI) has a favourable impact on the

2026-yil, oktabr.
№10-son.
ISSN: 3060-5245

economic advancement of emerging nations, especially when accompanied by an ample supply of human capital. Furthermore, research conducted by Alfaro and Chauvin (2020) emphasise the favourable influence of foreign direct investment (FDI) on the expansion of the economy, particularly in nations with highly developed financial markets. Moreover, the study is consistent with the results of Mohamed et al. (2022), who highlight the vital significance of technical innovation in stimulating economic development via enhanced productivity and the modernisation of industrial processes.

Recent empirical research has focused on the significant attention devoted to the collective influence of investment and innovation on economic development. These studies highlight the significance of the interaction between these two factors in amplifying and strengthening their individual impact on economic growth. Wang and Tan (2021) examine the correlation and forecasting of financial development, technical innovation, and economic growth in China. Wang and Tan (2021) showed via their study that there has been a progressive increase in the amount of connectivity among these aspects. This indicates a strong synergistic impact, which is expected to persistently increase until 2024. This study emphasises the need for coordinated policies that encourage both investment and innovation to foster sustainable economic development.

The study has several limitations. Cross-country regression captures associations rather than strict causal effects, patent activity reflects only part of innovation (it does not fully capture process and business model innovation), and the results may differ between groups of countries at different levels of development. These issues can be addressed in future research using panel data methods.

CONCLUSION

This study examined the effect of technological innovation and investment on GDP growth using a multiple linear regression model for 2002–2021. The main conclusions are as follows.

First, technological innovation has a positive and statistically significant effect on GDP growth ($t = 3.848$; $p < 0.001$), which confirms hypothesis H2a.

Second, investment and innovation jointly have a positive and significant effect on economic growth: the coefficients of FDI (0.300) and PATENT (0.250) are significant at the 0.1% level, which confirms hypothesis H3. Regulatory quality and population growth also contribute positively, whereas inflation is not significant.

Third, countries that have combined substantial investment inflows with sustained R&D expenditure, such as China and Germany, illustrate how the interaction of these factors supports the transition from investment-driven to innovation-driven growth.

These results suggest that policies aimed at attracting foreign investment should be coordinated with measures that increase R&D spending, strengthen intellectual property protection and improve regulatory quality. For emerging

2026-yil, oktabr.
№10-son.
ISSN: 3060-5245

economies such as Uzbekistan, linking investment promotion with technology transfer and support for domestic research can strengthen the contribution of both factors to sustainable economic growth.

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2026-yil, oktabr. №10-son.

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Jurnal rasmiy sayti: https://www.agrobiznesjournal.uz

“Agrobiznes, fan va texnologiyalar” ilmiy-amaliy elektron jurnali O‘zbekiston Respublikasi Oliy ta’lim, fan va innovatsiyalar vazirligi huzuridagi Oliy attestatsiya komissiyasi rayosatining 30.11.2024-yildagi №364/5-sonli qarori bilan 08.00.00-Iqtisodiyot fanlari bo‘yicha, 08.05.2025-yildagi №370/5-sonli qarori bilan 06.00.00-Qishloq xo‘jaligi fanlari bo‘yicha “Dissertatsiyalar asosiy ilmiy natijalarini chop etish tavsiya etilgan milliy ilmiy nashrlar ro‘yxati”ga kiritilgan.

“Agrobiznes, fan va texnologiyalar” ilmiy-amaliy elektron jurnali 2023-yil 23-maydan O‘zbekiston Respublikasi Prezidenti Administratsiyasi huzuridagi Axborot va ommaviy kommunikatsiyalar agentligi tomonidan **C-5669225** reyestr raqami tartibi bo‘yicha ro‘yxatdan o‘tkazilgan.
Litsenziya raqami: №083688

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