SHORT RESEARCH AND DISCUSSION ARTICLE

The health scare of COVID-19 amidst pandemics and the immune-related pharmaceutical products spillovers in the USA

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Abstract

In view of the sector-wide effect of the nCOVID-19 pandemic in the USA and the probable effect on certain over-the-counter (OTC) pharmaceutical products, the current study examined potential inflation in the pharmaceutical industry arising from the pandemic-related uncertainty. In this case, the USA's producer price indexes vis-à-vis inflation of the immune-related pharmaceutical items: multivitamin, vitamins nutrients and hematinic (V-N-H), other vitamins (other-V), antidepressant, and antidiabetic were examined alongside the uncertainties arising from the world pandemic and economic policy. Thus, the (Diebold and Yilmaz in Int J Forecast 28(1): 57–66, 2012) result implied that the world pandemic uncertainty contributed a significantly huge shock to the examined pharmaceutical compounds, thus affirming the vulnerability of certain pharmaceuticals to pandemic-related uncertainty. The total spillover increased from 34.2% (with economic policy uncertainty) to 47.6% (when pandemic uncertainty is incorporated). In specific, there are negative net spillovers from the multivitamins, other vitamins, antidiabetic, and antidepressant especially due to high pandemic and economic policy uncertainties. However, the statistical evidence implied that higher uncertainty arising from the pandemic is responsible for the severity of shock received by the indicated pharmaceutical products as against economic policy uncertainty. Thus, a relevant policy inference is posited from the result of the study.

Keywords nCOVID-19 · Uncertainty · Pharmaceutical · Vitamins · USA

JEL codes C53 · F64 · H15

Introduction

After more than 100 years that the influenza pandemic commonly called "Spanish Flu" of 1918 ravaged the world, the novel severe acute respiratory syndrome coronavirus 2 (known as (n)COVID-19 or SARS-CoV-2) that has affected

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more than 216 countries and territories has remained a prevailing mystery. Currently, 962,008 human lives have been lost and 31,132,906 confirmed cases have been recorded globally as of 22 September 2020 (World Health Organization, WHO 2020). Since the emergency of the nCOVID-19 pandemic, governments across the globe and the collaborating effort of both the intergovernmental agencies and the private institutions have extensively deployed various measures to mitigate the spread of the virus or "flatten the curve." In addition to some of the measures that have been implemented (such as "lockdown," social distancing, travel restriction/suspension across borders, and other measures), scientists have proposed a few inference. So far, the proffered pathogenesis of (n)COVID-19 has obviously been presented in three phases: (1) the asymptomatic, (2) symptomatic but a not severe phase, and (3) the symptomatic stage with a severe and high viral load (Shi et al. 2020). As such, among other factors, the pandemic is expected to have affected both the manufacturing and the over-the-counter (OTC)

pharmaceutical product demand through the application of prevention mechanisms (Singh and Avikal 2020; Srivastava and Wagh 2020). This is in addition to other health-related and socioeconomic factors that have been linked with the COVID-19 pandemic (Alhassan et al. 2020; Balsalobre-Lorente et al. 2020; Sarkodie and Owusu 2020).

Accordingly, COVID-19 has been associated with the human immune system (Li et al. 2020; Russell et al. 2020; Shi et al. 2020). In specific, Li et al. (2020) opined that the body's humoral immunity and cellular immunity are stimulated by the immunity antigens in the human cells, thus expectedly preventing the advancement of the nCOVID-19 disease to the severe stage. Indicatively, the appropriateness of human genetic structure, depicting a good health status, is responsible for the response of the endogenous protective immune that is potentially capable of inhibiting the nCOVID-19 viral replication as an antiviral immunity (Shi et al. 2020). This is because ongoing studies have noted cases of nCOVID-19 sufferers that are either impervious to nCOVID-19 or immuno-compromised (Centers for Disease Control and Prevention, CDC 2020; Nature 2020). As such, scientists and medical experts have consistently outlined the role of individuals in maintaining a boosted immune system (Brand South Africa 2020; DW 2020; Tufan et al. 2020). In this perspective, in addition to living a healthy lifestyle, and the "phobia" for COVID-19, the use of supplements and nutritional medications or compounds such as vitamin C, antioxidants, and other compounds is being encouraged to booting the human immune system (Amin 2020; Brand South Africa 2020).

