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ARTÍCULO

EXCHANGE RATE PASS-THROUGH INTO CONSUMER HEALTHCARE PRICES IN COLOMBIA

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Prada, S. I., Alonso, J. C., & Fernández, J. (2019). Exchange rate pass-through into consumer healthcare prices in Colombia. *Cuadernos de Economía*, *38*(77), 523-550.

The exchange rate pass-through into the consumer price index on healthcare goods and services was measured by estimating a FAVAR model for Colombia. Results provide evidence of an incomplete and heterogeneous effect. There is no indication of transmission to the services or insurance indexes, but there is a significant effect on the medicines and devices indexes that have implications for out-of-pocket expenditure. Therefore, this indicates that the Colombian healthcare system effectively protects consumers from exchange rate volatility, but may need to design policies to protect consumers from price rises in medicines and goods that are not covered by the national benefits package.

Keywords: Healthcare, pass-through, exchange rate, FAVAR, inflation.
JEL: I10, I18, E31, E37, F31.

Prada, S. I., Alonso, J. C., & Fernández, J. (2019). Transferencia del tipo de cambio a los precios de salud de los consumidores en Colombia. *Cuadernos de Economía*, *38*(77), 523-550.

Se mide el efecto transmisión de la tasa de cambio al índice de precios al consumidor de los bienes y servicios de salud haciendo uso de un modelo FAVAR. Los resultados obtenidos proveen evidencia de un efecto incompleto y heterogéneo. No se encuentra un efecto transmisión a los sectores de servicios y seguros, sin embargo, se encuentra dicho efecto en medicinas y bienes, que tienen implicaciones para el gasto de bolsillo. Lo anterior indica que el sistema de salud colombiano protege a los consumidores de la volatilidad de la tasa de cambio, pero necesita políticas orientadas a sectores no cubiertos.

Palabras clave: salud, *pass-through*, tasa de cambio, FAVAR, inflación.
JEL: I10, I18, E31, E37, F31.

Prada, S. I., Alonso, J. C., & Fernández, J. (2019). L'effet de la transmission du type de change sur le prix des soins médicaux au consommateur en Colombie. *Cuadernos de Economía*, *38*(77), 523-550.

On mesure l'effet de la transmission du taux de change à l'indice de prix au consommateur des biens et services de santé en utilisant un modèle FAVAR. Les résultats révèlent un effet incomplet et hétérogène. On ne trouve pas d'effet de transmission aux secteurs de services et d'assurances, cependant on trouve cet effet sur les soins médicaux et les biens avec des implications sur les dépenses personnelles. Ce qui précède montre que le système de santé colombien protège les consommateurs de la volatilité du taux de change, mais requiert des politiques orientées vers des secteurs non couverts.
Mots-clés: santé, *pass-through*, taux de change, FAVAR, inflation.
JEL: I10, I18, E31, E37, F31.

Prada, S. I., Alonso, J. C., & Fernández, J. (2019). Repasse da taxa de câmbio para os preços de saúde do consumidor na Colômbia. *Cuadernos de Economía*, *38*(77), 523-550.

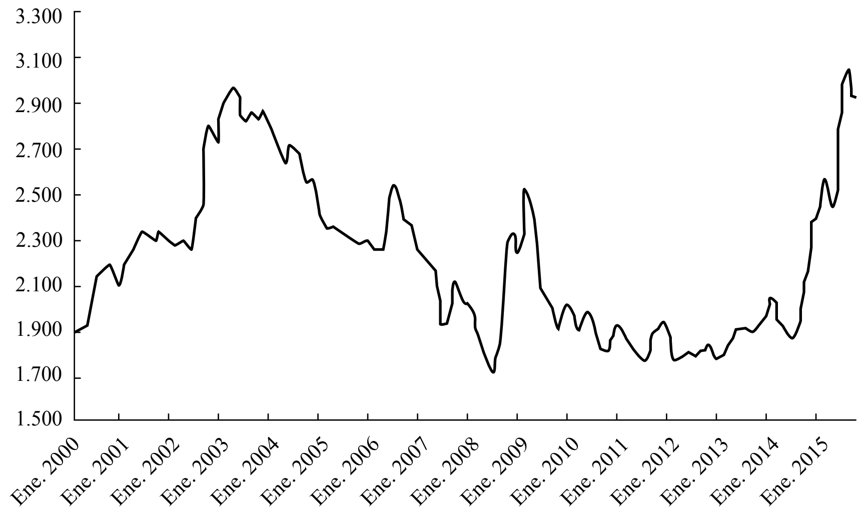
O efeito da transmissão da taxa de câmbio sobre o índice de preços ao consumidor de bens e serviços de saúde é medido usando um modelo FAVAR. Os resultados obtidos fornecem evidências de um efeito incompleto e heterogêneo. Não se encontra nenhum efeito de transmissão para os setores de serviços e de seguros; no entanto, esse efeito é encontrado em medicamentos e bens, que têm implicações para as despesas extras. Isso indica que o sistema de saúde colombiano protege os consumidores da volatilidade da taxa de câmbio, mas precisa de políticas orientadas para os setores não cobertos.

Palavras-chave: saúde, pass-through, taxa de câmbio, FAVAR, inflação.
JEL: I10, I18, E31, E37, F31.

INTRODUCTION

After a period of stability between 2010 and 2014, the Colombian peso experienced an unprecedented undervaluation. Figure 1 shows the exchange rate (peso/USD) from January 2010 to May 2016. At the end of September 2014, the exchange rate started to trend upward from around COP$2,007 per USD on September 25th, reaching its highest valuation on February 12, 2016, at COL$3,434 per USD. Depending on the period, the undervaluation may be as high as 50% or as low as 30%, approximately.

Figure 1.
Colombian Peso/USD Exchange Rate 2010-2015



Source: Colombian Central Bank.

The transmission of exchange rate changes to domestic prices is known as Exchange Rate Pass-Through (ERPT). ERPT has been widely analysed in the literature. Although the findings of these analyses suggest the presence of such effect in different economies, most findings differ according to which methodology is used. Campa and Goldberg (2002, 2005) and Baqueiro, León and Torres (2003) measured the ERPT for a panel of countries, and find a partial effect that depends on the level of inflation of the economy, this being coherent with Taylor (2000), who found that high volatility is related to high levels of pass-through. Similarly, López-Villavicencio and Mignon (2017) measured variables related to the behaviour of monetary policy and its inflation volatility, finding that countries with a higher level of inflation and monetary uncertainty have a higher level of ERPT.

