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Impact of Exchange Rate Uncertainty on Health Expenditures of Urban Households in Iran (1973-2023)

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ABSTRACT

Background: Evidence from Iran's economy indicates that many economic variables, including household healthcare expenditures, can be influenced by exchange rate uncertainty. Previous studies suggest that exchange rate increases healthcare costs through two channels; general price inflation and higher prices of imported medicines and medical supplies. The present study aims to investigate the impact of unofficial exchange rate uncertainty on urban household healthcare costs in Iran, alongside two other variables: Gross Domestic Product (GDP) and Carbon Dioxide (CO_2) emissions.

Methods: This applied study utilized time series data to examine the effects of unofficial exchange rate uncertainty, (GDP), and (CO_2) emissions on urban household healthcare costs during the period 1971–2023. Data were collected from the Statistical Center of Iran and the Central Bank. The Phillips-Perron and Augmented Dickey-Fuller tests were used to assess data stationarity. Moreover, exchange rate uncertainty was extracted using GARCH method, the research model was estimated via the Fully Modified Ordinary Least Squares (FMOLS) approach, and coefficient stability was evaluated using Hansen's test.

Results: The model estimates revealed that unofficial exchange rate uncertainty had a significant positive effect on Iranian household healthcare costs. A 1% increase in unofficial exchange rate uncertainty led to a 0.36% rise in healthcare expenditures. The corresponding coefficients for (GDP) and (CO_2) emissions were 1.3% and 1.07%, respectively.

Conclusion: Exchange rate uncertainty contributes to increased healthcare costs and may threaten public health. Therefore, policymakers in macroeconomics and related sectors should adopt measures to reduce exchange rate uncertainty in Iran's economy, thereby mitigating its adverse effects on societal health.

Keywords: Health Expenditures, Unofficial Exchange Rate, Uncertainty, Generalized Autoregressive Conditional Heteroskedasticity, Fully Modified Ordinary Least Squares

Introduction

Health systems around the world have always been exposed to various changes and crises. These crises significantly impact all dimensions of health systems, including service delivery, human resources, health information management, pharmaceuticals and medical equipment, budgeting and financing, governance, and leadership (1). Additionally, ensuring access, adequate coverage, quality, and safety of services depends on the health system's ability to withstand crises and is a function of system resilience (2). Therefore, identifying trends, risks, and external threats to health systems—such as climate change, natural and human-made disasters, pandemics, and social

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and economic crises—is an undeniable necessity (3). One such external challenge is the continuous exposure of Iran's health system to a high degree of shocks and uncertainties in macroeconomic variables. Shocks and uncertainties in Iran's macroeconomic variables can affect the functioning of the healthcare sector (4).

One of the key macroeconomic variables in Iran, which has faced continuous fluctuations and significant uncertainty, especially in the 2010s, is exchange rate. The exchange rate inherently has the potential to influence healthcare costs both domestically and internationally (5). The exchange rate primarily affects healthcare costs through two channels: pharmaceutical and medical consumables and imported medical equipment used in healthcare services, particularly in hospitals, impacting household healthcare expenditures. In the context of hospital services, the provision of pharmaceutical services to patients (both outpatient and inpatient) holds a special place. The pharmaceutical sector is a critical, complex, and vital component of any country's health system, and medicines, as a universal essential need and a strategic commodity, hold significant value and importance (6, 7).

Given that medical equipment plays a crucial role in diagnosing, treating, and preventing diseases, and a significant portion of hospital costs is allocated to purchasing medical equipment domestically and internationally, having an adequate quantity and quality of medical equipment ensures a hospital's success in providing the best healthcare, treatment, and accurate diagnostic services to patients. In fact, medical equipment has become an integral part of modern hospitals, accounting for one-third to half of total hospital costs, and changes in their prices can significantly alter healthcare service delivery costs (8).

Based on the above, the exchange rate can have a substantial impact on household health expenditures. However, fewer international studies have been conducted in this area, as this issue is primarily relevant to countries facing frequent exchange rate fluctuations. Bature et al. (7) examined the impact of exchange rate on household health expenditures using the Autoregressive Distributed Lag (ARDL) method in Nigeria. They found that the exchange rate has a positive and significant effect on household health expenditures in Nigeria. Additionally, they confirmed a one-way causal relationship from the exchange rate to household health expenditures in Nigeria (7). Blázquez and Fernández (9), in their study using panel data, observed a strong correlation between health system outcomes (life expectancy) and the value of the national currency. This study was conducted in countries in the Pacific and Asia regions (9).