In view of the above motivation, the current study look at the performance of the pharmaceutical industries, especially those associated with the production of vitamins and other immune-related drugs in the framework of the USA's COVID-19 situation. Although Nicola et al. (2020) and Mason-D'Croz et al. (2020) have earlier suggested the likelihood of spillover effect of the COVID-19 pandemic to the socio-economic aspects, there is no study that specifically noted a pharmaceutical sector-specific effect from the nCOVID-19 pandemic. Hence, the novelty of the current study is that it offers a highlight of a few important contributions to the existing nCOVID-19 literature in a unique pattern. Foremost, the study offers explanation on the probable vulnerability of the producer price index (PPI) vis-à-vis inflation associated with the production of the immune-related pharmaceutical compound or supplements: vitamins nutrients, hematinic, multivitamin. In context, the USA has reported an overall relative rise in import and export prices since May 2020. In addition, the uncertainty associated with the economic policy and the pandemic (i.e., the economic policy uncertainty and pandemic uncertainty) is employed in examining the vulnerability of the aforementioned pharmaceutical compounds. Thus, with the aforementioned novel approach and considering that the USA has reported more cases and number of

deaths from COVID-19 than any other country in the world (~ 6.9 million reported cases and over 200,252 deaths as at 22 September 2020) according to the Johns Hopkins University and Medicine (2020), this study is capable of providing a new significant insight.

In the other section of this study, the material employed, theoretical concept, the discussion of the results, and the conclusion of the study are all described sequentially in the "Material and theoretical concept" section. The discussion of the results and conclusion remarks are rendered in the "Findings and discussion" section and the "Concluding remark" section respectively.

Material and theoretical concept

Material

The theoretical concept of the study is based on the use of the producer price indexes of pharmaceutical items: multivitamin and vitamins nutrients hematinic (V-N-H), other vitamins (other-V), antidepressant, and antidiabetic. The indexes of the aforementioned pharmaceutical materials were retrieved from the Federal Reserve Economic Data, FRED (2020).[1] In addition, the employed world pandemic uncertainty index (denoted as WPU) and economic policy uncertainty index (denoted as EPU) were retrieved from the world pandemic index (2020) and FRED (2020) respectively. The aforementioned dataset covers the period of June 2001 to June 2020. We have restricted the data collection to June 2001 because of data availability especially for vitamins nutrients hematinic (V-N-H) and other vitamins. Similarly, the data availability for WPU is responsible for the limitation to June 2020.

Theoretical concept

In Table 1, the descriptive statistics of the employed aforementioned materials are presented in addition to the respective graphical illustrations in Fig. 2 (i–vii) of Appendix A. With 229 observations, the volatility is observed to be highest in index of antidiabetic, and followed by antidepressant, EPU, other vitamins, V-N-H, WPU, and lastly by multivitamins. Therefore, we proceed to employ the Diebold Yilmaz spillover index approach (Diebold and Yilmaz 2012).

The *V-N-H* (vitamin, nutrient, and hematinic preparations), *Other-V* (other vitamins and nutrients), multivitamins, antidiabetic, and antidepressant are the respective producer price index (PPI) of pharmaceutical compounds. In addition, WPU and EPU are the indexes of the world pandemic uncertainty and economic policy uncertainty

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[1] The Federal Reserve Economic Data, FRED (2020) is available on https://fred.stlouisfed.org/.

Table 1　Statistical inference

	WPU	V-N-H	Other-V	Multivitamins	EPU	Antidiabetic	Antidepressant
Mean	4.782463	116.2614	123.1605	170.9700	104.7842	733.7027	714.6274
Median	1.882653	117.4000	127.9000	172.1000	90.93871	570.5000	670.2000
Maximum	141.5323	137.8000	151.3000	184.4000	253.9187	1506.400	1153.100
Minimum	− 18.83425	98.60000	97.80000	155.3000	38.20903	312.5000	264.8000
Standard Deviation	11.84658	13.37791	19.01948	9.681883	47.09574	392.0075	308.3119
Skewness	8.133492	0.246458	0.010960	− 0.124159	1.136607	0.719962	0.048979
Kurtosis	87.24622	1.607648	1.437808	1.591436	3.727792	1.987633	1.426031
Jarque-Bera	68,405.62	20.27080	22.68026	19.00809	52.93633	28.78807	23.10812
Probability	*(0.00000)*	*(0.00004)*	*(0.00001)*	*(0.00008)*	*(0.00000)*	*(0.000001)*	*(0.00001)*
Observations	229	229	229	229	229	229	229