Delatte and López-Villavicencio (2012) used asymmetric cointegration models to measure the effect of an appreciation and depreciation of the currency and found that the pass-through has a heterogeneous effect, where a depreciation has a higher effect than an appreciation. Choudhri, Faruqee and Hakura (2005) and Ito and Sato (2008), using VAR models, measured the ERPT for different countries and found evidence of an incomplete effect. Recently, Brun-Aguerre, Fuertes and Greenwood-Nimmo (2017) used the non-linear auto-regressive distributed lag (NARDL) for 33 developing and developed countries to measure the asymmetric effect of exchange rate variations on inflation prices and found no conditional effect for the type of country. For Colombia, González, Rincón and Niño (2008); Rincón Caicedo, and Rodríguez (2007) and Rincón and Rodriguez (2014) found evidence of an incomplete effect on the consumer price index (CPI), with variations in the effect associated with the economic cycle.[1]

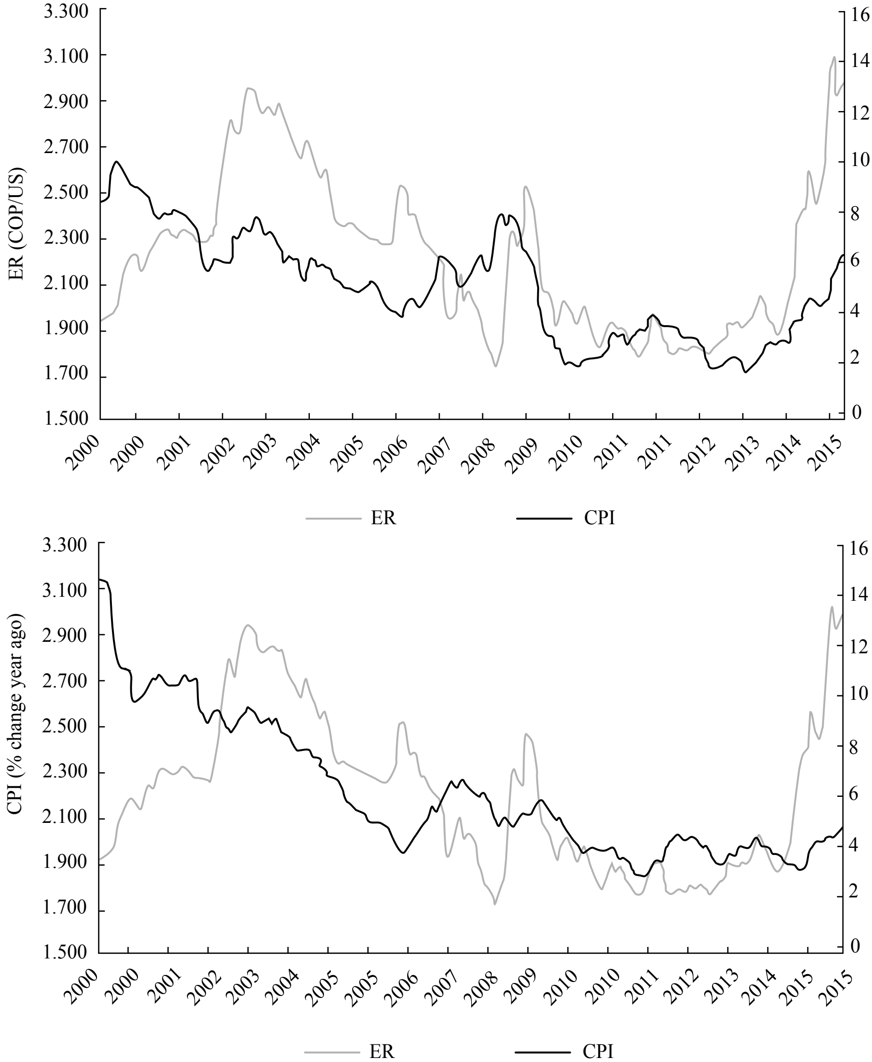
There is a lack of literature regarding ERPT into the prices of healthcare goods and services paid for by consumers. A likely explanation is that in most countries, consumers are "protected" by healthcare insurance, and therefore consumers do not face full prices but deductibles and coinsurance. Colombia's health system is mainly designed around the managed competition model. Funding comes from employee-employer mandatory contributions and general taxes. Private insurers compete for members nationally and receive a risk-adjusted capita per member from the government to cover a government-defined benefits package. Providers compete to be included in the insurer's networks. Additionally, there is a private market for supplementary health insurance. Public providers are mostly dominant in rural towns while private providers are abundant in highly populated cities.

Figure 2 shows the relationship between the exchange rate (ER) of the Colombian peso to US dollar (COP/US) and inflation measured as the yearly change in the Consumer Price Index (CPI) for all goods and services and that of healthcare goods and services. Both graphs give an initial approximation on the effect of ER on both general and healthcare inflation. Based on the graphs, the ERPT of both series can be described as unequal, as the general inflation exhibits higher sensitivity to changes in exchange rate than healthcare, especially to the depreciation of recent years. It can be expected that the ERPT of general inflation be higher than that of healthcare.

Taking advantage of the unprecedented depreciation of the peso, our goal is to test whether there is an ERPT into the Healthcare CPI in Colombia and its subgroups (i.e., over-the-counter medicines, etc.) and if there is, what its magnitude is. This question is of policy relevance for at least two reasons. First, Colombia is perhaps the country with the lowest out-of-pocket (OOP) expenditure as a percentage of total healthcare expenses in the developing world, at 14% (Fan & Savedoff, 2014). At the same time, the country is in severe financial distress, which has policymakers discussing the possibility of increasing OOP as a way to find additional financial resources for the system. Second, for equity reasons, an unexpected increase in consumer prices of healthcare goods and services may disproportionally affect vulnerable populations such as the poor and the elderly.

[1] Aron, Macdonald and Muellbauer (2014) provides a complete survey on the ERPT into the emerging economies up to 2014.

Figure 2.
ER and General CPI, ER and Healthcare CPI in Colombia



Source: Departamento Administrativo Nacional de Estadística (DANE).

The effect was estimated using a FAVAR model following Bernanke, Boivin and Eliasz's (2005) approach, which has been widely used in the macroeconomic literature to analyse the impact of economic shocks (Kilian & Lütkepohl, 2017; Stock & Watson, 2016). This model takes into account the information contained in a large number of time series, to avoid the bias generated by using a smaller set of variables to model the relationship between the exchange rate and the health CPI and its components. The results of the model suggest that, although there is an incomplete effect of the exchange rate on the healthcare CPI, there is a significant effect of the ERPT on over-the-counter (OTC) medicines and durable medical equipment prices.

