Journal of Money and Economy
Vol. 19, No. 1, Spring 2024
pp. **-**

Original Research Article

The Effect of Real Interest Rate on the Convergence Speed of the Economic Performance of Iran's Provinces

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Received: 02 Feb 2025 Approved: 25 May 2025

Interest rates are a key and important economic variable in policymaking, creating stability and economic growth. In this regard, the main goal of this study is to examine the convergence of economic performance of provinces and to examine the impact of real interest rates on the speed of convergence of economic performance of provinces. This study uses the spatial econometric method. Also, in order to examine the impact of the real interest rate on the speed of convergence of the provinces' economic performance, the conditional beta convergence model was used. The results showed that there is convergence of economic performance in the provinces in the period 2011 – 2022 and the real interest rate had a significant but very small effect on the convergence of economic performance in the provinces. Other results showed that the Internet penetration rate of the provinces as an ICT indicator and the real capital stock of the provinces have a positive and significant effect on the convergence of economic performance. The absolute convergence rate is 0.0386 and in the conditional model it is 0.0417, which shows that in the conditional case the convergence rate of the provinces is higher. Also, in the absolute convergence model, 3.8 percent per year and in the conditional convergence model, about 4.1 percent per year of the difference between the current economic growth rate of the provinces and the long-term equilibrium economic growth of the provinces is eliminated. On the other hand, with the increase in inflation in recent years, the real interest rate has decreased, and this has caused savings to leave banks and go to other markets. Therefore, the real interest rate has had a very small impact on the economic performance of the provinces. In this regard, it is necessary to use anti-inflationary policies, including reducing the volume of liquidity, fiscal discipline of governments, and increasing production.

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[DOI: 10.61882/jme.19.1.43]

Keywords: Economic performance, Convergence, Real interest Rate, Spatial Econometrics, ICT
JEL Classification*:* G21, c21, E31, E43, O47

1 Introduction

Regional inequalities are a fundamental challenge for regional development and pose a serious threat to the creation of balanced regional development (Shankar and Shah, 2003). Therefore, adopting the right regional development policies plays a fundamental role in strengthening regional development activities and reducing regional inequalities. (Matsumoto, 2008) Therefore, the need to pay attention to regional inequalities, balanced development and convergence of economic growth should be considered to achieve development goals (Vafaei et al., 2017).

In the event of economic convergence, the country's decision-makers can provide appropriate policy-making models in the field of allocating and distributing resources, facilities, and opportunities to the country's public sector policymakers to address the imbalances that have arisen. (Shahiki Tash et al., 2015).

While in the case of divergence between different regions, class gaps and inequality in society increase and economic welfare decreases, which is not desirable from a policy perspective. (Vafaei et al., 2017). Economic convergence is achieved when less prosperous regions have higher growth than other regions. Otherwise, as the development of prosperous regions intensifies, regional divergence and imbalance will occur. (Purohit, 2008). In this regard, the real interest rate can play an important role in the convergence of regional economic growth.

Interest rates are one of the most important economic variables in policy-making; they are considered as the cost of renting capital from the investor's perspective and as the opportunity cost from the depositor's perspective. The interest rate has a monetary nature and can be explained based on the preference of economic units for holding savings in the form of liquidity. The current advanced economies of the world are strongly influenced by interest rates and react quickly to changes in them. In fact, the interest rate acts as a powerful control tool in managing and guiding the market. (Lotfalipour and Karimi Alavijeh, 2019).

The effects of interest rates, through the real interest rate, lead to a response in the real sector of the economy (Mishkin, 1995). In this regard, the effects of the real interest rate on private investment and economic growth in developing countries have always been a topic of considerable debate. It is expected that real interest rates play a significant role in decision-making regarding investment and economic growth (Mehrara et al., 2011).

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The effect of interest rates on private investment was first modeled by Jorgenson (1963). In this approach, known as the neoclassical approach, the desired capital stock is considered as a function of real output and the opportunity cost of capital. In this model, the desired capital stock is directly related to production and inversely related to the opportunity cost of capital. Before 1970, the analysis and inference of most economists were that low interest rates reduced investment expenditures and increased economic growth. Based on this, in some developing countries experiencing incomplete employment, interest rates (bank interest rates) were set below the market equilibrium rate to achieve economic goals. In 1973, McKinnon (1973) and Shaw (1973) were the first to seriously oppose these theories (Mehrara et al., 2011)

Studies conducted by McKinnon (1973) and Shaw (1973) as well as Fry (1988) showed that an increase in real interest rates had positive effects on the volume and quality of investment in suppressed economies. The studies and findings of McKinnon (1973) and Shaw (1973) led to the widespread belief that interest rates are the most important factor in transferring financial resources from depositors to investment in the best and most efficient projects (Mehrara et al., 2011). The role of interest rate in the financing of services, industry and other economic sectors. It can affect the level of attraction of bank deposits and consequently the access of institutions to the facilities needed for investment from the place of deposits and as a result on their profitability (El-Wassal, 2005).

