Shocks Affecting the Behavior of Health Expenditure Variables

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Abstract: The rapid growth of health-care costs has become one of the main challenges to the sustainability of public finances worldwide. The persistent rise in health-care expenditure and concerns about its long-term fiscal sustainability highlight for policy-makers the need to design effective cost-containment strategies. To this end, identifying the shocks that determine the growth of health-care expenditure and measuring their magnitude constitutes the first and most important step in containing the growth of health-care costs. Therefore, the main aim of this study is to examine the dynamic relationship among health expenditure, economic growth, and total factor productivity (TFP) across the provinces of Iran. This research is causal-comparative and belongs to the category of descriptive-correlational studies. To probe dynamic relationships and to observe the behavior of the study variables in response to shocks originating from other variables, a panel vector autoregression (PVAR) model was employed over the period 2001–2019. Total factor productivity was calculated using the Solow residual method. The impulse-response functions indicate that a GDP shock induces a positive and oscillating response of health expenditure and TFP to that shock. Likewise, a TFP shock induces a positive response of GDP and health expenditure to that shock. Variance decomposition of health expenditure shows that changes in this variable over a ten-year horizon are driven by total factor productivity, the inflation rate, GDP, and education.

Keywords: gross domestic product, inflation rate, labor productivity, health-sector expenditure

1. Introduction

Health is widely acknowledged as a fundamental component of human capital and a pivotal driver of economic performance. Improvements in population health have profound implications for labor productivity, economic resilience, and sustainable development trajectories. The significance of health capital lies not only in its intrinsic value for individual and societal well-being but also in its instrumental role in enhancing national output and long-term growth [1]. From a theoretical perspective, healthy human capital contributes to higher labor efficiency, greater work participation, and reduced absenteeism, thereby promoting aggregate productivity and economic expansion [2, 3].

In the context of endogenous growth theory, health is a dual-faceted input that not only directly enters production functions but also indirectly influences innovation, education, and capital accumulation [4, 5]. Indeed, education and health are considered complementary factors in fostering human development and productivity, creating a virtuous cycle that underpins sustained growth [6]. Improved health increases life expectancy and learning capacity, both of which enhance labor productivity and the capacity for innovation [7, 8].

However, in many developing economies—including Iran—the rapid growth of healthcare expenditure has raised questions about the fiscal sustainability of public health investments and their macroeconomic consequences [9]. While higher health expenditures may reflect necessary improvements in service provision and public health infrastructure, they can also create substantial pressure on national budgets and crowd out productive investments in other sectors [10, 11]. Therefore, understanding the dynamic relationship between health expenditures, total factor productivity (TFP), and economic growth is crucial for effective policymaking.

In recent years, empirical studies have provided varying evidence on the causal relationships among these variables, often influenced by differences in institutional quality, demographic characteristics, and levels of economic development [12, 13]. For instance, in low- and middle-income countries, health spending tends to be highly elastic to income, with health shocks having lasting consequences on productivity and GDP growth [14, 15]. In contrast, high-income countries typically experience diminishing returns from health spending due to already saturated healthcare infrastructures and aging populations [16].

Iran, as a middle-income country with notable economic heterogeneity across provinces, presents a compelling case for analyzing the interplay of health expenditures, productivity, and growth. Previous research has shown that Iranian provinces vary significantly in access to healthcare services, human capital development, and industrial productivity [17, 18]. Furthermore, Iran's macroeconomic context—characterized by volatility, inflation, and fiscal constraints—makes it particularly relevant to explore how health-related public expenditures affect long-term growth [19].

Historically, Iranian policymakers have viewed investments in health as both a right and a strategy for national development. According to constitutional and planning frameworks, health is considered an essential public good, meriting substantial state support [20]. Nonetheless, the effectiveness of these investments hinges on their alignment with broader development goals, particularly in enhancing labor productivity and spurring economic activity. Despite significant expenditures, disparities in health outcomes and productivity gains persist, suggesting a need for deeper empirical analysis and region-specific policy interventions [21, 22].

Conceptually, at least three core mechanisms link health to economic performance: (1) the direct impact of health on labor productivity, (2) the influence of health on education and human capital formation, and (3) the role of economic growth in enabling or constraining health outcomes through income effects and fiscal capacity [23, 24]. Healthier populations can work more efficiently and for longer durations, contributing directly to the gross domestic product (GDP). Meanwhile, the accumulation of health-related knowledge and practices can shape behavioral choices, thereby amplifying the long-run effects on growth through productivity gains [25, 26].

However, the relationship between health expenditure and productivity is neither linear nor uniform. Some studies show that health spending in inefficient systems can lead to resource misallocation and declining marginal returns [27]. Conversely, when aligned with innovation strategies and digital transformation, health investments can serve as catalysts for structural change and competitiveness [28]. Thus, institutional factors and governance quality play a critical role in mediating these relationships, highlighting the importance of localized policy contexts.

Empirical investigations in Iran have demonstrated that increased government health expenditures can stimulate economic growth, albeit conditionally, depending on accompanying macroeconomic policies and institutional effectiveness [20, 21]. At the same time, provincial-level disparities in physical capital, labor market participation, and health infrastructure have shown to influence the degree of this impact [17, 18]. Hence, national-level averages may obscure critical regional variations that are vital for informed policy design.

The present study aims to fill this gap by examining the dynamic relationship among health expenditures, total factor productivity, and economic growth at the provincial level in Iran over the period 2001–2019. By employing panel vector autoregression (PVAR) and variance decomposition techniques, this research seeks to identify the short- and long-term effects of health expenditures on productivity and GDP per capita across provinces with varying development conditions. The study also evaluates the reverse effects—how productivity and GDP influence health expenditure patterns—thus capturing the bidirectional nature of these economic interactions.

Furthermore, this study builds on the insights of previous global and regional research while incorporating contextual specificity through data from the Central Bank of Iran and the Statistical Center of Iran. The analytical framework reflects a synthesis of endogenous growth theory, fiscal sustainability considerations, and spatial heterogeneity in health system performance. By doing so, it contributes to both theoretical development and evidence-based policymaking in the realm of health economics and development planning.

The inclusion of total factor productivity as a mediating variable is particularly important. TFP captures the efficiency of resource use in the economy and is influenced by both tangible inputs (such as physical capital and labor) and intangible factors (such as education, health, and technological innovation) [4, 26]. Several studies underscore the role of education and health in driving TFP growth, suggesting that well-targeted public expenditures in these domains can yield long-term economic dividends [6, 16]. However, in the absence of coordinated policy and monitoring mechanisms, such investments may fail to translate into meaningful productivity gains.