This study expands on the previous literature by tackling the concept of ERPT by focusing on a desegregated measure of inflation instead of the aggregate Import-Consumer inflation. We focus on healthcare inflation and its subgroups. This approach allows us to analyse a specific policy and market that traditional measurements cannot achieve. By using disaggregated indexes, we can trace the specific markets that transmit the effect to the general level of healthcare inflation, and so, understand the shock sources and transmission to design an optimal health policy. On the methodological side, the present study expands on the Colombian literature by using a novel econometric methodology to research ERPT in Colombia which tackles some of the critiques made of the previous methods used for the Colombian case. Furthermore, this econometric approach offers a comprehensive measurement of the effect of exchange rate on healthcare prices.

METHODOLOGY

The effect of unexpected innovations in the exchange rate on the healthcare CPI inflation and its components of expenditure is estimated using the methodology proposed by Bernanke et al. (2005), the Factor-Augmented Vector Autoregressive (FAVAR). The use of factors is related to the theory of rational expectations, as this measures all the information captured by the all of the variables that are used in the identification of the factor model. Therefore, the methodology overcomes most of the criticism made by Evans and Kuttner (1998) and Rudebusch (1998a, 1998b) about the VAR models. Their criticism is related to the bias generated in the Impulse Response Functions (IRF) by the inclusion of a scarce number of variables that do not characterize the economy adequately. Consequently, these factors allow for the introduction of more information, without losing many degrees of freedom and maintaining a relatively simple specification of the model.

FAVAR framework

As proposed by Bernanke et al. (2005), let Y_t be vector $L \times 1$ of the L observable variables that are supposed to interact within the economic activity. In our case, this vector includes the different components of consumer health price indexes (one at a time), and the indicator of economic activity, and trade measurements. To capture the effect of additional information not included in Y_t on each of its components, the FAVAR model includes a vector, $K \times 1$, of the K non-observable factors, F_t. The latter vector summarizes all information that is available in the economic indicators that are not included in Y_t. The number of factors (of dimension F_t) are expected to be few, as the aim of the methodology is to include as small a number of variables as possible to reduce the loss of degrees of freedom.

The factors may or may not have an economic definition, as they can be created as a general group (Bernanke et al., 2005) or as different groups of factors within economic activity (Belviso & Milani, 2006). In other words, the factors collect the available information in a wide number of economic variables that could not be included one by one in a VAR estimation.

Adhering to Bernanke et al. (2005), the FAVAR model can be expressed as

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \varphi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + v_t \tag{1}$$

where $\varphi(L)$ is a lag polynomial of order p, which may contain the a priori restrictions of the structural VAR, and v_t represents the vector of errors that follows a normal distribution with mean zero and covariance matrix Q.

As pointed out by Bernanke et al. (2005), factors F_t are unobserved, therefore model [1] cannot be estimated directly. The authors propose two identification methods: the two-step procedure and the Bayesian Likelihood approach. They conclude that both methods arrive at relatively similar results, but the first provides "plausible responses" without the highly computational and restrictive identification of the latter approach. Considering these findings, we employ the two-step method in this study. Following this approach, first, K is identified and F_t estimated, and second, [1] is estimated using the estimates of F_t.

Bernanke et al. (2005) propose that to identify the number and the factors, the method put forward by Stock and Watson (2002, 2005) and Bai and Ng (2008) should be used. In other words, they suggest using a Dynamic Factor Model (DFM). The DFM implies the decomposition of a set, i, of observable time series (X_{it}) as a distribution of the lags of a small set of unobserved factors, f_t, and an idiosyncratic error, u_{it}. The factors can be expressed as the following equation,

$$X_{it} = \lambda_i(L) f_t + u_{it} \tag{2}$$

where X_{it} represents the set of the series $i = 1,\ldots,n$; whereas $\lambda_i(L) = [1 - \lambda_{i1} L - \ldots - \lambda_{is} L^s]$ is the vector of the dynamic loadings of order s; f_t is the vector of the q unobserved factors; u_{it} are the idiosyncratic innovations; and t the analysed period $t = 1,\ldots,T$.

The DFM model can be expressed as a static model with r factors,

$$X_t = \Lambda F_t + e_t \tag{3}$$

where F_t has a larger dimension than f_t, as it includes the dynamic and static factors. The number of static factors can be expressed as $r = q(s+1)$. Principal Component Analysis (PCA) is used to estimate the factors and the selection of the number of factors is determined using the information criteria presented in Bai and Ng (2002, 2007) for DFM.

The common components of X_t, $\tilde{C}_t$, are estimated using the first principal of PCA. As the information contained in C_t is a lineal combination of F_t and Y_t, a particular order cannot be imposed for the VAR identification of the innovation. Henceforth, the information in C_t that is not represented by Y_t, $\tilde{F}_t$, needs to be estimated. The estimation is carried out by dividing the series into "slow-moving" and "fast-moving" variables. Each classification depends on how each variable responds contemporaneously to Y_t, where variables that do not respond contemporaneously to shocks (like economic activity) are slow-moving. Consequently, variables that respond contemporaneously (such as financial asset prices) are fast-moving. Then, the information contained in the slow-moving variables and Y_t is extracted. The linear regression is determined using the following equation,

$$\tilde{C}_t = B_f F_t^s + b_y Y_t + e_t \tag{4}$$

where F_t^l represents the factor estimated for the slow-moving variables. $\tilde{F}_t$ is calculated as the difference between the common components C_t and Y_t, constructed as $\tilde{C}_t - b_y Y_t$. Then, the estimated factors $(\widetilde{F}_t)$ are used to estimate the VAR model expressed in [1]. In this particular case, a Cholesky Decomposition is needed to estimate the IRF from [1], and the exchange rate is the last variable.

DATA AND RESULTS

To analyse the effect of the Exchange Rate on the Healthcare CPI (and its components), a database of 131 monthly economic variables was created. These variables span from January 2000 to December 2015.[2] Because most of the series originate in the 2000s, previous years cannot be analysed in our FAVAR framework. The main sources of data are the national statistics agency —Departamento Administrativo Nacional de Estadística (DANE)— and the data repository of Colombia's Central Bank.[3] All series were periodically adjusted, if necessary, following the X13-ARIMA algorithm. These series were then transformed to induce stationarity.[4]

Using the stationary transformation of the original series, the number of static and dynamic factors to be included in the model are determined following the information criteria provided by Bai and Ng (2002, 2007). The results of the information