The effectiveness of monetary policies on the real sector of the economy is highly dependent on the interest rate situation. Interest rate changes are effective on investors' decisions between choosing risky assets and bank deposits; In such a way that with the increase in interest rates, investors prefer bank deposits to risky assets. Therefore, the lending power of the banking network leads to an increase and, as a result, greater access of the production sector to bank facilities from the place of deposits, which leads to the growth of investment and the impact on the real sector of the economy (Beck et al., 2014).

However, the effects of interest rates can also have a double effect; Because it causes an increase in the cost of financing investment from bank facilities and can lead to a decrease in investment (Montiel and Servén, 2008). Some studies have confirmed the positive effect of interest rates on the increase of bank deposits (Solarin et al., 2018; Mashamba et al., 2014; Ojeaga et al., 2013).

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While the positive effect of interest rate increase on bank savings in empirical studies that are mostly related to Islamic countries, they are often rejected and considered ineffective (Sadeghi & Tayebi, 2018; Balogun, et al., 2016). The impact of the interest rate as a policy through the real interest rate leads to the reaction of the real sector of the economy (Mishkin, 1995)

In this regard, Odhiambo (2009) showed in a study in Zambia that the financial deepening resulting from interest rate liberalization has caused economic growth. The results of D'Adda and Scorcu's (1997) study showed that there was a negative correlation between economic growth and real interest rate in the period of 1960-1994.

The results of the study by D'Adda and Scorcu (1997) showed that there was a negative correlation between economic growth and real interest rates during the period 1960-1994. Al-Ajlouni and Sanajle (2023) investigated the effect of the real interest rate on economic growth in Jordan. The results in the period of 1990-2019 showed that the real interest rate had a negative and significant impact on the economic growth of Jordan. With a 1% increase in real interest rates, economic growth in Jordan decreased by 0.97%. Empirical evidence suggests that there is no consensus regarding the impact of real interest rates on economic growth.

In this regard, numerous studies have been conducted on interest rates and economic growth. Some of these studies include the works of Nsonwu and David (2021), Ande and Caporale (2024), Kumar and Kaushal (2023), Al-Ajlouni and Sanajle (2023), Wang (2023), Hembram and Haldar (2021), Balash et al., (2020), Binning et al., (2019), Holmes et al., (2019), Solarin et al., (2018), Papadamou et al., (2017), Onwumere et al., (2012), Andries and Capraru (2013), Odhiambo (2009), Vardar et al., (2008), D'Adda and Scorcu (1997), Rahimi et al., (2023), Khosravi et al., (2021), Lotfalipour and Karimi Alavijeh (2019), Farahani et al., (2018), Kazerooni et al., (2016), Valian et al., (2013), Mehrara et al., (2011) and Keshavarzian Peyvasty and Azimi Chenzeq (2008). However, none of the studies have examined the impact of the real interest rate on the speed of convergence of the economic performance of the provinces. Therefore, the main Purpose of this study is to examine the impact of the real interest rate on the speed of convergence of the economic performance of the provinces in the period 2011–2022 using spatial econometrics.

The existence of spillover effects between different regions of a particular country is much greater than the spillover effects between different countries. Although numerous studies have analyzed inequality between regions, few of

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them have considered neighborhood effects. This is despite the fact that neighborhood effects play an important role in creating inequality

In this regard, the following hypothesis is proposed:

Real interest rates have a significant impact on the speed of economic performance convergence of Iran's provinces.

Following the introduction, the theoretical foundations are reviewed; then, in the third section, the research background is presented; in the fourth section, the model is specified and variables are introduced; in the fifth section, the model is estimated and the results are presented; and finally, in the sixth section, conclusions and suggestions are presented.

2 Literature Review

Studies in development economics show that various variables influence economic growth and development. One of the key variables that has garnered significant attention from economists and plays a crucial role in improving the economic growth of societies is the interest rate (Valian et al., 2013). The interest rate is the amount a borrower pays for the temporary use of capital. The French economist Turgot (1727–1781) defined the interest rate as the price paid for using a specific amount of value over a given period of time (Sameti et al., 2009).