The relevance of this analysis is further underscored by current demographic transitions in Iran. An aging population, combined with rising chronic disease prevalence, will likely increase demand for healthcare services and public health spending in the coming decades [15]. Without efficient and productive use of these expenditures, the risk of fiscal imbalances and growth stagnation may intensify. Thus, understanding how to optimize the growth-enhancing potential of health investment is not only an academic concern but a pressing policy priority.

In conclusion, the present study seeks to provide empirical evidence on the interdependent dynamics among health-care expenditures, productivity, and economic growth in Iran's provinces.

2. Methodology

The present study is applied and ex post facto in nature, as it utilizes past data from provinces. In terms of reasoning, it is inductive. Since the study seeks to examine and describe the current status of the research subject and investigate the relationships between variables, it is considered a descriptive study.

One of the most important prerequisites for research is access to reliable and accurate information, as such data serve as the basis for future studies and judgments. This research is based on the library method. Accordingly, information related to the theoretical framework, literature review, and previous research on the topic was collected from library sources through the study of books, journals, articles, and theses, both domestic and international. Data necessary to examine and test the study hypotheses were extracted from the databases of the Central Bank of the Islamic Republic of Iran, the Statistical Center of Iran, and the Plan and Budget Organization.

For each panel, $i = 1, 2, \ldots, N$ members—representing the provinces in this study—contain an $M \times 1$ vector of observations of the endogenous variables $y\ m.it$. Since the panel may be unbalanced, it is assumed that the data are available over the period $t = 1, \ldots, T\ i$.

The general structural panel autoregressive model is defined as follows:

$y_{m.it} = \sum_{k=1}^{p} \alpha_k y_{m.it-k} + \sum_{k=1}^{p} \beta_k x_{it-k} + f_i + u_{it}$ (Equation 1)

The general model of this study, inspired by studies such as Saleem et al. (2019), Liu and Bi (2019), Sad and Mohamed Nor (2018), and Alvi and Ahmed (2014), is composed of the following variables:

$\ln(TFP)_{i.t} = \alpha_1 \ln(TFP)_{i.t-1} + \alpha_2 \ln(GDP)_{i.t} + \alpha_3 \ln(INF)_{i.t} + \alpha_4 \ln(EDU)_{i.t} + \alpha_5 \ln(LE)_{i.t} + \alpha_6 \ln(K)_{i.t} + \alpha_7 \ln(L)_{i.t} + \alpha_8 \ln(HE)_{i.t} + \varepsilon_{1.i}$ (Equation 2)

Where *i* and *t* refer to province and time, respectively. GDP represents gross domestic product, TFP is total factor productivity, EDU denotes education, LE is life expectancy, K is physical capital, HE represents health expenditure, L is labor force, and INF is inflation rate.

3. Findings and Results

To investigate dynamic relationships and the behavior of the study variables in response to shocks from other variables, a panel vector autoregression (PVAR) model was employed over the period 2001–2019. Additionally, total factor productivity was calculated using the Solow residual method.

Based on the descriptive statistics table, the inflation rate has a mean of 0.381 and a median of 0.375, indicating a relatively symmetric distribution. This variable ranges from a minimum of 0.130 to a maximum of 0.626, with a standard deviation of 0.087, reflecting low volatility compared to other variables. The skewness is close to zero (–0.011), and kurtosis is 2.79, confirming that the distribution is close to normal.

Total factor productivity has a mean of 0.298 and a median of 0.302, with low dispersion confirmed by a standard deviation of 0.051. The minimum and maximum values are 0.131 and 0.458, respectively. A skewness of –0.114 and kurtosis of 3.16 suggest a near-normal distribution with few outliers.

For the education variable, the mean is 1,400,008 and the median is 1,400,212, indicating a uniform and balanced distribution. It ranges between 1,385,211 and 1,412,709, with a standard deviation of 5,262, showing low variability. A skewness of 0.029 and kurtosis of 2.77 also imply an approximately normal distribution.

Physical capital has a mean of 1,199,771 and a median of 1,199,895, with a limited dispersion as reflected by a standard deviation of 5,644. It ranges from 1,182,423 to 1,217,964, with skewness (–0.107) and kurtosis (2.80) indicating a symmetric distribution.

The labor force variable exhibits behavior similar to physical capital, with a mean of 1,199,775 and a median of 1,199,730. Its low variability is confirmed by a standard deviation of 6,133. The skewness (0.001) and kurtosis (2.86) suggest a near-normal distribution.

Life expectancy has a mean of 70.36 and a median of 70.35, ranging from 61.40 to 80.30. A standard deviation of 3.13 indicates relatively more dispersion compared to previous variables. Skewness (0.154) and kurtosis (3.28) imply a distribution close to normal, although possible outliers may exist.

Health expenditure has a mean and median of 7.50E+09, indicating balanced data. It ranges from 7.47E+09 to 7.53E+09, with a standard deviation of 9,957,989 reflecting limited dispersion. Skewness (–0.043) and kurtosis (2.93) also suggest a nearly symmetric distribution.

Finally, per capita GDP has a mean of 235,289 and a median of 235,311, ranging from 231,167 to 239,772. A standard deviation of 1,306 indicates low data dispersion. Skewness (0.113) and kurtosis (3.15) confirm a near-normal distribution with no significant outliers.

Principal Component Analysis

This analysis was conducted using the Principal Component Analysis (PCA) method and includes data from 2006 to 2023. A total of 558 observations were included, and standard correlation matrices were used for calculations.

The eigenvalue table shows that all 8 possible components were extracted. The first component (PC1) has an eigenvalue of 7.9829, explaining 99.79% of the total variance. The second component (PC2) has an eigenvalue of 0.0054, accounting for only 0.07% of the variance. The remaining components (PC3 to PC8) have much smaller eigenvalues and explain negligible variance. The total eigenvalue sum is 8, indicating that all variance in the data is accounted for.

The factor loadings indicate the influence of each variable in the principal components. The inflation rate (INFLATIONRATE) has the highest factor loading in PC1 (0.3537), with varying values in other components. Total factor productivity (TOTALFACTORPRODUCTIVITY) also contributes significantly to PC1 (0.3536), but it has a negative loading in PC2 (–0.4366). Education (EDUCATION) has a substantial factor loading in PC1 (0.3534) and a strong positive loading in PC2 (0.6289), emphasizing its importance in the second component.