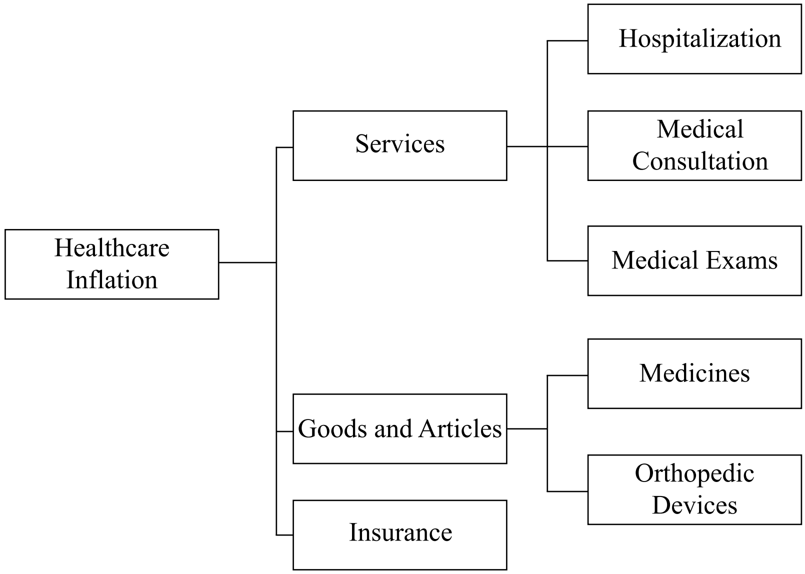
[2] The period was chosen based on the findings of González, Melo, Monroy and Rojas (2009), Echavarría, López and Misas, (2011) and Echavarría, Rodríguez and Rojas (2011). They detect a structural change in the late nineties, caused by the inflation targeting regime instituted as the monetary policy target by Banco de la República, Colombia's central bank.

[3] Appendix A presents the complete list of variables used in the estimation, its source and the transformation carried out to induce stationarity.

[4] We used the HEGY monthly unit root test to identify seasonal unit roots. In the case where a seasonal unit root was found, the original series was filtered to remove the seasonal and convectional series. The filtered series was checked again for stationarity.

criteria suggest the use of static factors 8, 5, 3, and 1.[5] As there is no clear evidence that suggests which of the information criteria offers better results, the selection of the number of factors is determined by the number of factors used in Sargent and Sims (1977), Bernanke et al. (2005) and Londoño, Tamayo and Velásquez (2012). Their applications suggest the use of two or three factors, without losing the robustness of the results. This is related to the fact that three factors normally explain at least 60% of the information of all the variables. In the present case, our results are similar. Hence, there are three factors included in our model, consistent with the information criteria and previous studies mentioned.

Figure 3.
Healthcare CPI: Groups and Subgroups of Goods and Services



Source: DANE.

To analyse the effect of the exchange rate on the CPI of healthcare goods and services, the estimation of the FAVAR is expanded to each one of its groups and subgroups. Figure 3 shows the grouping of goods and services included in the Colombian healthcare CPI. The three principal groups of healthcare inflation are Services, Goods and Articles, and Insurance. The subgroups of each are divided into those corresponding to Services: hospitalization, medical consultation and medical exams, and those of Goods and Articles: medicines and orthopedic devices. Because both Services and Insurance are not intensive in terms of import

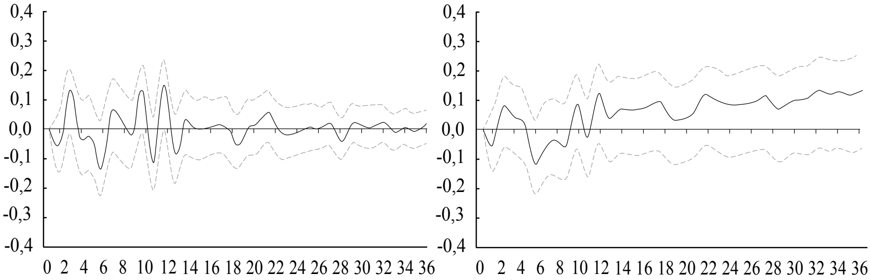
[5] The differences in the information criteria are related to the penalization involved in each of them. Appendix B presents results of the information criteria.

products or services, it is expected that the ERPT of the components be low or non-existent. Goods and Articles may have the contrary effect, as Colombia is not a net producer of either, and so they could be exposed to the effect of changes in the ER that affect their internal prices, and therefore, their ERPT.

The results of the present study are based on the measurement of the Exchange Rate Pass-Through, defined as the median ratios of the impulse responses of healthcare prices to exchange rate shocks. The orthogonal impulse response functions (IRF) for each expenditure component of the Colombian healthcare CPI are shown in Figures 4 to 9. The IRFs were estimated using a FAVAR with 12 lags and three factors. Confidence intervals of 95% were estimated using bootstrapping methods with 10,000 runs.[6] The impulse is generated by the novelty of an increase of one percentage point in the exchange rate growth.

Figure 4.

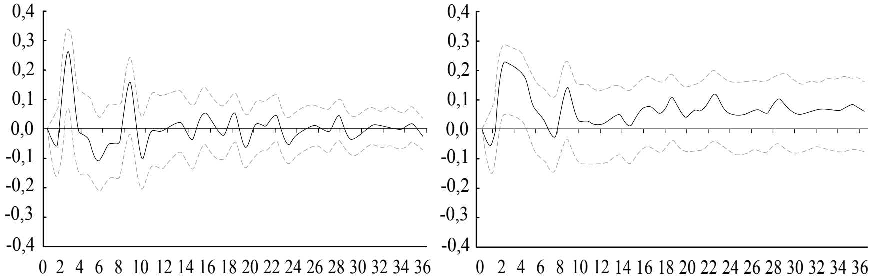
Response and Cumulative Response Function of the Inflation Rate



Note: The left panel represents the IRF and the right panel the cumulative response of the shock.
Source: Authors' calculations.

Figure 5.

Response and Cumulative Response Function of the Healthcare Inflation Rate



Note: The left panel represents the IRF and the right panel the cumulative response of the shock.
Source: Authors' calculations.

[6] The number of lags is determined by the Breusch-Godfrey LM test for serial correlation and multivariate ARCH-LM that guarantees that there is no presence of heteroscedasticity nor ARCH effects in the errors. The table with the results is presented in Appendix C.

Figure 5 presents the IRF of an ER change in the total Healthcare Inflation rate. There is a significant increase in inflation for only the second month of about 0.2. In the case of the cumulative effect (Figure 5), the only meaningful period corresponds to the interval between the second and fourth month. In conclusion, the ERPT effect produces an incomplete effect on health care CPI inflation in the short run, especially in the first four months, and the effect tends to stabilize to 0.1 in the long run.

Based on Figures 4 and 5, it can be concluded that the expected effect of the ER shock on healthcare inflation is greater than the general inflation response in the short term. The expected effect on the healthcare CPI inflation is, at times, greater than 0.2, contrary to general inflation, estimated at 0.1. This result means that the effect of an exchange rate shock has a higher impact in the months immediately following it, which may influence consumers with an inelastic price-elasticity of demand to a greater extent. Although the effect in the short term on healthcare inflation is higher, the cumulative effect on general inflation increases steadily in the long term, contrary to that of healthcare which stabilizes at 0.1 following the first year.