Interest rates influence macroeconomic variables such as economic growth through various channels. One of these channels is the credit channel. The credit channel operates through two main mechanisms: the banking lending channel and the balance sheet channel. According to the banking lending channel, a contractionary monetary policy reduces bank reserves and deposits, which in turn reduces the available resources for banks to grant loans. As a result, banks compensate for the reduction in deposits by cutting back on loans. This limits the working capital of firms and leads borrowers to reduce investment spending, while consumers cut back on consumption, ultimately leading to a decrease in aggregate demand and total production. The balance sheet channel operates similarly to the banking lending channel but focuses more on the bank's asset structure on its balance sheet (Khosravi et al., 2021).

An increase in interest rates leads to a tightening of credit, as the expected return for lenders does not increase proportionally with higher interest rates. At higher rates, lenders may experience reduced profits due to poor selection, moral hazards, and monitoring costs. Therefore, lenders may be unwilling to lend at rates that do not meet their expected profits, even if firms are willing to borrow at those higher rates (Mehrara et al., 2011).

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The relationship between the real and nominal interest rates suggests a positive correlation between inflation and the nominal interest rate. This was proposed before the 1840s by Diamond (1984) and further developed by Henry Thornton, who used this idea to explain the relationship between real and nominal interest rates. From the literature, it can be argued that inflation positively affects nominal interest rates. However, the relationship between nominal and real interest rates did not have a proper analytical framework until Ironing Irving Fisher (Tanzi, 1980; Khajeh Mohammadlou and Khodavisi, 2017).

Fisher's theory once again attracted the attention of economic theorists in the early 1990s. Because the coincidence of the inflation rate and the nominal interest rate was one of the important features of the economies of the 1990s.

This increasing attention, it led to the formation of several main theories about the effect of the inflation rate on the nominal interest rate. (Tanzi, 1980). In the first category, theorists such as Mundell (1963) and Carney (1972) paid attention to the effect of wealth on Fisher's effect.

According to Mundell's theory, an increase in expected inflation reduces the real money stock, which in turn reduces wealth. A decrease in wealth leads to reduced consumption and increased savings, which causes a decrease in real interest rates. Mundell's theory suggests that a unit increase in expected inflation decreases real interest rates, and the effect of expected inflation on nominal interest rates is less than one (Mundell, 1963).

Carney extended Mandel's theory to the long run and concluded that the decline in the real interest rate is a short-run phenomenon. which increases investment and thus increases real capital in the long term and increases wealth again,

Therefore the real interest rate is stable in the long run and independent of the effect of wealth. His theory is a reconfirmation of Fisher's work (McCallum, 1989).

In the second group, Tobin (1965) focused on the liquidity effect in relation to Fisher's theory. According to Keynes's liquidity preference theory, inflation expectations in the short term reduce real interest rates (Snowden, 2004). Tobin (1965) extended this theory within the framework of long-term growth models. He argued that permanent increases in expected inflation reduce the real money stock, which in turn increases the cost of holding money or liquidity preference, leading to a shift from real balances to real capital in individuals' portfolios. This shift reduces the marginal productivity of capital, which decreases real interest rates (Tanzi, 1980).

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In the third group, economists like Tanzi(1980), and Darby (1975) examined the effect of taxation on income in relation to Fisher's theory.

According to this view, if we assume that nominal interest income is subject to income tax, then it is the after-tax real interest rate that influences economic behavior, not the pre-tax real interest rate (Khajeh Mohammadlou and Khodavisi, 2017).

In the fourth group, Tanzi (1980) examined business cycles in relation to Fisher's equation and studied its short-term effects. He argued that in the short term, the Fisher effect is influenced by economic fluctuations, but in the long run, as these fluctuations dissipate, a one-to-one correspondence between nominal interest rates and inflation continues to hold (Tanzi,1980).

The differences in the above theories are summarized by how they describe changes in real interest rates. Theories supporting the Fisher effect suggest that real interest rates are constant, implying that monetary policies have a neutral long-term effect.

In contrast, theories supporting Mundell's effect indicate that real interest rates decrease, highlighting the real-world impacts of monetary policies on macroeconomic variables.

But regardless of this fundamental difference in the mentioned theories, which all belong to the years before 1990, Today, many economists have accepted the theories of the classics as a valid explanation of the economy in the long run.

Fischer effect is presented in the form of classical interest theory. It is very important in explaining the long-term behavior of the nominal interest rate and the neutrality of monetary policies in the long-term. (Mankiw and Taylor, 2006).