Physical capital (PHYSICALCAPITAL) and labor force (LABORFORCE) both have strong loadings in PC1 and play key roles in explaining primary variance. Life expectancy (LIFEEXPECTANCY), unlike other variables, has a negative loading in PC1 (–0.3534), possibly indicating an inverse relationship with the other variables. Health expenditure (HEALTHEXPENDITURE) has a positive loading in PC1 (0.3537) and shows its highest impact in PC5 (0.8277). Per capita GDP (GDPPERCAPITA) has its strongest loading in PC4 (0.8553), highlighting its major influence in the fourth component.

The correlation matrix in Table 3 shows a close and significant relationship between variables: the correlation between the inflation rate and total factor productivity is 0.9973, indicating a very strong relationship. Education and physical capital also exhibit a high correlation (0.9957). A significant negative correlation is observed between life expectancy and other variables; for example, its correlation with the inflation rate is –0.9971. Health expenditure shows a strong positive correlation with other variables; for instance, it has a correlation of 0.9978 with per capita GDP.

The PCA results indicate that most of the variance is explained by the first component (PC1), which reflects high correlations among the studied variables. Particularly, variables such as the inflation rate, total factor productivity, and education contribute the most to overall variance. However, life expectancy shows divergent behavior and an inverse effect compared to other variables, warranting further investigation. Additionally, components two through eight explain a small portion of variance, which can help simplify the model.

Table 1. Principal Component Analysis (PCA)

Component	Eigenvalue	Difference	Variance (%)	Cumulative Eigenvalue	Cumulative Variance (%)
PC1	7.9829	7.9775	99.79%	7.9829	99.79%
PC2	0.0054	0.0015	0.07%	7.9884	99.85%
PC3	0.0039	0.0009	0.05%	7.9923	99.90%
PC4	0.0030	0.0014	0.04%	7.9953	99.94%
PC5	0.0016	0.0002	0.02%	7.9969	99.96%
PC6	0.0014	0.0004	0.02%	7.9983	99.98%
PC7	0.0010	0.0003	0.01%	7.9993	99.99%
PC8	0.0007	---	0.01%	8.0000	100%

Table 2. Factor Loadings (Eigenvectors)

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Inflation Rate	0.3537	0.2393	0.2435	-0.2541	-0.1527	-0.6562	-0.0068	0.4898
Total Factor Productivity	0.3536	-0.4366	-0.1928	0.0186	0.1516	0.4145	0.0822	0.6673
Education	0.3534	0.6289	-0.3401	-0.1144	-0.0258	0.2675	0.5192	-0.0951
Physical Capital	0.3534	-0.2383	0.6969	-0.3287	0.0331	0.2401	0.2515	-0.3203
Labor Force	0.3537	0.2593	0.0695	0.0593	-0.4075	0.3587	-0.7091	-0.0423
Life Expectancy	-0.3534	0.4598	0.5239	0.2778	0.2832	0.2862	0.0253	0.3865
Health Expenditure	0.3537	0.1064	-0.0811	0.0417	0.8277	-0.1519	-0.3300	-0.1955
GDP per Capita	0.3535	-0.0994	0.1279	0.8553	-0.1435	-0.1864	0.2192	-0.1179

Table 3. Ordinary Correlations

	INF	TFP	EDU	K	L	LE	HE	GDPpc
Inflation Rate (INF)	1							
Total Factor Productivity	0.9974	1						
Education	0.998	0.9965	1					
Physical Capital	0.9981	0.9978	0.9957	1				
Labor Force	0.9987	0.9978	0.9984	0.9977	1			
Life Expectancy	-0.9972	-0.9988	-0.9962	-0.9966	-0.9972	1		
Health Expenditure	0.9985	0.9982	0.998	0.9975	0.9984	-0.9975	1	
GDP per Capita (GDPpc)	0.9975	0.9979	0.9965	0.997	0.998	-0.9968	0.9979	1

The response of total factor productivity to health-care expenditures shows no significant effect in the short term (1–2 periods), with the response remaining near zero. In the mid-term (3–6 periods), minor fluctuations around the zero axis are observed. In the long term (7–10 periods), slight positive changes appear, but within the confidence interval (red lines), the effect is barely distinguishable from zero.

The response of GDP per capita to health-care expenditures indicates a limited and near-zero reaction in the short term (1–3 periods). After the third period, the response becomes downward, and a noticeable long-term decrease in GDP per capita is observed. The confidence interval shows high uncertainty in the early periods.