In the long run, the effect can be measured by the Forecast Error Variance Decomposition (FEVD) of the healthcare CPI inflation rate (Table 1). This measurement allows us to estimate the contribution of each factor used in the FAVAR model to the h-step forecast error of the total consumer health basket inflation rate. Based on this result, apart from the healthcare inflation itself, the ER contributes to a significant portion of the healthcare forecast variance.

Table 1.
FEVD of Healthcare Inflation

	IPI	CPI Healthcare	Factor 1	Factor 2	Factor 3	ER
5	2.09%	89.09%	0.49%	0.54%	1.23%	6.55%
10	4.41%	79.73%	1.99%	1.79%	2.41%	9.67%
15	4.95%	77.45%	2.25%	2.37%	3.55%	9.43%
20	6.30%	74.74%	2.60%	2.54%	4.05%	9.77%
25	6.71%	73.66%	2.89%	2.67%	4.08%	9.99%
30	6.93%	73.02%	3.03%	2.69%	4.23%	10.09%
35	7.50%	72.20%	3.06%	2.68%	4.55%	10.01%

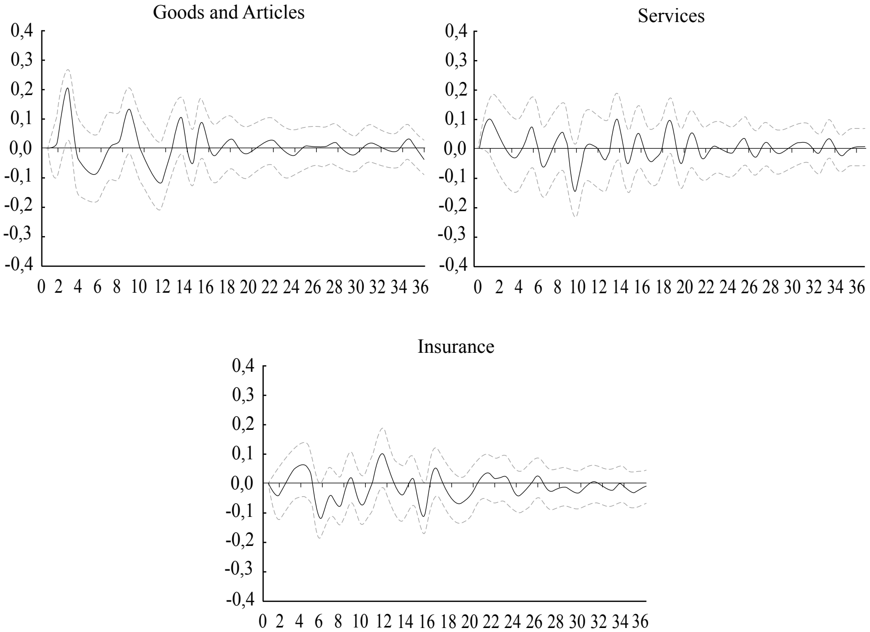
Source: Authors' calculations.

In sum, there is an ERPT into the total healthcare basket inflation rate, nonetheless, the effect is not complete, and does not exceed 0.3 percentage points in the short term and 0.1 percentage points in the long term.

Turning our attention to groups and subgroups of the healthcare basket to explore whether the effect on the aggregated health CPI holds for the divisions of goods and services, [1] is re-estimated using the corresponding groups and subgroups in Y_t. Figures 6 - 8 present the results of these estimations.

Figure 6.

Response Function of the Inflation Rates of the Healthcare Basket Groups

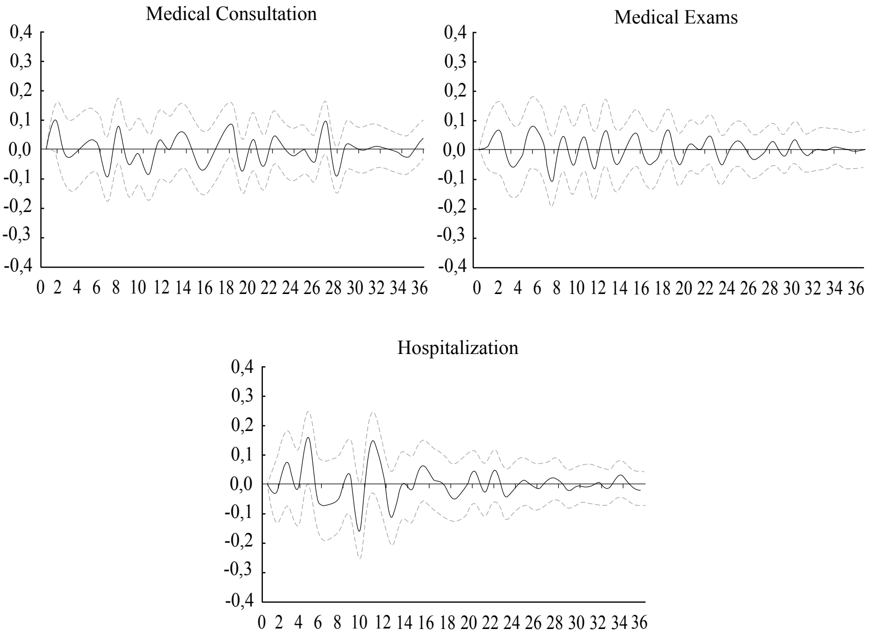


Note: Impulse responses (bootstrapping with 5% and 95% confidence intervals) of healthcare subgroups' inflation to an exchange rate shock: Goods and Articles, Services, and Insurance.

Source: Authors' calculations.

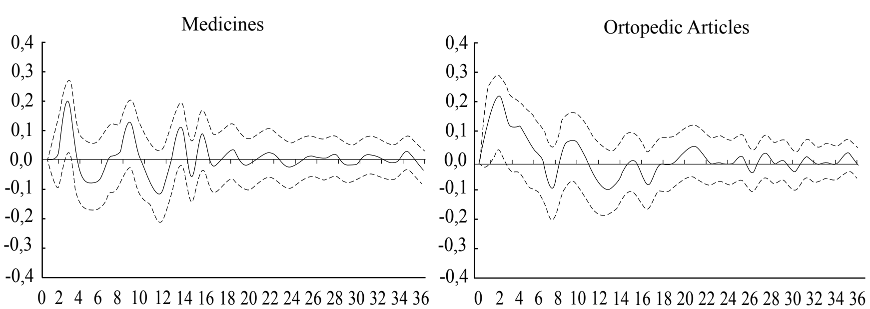
Results show that the effect of the ERPT on healthcare CPI inflation is mainly explained by the subgroup Goods and Devices, as there is not a significant effect on either of the other two components, Services and Insurance. This was expected because the latter are not imported input intensive, while medical devices are typically not produced in Colombia.