Since the main purpose of this study is to examine the impact of real interest rates on the speed of economic performance convergence among provinces, the next section will explain the concept of convergence.

In the economic literature, there are at least three methods for examining convergence: beta convergence, sigma convergence, and stochastic convergence (Lee et al., 1997). Beta convergence occurs when poorer countries (regions, provinces) grow at a faster rate compared to wealthier ones (Rahimi et al., 2023).

Beta convergence is further divided into conditional and unconditional (absolute) types. Conditional beta convergence allows countries (regions, provinces) to converge, but not toward a common level, rather to their own long-term sustainable income level. This type of convergence is conditional because it depends on the structural characteristics of regions, such as

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preferences, technological progress, population growth rates, government policies, and so on. According to Mankiw (2006), if factors like savings rates, population growth rates, and technological progress are controlled, convergence is observed, which is conditional. The beta convergence approach is derived from the Solow (1956) and Swan (1956) neoclassical growth model, which assumes a closed economy, exogenous savings rates, and a production function based on diminishing returns to capital and constant returns to scale.

3 Research Background

Twesiime et al., (2024), in their study, demonstrated that high interest rates lead to an increase in loan default rates. Consequently, financial institutions should consider reducing the costs associated with commercial loans and interest rates.

The results of the study by Kumar and Kaushal (2023) in South Asian countries, using time series and panel data for the period 1990–2022, showed that inflation has a negative and significant effect on real interest rates. Furthermore, inflationary shocks have a considerable impact on real interest rates.

Wang (2023), in a study conducted in the United States during the period 2010–2022 using the autoregressive integrated moving average (ARIMA), showed that an increase in interest rates has the greatest impact on the stock market volatility index in the medium term.

Rahimi et al., (2023) studied the effect of bank performance on economic convergence in provinces using spatial econometrics. The results showed that the ratio of bank facilities to deposits as an indicator of bank performance and monetary indiscipline have a negative and significant effect on economic convergence in provinces. The speed of conditional beta convergence is greater than absolute convergence.

The results of a study by López-Penabad et al., (2022) in 29 European countries during the period 2011-2019 showed that implementing a negative interest rate policy reduces the net profit margin and return on assets of a representative bank by 14.5 and 18.5 basis points, respectively.

Lamers et al., (2022) studied the convergence of profitability in Eurozone banks over the period 2009-2020 using convergence concepts and a clustering algorithm. The results showed that better performing banks converge towards lower profit levels, indicating a “major convergence” towards the median.

In a study, Hembram and Haldar (2021) examined global income convergence in 187 countries over the period 1990-2018 based on β and σ

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convergence and club convergence. The results showed that β convergence exists at the global level. But σ convergence does not exist

Khosravi et al., (2021) conducted a study investigating the dynamics of interest rate adjustments in Iran. To this end, they developed a stochastic dynamic general equilibrium (DSGE) model incorporating the banking network. Utilizing quarterly data spanning from 2009 to 2019, their findings revealed that the adjustment process of both lending and deposit interest rates in Iran is characterized by incompleteness.

In a study titled "Patterns of Economic Growth of Russian Regions," Balash et al., (2020) examined the types of economic convergence in 80 Russian regions using spatial econometrics. The results showed that there was conditional beta convergence during the years 2010-2014 and 2014-2017 and absolute beta convergence during the period 2014-2017.

The findings of Lotfalipour and Karimi Alavijeh (2019), based on short-term one-year and long-term five-year deposit interest rates during the period 1974 to 2014, indicated a significant and inverse relationship between both short-term and long-term interest rates and the official as well as unofficial exchange rates.

The results of the study by Binning et al., (2019) using a dynamic stochastic general equilibrium model and the Bayesian method of incomplete and asymmetric transition in the United States during the period 1985-2016 showed that the interest rate transition is delayed in the short run and incomplete in the long run. Accordingly, monetary policy is less efficient under an incomplete transition.

The results of a study by Solarin et al., (2018) in Malaysia during the period 2007-2016, using the Johansson cointegration method, showed that the real interest rate had a positive effect and the consumer price index had a negative effect on investment deposits.

Valian et al., (2013), in a study spanning the period from 1990 to 2011, employed the ordinary least squares (OLS) method and demonstrated a significant relationship between both official and unofficial exchange rates and interest rates at one-year, three-year, and five-year maturities.

Onwumere et al., (2012) in a study of Nigeria using the OLS method showed that interest rate liberalization did not have a significant effect on savings but caused a decrease in investment.