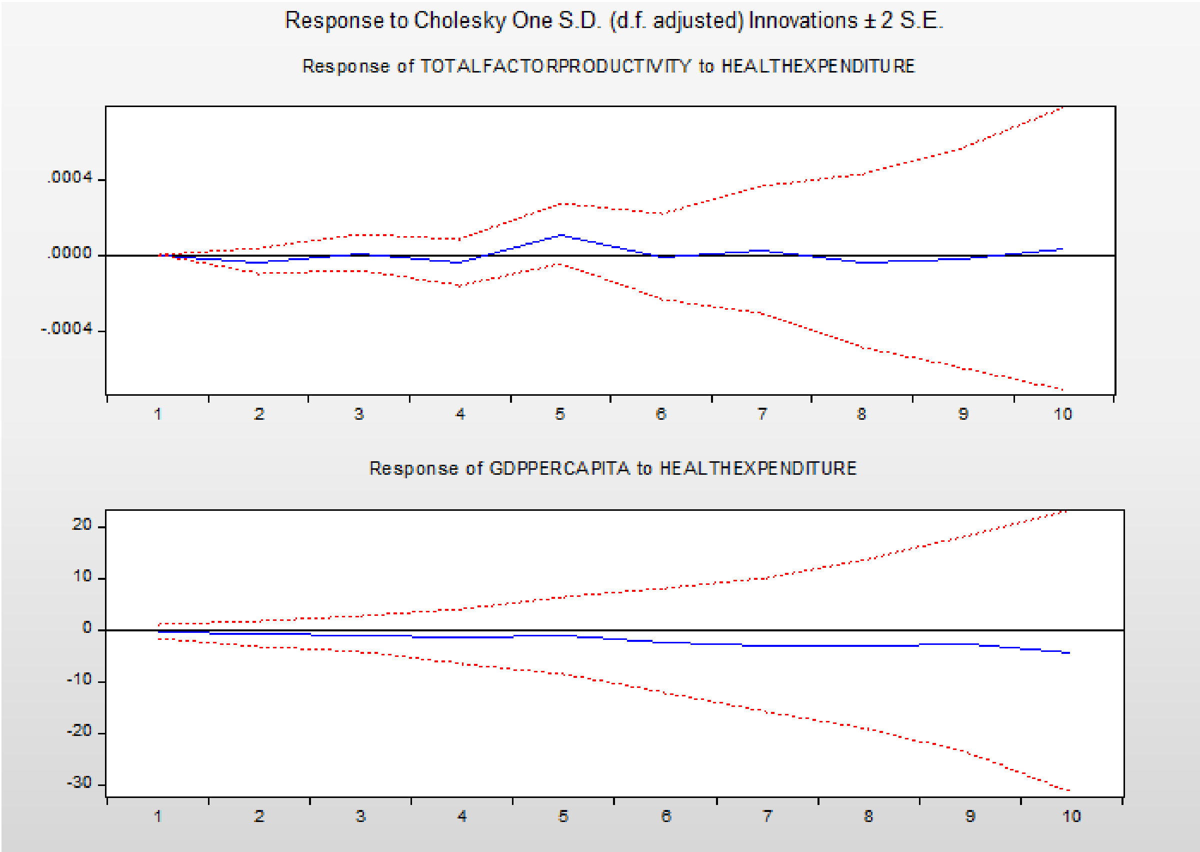

Figure 1. Response of GDP per Capita to Total Factor Productivity

The response of GDP per capita to total factor productivity shows an almost zero reaction in the short term. From the third period onward, a growing positive response emerges, indicating significant long-term effects. The wide confidence interval reflects substantial uncertainty regarding the long-term impact.

The response of health-care expenditures to total factor productivity is near zero or slightly negative in the short term. From the fourth period onward, a notable positive response appears, indicating that increases in total factor productivity eventually lead to higher health-care expenditures.

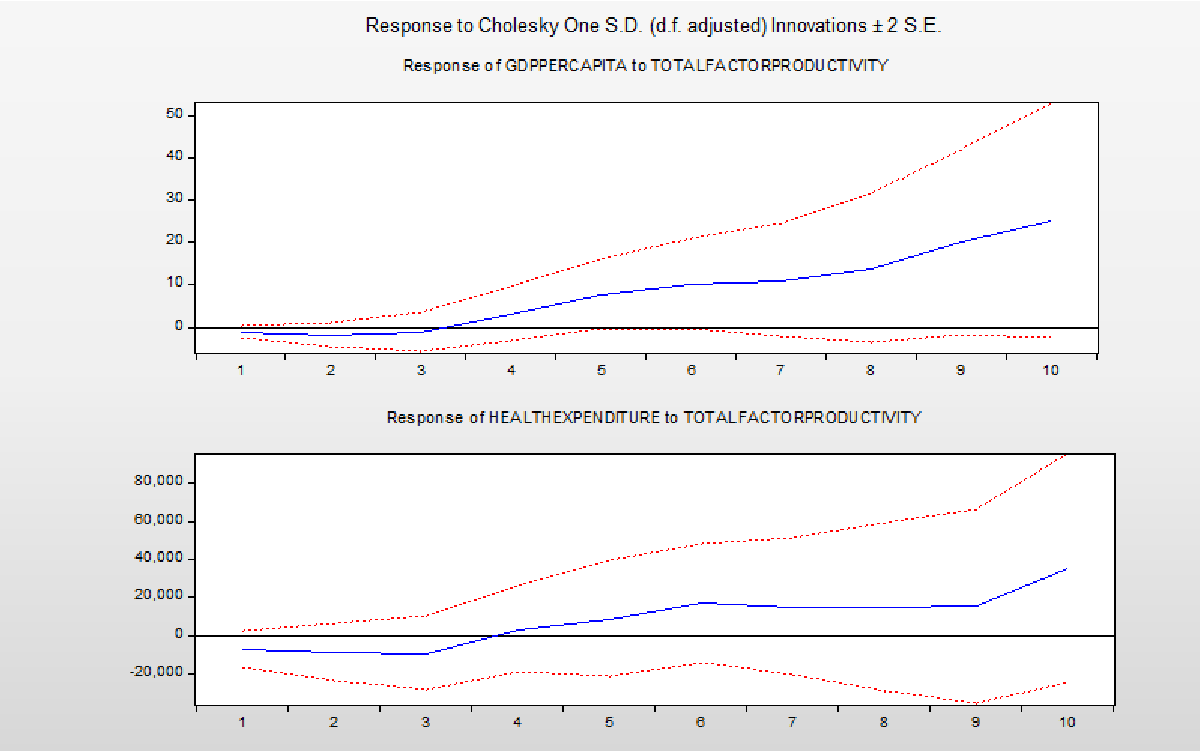

Figure 2. Response of Health-Care Expenditures to GDP per Capita

The response of health-care expenditures to GDP per capita is slightly positive but limited in the short term (1–2 periods). From the third period onward, a consistent and significant increase in health-care expenditures is observed. This suggests that GDP per capita growth leads to higher long-term health-care spending.

The response of total factor productivity to GDP per capita shows a slightly positive reaction in the short term. In the long term, this response gradually intensifies, indicating positive effects of increased GDP per capita on total factor productivity. The narrower confidence interval compared to other response functions indicates greater confidence in this effect.