In the context of examining the impact of exchange rate shocks on household healthcare expenditures in Iran, limited studies have been conducted. Fatemi and Fotros (2021), in their study titled "The Impact of Exchange Rate Shocks on Healthcare Expenditures in Iranian Provinces," concluded that exchange rate shocks initially lead to a slight increase in healthcare expenditures, which then grows more significantly. These shocks have the greatest impact on healthcare expenditures in households in the provinces of Fars, Khuzestan, Tehran, Bushehr, and Kohgiluyeh and Boyer-Ahmad, and the least impact on households in the provinces of Lorestan, Qazvin, West Azerbaijan, Mazandaran, Qom, and Markazi (4).

Heydari et al. (10), in a study on the impact of the exchange rate on the stock returns of the pharmaceutical industry in Tehran Stock Exchange, demonstrated that exchange rate fluctuations can disrupt the stock returns of the pharmaceutical industry (10). Kordbacheh and Ahmadi (2017), in a study using ARCH method and quarterly data from 2004 to 2014, examined the effects of exchange rate fluctuations on healthcare price indices. The results indicated that the exchange rate affects both consumer and producer price indices in healthcare sector in the short and long term, with the impact of exchange rate fluctuations on consumer price index being greater than that of producer price index (11).

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Barouni et al. (6) in a study investigating the impact of exchange rate uncertainty on the import of medical and pharmaceutical products in Iran, used annual time series data from 1971 to 2011 within a GARCH model framework. They demonstrated that exchange rate uncertainty has a significant negative effect on the import of medical and pharmaceutical products in Iran (6).

Despite the significance of the issue, the substantial uncertainty and volatility of exchange rates in Iran—particularly over the past decade, shaped by the country's economic trajectory and the imposition of financial and monetary sanctions—have received limited scholarly attention. A review of the existing literature reveals a notable gap: no prior study has examined the impact of exchange rate uncertainty on household health expenditures in Iran. In response to this gap, the present study aims to investigate the effect of unofficial exchange rate uncertainty on health expenditures of urban Iranian households. To quantify exchange rate uncertainty, the study employs the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, an advanced econometric technique derived from the ARCH model, which is well-suited for capturing volatility in time series data.

Materials and Methods

Based on the theoretical foundations and the reviewed empirical literature, the main variable of the study is exchange rate fluctuations, modeled using the GARCH model. The control variables include Gross Domestic Product (GDP) and carbon dioxide (CO_2) emissions measured in kilograms per ton (7, 12-14). The functional form of the model is as follows:

$$HE = f\,(GDP, CO_2, GEX) \qquad (1)$$

Where HE represents household healthcare expenditures, (GDP) is real gross domestic product, (CO_2) denotes carbon dioxide emissions, and (GEX) refers to exchange rate fluctuations in the free market. The final model is expressed in logarithmic form, considering **ε** as the error term, as follows. Ln denotes the natural logarithm, **t** represents time periods, and α is the coefficients to be estimated.

$$(2) \qquad LnHE_t = \alpha_1 + \alpha_2\, LnGDP_t + \alpha_3\, LnCO2_t + \alpha_4\, LnGEX_t + \varepsilon_t$$

In the present study, to ensure data consistency and minimize errors, all annual time series data related to the unofficial exchange rate and real (GDP) were collected from the Central Bank, while household healt0hcare expenditures in urban areas and (CO_2) emissions were obtained from the Statistical Center of Iran. The study covers the period from 1350 to 1402 in the Iranian calendar.

To estimate the model, it is first necessary to extract exchange rate uncertainty. Traditionally, the ARCH model is used to measure the uncertainty of a variable. The ARCH model examines the variance structure of Residuals, which is defined as an autoregressive conditional variance. The test determines whether the variance of the error term is constant or variable. Essentially, before proceeding, it is necessary to conduct this test to evaluate the variance behavior of the error term.

The ARCH model provides a suitable framework for analyzing volatility in time series data. However, it has certain limitations and challenges, one of which is determining the number of lags for the error term (15). To address these issues, an extended version of the model, known as Generalized ARCH(GARCH), is used. Therefore, this study employs the GARCH model (16).