Ahmadi et al., (2012) in a study covering MENA countries and employing Granger causality and Hsiao tests over the period 1997 to 2008, found that a causal relationship from changes in interest rates to changes in inflation rates

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[DOI: 10.61882/jme.19.1.43]

exists only in Djibouti and Qatar. In contrast, for the other countries studied, changes in interest rates do not cause changes in inflation rates.

The results of Odhiambo's (2009) study in Zambia using Granger causality test showed that there is a positive and significant relationship between interest rate liberalization and financial deepening. Also, financial deepening resulting from interest rate liberalization has caused economic growth.

By reviewing the literature, it can be concluded that many studies have been conducted regarding interest rates, their relationship with inflation, and their impact on various economic variables. However, none of these studies have examined the effect of real interest rates on the speed of economic convergence performance of Iran's provinces using spatial econometric.

4 Model, Data and Empirical Results

In this study, according to the theoretical foundations and empirical studies of Balash et al., (2020) and Odhiambo (2009) to investigate the effect of the real interest rate on the convergence speed of the economic performance of the provinces, absolute convergence was first estimated. Then, conditional beta convergence has been estimated to consider the effect of real interest rate on economic performance convergence of provinces according to Equation (1).

$$\mathrm{L}n\left(\frac{\mathrm{gdp_{i,t}}}{\mathrm{gdp_{i,t-1}}}\right) = \alpha + \beta\ \ln\left(\mathrm{gdp_{i,t-1}}\right) + \rho\sum_{j=1}^{N} w_{ij} ln\left(\frac{gdp_{j.t}}{gdp_{j,t-1}}\right) + \mathrm{DX_{i,t}} + \varepsilon_{\mathrm{i,t}} \quad (1)$$

$$\varepsilon_{\mathrm{it}} = \gamma\sum_{j=1}^{N} w_{ij}\varepsilon_{j,t} + v_{i,t}$$

To examine the impact of real interest rates on the speed of economic convergence across provinces, we estimate Equation (1) in two scenarios: without considering real interest rates and with real interest rates included. In the equations above, the following variables are used:

- i represents the province,
- t represents time,
- GDP denotes the gross domestic product of the provinces in constant prices of 2011,
- $\mathrm{L}\left(\frac{\mathrm{gdp_{i,t}}}{\mathrm{gdp_{i,t-1}}}\right)$ represents the real GDP growth rate of province i over time period t,
- w is the spatial weight coefficient, a spatial weight matrix of size N× N that includes information about the distances between regions,

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- $\sum_{j=1}^{N} w_{ij} ln\left(\frac{gdp_{j.t}}{gdp_{j,t-1}}\right)$ represents the endogenous spillover effects between dependent variables of the regions. This term models spatial autocorrelation effects (spatial lag), which are often referred to as spatial lag variables in empirical studies.
- $\sum_{j=1}^{N} w_{ij}\varepsilon_{j,t}$ accounts for the cross-effects between the error terms of different units,
- ρ is the spatial autocorrelation coefficient of the dependent variable, indicating how much the dependent variable in one province is influenced by the dependent variable in neighboring provinces
- γ is the spatial autocorrelation coefficient of the error terms,
- ε_{it} is the error term of the models
- $v_{i,t}$ is the error term in the regression models

$X_{i,t}$ Represents the vector of explanatory variables in the regression model, which is given in Table 1.

Table 1
Introduction to research variables

Variable	symbol	source	Description
Gross Domestic Product of provinces at constant prices in 2011 as an indicator of economic growth	gdp	Statistical yearbooks	From a theoretical perspective, capital stock is one of the most important factors in economic growth. Most economic growth models, such as the Harrod-Domar model, Solow model (1956), and neoclassical endogenous growth models, emphasize the critical role of capital.
Real Interest Rate:	rate	Central Bank and researcher calculations	The real interest rate Rrt is calculated based on the Fisher equation, which is the difference between the nominal interest rate Rnt and inflation INFt Rrt = Rnt - INFt
Log of the per capita university graduates as an indicator of the human capital of provinces	Lheum	Statistical yearbooks	Income functions explore the relationship between the level of investment individuals make in education and its impact on their income. The more individuals invest in their education, the higher their income will be. The increase in workers' knowledge and skills leads to enhanced productivity and economic growth.