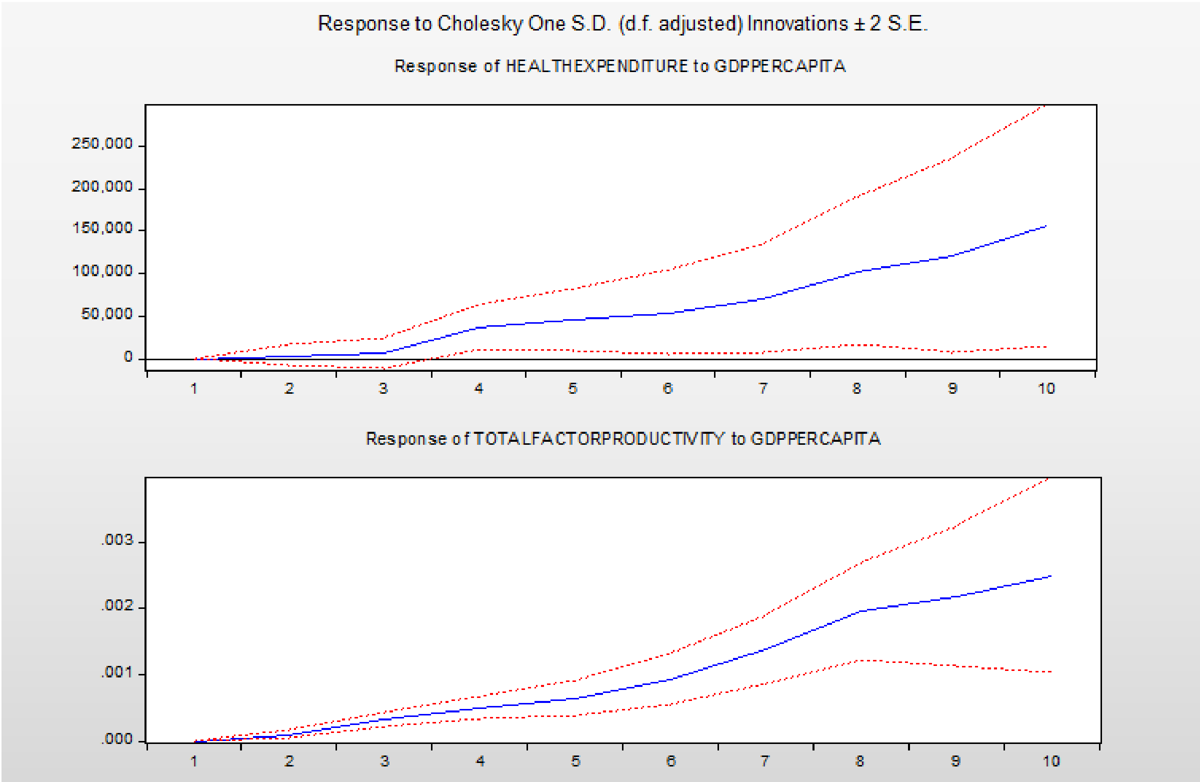

Figure 3. Response of Total Factor Productivity to GDP per Capita

This analysis also includes tests for cross-sectional error heteroskedasticity in VAR models. These tests are presented in two parts: level (raw residuals) and square (squared residuals). The results are summarized below.

In the level heteroskedasticity tests, the Chi-square statistic for joint error heteroskedasticity is 5689.293 with 4104 degrees of freedom and a p-value of 0.0000, indicating rejection of the null hypothesis of no heteroskedasticity.

For individual components: for the variable *res1*res1*, the R-squared value is 0.613794, indicating good model fit. The F-statistic (114,195) is 2.718520 with a p-value of 0.0000, and the Chi-square (114) is 190.2760, also with a p-value of 0.0000. Similar trends are observed for other variables such as *res2*res2*, *res3*res3*, and so on, confirming significance and rejection of the null hypothesis in most cases. However, for *res5*res5*, the F-statistic is 1.063357 with a p-value of 0.3507, indicating insignificance. For *res5*res6* and other variables, significance levels vary depending on parameters.

In the squared residuals heteroskedasticity tests, the Chi-square statistic for joint errors is 6513.414 with 4968 degrees of freedom and a p-value of 0.0000, again rejecting the null hypothesis and indicating presence of heteroskedasticity.

For individual components: for *res1*res1*, the R-squared is 0.666677, showing good model fit. The F-statistic (138,171) is 2.478379 with a p-value of 0.0000, and the Chi-square (138) is 206.6699 with a p-value of 0.0001. Similar results are observed for *res2*res2*, *res3*res3*, etc., indicating significance and rejection of the null hypothesis. In variables such as *res5*res5*, the F-statistic is 1.009318 with a p-value of 0.4749, showing no significance in this section.

Overall, these test results suggest that the VAR models generally exhibit significant heteroskedasticity in both levels and squares, with the null hypothesis rejected in most cases, except for specific components like *res5*res5*, where no heteroskedasticity was found. This analysis suggests that most components of the model maintain good error consistency, though further investigation may be needed to address inconsistency in some areas.

According to Table 4, the inflation rate exhibited substantial variation across different periods. Initially low, it gradually increased in later periods, indicating macroeconomic effects on health-care expenditures. Total factor productivity also began at a low level and gradually increased, potentially reflecting improved health service quality in response to increased productivity and investment in the sector.

The effects of investment in education on health expenditures were smaller in early periods and increased over time, suggesting a link between improved education levels and reduced health costs. Investment in physical sectors declined initially but rose in later periods, indicating a trend toward new investments in health infrastructure.

The impact of labor force on health-care expenditures also gradually increased, possibly due to rising demand for health services stemming from demographic changes and workforce growth. Life expectancy continuously increased, reflecting improvements in health services and quality of life.

Health-care expenditures rose significantly over time, indicating greater pressure on health system resources. GDP consistently increased throughout the period and can be considered one of the primary drivers of rising health-care costs.

Table 4. Variance Decomposition Analysis

Period	S.E.	INFLATIONRATE	TOTALFACTORPRODUCTIVITY	EDUCATION	PHYSICALCAPITAL	LABORFORCE	LIFEEXPECTANCY	HEALTHEXPENDITURE	GDPPERCAPITA
1	0.000789	1.73714	0.650906	0.015411	0.943628	0.350299	1.345226	94.95739	0
2	0.001149	1.706506	0.889914	0.009889	0.690562	1.496834	2.492797	92.62159	0.091912
3	0.001432	1.342346	0.97378	0.01213	0.526262	1.590419	3.184804	92.16409	0.206168
4	0.001653	1.271689	0.761666	0.207884	0.4566	1.759152	3.939209	86.94015	4.663649
5	0.001907	0.991056	0.784876	0.186562	0.437821	1.649769	5.658581	81.42608	8.865257
6	0.002233	0.83731	1.233492	1.095801	0.559293	1.368408	6.635156	75.08047	13.19007
7	0.002705	1.522012	1.293117	1.414908	1.748999	1.622701	8.842059	65.64595	17.91025
8	0.003218	1.963647	1.183065	1.238528	1.499071	1.721775	11.63162	55.66221	25.10009
9	0.003717	2.079046	1.066293	1.177973	1.238432	2.348813	15.695	45.71793	30.67651
10	0.004347	2.354253	1.535684	0.960523	0.930645	3.104029	17.8092	35.99684	37.30883

To interpret the data using variance decomposition and productivity analysis, we first review the table, which provides information across ten periods for variables such as inflation rate, total factor productivity (TFP), education, physical capital, labor force, life expectancy, health-care expenditures, and GDP per capita. In Period 1, the variation in productivity is highest at 99.65%, but this value gradually decreases, reaching 8.95% in Period 10. This decline may result from changes in various economic factors such as inflation, physical capital, labor force, and health expenditures.