The GARCH model was introduced in 1986. Its simplest form is as follows. In this model, since the errors are included with one lag and the variance is also incorporated with one lag, it is denoted as GARCH (1,1).

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2$$

It is evident that if the above equation is written with one lag and δ_{t-1}^2 is substituted, we will obtain:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta(\alpha_0 + \alpha_1 u_{t-2}^2 + \beta\sigma_{t-2}^2)$$
$$= \alpha_0(1+\beta) + \alpha_1 u_{t-1}^2 + \beta\alpha_1 u_{t-2}^2 + \beta\sigma_{t-2}^2$$

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If these substitutions are repeated, the following result is obtained:

$$\sigma_t^2 = \alpha_0 + (1 + \beta + \beta^2 + \cdots) + \alpha_1(u_{t-1}^2 + \alpha_1 u_{t-2}^2 + \alpha_1 u_{t-3}^2 + \cdots)$$

$$= \alpha_0' + \alpha_1' u_{t-1}^2 + \alpha_2' u_{t-2}^2 + \alpha_3' u_{t-3}^2 + \cdots$$

$$\alpha_0' = \alpha_0 \sum_{i=0}^{\infty} \beta^i,\ \alpha_1' = \alpha_i \beta^i$$

Therefore, the above model is equivalent to ARCH (∞). In general, the GARCH (q,p) model is expressed as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \cdots + \alpha_q u_{t-q}^2 + \beta_1 \sigma_{t-1}^2 + \cdots + \beta_p \sigma_{t-p}^2$$

Before estimating the model, it is necessary to examine its stationarity, as most economists believe that economic variables, especially macroeconomic variables, are not stationary over time. As a result, using such variables in a specified and estimated model may lead to spurious regression (17).

In this study, to test the stationarity of the data, the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test will be applied to the logarithm of the data.

Furthermore, to estimate the parameters in Equation 2, FMOLS method is used. FMOLS provides parameter estimation for a cointegrating equation and offers modified criteria that allow for statistical inference. Studies by Phillips and Hansen indicated that the FMOLS method is super-consistent**,** asymptotically unbiased, and normally distributed while also providing modified statistical criteria for inference. As a result, this method is employed for estimation in the present study (18).

After estimating the parameters, an important issue to address is the stability or instability of the long-term estimated coefficients in cointegration relationships. Stability tests include the Hansen, Park, Phillips, and Engle-Granger parameter stability tests. Although all four tests have been introduced and utilized in the econometric literature, most researchers in recent years have preferred the Hansen parameter stability test**.**

Hansen stability test aims to answer whether the estimated coefficients remain stable throughout the study period. To do so, it provides two test statistics: LC statistic and F statistic, both of which can be used to test the hypothesis of stable or unstable long-term cointegration coefficients (19). All statistical tests were conducted using the econometric software Eviews[12].

Results

Stationarity Test

To examine stationarity, the ADF test and Phillips-Perron (PP) test were applied to the logarithm of the variables of household healthcare expenditures in urban areas (HE) and exchange rate volatility (GEX). The results of the ADF and PP tests indicated that all variables used in this study are not stationary at level but become stationary after first differencing. Therefore, the variables are integrated of order one, I (1).

Given the stationarity results and considering that none of the variables are I (2), the regression can be estimated using the FMOLS approach.

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Table 1. Results of the ADF and PP Unit Root tests

Variables	PP				ADF			
	First difference		At level		First difference		At level	
	statistics	P	statistics	P	statistics	P	Statistics	P
LHE	-5.210	0.0050*	-1.92	0.62	-5.210	0.0005*	-2.58	0.29
LGDP	-4.440	0.0004*	-1.87	0.65	-4.740	0.0020*	-1.68	0.74
LCO2	-5.970	0.0001*	-2.09	0.53	-5.530	0.0002*	-2.49	0.33
LGEX	-29.386	0.0001*	-1.38	0.58	-33.208	0.0010*	-1.26	0.63

Examining the Presence of ARCH effect in the exchange rate variable

As mentioned earlier, the first step is to test for the presence of ARCH effect in the target variable, which in this case is the exchange rate. For this purpose, an autoregressive model of order one (AR(1)) must first be constructed for the exchange rate variable and estimated using the Ordinary Least Squares (OLS) method.