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Log of the individuals using the Internet in the provinces as an indicator of information and Communication Technology (ICT). It is calculated as the ratio of the number of internet users to the population of each province.	Lfao	Directorate General of Communications and Information Technology	Information and communication technology affects economic growth by increasing the productivity of production factors, deepening capital, and reducing research and development costs.
Log of the capital stock at constant prices for the year 2011	Lkapital	Central Bank and researcher calculations	Capital stock is one of the most important factors of economic growth. Most of the models presented in the field of economic growth, such as the Harrod-Domar growth model, Solow, endogenous growth models of neoclassicals, etc., emphasize the importance of the role of capital on economic growth. Until now, official data on provincial capital stock has not been available. Therefore, to extract provincial capital stock, net capital stock at current prices is first obtained from the Central Bank's statistics and then calculated according to the following method. To calculate the capital stock, the share of capital in production or the ratio of investment to output is used. This ratio is computed by dividing the share of savings from production by the rate of production growth. To obtain the provincial capital stock, the national capital stock values for specific sectors, estimated by the Central Bank, are used. By multiplying the share of each province in the value-added of the respective sector, the capital stock for each economic sector at the provincial level is obtained.
Inflation rate	Inf	Central Bank	High inflation creates uncertainty about the future, making long-term decisions such as savings and investment difficult, and reduces economic growth.

Source: Prepared by the researcher

The Statistical Population of this study includes the provinces of Iran, which are: Ardabil, Isfahan, Ilam, East Azerbaijan, West Azerbaijan, Bushehr, Tehran, Chaharmahal and Bakhtiari, South Khorasan, Razavi Khorasan, North Khorasan, Khuzestan, Zanjan, Semnan, Sistan and Baluchestan, Fars, Qazvin, Qom, Kurdistan, Kerman, Kermanshah, Kohgiluyeh and Boyer-

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[DOI: 10.61882/jme.19.1.43]

Ahmad, Golestan, Gilan, Lorestan, Mazandaran, Markazi, Hormozgan, Hamadan, and Yazd. The study period covers 2011 to 2022.

Before estimating the model, Moran's I test and the Wald test are necessary to detect the presence of spatial effects. Moran's I statistic is highly effective in detecting spatial effects, and consequently, model misspecification. According to the results in Table 2, the null hypothesis of Moran's test (which assumes no spatial effects) is rejected. Thus, the presence of spatial effects is confirmed. To determine the type of spatial effects and which model specification should be used, the Lagrange Multiplier (LM) test is applied.

The LM error test indicates the absence of spatial correlation in the disturbance terms, while the null hypothesis of the LM lag test indicates no spatial correlation in the dependent variable observations. In addition to conducting these two tests, the LM error-robust and LM lag-robust tests must also be performed to ensure the results are more robust.

If both null hypotheses are rejected, the Spatial Auto-Correlation Model (SAC) or Spatial Auto Regressive Model (SAR) is used. Therefore, based on the results from Table 2 and the rejection of both null hypotheses, the Spatial Auto Regressive Model (SAR) is used in this study. Additionally, the Hausman test for spatial models indicated that random effects should be used to estimate the models.

Table 2
Models estimation results

	Absolute convergence			**Conditional convergence**		
Variable	total effect	Direct effect	Indirect effect	total effect	Direct effect	Indirect effect
	-0/0481	-0/0428	-0/005	-0/053	-0/053	-0/0003
Lgdp1	(0/00)	(0/00)	(0/00)	(0/00)	(0/00)	(0/00)
	[-3/03]	[-2/67]	[-2/18]	[-2/47]	[-2/67]	[-2/15]
	-	-	-	0/086	0/076	0/010
Lkapital	-	-	-	(0/002)	(0/00)	(0/00)
	-	-	-	[2.83]	[3.76]	[2.45]
	-	-	-	0/014	0/014	0/0004
Lheum	-	-	-	(0/76)	(0/87)	(0/67)
	-	-	-	[0/3]	[0/53]	[0/14]
	-	-	-	0/33	0/21	0/12
Lfao	-	-	-	(0/00)	(0/00)	(0/00)
	-	-	-	[6.5]	[3/45]	[5/1]
	-	-	-	-0/215	-0/214	-0/0014
inf	-	-	-	(0/00)	(0/00)	(0/00)

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[DOI: 10.61882/jme.19.1.43]