Figure 7.
Response Function of the Inflation Rate of the Subgroup Services



Note: Impulse responses (bootstrapping with 5% and 95% confidence intervals) of Services subgroups' inflation to an exchange rate shock: Medical Consultation, Exams, and Hospitalization.
Source: Authors' calculations.

Figure 8.
Response Function of the Inflation Rate of the Subgroup Goods and Articles



Note: Impulse responses (bootstrapping with a 5% and 95% confidence intervals) of Goods and Articles subgroups' inflation to a shock of the Exchange rate: Medicines and Orthopedic Articles.
Source: Authors' calculations.

DISCUSSION AND CONCLUSIONS

In the context of an unprecedented depreciation of the Colombian peso against the US dollar, the existence and the magnitude of the exchange rate pass-through to the Healthcare CPI in Colombia and its subgroups was studied. The results of low levels of ERPT are consistent with the study by Aron et al. (2014) on emerging markets with floating exchange rates. Nonetheless, the result of the ERPT to healthcare inflation was lower than the effect on the general level of inflation in the referenced literature (between 0.7 and 0.3).

The evidence shows the existence of a slightly low ERPT to consumer healthcare prices, explained by an increase in the price of imported devices not covered by the defined national package (i.e., hearing devices). Within this category of goods, the effect is shared by both medicines and orthopaedic devices, but the effect is bigger for the latter.

There are two policy implications. First, the ERPT to consumer healthcare prices is relatively low in comparison to the general ERPT and to the measurements for emerging countries presented in the literature (see Aron et al., 2014). This means that the Colombian healthcare system effectively protects consumers from ER volatility. Thus, ER volatility may not be a reason for the government to increase the share of OOP to help finance the current deficit in the system.

Nonetheless, imported goods are critical to the healthcare provision of medical services, and as such, protection comes at a cost to either providers or insurers. Providers may control costs by lowering the quality of their imported inputs, and insurers by increasing waiting times for elective surgeries, especially those where the imported inputs represent a significant share of the cost.

Second, for equity reasons, the government may need to regulate consumer prices for those items that hit the pockets of vulnerable populations hardest, such as non-covered medical devices and OTC drugs (Prada, Duarte & Guerrero, 2015). Further research may focus specifically on the non-covered and highly demanded retail drugs and their price changes in response to the fluctuations of the exchange rate.

One limitation of the present study is that the Colombian healthcare system has a particular structure and context; the market frictions and agents' dynamics are a unique case among world health systems. For example, the government subsidises some drugs covered in the universal health plan. Thus, the results, and thus the real effect of the ER, may be distorted by the distinctive characteristics of the Colombian system. Hence, the previous results cannot be easily compared or extrapolated to other emerging economies, with similar macroeconomic characteristics but different health systems.

Another limitation of the study is that the identification scheme can be uninformative if the goal of the analysis varies. The estimated ERPT depends on the identification scheme selected. In our case, the Cholesky identification scheme was used and thus, the principal source of shock is the exchange rate, and so, the measurement will be the median effect of the exchange rate shock. As argued by Forbes, Hjortsoe and Nenova (2015), different sources of shock have an impact on the magnitude of the ERPT. Their methodology may be more informative than the present procedure, but it implies the imposition of a higher number of restrictions on the model to isolate the shock and desired effect. In the present study, the variation in healthcare prices is the result of interest, especially in the context of the price regulation policy. For the Colombian government, regulating the price of a few components may be more efficient than coordinating a monetary policy with the Central Bank to reduce price variations in the health sector. Nevertheless, further research should combine both methodologies to determine the sources of the variations in the health components of medicine and orthopaedic aids.

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APPENDIX

Data Description

The variables included in the article allow for the incorporation of information from diverse sources and sectors of the economy, so the factors concentrate as much as information possible and give a more accurate estimation of the model. Table 2 presents the information by the number of the variable, name, source, and transformation code. The transformation code (in the last column) refers to 1 - no transformation, 2 - first difference, 4 - logarithm, 5 - first difference of the logarithm. The classifications proposed by both Bernanke et al. (2005) and Londoño et al. (2012) are assigned to define the variables as either "slow-moving" and "fast-moving", the latter is signalled by an asterisk (*) next to the name. The sources are Banco de la República (Banrep), Departamento Administrativo Nacional de Estadística (DANE), Bloomberg, and XM.

Table 2.
Data Description

Num.	Name	Source	Trans.
	I. Real Sector		
1	Economic Activity Index (IMACO)*	Banrep	2
2	Industrial Production Index (IPI): Products Total (1990=100)*	DANE	5
3	Economic Condition Indicator (ISE, 2005=100)*	DANE	5
4	ISE: Agriculture, livestock farming, hunting, and fishing industries (2005=100)*	DANE	5
5	ISE: Mining (2005=100)*	DANE	5
6	ISE: Manufacturing industries (2005=100)*	DANE	5
7	ISE: Electricity, gas, and water*	DANE	5
8	ISE: Construction*	DANE	5
9	ISE: Trade, repairs, restaurants, and hotels*	DANE	5
10	ISE: Transport, storage, and communications*	DANE	5
11	ISE: Financial services, insurance, real estate business, and general services*	DANE	5
12	ISE: Social, communal, and personal services*	DANE	5
13	Employment rate: National total*	DANE	1
14	Unemployment rate: National total*	DANE	5
15	Nominal salaries index: retail trade (2013=100)*	DANE	5

(*Continued*)

Table 2.
Data Description

Num.	Name	Source	Trans.
I. Real Sector			
16	Real salaries index for the manufacturing industry with threshing (1990=100)*	DANE	5
17	Real salaries index for the manufacturing industry without threshing (1990=100)*	DANE	5
18	Production of sugar (tons)*	Banrep	5
19	Production of grey cement (tons)*	Banrep	5
20	Production of Coil (tons)*	Banrep	5
21	Production of Vehicles (tons)*	Banrep	5
II. Prices			
22	Consumer Price Index (CPI): All times (2008=100)*	DANE	5
23	CPI: Food (2008=100)*	DANE	5
24	CPI: Housing (2008=100)*	DANE	5
25	CPI: Apparel (2008=100)*	DANE	5
26	CPI: Education (2008=100)*	DANE	5
27	CPI: Entertainment (2008=100)*	DANE	5
28	CPI: Transportation (2008=100)*	DANE	5
29	CPI: Communications (2008=100)*	DANE	5
30	CPI: Healthcare (2008=100)*	DANE	5
31	CPI: Healthcare. Services (2008=100)*	DANE	5
32	CPI: Healthcare. Services - Hospitalization (2008=100)*	DANE	5
33	CPI: Healthcare. Services - Outpatient visits (2008=100)*	DANE	5
34	CPI: Healthcare. Services - Laboratory (2008=100)*	DANE	5
35	CPI: Healthcare. Goods and Devices (2008=100)*	DANE	5
36	CPI: Healthcare. Goods and Devices - Drugs (2008=100)*	DANE	5
37	CPI: Healthcare. Goods and Devices - Orthopaedic Devices (2008=100)*	DANE	5
38	CPI: Healthcare. Private Insurance (2008=100)*	DANE	5
39	CPI: Other expenditures (2008=100)*	DANE	5
40	CPI: All items less Food - Tradable*	DANE	5