Spillover effect approach

In this part, the Diebold and Yilmaz (2012) approach is employed to illustrate the Total, Directional, Net, and Net Pairwise Spillovers as the categories of spillover effects. This approach is employed through the covariance stationary VAR (p) of each variable y that can be represented as

$$y_t = \sum_{i=1}^{p} \Phi_i y_{t-1} + \varepsilon_t \sim (0, \Sigma) \tag{1}$$

such that

$$y_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-1} \tag{2}$$

is the moving average of the covariance stationary process and $y_t = (y_{1t}, y_{2t}, \ldots, y_{Nt})'$ is N × 1 vector of the individual return and volatility series. Also, Φ is N x N, ε is the vector of disturbance that is assumed to be independently (not necessarily identically) distributed over time such that $A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \ldots + \Phi_p A_{i-p}$. A_0 is the identity matrix with N x N dimension, and $A_i = 0$ for all $i < 0$.

In determining the magnitude of the spillovers among the pharmaceutical items, WPU and EPU, we adopt the conventional VAR framework such that the H-step-ahead forecast error variance contribution becomes

$$\theta_{ij}^g (H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e'_i A_h \sum e_j \right)^2}{\sum_{h=0}^{H-1} \left(e'_i A_h \sum A_h e'_i \right)^2} \tag{3}$$

Such that the variance matrix of the error vector is Σ, σ_{jj} is the standard deviation of the error term for variable j, e_i is the selection vector with 1 = ith element, and 0 = otherwise. Then, the diagonally centralized elements (the own variance shares of shocks to variable y_i) is the fraction of the H-step-ahead error variance in forecasting y_i, given that $i = 1, 2, \ldots N$. Also, the off-diagonal (cross variance shares or spillovers) are the

fractions of the H-step-ahead error variances in forecasting y_i that are due to shocks to y_j, given that $j = 1, 2, \ldots N$ and i is not equal j. Furthermore, to use the full information, each entry of the variance decomposition matrix is normalized by taking the row sum such that

$$\theta_{ij}^g (H) = \frac{\theta_{ij}^g (H)}{\sum_{j=1}^{N} \theta_{ij}^g (H)} \tag{4}$$

where $\sum_{j=1}^{N} \theta_{ij}^g(\text{H})$ (sum of the contributions to the variance of the forecast error) is not equal to 1, but $\sum_{j=1}^{N} \widetilde{\theta}_{ij}^g (H) = 1$ and $\sum_{i,j=1}^{N} \widetilde{\theta}_{ij}^g (H) = N$.

Consequently, the total spillover index among the examined commodity markets is provided as

$$S^g(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \widetilde{\theta}_{ij}^g (H)}{\sum_{i,j=1}^{N} \widetilde{\theta}_{ij}^g (H)} \times 100 = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \widetilde{\theta}_{ij}^g (H)}{N} \times 100 \tag{5}$$

But, the total directional spillover exhibits two indicators: "to others" and "from other". Then, the directional spillover index from others is computed as

$$S_i^g(H) = \frac{\sum_{\substack{J=1 \\ j \neq 1}}^{N} \widetilde{\theta}_{ij}^g (H)}{\sum_{i,J=1}^{N} \widetilde{\theta}_{ij}^g (H)} \times 100 = \frac{\sum_{\substack{J=1 \\ j \neq 1}}^{N} \widetilde{\theta}_{ij}^g (H)}{N} \times 100 \tag{6}$$

While the directional spillover index to others is calculated as

$$S_i^g(H) = \frac{\sum_{\substack{J=1 \\ j \neq 1}}^{N} \widetilde{\theta}_{ji}^g (H)}{\sum_{i,J=1}^{N} \widetilde{\theta}_{ji}^g (H)} \times 100 = \frac{\sum_{\substack{J=1 \\ j \neq 1}}^{N} \widetilde{\theta}_{ji}^g (H)}{N} \times 100 \tag{7}$$