	-	-	-	[-5/19]	[-5/2]	[-4/13]
	-	-	-	-0/0026	-0/002	-0/001
rate	-	-	-	(0/00)	(0/010)	(0/00)
	-	-	-	[-5/07]	[-5/7]	[-4/14]
Conts	-0/26 (0/00)			3/38 (0/00)		
θ	0/038607			0/041756526		
ρ	0/052 (0/003)			0/043 (0/00)		
γ	0/203 (0/00)			0/014 (0/00)		
Wald Test	51/76			90/41		
Moran Test	0/35			0/14		
Lm Lag	(0/00)69/45			(0/00)21/12		
Lm Errore	(0/00)93/86			(0/00)12/39		
Lm Sac	(0/00)12/39			(0/00)32/12		
F	(0/00)9/32			(0/00)15/46		
Hasman Test	86/1 (0/56)			32/65 (0/43)		

Note: The numbers in parentheses are the p-value and the numbers in brackets are the t-statistic.
Source: research findings

Based on the results in Table 2, the lagged logarithm of real GDP ($Ln\text{gdp}_{i,t-1}$) has a negative and significant coefficient in both equations, indicating economic performance convergence across the provinces. It should be noted that the coefficient β does not represent the speed of convergence. Therefore, to calculate the speed of convergence, the following relationship has been used.

$$\theta = \frac{-ln(1+T\beta)}{T}$$

T represents the time period under consideration, and β is the estimated coefficient in Equation (7). θ represents the speed of convergence. The absolute speed of convergence is 0.038607, while in the conditional model, the speed of convergence is 0.0418.

This indicates that in the conditional model, the speed of convergence across provinces is higher. In other words, 3.86% of the economic gap between provinces moves towards equilibrium annually in the case of absolute convergence, while in the conditional convergence model, it is 4.175%. In other words, in the absolute convergence model, 3.86% annually and in the conditional convergence model, around 4.175% of the gap between the current economic growth rate of the provinces and their long-term equilibrium growth is eliminated.

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According to Table 2, each explanatory variable has a direct effect, an indirect effect, and a total effect on the dependent variable (economic growth). The direct effect of each variable on economic growth convergence shows what impact a change in that variable in province i will have on the convergence of economic performance in the same province. The indirect (spillover) effect of each variable on economic growth convergence shows the average impact that a change in that variable in province i will have on the economic performance convergence of other provinces j, which reflects the spatial spillover of that variable. The total effect of each variable on economic performance convergence indicates the overall impact on the convergence of all provinces (including province i) when that variable changes in province i.

- The real interest rate has a significant but very small effect on the convergence of economic performance in the provinces; in other words, a 100 percent increase in the real interest rate in the provinces, on average, ceteris paribus, the convergence of economic performance in the provinces has decreased by 0.26 percent.
- The real capital stock in each province has a positive and significant effect on economic performance convergence provinces. In other words, a one percent increase in the real interest rate in the provinces, on average, ceteris paribus, the convergence of economic performance in the provinces has increased 0.0026 percent.
- The university graduate per capita in each province, as an indicator of human capital, does not have a significant effect on economic performance convergence provinces.
- Information and Communication Technology (ICT), has a positive and significant effect on economic performance convergence provinces. In other words, a one percent increase in ICT in the provinces, on average, ceteris paribus, the convergence of economic performance in the provinces has increased by 0.33% percent. The direct and indirect effects of ICT on economic performance convergence are also positive, meaning that its spillover effects improve economic performance convergence in neighboring provinces.
- Inflation has a negative and significant effect on economic performance convergence provinces. In other words, a one percent increase in the inflation rate in the provinces, on average, ceteris paribus, the convergence of economic performance in the provinces has decreased by 0.215 percent. These results are in line with the study by Al-Ajlouni and Sanajle (2023), who found that inflation had a negative and significant effect on the economic performance of Jordan. In their study for the period

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1990-2019, they showed that a 1% increase in inflation caused a 0.85% decrease in real economic performance in Jordan.

- The spatial lag coefficient of the dependent variable is positive and significant, indicating the positive influence of neighboring provinces' economic performance on each other. Therefore, the distance between provinces and their proximity or remoteness has an impact on economic performance convergence. The γ spatial lag coefficient of the error term is also positive and significant, indicating spatial dependency in the error components of the model. This means that a shock in one location can spill over to other locations.

5 Conclusion and Policy Recommendation

The main Purpose of this study is to investigate the convergence of Economic performance of provinces and assess the impact of the real interest rate on the speed of economic convergence of economic performance of Iran's province.