(*Continued*)

Table 2.
Data Description

Num.	Name	Source	Trans.
II. Prices			
41	CPI: All items less Food - Nontradable*	DANE	5
42	CPI: All items less Food - Regulated*	DANE	5
43	Producer Price Index (PPI): National total (1999=100)*	DANE	5
44	PPI: Agriculture, livestock farming, hunting, and fishing industries (1999=100)*	DANE	5
45	PPI: Mining (1999=100)*	DANE	5
46	PPI: Manufacturing industries (1999=100)*	DANE	5
47	PPI: Imports (1999=100)*	DANE	5
48	PPI: Exports (1999=100)*	DANE	5
49	New housing price index (IPVNBR, 2006=100)*	Banrep	5
50	Construction Price Index: Housing (ICCV, 1999=100)*	DANE	5
51	Construction Price Index: Heavy constructions (ICCP, 1999=100)*	DANE	5
52	West Texas Intermediate spot price (WTI, US per barrel)	Bloomberg	5
53	Electricity Prices (COP/KWh)	XM	5
54	Forward contract of Arabica coffee (KC1, US cts./lbs)	Bloomberg	5
55	International price of coil (US/lbs)	Bloomberg	5
III. Monetary and Credit Quantity Aggregates			
56	Monetary Base (Thousands of Millions of COP)	Banrep	5
57	Money Stock: M1 (Thousands of Millions of COP)	Banrep	5
58	Money Stock: M2 (Thousands of Millions of COP)	Banrep	5
59	Money Stock: M3 (Thousands of Millions of COP)	Banrep	5
60	Cash (Millions of COP)	Banrep	5
61	Depository reserves: Total (Millions of COP)	Banrep	5
62	Current Account: Private sector (Thousands of Millions of COP)	Banrep	5
63	Current Account: Public sector (Thousands of Millions of COP)	Banrep	5
64	Current Account: Total (Thousands of Millions of COP)	Banrep	5
65	Near money: Savings Account (Thousands of Millions of COP)	Banrep	5
66	Near money: Term Deposits (Thousands of Millions of COP)	Banrep	5

(*Continued*)

Table 2.
Data Description

Num.	Name	Source	Trans.
III. Monetary and Credit Quantity Aggregates			
67	Near money: Total (Thousands of Millions of COP)	Banrep	5
68	Demand deposit (Thousands of Millions of COP)	Banrep	5
69	Fiduciary deposit (Thousands of Millions of COP)	Banrep	5
70	Bonds (Thousands of Millions of COP)	Banrep	5
71	REPOS with the Treasury (Thousands of Millions of COP)	Banrep	5
72	REPOS with the real sector (Thousands of Millions of COP)	Banrep	5
73	REPOS: Total (Thousands of Millions of COP).	Banrep	5
74	Liabilities (Thousands of Millions of COP)	Banrep	5
III. Interest Rates			
75	Interbank Interest Rate (% per annum)	Banrep	1
76	Interest Rate: Average fixed term deposit of 90 days (DTF, % per annum)	Banrep	1
77	Interest Rate: Average fixed term deposit of 90 days for Banks (CDT, % per annum)	Banrep	1
78	Interest Rate: Colombian Treasury (% per annum)	Banrep	1
79	Interest Rate: Federal Reserve Funds (Effective, % per annum)	Banrep	1
80	Interest Rate: London Interbank Offered Rate (LIBOR, % per annum)	Banrep	1
81	Interest Rate: PRIME rate (% per annum)	Banrep	1
IV. External sector and Exchange Rates			
82	Real Exchange Rate Index: Non-traditional exports weighted. PPI deflator (2010=100)	Banrep	5
83	Real Exchange Rate Index: Non-traditional exports weighting. CPI deflator (2010=100)	Banrep	5
84	Real Exchange Rate Index: Total weighting. PPI deflator (2010=100)	Banrep	5
85	Real Exchange Rate Index: Total weighting. CPI deflator (2010=100)	Banrep	5
86	United States market competitiveness index. CPI Deflator (2010=100)	Banrep	5
87	Real Exchange Rate Index: Colombian Peso against 18 countries of the IMF. CPI Deflator (2010=100)	Banrep	5

(*Continued*)

Table 2.
Data Description

Num.	Name	Source	Trans.
IV. External sector and Exchange Rates			
88	Exports: Total (millions of US, FOB)*	Banrep	5
89	Exports: Traditional (millions of US, FOB)*	Banrep	5
90	Exports: Traditional - Coffee(millions of US, FOB)*	Banrep	5
91	Exports: Traditional - Coil (millions of US, FOB)*	Banrep	5
92	Exports: Traditional - Oil (millions of US, FOB)*	Banrep	5
93	Exports: Traditional - Nickel(millions of US, FOB)*	Banrep	5
94	Exports: Non-traditional (millions of US, FOB)*	Banrep	5
95	Exports: Non-traditional - Banana (millions of US, FOB)*	Banrep	5
96	Exports: Non-traditional - Flowers (millions of US, FOB)*	Banrep	5
97	Exports: Non-traditional - Agricultural Total (millions of US, FOB)*	Banrep	5
98	Exports: Non-traditional - Gold (millions of US, FOB)*	Banrep	5
99	Exports: Non-traditional - Emeralds (millions of US, FOB)*	Banrep	5
100	Exports: Non-traditional - Total mining (millions of US, FOB)*	Banrep	5
101	Exports: Non-traditional - Apparel (millions of US, FOB)*	Banrep	5
102	Exports: Non-traditional - Chemicals (millions of US, FOB)*	Banrep	5
103	Exports: Non-traditional - Paper Manufactures (millions of US, FOB)*	Banrep	5
104	Exports: Non-traditional - Leather Manufactures (millions of US, FOB)*	Banrep	5
105	Exports: Non-traditional - Food (millions of US, FOB)*	Banrep	5
106	Exports: Non-traditional - Industrial (millions of US, FOB)*	Banrep	5
107	Imports: Total (Millions of US, CIF)*	Banrep	5
108	Imports: Nondurable Goods (Millions of US, CIF)*	Banrep	5
109	Imports: Durable Goods (Millions of US, CIF)*	Banrep	5
110	Imports: Intermediate goods - Fuels (Millions of US, CIF)*	Banrep	5
111	Imports: intermediate goods - Agriculture (Millions of US, CIF)*	Banrep	5
112	Imports: intermediate goods - Industrial goods (Millions of US, CIF)*	Banrep	5
113	Imports: Construction assets (Millions of US, CIF)*	Banrep	5