Moreover, the difference between the "to other" and "from others" indicators is calculated using

$$S_i{}^g(H) = S_{.i}{}^g(H) - S_{i.}{}^g(H) \quad (8)$$

In addition, the net pairwise directional spillovers is also computed from

$$S_{ij}{}^g(H) = \left\{ \frac{\widetilde{\theta}_{ji}{}^g(H)}{\sum\limits_{i,k=1}^{N} \widetilde{\theta}_{ik}{}^g(H)} - \frac{\widetilde{\theta}_{ij}{}^g(H)}{\sum\limits_{j,k=1}^{N} \widetilde{\theta}_{jk}{}^g(H)} \right\} \times 100$$

$$= \left\{ \frac{\widetilde{\theta}_{ji}{}^g(H) - \widetilde{\theta}_{ij}{}^g(H)}{N} \right\} \times 100 \quad (9)$$

Thus, the current study measures the total spillover index, the contributions of spillovers of the WPU, EMU, and the inflation (producer price indexes) of pharmaceutical items: multivitamin, vitamins nutrients and hematinic (V-N-H), other vitamins (other-V), anti-depressant, and antidiabetic. As revealed, the indicated spillover indices and other results are presented in Table 2 while respective rolling windows are illustrated in Fig. 1.

Findings and discussion

By employing the step-step procedures (Eq. 1 to 9) above, the approach is employed for three different categories:

Table 2 Spillover indexes for cases of Economic Policy and World Pandemic Uncertainties

With economic policy (panel A)

	EPU	V-N-H	Other-V	Multivatmins	Antidiabetic	Antidepressant		From others
EPU	91.6	3.8	0.2	0.1	1.4	3.1		8.4
V-N-H	1.8	84.5	5.0	2.8	7.6	0.9		15.5
Other-V	0.6	86.8	54.1	13.4	1.9	0.9		95.1
Multivatmins	4.2	11.4	1.6	79.7	0.2	1.4		64.2
Antidiabetic	0.3	0.4	0.4	0.4	95.5	3.4		5.2
Antidepressant	7.2	1.1	0.1	5.2	1.6	85.9		17.0
Contribution to others	14.1	103.6	60.6	11.7	6.6	8.8		205.5
Contribution including own	105.7	188.1	65.5	47.5	101.4	91.8		(34.2%)

With pandemic (panel B)

	WPU	V-N-H	Other-V	Multivatmins	Antidiabetic		Antidepressant	From others
WPU	98.4	0.0	0.3	0.1	0.4		0.2	1.2
V-N-H	0.2	69.4	5.5	1.9	6.1		0.8	14.7
OTHER-V	2.0	23.6	40.3	9.3	1.6		0.8	95.4
Multivatmins	1.4	13.5	1.4	81.3	0.2		1.6	65.3
Antidiabetic	38.1	0.2	0.6	0.1	39.9		0.9	40.9
Antidepressant	20.5	0.3	0.2	5.6	1.7		77.6	30.0
Contribution to others	62.2	99.6	63.9	11.0	6.4		4.3	247.4
Contribution including own	161.0	184.9	68.6	45.8	65.6		74.2	(41.2%)

With both pandemic and economic policy uncertainties (panel C)

	WPU	V-N-H	Other-V	Multivatmins	EPU	Antidiabetic	Antidepressant	From others
WPU	98.7	0.6	0.4	0.1	0.5	0.4	0.2	1.3
V-N-H	0.1	66.6	5.1	1.8	2.1	5.7	0.8	15.6
Other-V	2.5	23.8	40.1	9.4	2.5	1.5	0.8	95.3
Multivatmins	1.0	13.4	1.8	81.6	0.6	0.2	1.4	650
EPU	86.4	1.3	0.1	0.2	58.6	0.4	0.1	88.0
Antidiabetic	38.4	0.2	0.6	0.1	0.2	40.9	0.9	41.4
Antidepressant	14.1	0.5	0.0	5.5	3.6	1.5	73.3	26.7
Contribution to others	142.6	97.3	64.8	11.3	6.8	6.3	4.2	333.2
Contribution including own	241.3	181.7	69.5	46.4	18.8	64.9	77.8	(47.6%)