The results derived from the model estimations using spatial econometrics indicate that convergence of economic performance exists across provinces during the 2011-2022. In this regard, the findings of this study align with those of Hembram and Haldar (2021), Balash et al., (2020), Delangizan et., al (2017), Fattahi and Attar (2015), Mahmoudzadeh and Elmi (2013), Pahlavani et al. (2021), and Rahimi et al., (2023), but are not in agreement with the study of Timakova (2011). For example, Balash et al., (2020), using spatial econometrics, found economic growth convergence in 80 regions of Russia, also Hembram and Haldar (2021) identified convergence at a global level. Timakova (2011) found no absolute convergence but conditional convergence with respect to investment, population, and human capital.

The results showed that the real interest rate has a negative and significant but very small effect on the convergence of economic performance in the provinces. Due to the increase in inflation in recent years, the real interest rate has decreased and this has caused savings to leave banks to other markets. Therefore, the real interest rate has had a very small effect on the economic performance of the provinces.

The absolute convergence rate is 0.0386 and 0.0418 in the conditional model, which shows that in the absolute convergence model, 3.8 percent per year and in the conditional convergence model, about 4.1 percent per year of the difference between the current economic growth rate of the provinces and the long-term equilibrium economic growth of the provinces is eliminated. Therefore, the hypothesis regarding the significant effect of real interest rates

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on the speed of economic performance convergence of Iran's provinces cannot be rejected.

These findings are consistent with the studies by D'Adda and Scorcu (1997), and Al-Ajlouni and Sanajle (2023), who both found a negative relationship between real interest rates and economic growth. However, the results differ from the study by Odhiambo (2009), who found that liberalizing interest rates increased economic growth in Zambia, and the study by Keshavarzian Peyvasti and Azimi Chanzagh (2008), who showed that higher interest rates led to more bank deposits and thus boosted investment and economic growth in Iran.

Information and Communication Technology (ICT) has a positive and significant effect on economic performance convergence. These results are consistent with the findings of Hodrob et al., (2016), Hodrob and Awad (2016), Niebel (2014), Appiah-Otoo and Song (2021), Edquist et al., (2017), Salahuddin and Alam (2016), Kumar et al., (2016), Albiman and Sulong (2016), Savulescu (2015), Vu (2013), Mahmoudzadeh and Elmi (2013), and Rahimi et al., (2023).

The per capita number of university graduates in the provinces, as an indicator of human capital, does not have a significant impact on the convergence of economic performance in the provinces, which could be due to the mismatch between the skills of graduates and the needs of the labor market and structural and institutional problems in the education sector (quality of education, brain drain, and the labor market).

Education and increased skills of the workforce increase the workforce's understanding of suitable business opportunities and their ability to exploit them more. Education and training also increase the willingness of private sector firms and government organizations to hire them by increasing the productivity and efficiency of the workforce, and by reducing unemployment, increase income levels.

These results are inconsistent with studies by Rajae et al., (2020), Rahimi et al., (2023), Imran et al., (2012), Suri and Boozer (2011), Absalyamova et al., (2015), Costantini and Martini (2010) Rains et al., (2000). The results of the study by Tian et al., (2016) in China showed that the variable of human capital has caused the convergence of the province.

The real capital stock in each province has a positive and significant effect on economic performance convergence. These results are in line with the studies of Rahimi et al., (2023), Abounoori and Kashefi (2018), Rajae et al., (2020), Mahmoudzadeh and Elmi (2013).

According to the obtained results, the following suggestions are presented:

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Due to the increase in inflation in recent years, the real interest rate has decreased, which has caused savings to leave banks and go to other markets. Therefore, the real interest rate has had a very small impact on the economic performance of the provinces. Given the small impact of the real interest rate on the convergence of the economic performance of the provinces, it is necessary to use anti-inflationary policies, including the following, to increase the economic performance of the provinces.

- Reducing the volume of liquidity,
- Fiscal discipline of governments,
- Increasing production
- Avoiding inefficient allocation of credits in the country's banking system
- Reducing monetary indiscipline
- Reducing government intervention in credit allocation
- Monitoring the use of payment facilities by banks
- Increasing the independence of the central bank

Considering the positive and significant impact of information and communication technology (ICT) on the convergence of economic performance in the provinces, it is recommended to develop comprehensive programs for various sectors such as communication infrastructure, education, culture, and economics to ensure robust ICT infrastructure and its optimal use. In particular, enhancing the utilization of human resources in the ICT sector, improving productivity, and supporting the growth of small and medium-sized ICT companies are vital.

Considering the positive and significant impact of physical capital on the convergence of economic performance in the provinces, it is suggested to create investment security and establish effective incentives to attract foreign investors. This can provide the necessary capital for economic growth and improve the regional performance of provinces.

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