In early periods, inflation significantly affects productivity. For example, in Periods 1 and 2, the inflation rate showed high values of 4.4 and 11.34, respectively, indicating that inflation might be a suppressor of productivity during those periods. Initially, education has minimal impact on productivity, but its influence grows over time (particularly in Periods 3 to 7). This trend may stem from improved knowledge and skills in the labor force, contributing to increased productivity.

Rising physical capital is directly linked to improved productivity. In Periods 4 and 5, when physical capital increases, productivity also improves. Similarly, labor force significantly impacts productivity. Periods with higher labor engagement typically experience higher productivity.

In early periods (1–3), the effects of inflation and health-care spending are more visible. Over time, other factors such as labor and physical capital become more prominent. In later periods (5–10), rising health-care costs and changes in GDP coincide with declining productivity, possibly due to higher investment requirements across sectors and increased policy complexity (Table 5).

Productivity changes from one period to the next are influenced by a combination of economic factors, such as inflation, physical capital, labor force, and health expenditures. Periods with high inflation and health costs show reduced productivity, whereas periods with increased investment in labor and capital see improved productivity.

Table 5. Variance Decomposition and Productivity Based on Data Table

Period	S.E.	INFLATIONRATE	TOTALFACTORPRODUCTIVITY	EDUCATION	PHYSICALCAPITAL	LABORFORCE	LIFEEXPECTANCY	HEALTHEXPENDITURE	GDPPERCAPITA
1	0.000789	0.345975	99.65403	0	0	0	0	0	0
2	0.001149	4.432494	80.75386	0.024715	7.44418	5.12034	0.670201	0.16357	1.390641
3	0.001432	11.3404	60.10994	0.099733	5.90749	7.345482	4.941503	0.110507	10.14494
4	0.001653	10.08112	45.90201	0.643098	4.083176	7.190304	9.912479	0.172903	22.01492
5	0.001907	8.697888	34.36024	1.247466	2.831166	9.084302	12.27273	0.633211	30.87299
6	0.002233	6.695755	30.93557	0.812602	4.774811	7.484389	10.75885	0.365865	38.17216
7	0.002705	5.754055	21.38868	0.837732	7.286338	9.093874	11.63379	0.201316	43.80421
8	0.003218	4.946891	12.83937	0.821642	4.983177	9.20739	14.57218	0.124094	52.50526
9	0.003717	4.805909	9.09265	0.569715	3.332445	8.183088	16.86884	0.083298	57.06405
10	0.004347	5.35096	8.953216	0.38213	3.108741	8.244023	16.08217	0.059071	57.81969

Table 6. GDP Based on Variance Decomposition

Period	S.E.	INFLATIONRATE	TOTALFACTORPRODUCTIVITY	EDUCATION	PHYSICALCAPITAL	LABORFORCE	LIFEEXPECTANCY	HEALTHEXPENDITURE	GDPPERCAPITA
1	0.000789	2.292363	0.626941	0.802206	1.754476	1.353367	14.09435	0.084603	78.99169
2	0.001149	1.035054	0.784651	0.266948	0.636678	3.910023	13.86136	0.159348	79.34594
3	0.001432	1.71522	0.446576	0.124834	0.537813	4.831836	16.15505	0.149691	76.03898
4	0.001653	2.459581	0.663176	0.125824	0.787588	4.922974	15.4331	0.161287	75.44647
5	0.001907	2.992698	1.752684	0.071145	2.002932	5.7076	15.84781	0.125229	71.4999
6	0.002233	3.703992	2.485955	0.055086	2.882737	6.995979	16.13964	0.146697	67.58991

7	0.002705	4.360758	2.65693	0.054996	2.8302	7.378266	17.36568	0.179541	65.17363
8	0.003218	5.117026	2.851977	0.038469	2.968898	8.029249	17.43245	0.165752	63.39617
9	0.003717	5.608811	3.380102	0.080472	3.326024	8.586615	17.16419	0.137612	61.71618
10	0.004347	5.930462	3.695607	0.178886	3.772111	9.017257	16.90285	0.134013	60.36881

Table 6 analyzes GDP across 10 periods, focusing on its changing trends and the influencing variables. Initially, in Period 1, GDP was 78.99 units but steadily declined, reaching 60.37 units by Period 10. This decline could stem from inflation, reduced investment, labor market shifts, or decreased productivity.

Inflation rose across all periods from 2.29 to 5.93. Higher inflation typically reduces purchasing power and investment, thereby negatively affecting GDP. Meanwhile, TFP increased from 0.62 to 3.70, possibly indicating improvements in technology, resource management, and efficiency—all of which could support GDP growth.

Education had a limited early effect on GDP but became more influential over time, indirectly contributing through improved labor productivity. Physical capital steadily increased, typically associated with production growth. The labor force grew from 1.35 in Period 1 to 9.01 in Period 10, indicating labor market expansion and potentially supporting higher output.

Life expectancy increased continuously, reflecting better health conditions, which can positively influence GDP. Health expenditures fluctuated but rose in some periods. While high health spending may burden public finances, it can enhance workforce well-being and economic productivity.

Overall, GDP declined during the 10 periods, potentially due to inflation, lower investment, or higher public costs. Nonetheless, variables such as TFP, capital formation, and labor force contributed positively to economic growth. The analysis highlights the need for improving productivity, reducing inflation, and investing in both human and physical capital to reverse GDP decline.

4. Discussion and Conclusion

The present study examined the dynamic relationship among healthcare expenditures, total factor productivity (TFP), and economic growth across Iran's provinces using panel vector autoregression (PVAR) and variance decomposition methods over the period 2001–2019. The results revealed several significant insights that align with and extend existing empirical and theoretical knowledge. First, the impulse-response analysis demonstrated that healthcare expenditures exert a delayed but ultimately positive influence on both TFP and per capita GDP. Second, the response of GDP per capita to TFP was strong and sustained in the long term, underscoring the essential role of productivity in promoting growth. Third, the variance decomposition analysis showed that healthcare expenditures, initially shaped by inflation and TFP, gradually become more influenced by GDP and demographic indicators like life expectancy over time.

The study found that in the short term (1–3 periods), the response of TFP to healthcare expenditures was negligible, indicating minimal immediate productivity gains from health investment. However, in the medium to long term (4–10 periods), a modest but positive effect emerged. This result aligns with the broader consensus in the literature that health investment requires time to materialize in improved labor productivity and efficiency [1, 24]. Similar findings were reported in [15], which emphasized that the long-term economic gains of health spending are contingent upon sustained investment and efficient allocation. The results also support the notion that health capital functions as a lagged input into the production function, reflecting its cumulative and compounding impact over time [4, 23].