(1) using the EPU (result in panel A of Table 2), (2) using the pandemic uncertainty index (result in panel B of Table 2), and (3) employing with both the EPU and WPU (result in panel C of Table 2). In panel A, where the EPU was employed with the PPI of the pharmaceutical materials, the total spillover index that signifies the total transfer of information among the variable is 34.2%. However, with the use of the WPU in lieu of the EPU, the total spillover index increased to 47.6% (see panel B) and this information is further affirmed by the rolling window for the three cases in Fig. 1. This implies that the uncertainty caused by the world pandemic is capable of causing the spread of higher level of uncertainty

Fig. 1 A, B, and C are respective rolling window evidence. A: Rolling window with Economic Policy Uncertainty. B: Rolling window with the World Pandemic Uncertainty. C: Rolling window with Pandemic and Economic Policy Uncertainties

(a) Rolling window with Economic Policy Uncertainty

(b) Rolling window with the World Pandemic Uncertainty

(c) Rolling window with Pandemic and Economic Policy Uncertainties
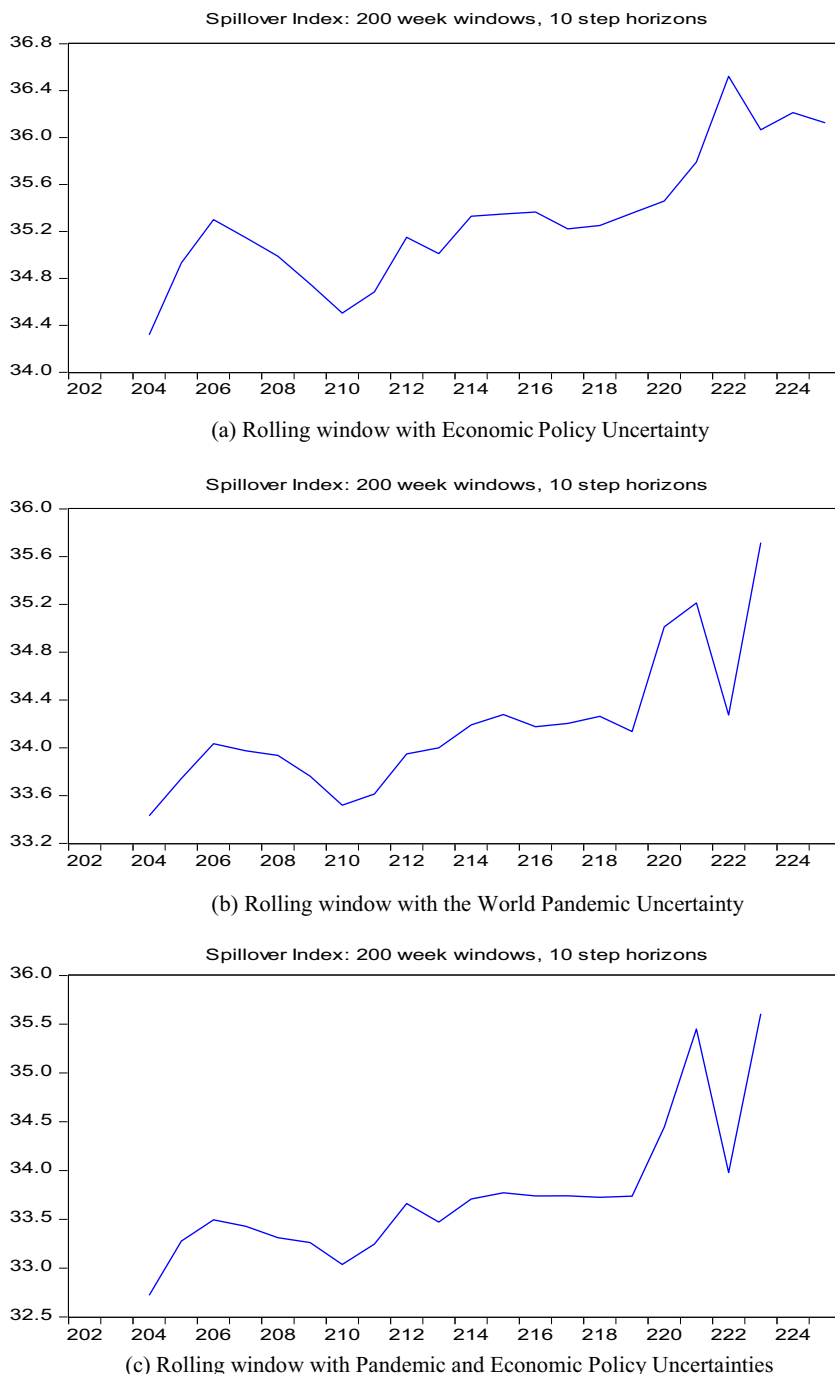
as compared with the uncertainty caused by economic policy (EPU).