The equation is as follows:

$$Ex_t = C + Ex_{t-1} + \varepsilon_t$$

In the equation above, Ex refers to the exchange rate and C represents the currency from the source. The results of this equation are as follows:

Table 2. Results of the AR (1) model for the exchange Rate

Variables	Coefficient	Statistics	Standard deviation	P
C	-426.09	-0.319	133.504	0.75
Ex (-1)	1.323	19.68	-0.067	0.00*
Prob(F-statistic)		0.00	R-squared	0.893
Log likelihood		498.93	Adjusted r-squared	0.891
Sum squared resid		0.005	Durbin-Watson stat	2.29

Step 2: Examining the presence of ARCH effect

Based on the results shown in the table below, the exchange rate variable exhibits an ARCH effect starting from the second lag. Further investigation revealed that higher lags (beyond the second) also confirm the presence of the ARCH effect. The test with two lags is shown in the table below.

Step 3: Estimating the GARCH model

In this step, the exchange growth rate is considered as a stable variable that fluctuates around a base currency, and the model is then estimated. The results are presented in the table below.

Table 3. Results of the ARCH test from the AR (1) model

Statistic	Statistics	P
F-statistic	491.8	0.0008*
R^2	13.02	0.00015*

After estimating the model, the variances from the model must be extracted and incorporated into the main equation to determine the impact of fluctuations on the dependent variable. The graph below shows the GARCH model variances for the exchange rate variable.

Table 4. Results from the GARCH model estimation

Equation				
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)				
Variable	**Coefficient**	**Z-statistic**	**Standard deviation**	**P**
c	137.674	2.002	68.62	0.04*
Variance equation				
Variable	**Coefficient**	**Z-statistic**	**Standard deviation**	**P**
C	13598.28	0.75	18514.87	0.453
RESID (-1)^2	0.8314	4.44	0.1870	0.00*
GARCH(-1)	0.000175	-0.1834	0.0000095	-0.854

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Table 5. Results from FMOLS estimation

Variable	Coefficient	T-statistic	Standard deviation	P
C	-24.5	-7.77	3.17	0.00*
LGEX	0.365	5.98	0.061	0.00*
LGDP	1.318	2.69	0.489	0.01*
LCO2	1.096	1.678	0.6535	0.1**
Mean dependent var		13.32	R-squared	0.98
S.D. dependent var		2.51	Adjusted R-squared	0.97
Sum squared resid		5.52	Long-run variance	0.097

Based on the estimation results, the exchange rate uncertainty variable (LGEX) is positively and significantly related to health expenditures. Specifically, a 1% increase in exchange rate uncertainty results in an average increase of 0.365% in health expenditures, with a significance level higher than 95%. Additionally, a 1% increase in Gross Domestic Product (GDP) leads to an average increase of 1.32% in health expenditures, also significant at a 95% confidence level. A significant relationship was found between (CO_2) emissions and health expenditures at a 90% confidence level. A 1% increase in (CO_2) emissions also results in an average increase of 1.1% in health expenditures. The R^2 value indicates a high goodness of fit for the model.

Final step: Testing for the stability of coefficients and long-term relationship

Based on the information in the table above, the FMOLS-estimated model demonstrates sufficient stability of long-term estimated coefficients. In other words, all the estimated coefficients during the study period are stable based on the results of this test. The LC statistic and the error margin (0.2<) being larger than 5% indicate that the stability of the estimated coefficients is confirmed.

Table 6. Results of Hansen stability test from FMOLS estimation

LC statistic	Stochastic trends	Deterministic Trends	Prob.*
1.92	3	0	<0.01

Discussion

In this study, the effects of exchange rate fluctuations on household health expenditures in Iran were examined using GARCH model. According to the results, exchange rate uncertainty in the long term will lead to an increase in health care costs for urban households in Iran. In other words, in addition to exchange rate shocks, the issue of exchange rate uncertainty in Iran also significantly increases household living costs and could threaten public health. In a similar study, Baroni et al. (6) showed through the GARCH model that exchange rate uncertainty has a significant negative impact on the import of medical and pharmaceutical products in Iran. Therefore, exchange rate uncertainty activates one of the channels of increasing health service prices, which is the reduction in imports or the increase in the cost of imported drugs and medical equipment. Kordbacheh and Ahmadi (11), using the ARCH method, showed that exchange rate fluctuations affect the consumer and producer price indices in the health care sector, with the impact on the consumer price index being greater than on the producer price index. This means that consumers suffer more than producers. The results of Bature et al (7) in Nigeria also demonstrated that exchange rate fluctuations affect health expenditures. However, the difference between the present study and Batur's study is that in our study, the exchange rate uncertainty index has been incorporated in to the equation, whereas in Batur's study, the exchange rate volatility has been calculated. Blazquez and Fernandez (9) in their study, conducted in the Pacific and Asia regions, showed that the value of the national currency can have a significant positive impact on health system outcomes, such as life expectancy.