(*Continued*)

Table 2.
Data Description

Num.	Name	Source	Trans.
IV. External sector and Exchange Rates			
114	Imports: Agricultural assets (Millions of US, CIF)*	Banrep	5
115	Imports: Industrial assets (Millions of US, CIF)*	Banrep	5
116	Imports: Transportation equipment (Millions of US, CIF)*	Banrep	5
117	International Reserves: Net reserves (millions of US)*	Banrep	5
118	International Reserves: Gross reserves (millions of US)*	Banrep	5
119	International Reserves: Short-term Liabilities (millions of US)*	Banrep	5
120	Foreign Exchange Balance: Income (millions of US)*	Banrep	5
121	Foreign Exchange Balance: Outflow (millions of US)*	Banrep	5
122	Foreign Exchange Balance: Current Account (millions of US)*	Banrep	5
123	Foreign Exchange Balance: Trade Balance (millions of US)*	Banrep	5
124	Foreign Exchange Balance: Services and Transfers (millions of US)*	Banrep	5
125	Terms of exchange Index based on foreign trade*	Banrep	5
126	Exports price index based on foreign trade*	Banrep	5
127	Imports price index based on foreign trade*	Banrep	5
128	Terms of exchange Index based on PPI*	Banrep	5
129	Exports price index based on PPI*	Banrep	5
130	Imports price index based on PPI*	Banrep	5
131	Remittances (Thousands of Millions of COP)*	Banrep	5

Source: Compiled by the authors.

A. In-Sample Models and Out-of-Sample accuracy measurements

To determine the fit and accuracy of the forecast of Health Inflation, the FAVAR model is compared to the standard VAR model and the autoregressive integrated moving average (ARIMA) model, using the Modified Diebold-Mariano (1995) test of forecast accuracy proposed by Harvey, Leybourne and Newbold (1997). The null hypothesis of the test is that the forecast performance is approximately equal versus the alternative of statistically different predictions. To determine the best model, we used four traditional forecast error measures: Mean Absolute Error (MAE), Mean Squared Error (MSE), Sum of the Squared Errors (SSE) and Root Mean Square Error (RMSE).

A.1 In-Sample Models model fit

To examine the model in-sample fit, we use the Modified Diebold-Mariano to determine if the models' fits are statistically the same or if they differ. The results presented in Table 3 implies that both the VAR and FAVAR provide a similar fit to the original series, but the ARIMA model shows that both of the previous models' fits differ.

Table 4 provides different model forecast error measurements. The VAR and FAVAR model, consistent with the previous results, both exhibit similar results. FAVAR is the model with the lowest measurements. The ARIMA model displays the lowest error measurements, and is the model with the best fit for the data. This result is expected, as the ARIMA is based only on the behaviour of the healthcare inflation itself, and as the lags of other variables are not involved, the in-sample fit is superior to the other models.

Table 3.
Modified Diebold-Mariano Test of Forecast Accuracy Statistic

	VAR	FAVAR	ARIMA
VAR			
FAVAR	-1.04		
ARIMA	-4.14***	-4.00***	

Note: The loss function is the square of the difference of the errors.
Source: Authors' calculations. (*) significance at 1% (**) Significance at 5% (***) Significance at 10%.

Table 4.
Forecast Error Measure

	MAE	MSE	SSE	RMSE
FAVAR	0.20	0.08	11.87	0.28
VAR	0.21	0.08	12.33	0.29
ARIMA	0.14	0.03	4.93	0.18

Source: Authors' calculations.

A.2. Out-of-Sample forecast accuracy measurements

The Diebold-Mariano test is also applied to measure out-of-sample forecast accuracy and forecast error measures the rolling forecasts of each of the models used to compare the FAVAR model. Table 5 provides the results of the Diebold-Mariano test, where the models have statically equal forecasts. Table 6 shows the forecast error measurements for the three models, where the FAVAR model outperforms the VAR and the ARIMA models in terms of the forecast.

Table 5.
Modified Diebold-Mariano Test of Forecast Accuracy Statistic

	ARIMA	FAVAR	VAR
ARIMA			
FAVAR	-2.39*		
VAR	1.05***	1.99**	

Source: Authors' calculations. (*) significance at 1% (**) Significance at 5% (***) Significance at 10%

Table 6.
Forecast Error Measurements

	MAE	MSE	SSE	RMSE
FAVAR	0.26	0.12	1.10	0.35
VAR	1.41	3.19	28.73	1.79
ARIMA	1.30	2.40	21.61	1.55

Source: Authors' calculations.

B. Diagnostic Tests of the FAVAR Model

To determine the correct specification of the model, three different tests were applied to the errors of the FAVAR model. The tests applied are the ARCH-LM, Breusch-Godfrey Serial Correlation test, and the Jarque-Bera Multivariate test. Based on the test, the lags of the model were chosen as the minimum number of lags that provide no serial correlation or ARCH effects.

Table 7.
ARCH-LM Test

Lag	Statistic	p-value
1	471.15	0.15***
2	962.75	0.03*
3	1336.27	0.39***
4	1731.50	0.71***
5	2222.57	0.39***
6	2646.69	0.49***
7	3079.90	0.53***
8	3507.00	0.60***
9	3486.00	1***
10	3465.00	1***
11	3444.00	1***
12	3423.00	1***

Source: Authors' calculations. (*) significance at 1% (**) Significance at 5% (***) Significance at 10%

Table 8.
Breusch-Godfrey Serial Correlation Test

Lag	Statistic	p-value
1	1.32	0.11***
2	1.23	0.11***
3	1.18	0.13***
4	1.15	0.15***
5	1.19	0.08***
6	1.13	0.15***
7	1.07	0.29***
8	1.08	0.26***
9	1.12	0.16***
10	1.11	0.20***
11	1.14	0.15***
12	1.13	0.19***

Source: Authors' calculations. (*) significance at 1% (**) Significance at 5% (***) Significance at 10%

Table 9.
Multivariate Jarque-Bera Normality Test

Statistic	d.f.	p-value
4,852	3	0,183

Note: The null hypothesis is that the residuals of the VAR model follow a normal distribution.
Source: Authors' calculations.