In specific, as seen in panel B of Table 2, the world pandemic uncertainty contributes 62.2% shock to other element of the estimation. In this context, other vitamins, multivitamins, antidiabetic, and antidepressant receive 95.4%, 65.3%, 40.9%, and 30.0% shock respectively from others. Similarly, other vitamins, multivitamins, antidiabetic, and antidepressant are all net receivers. Indicatively, the net spillovers by other vitamins, multivitamins, antidiabetic, and antidepressant are respectively −31.5%, −54.3%. −34.5%, and −25.8%. Furthermore, the result of the panel C (Table 2) provides an additional supporting evidence. This result implies that when both EPU and WPU are employed along with the pharmaceutical compounds, the contribution of shock from the WPU and EPU to other elements now increased to 142.6% and 6.8%. Similarly, other vitamins, multivitamins, antidiabetic, and antidepressant receive 95.3%, 65.0%, 41.4%, and 26.7% shock respectively from others. This implies that other vitamins, multivitamins, antidiabetic, and antidepressant are all net receivers. The indication is because the net spillovers by other vitamins, multivitamins, antidiabetic, and antidepressant are respectively −30.5%, −53.7%. −35.1%, and −22.5%. In addition, the EPU with −81.2% is also a net receiver.

Moreover, this evidence shows that total spillover of information (with only EPU) increased from 34.2 to 41.2% (with WPU) and to the highest value of 47.6% especially when both WPU and EPU are at play. Indicatively, the spike in EPU and WPU as illustrated in Fig. 2 (vi–vii) further affirmed the tendency of uncertainties from both pandemic and economic policy to trigger information transfer. The negative net spillover for the other vitamins, multivitamins, antidiabetic, and antidepressant demonstrates the vulnerability of these pharmaceutical compounds to degree of uncertainty. This is an indication that world pandemic uncertainty such as the COVID-19 is capable of contributing a significant amount of shock to the production of pandemic-related medications.

Concluding remark

This study examined the potential and magnitude of shock associated with production of immune-related pharmaceutical products or compounds especially in the context of the COVID-19 pandemic. Considering that the severity of COVID-19 has been largely linked with the sufferers' immune system and evidence of underlying illness, the industrial production of immune-related pharmaceutical drugs such as the multivitamin, vitamins nutrients and hematinic (V-N-H), antidepressant, and antidiabetic is expected to increase during the pandemic. As such, the current study examined the spillover effect arising from the world pandemic uncertainty and economic policy uncertainty to the producer price indexes of pharmaceutical items: multivitamin, vitamins nutrients and hematinic (V-N-H), other vitamins (other-V), antidepressant, and antidiabetic in the USA. The result posited that the uncertainty arising from the world pandemics such as COVID-19 in the USA is responsible for high shock in the producer price index of all the examined pharmaceutical items. The study further showed that the shock arising from the world pandemic uncertainty is significantly higher than that of the economic policy in the USA. Importantly, the other vitamins, multivitamins, antidiabetic, and antidepressant all exhibit a high degree of net spillovers, thus affirming the pharmaceutical compounds' vulnerability to shocks from pandemic and economic policy–related uncertainties.

By implication, if the USA is mindful at addressing the adverse effect of inflation associated with the immune-specific pharmaceutical compounds, the government should foster policy that target the COVID-19 scenario in the USA. With such effective policy, potential surge in inflation in the pharmaceutical industry can be curbed, thus reducing the burden the consumers.