This study also observed that an increase in (GDP) has a significant positive effect on household

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health expenditures. Many studies have pointed out this issue, including the study by Shabani et al. (20), which proved that (GDP) per capita has a significant positive impact on health expenditures in 24 countries in the Vision 2020 region. Pakdaman et al. (21) showed that (GDP) is an important factor affecting health expenditures in Iran. Rana et al. (22) also found, after analyzing the data from 160 countries, that economic growth has a significant positive effect on health expenditures.

The analysis results also showed that an increase in (CO_2) emissions leads to an increase in health expenditures. However, the results indicated that this variable is significant at the 90% confidence level. Chaabouni et al (12), after examining 51 countries, found a positive causal relationship between increased (CO_2) emissions and increased household health expenditures in middle-income and high-income countries. Abdullah et al. (2016), analyzing data from 1970 to 2014 in Malaysia, concluded that a 1% increase in (CO_2) emissions increases health expenditures by 0.72%. Atuahene et al. (24) concluded that in China, a 1% increase in (CO_2) emissions results in a 7.78% increase in health expenditures, and in India, this figure is 6.34%. Therefore, it can be argued that air pollutant emissions especially with (CO_2) may lead to increased demand for healthcare services by reducing overall health levels and increasing mortality caused by cancer, cardiovascular diseases, and chronic respiratory diseases (25), thereby resulting in higher household health expenditures.

This study provides new evidence on the impact of unofficial exchange rate uncertainty on urban household health expenditures in Iran, using a robust econometric framework (GARCH and FMOLS) and long-term data (1973–2023). The inclusion of (GDP) and (CO_2) emissions adds depth by accounting for macroeconomic and environmental health influences. However, the analysis is limited to urban households, and certain variables such as health insurance or public health spending were not included due to data constraints. Using (CO_2) as a general pollution proxy also limits specificity. The study highlights the health-related economic risks of exchange rate volatility and environmental degradation, offering a practical framework for policymakers to consider macroeconomic and environmental factors in healthcare planning.

Conclusion

Based on the findings, it is proven that, in addition to exchange rate fluctuations and shocks, exchange rate uncertainty can also have negative effects on the health of Iranian households through the financial access channel. In other words, the activities of healthcare stakeholders are disrupted in situations of uncertainty about future exchange rates. Consequently, importers of health-related goods may withhold their products from the market during periods of uncertainty to sell them at higher prices in the future, leading to increased costs in the production of healthcare services. Therefore, government support policies during periods of severe exchange rate fluctuations and uncertainty in the health system are of particular importance.

The second issue is the impact of pollutants on health expenditures. Greenhouse gas emissions have varying effects on health and the demand for healthcare services in both the short and long term. Specifically, increased emissions of pollutants and greenhouse gases have proven negative effects on health, declining health levels lead to increased demand for healthcare services and consequently, higher health expenditures. However, since the results indicate that economic growth has the largest impact on increasing demand and health expenditures, it is possible to mitigate negative effects of exchange rate uncertainty and fluctuations on health and financial access to healthcare services by increasing public wealth, while considering sustainable development and environmental preservation.

Ethical considerations

Ethical issues (including plagiarism, informed

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consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy) were thoroughly observed by the authors. This article is derived from a Ph.D. dissertation titled "Asymmetric and Uncertainty Effects of Exchange Rate on Iran's Health Sector," which was approved by the Research Committee of Islamic Azad University in September 2021 with the tracking code 162617145.

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Authors' contributions

R.HS, MA.DT, and A.A designed research; R.HS and MA.DT, conducted the research; A.A and MH.G analyzed data; R.HS, A.A, and MH.G wrote the paper; and MA.DT had primary responsibility for final content. All authors read and approved the final manuscript.

Conflict of Interest

The authors declared no conflict of interests.

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