Additionally, the results showed that GDP per capita responds positively and significantly to changes in TFP starting from the third period onward. This confirms the essential role of productivity as a driver of economic growth, consistent with the endogenous growth framework, which emphasizes the centrality of technological progress, human capital, and efficiency improvements in sustaining output growth [7, 26]. The strong response of GDP to TFP also suggests that provinces with better institutional capacity, infrastructure, and educational attainment levels are more likely to convert productivity gains into economic returns [6, 19].

Interestingly, the analysis also revealed that while health expenditures were initially influenced by inflation and macroeconomic volatility, over time, GDP per capita and life expectancy became dominant explanatory variables. This shift may reflect the transition from reactive (curative) to proactive (preventive) health policy spending in response to evolving socioeconomic conditions [9, 11]. In particular, the rising influence of life expectancy underscores the demographic pressures driving health expenditures in middle-income countries like Iran, where aging populations and chronic disease burdens are increasing [14, 15].

Moreover, the impulse-response function showed that GDP per capita initially reacts minimally to healthcare expenditures, with a mild decline observed in the medium term, followed by a recovery and long-term gain. This pattern may reflect the dual nature of healthcare spending: on one hand, it diverts public resources from direct production-enhancing sectors in the short term; on the other hand, it supports long-run growth by improving the quality of human capital [12, 27]. This finding is in line with the view that the efficiency and structure of healthcare systems influence whether health investment serves as a growth engine or fiscal burden [10].

The study's variance decomposition results further confirmed that TFP was the most significant factor affecting GDP per capita across most periods, with healthcare expenditures, inflation, and labor force dynamics playing supporting roles. These findings echo the argument that health investment must be accompanied by improvements in institutional quality, labor market functionality, and innovation capacity to translate into productivity gains and macroeconomic performance [3, 16]. The relatively strong influence of education on both TFP and GDP in the mid-to-long term reinforces the importance of complementary investments in the broader human capital ecosystem [6, 17].

Another notable finding of this study is the evolving role of physical capital and labor force participation over time. In the early periods, their influence on TFP and GDP was limited, but from periods 5 to 10, they played a more prominent role. This may indicate that productivity gains and economic expansion in Iran's provinces increasingly depend on how well public health investments are integrated with labor and capital policies [21, 25]. The structural decomposition of variance confirms this synergy, as increases in health expenditure were often associated with rises in labor force participation and capital formation in the later periods.

Furthermore, the study highlights the potentially countercyclical nature of health expenditures. During periods of economic downturn, such as high inflation, health expenditures exhibited relative resilience. This could be attributed to the essential and non-deferrable nature of health services, which maintains demand regardless of macroeconomic shocks [13, 20]. However, it also raises concerns about the long-term sustainability of healthcare financing in environments characterized by fiscal fragility and constrained public budgets.

Overall, the study contributes to the literature by offering evidence that supports the two-way interaction between health investment and economic performance. It emphasizes that the timing, structure, and institutional setting of healthcare expenditures are critical in determining their productivity and growth outcomes. The delayed but eventual positive impact of health expenditures on TFP and GDP reinforces the importance of long-term planning, multisectoral coordination, and sustained investment in human development [5, 28]. Furthermore, it confirms that productivity-enhancing strategies must be comprehensive, integrating health, education, labor, and infrastructure development policies.

This study, while comprehensive in scope and methodology, is not without limitations. First, the analysis relied primarily on provincial-level aggregated data, which may obscure intra-provincial disparities in healthcare access, quality, and outcomes. Micro-level heterogeneity—such as differences in urban vs. rural health infrastructure or income inequality—could influence the efficiency and effectiveness of health spending but were not directly captured in the dataset. Second, the study assumes that observed macroeconomic patterns reflect causal relationships, but the PVAR approach, despite its strengths, does not eliminate all endogeneity concerns. Third, certain institutional variables such as governance quality, policy implementation efficiency, or corruption levels, which may moderate the health-growth relationship, were not included due to data unavailability.

Future studies can build on these findings by incorporating spatial econometric techniques to capture geographic spillover effects among provinces. Additionally, disaggregating healthcare expenditures into preventive, curative, and administrative categories could provide deeper insights into which types of health investment yield the highest productivity returns. Longitudinal microdata on households, firms, or health facilities could also enable a more granular analysis of the pathways through which health affects productivity and growth. Moreover, including institutional quality indicators could help unpack the role of governance and public sector performance in shaping the efficiency of health investment.

Policymakers should recognize that the economic benefits of health investments are neither immediate nor automatic. Strategic planning should align health expenditures with broader development goals, particularly in education, labor, and physical capital formation. Provinces with limited fiscal capacity should prioritize high-impact, preventive health services that yield longer-term economic gains. Furthermore, integrated policy frameworks that address demographic transitions, technological change, and regional inequalities will be essential for maximizing the productivity and growth effects of healthcare spending. Enhanced monitoring and evaluation systems are also necessary to ensure that resources are used effectively and equitably.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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References

[1] H. N. Khan, R. B. Razali, and A. B. Shafie, "Modeling determinants of health expenditures in Malaysia: evidence from time series analysis," *Frontiers in pharmacology,* vol. 7, p. 69, 2016, doi: 10.3389/fphar.2016.00069.

[2] B. Taher, "Examining Factors Affecting Human Resource Productivity," *Monthly Social, Economic, Scientific, and Cultural Journal of Work and Society*, no. 190, pp. 58-71, 2015.

[3] T. J. Hyclak, C. L. Skeels, and L. W. Taylor, "The cardiovascular revolution and economic performance in the OECD countries," *Journal of Macroeconomics,* vol. 50, pp. 114EP - 125, 2016, doi: 10.1016/j.jmacro.2016.09.005.

[4] J. Zhao and N. Zhou, "Impact of human health on economic growth under the constraint of environment pollution," *Technological Forecasting and Social Change,* vol. 169, p. 120828, 2021, doi: 10.1016/j.techfore.2021.120828.

[5] J. Zhao, W. Yang, N. Zhou, Q. U. Ain, and K. Zhao, "Measurement and space-time evolution of health level under constraint of environmental pollution, China: 2002-2016," *Environmental science and pollution research,* vol. 27, no. 21, pp. 26725-26741, 2020, doi: 10.1007/s11356-020-08931-w.