Compliance with ethical standards

Appendix
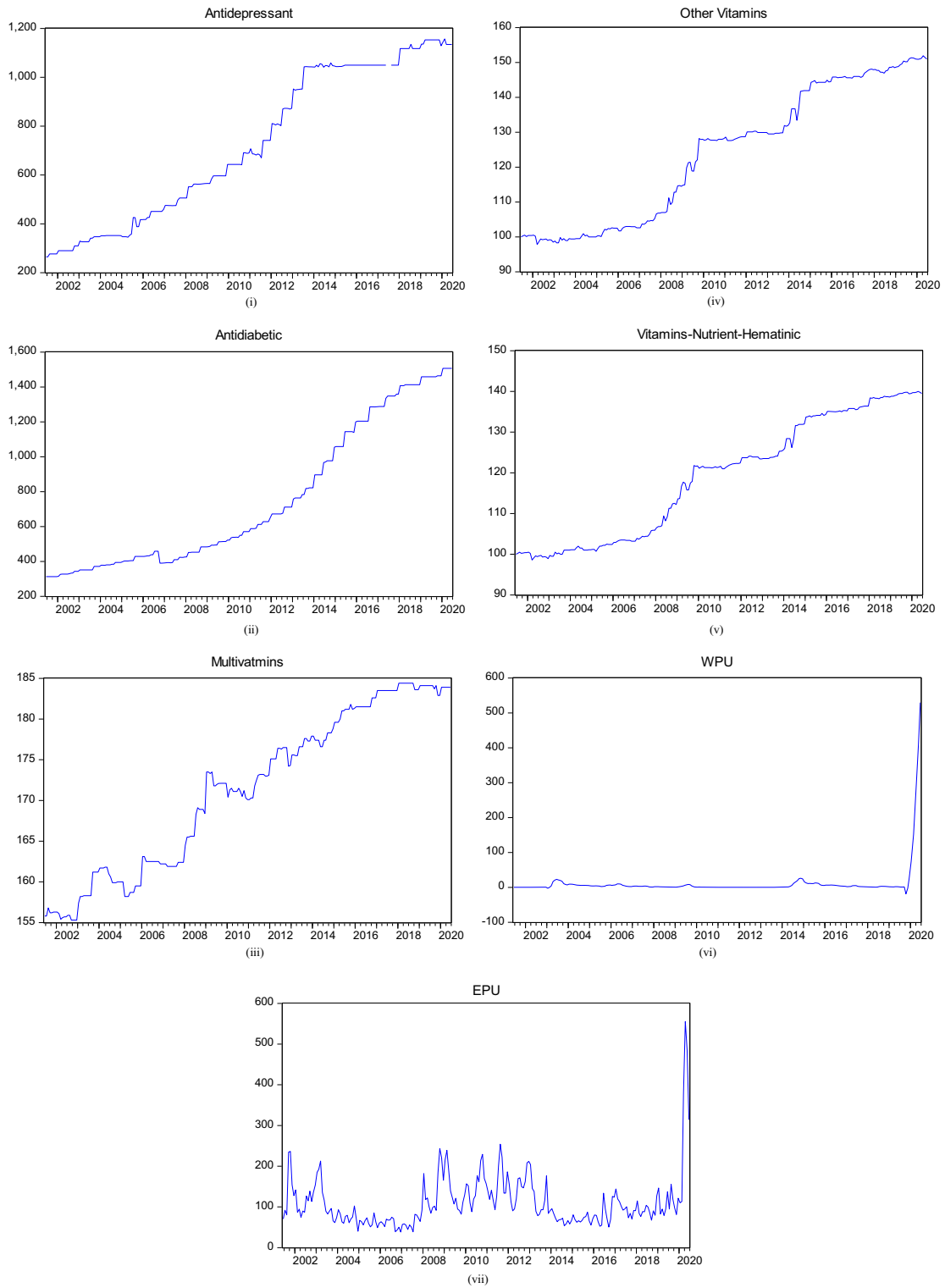
Fig. 2 The graphical illustrations of the examined variables

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