[6] J. Liu and C. Bi, "Effects of higher education levels on total factor productivity growth," *Sustainability,* vol. 11, no. 6, p. 1790, 2019, doi: 10.3390/su11061790.

[7] W. M. Cole, "Wealth and health revisited: Economic growth and wellbeing in developing countries, 1970 to 2015," *Social Science Research,* vol. 77, pp. 45-67, 2019, doi: 10.1016/j.ssresearch.2018.09.003.

[8] A. Mason, R. Lee, and J. X. Jiang, "Demographic dividends, human capital, and saving," *The Journal of the Economics of Ageing,* vol. 7, pp. 106-122, 2016, doi: 10.1016/j.jeoa.2016.02.004.

[9] M. Meskarpour Amiri, M. Kazemian, Z. Motaghed, and Z. Abdi, "Systematic review of factors determining health care expenditures," *Health Policy and Technology,* vol. 10, no. 2, p. 100498, 2021, doi: 10.1016/j.hlpt.2021.01.004.

[10] P. C. Wu, S. Y. Liu, and S. C. Pan, "Nonlinear relationship between health care expenditure and its determinants: a panel smooth transition regression model," *Empirica,* vol. 41, no. 4, pp. 713EP - 729, 2014, doi: 10.1007/s10663-013-9233-z.

[11] M. Younsi, M. Chakroun, and A. Nafla, "Robust analysis of the determinants of healthcare expenditure growth: evidence from panel data for low-, middle-and high-income countriesJO - The International journal of health planning and management," vol. 31, no. 4, pp. 580-601, 2016, doi: 10.1002/hpm.2358.

[12] S. Sad and N. Mohamed Nor, "Health Expenditure and Economic Development in Low-and Middle-Income Countries," *Jurnal Ekonomi Malaysia,* vol. 52, no. 3, pp. 181-189, 2018, doi: 10.17576/JEM-2018-5203-14.

[13] M. H. Mousavi and E. Khezri, "The Impact of Health Shocks on Life Insurance Consumption and Economic Growth in Developed and Developing Countries," *Scientific-Research Quarterly of Insurance Research,* vol. 35, no. 4, pp. 9-41, 2020.

[14] A. V. Bustamante and S. V. Shimoga, "Comparing the income elasticity of health spending in middle-income and high-income countries: the role of financial protection," *International journal of health policy and management,* vol. 7, no. 3, p. 255, 2018, doi: 10.15171/ijhpm.2017.83.

[15] M. Lopreite and Z. Zhu, "The effects of ageing population on health expenditure and economic growth in China: A Bayesian-VAR approach," *Social Science & Medicine,* vol. 265, p. 113513, 2020, doi: 10.1016/j.socscimed.2020.113513.

[16] B. Yang, M. Usman, and A. jahanger, "Do industrialization, economic growth and globalization processes influence the ecological footprint and healthcare expenditures? Fresh insights based on the STIRPAT model for countries with the highest healthcare expenditures," *Sustainable Production and Consumption,* vol. 28, pp. 893-910, 2021, doi: 10.1016/j.spc.2021.07.020.

[17] Y. Mehri-Karnami, "Decomposition of Economic Growth and Total Factor Productivity Growth in D8 Countries," University of Mazandaran, Mazandaran, 2018.

[18] S. Sangsari, M. Q. Yousefi, and H. Amadeh, "The Impact of Total Factor Productivity on Employment in Iran's Manufacturing Industries," *Scientific Quarterly of Economic Modeling,* vol. 13, no. 47, pp. 129-157UR - http://eco.iaufb.ac.ir/article_670767_53c484d1ccd2a4991945a2504dff9a7c.pdf, 2019.

[19] M. Pourali, Y. Rajayi, and M. Dalmanpour, "Effects of Macroeconomic and Institutional Variables on Economic Growth in Selected Developing Countries," *Applied EconomicsVL - 10,* no. 32, pp. 79-96, 2020.

[20] P. Abassian and M. A. Mousa Hassan Khani, "Examining the Relationship Between Government Health Expenditures and Economic Growth in Iran," in *21st Century International Conference on Management and Economics*, 2015. [Online]. Available: https://civilica.com/doc/508638.

[21] H. Panahi and A. Omran, "Examining the Impact of Government Health Expenditures on Economic Growth in D8 Organization of Economic Cooperation Countries," *Journal of Health and DevelopmentVL - 4,* no. 4, pp. 327-336, 2015.

[22] M. H. Mozan Jamshidi and N. Haqparast Kanarsari, "Measuring the Impact of Social Capital on Employee Creativity (Case Study: Electrical and Electronic Appliance Manufacturing Companies in Iran)," *Scientific Journal of Social Capital Management,* vol. 2, no. 1, pp. 49-74, 2015.

[23] B. Wan and L. Tian, "Health-education-disaster green low-carbon endogenous economic growth model and its new accompanying effects," *Journal of Cleaner Production,* p. 131923, 2022, doi: 10.1016/j.jclepro.2022.131923.
[24] L. Chengjie, "The Dual Effect of Health Investment and Healthy Economic Growth," *Journal of Shanghai University of Finance and Economics,* vol. 19, no. 03, pp. 22-30, 2017.
[25] K. Jerjerzadeh, Shaghayegh, and Basirat, "The Relationship Between Health and Labor Productivity in Developing Countries," *Productivity Management,* vol. 10, no. 2, pp. 71-80, 2016.
[26] H. Saleem, M. Shahzad, M. B. Khan, and B. A. Khilji, "Innovation, total factor productivity and economic growth in Pakistan: a policy perspective," *Journal of Economic Structures,* vol. 8, no. 1, pp. 1-18, 2019, doi: 10.1186/s40008-019-0134-6.
[27] M. Shokrollahi, E. Eftekhari, M. Mostahfezian, and H. Zahedi, "Adoption of Strategies of Electronic Digital Innovation and Transformation and New Information Technologies Via Application of AI based on Organizational Culture Within Commercial Companies," *power system technology journal,* vol. 48, no. 2, p. 418, 2024.
[28] M. Shokrollahi, E. Eftekhari, M. Mostahfezian, and H. Zahedi, "The Complex Relationship, Between The Culture Of An Organization And Its Significant Impact On Promoting Novel Principeles Entrepreneurship Within Knowledge Based Companies, In Iran," *Educational Administration: Theory and Practice,* vol. 30, no. 7, pp. 903-910, 2024, doi: 10.53555/kuey.v30i7.6886.