

1 **The Health Scare of COVID-19: Implication of Pandemics and the immune-**
2 **related pharmaceutical products spillovers in USA**

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31 **Abstract**

32 In view of the sector-wide effect of the nCOVID-19 pandemic in the United States and the probable
33 effect on certain over-the-counter (OTC) pharmaceutical products, the current study examined
34 potential inflation in the pharmaceutical industry due to uncertainty in pandemics. In this case, the
35 United States' producer price indexes vis-à-vis inflation of the immune-related pharmaceutical
36 items: multivitamin, vitamins nutrients and hematinic (V-N-H), other vitamins (other-V),
37 antidepressant, and antidiabetic were examined alongside the uncertainties arising from the world
38 pandemic and economic policy. Thus, the Diebold and Yilmaz (2012) result implied that the world
39 pandemic uncertainty contributed a significantly huge shock to the entire elements such that the
40 shocks to V-N-H and multivitamins are larger than the other examined pharmaceutical compounds.
41 Importantly, the statistical evidence implied that uncertainty arising from pandemic is responsible
42 for the severity of shock received by the indicated pharmaceutical products as against economic
43 policy uncertainty. Thus, a relevant policy inference is posited from the result of the study.

44 **Keyword:** nCOVID-19; pandemic; vitamins; uncertainty; United States

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46 **JEL codes:** C53, F64, H15

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54 **1. Introduction**

55 After more than 100 years that the influenza pandemic commonly called ‘Spanish Flu’ of 1918
56 ravaged the world, the novel severe acute respiratory syndrome coronavirus 2 (known as nCOVID-
57 19 or SARS-CoV-2) that has affected more than 216 countries and territories has remained a
58 prevailing mystery. Currently, about 600,000 human lives has been lost and almost 14 million
59 confirmed cases has been recorded globally (World Health Organization, WHO, 2020). Since the
60 emergency of the nCOVID-19 pandemic, governments across the globe and the collaborating
61 effort of both the intergovernmental agencies and the private institutions have extensively
62 deployed various measures to mitigate the spread of the virus or ‘flatten the curve’. In addition to
63 some of the measures that have been implemented (such as ‘lockdown’, ‘social distancing, travel
64 restriction/suspension across borders and other measures), scientists have proposed a few
65 inference. So far, the proffered pathogenesis of nCOVID-19 has obviously presented in three
66 phases: (1) the asymptomatic (2) symptomatic but a not severe phase, and (3) the symptomatic
67 stage with a severe and high viral load (Shi et al., 2020). As such, among other factors, the
68 pandemic is expected to have impacted both the manufacturing and the over-the-counter (OTC)
69 pharmaceutical products demand through the application of prevention mechanisms (Singh &
70 Avikal, 2020; Srivastava & Wagh, 2020).

71 Accordingly, the nCOVID-19 has been associated with the human immune system (Li et al., 2020;
72 Russell et al., 2020; Shi et al., 2020). In specific, Li et al (2020) opined that the body’s humoral
73 and cellular is stimulated by the immunity Antigens in the human cells, thus expectedly preventing
74 the advancement of the nCOVID-19 disease to the severe stage. Indicatively, the appropriateness
75 of human genetic structure, depicting a good health status, is responsible for the response of the
76 endogenous protective immune that is potentially capable of inhibiting the nCOVID-19 viral

77 replication as an antiviral immunity (Shi et al., 2020). This is because ongoing studies have noted
78 cases of nCOVID-19 sufferers that are either impervious to nCOVID-19 or immunocompromised
79 (Centers for Disease Control and Prevention, CDC, 2020; Nature, 2020). As such, scientists and
80 medical experts have consistently outlined the role of individuals in maintaining a boosted immune
81 system (Brand South Africa, 2020; DW, 2020; Tufan, GÜLER & Matucci-Cerinic, 2020). In this
82 perspective, in addition to living a healthy lifestyle, and the ‘phobia’ for COVID-19, the use of
83 supplements and nutritional medications or compounds such as vitamin C, antioxidants and other
84 compounds are being encouraged to booting the human immune system (Amin, 2020; Brand South
85 Africa, 2020).

86 In view of the above motivation, the current study look at the performance of the pharmaceutical
87 industries, especially those associated with the production of vitamins and other immune-related
88 drugs in the framework of the United States’ COVID-19 situation. Although Nicola et al (2020)
89 and Mason-D’Croz et al (2020) have earlier suggested the likelihood of spillover effect of the
90 COVID-19 pandemic to the socio-economic aspects, there is no study that specifically noted a
91 pharmaceutical sector-specific effect from the nCOVID-19 pandemic. Hence, the novelty of the
92 current study is that it offers a highlight of a few important contribution to the existing nCOVID-
93 19 literature in a unique pattern. Foremost, the study offers explanation on the probable
94 vulnerability of the producer price index (PPI) vis-à-vis inflation associated with the production
95 of the immune-related pharmaceutical compound or supplements: Vitamins nutrients, hematinic,
96 multivitamin. In context, the United States has reported an overall relative rise in import and export
97 prices since May 2020. In addition, the uncertainty associated with the economic policy and the
98 pandemic (i.e. the economic policy uncertainty and pandemic uncertainty) are employed in
99 examining the vulnerability of the aforementioned pharmaceutical compounds. Thus, with the

100 aforementioned novel approach and considering that United States has reported more cases and
101 number of death from COVID-19 than any other country in the world (~3.7 million reported cases
102 and ~140,000 deaths) according to the Johns Hopkins University and Medicine (2020), this study
103 is capable of providing a new significant insight.

104 In the other section of this study, the material employed, theoretical concept, the discussion of the
105 results, and the conclusion of the study are all described sequentially in section two. The discussion
106 of the results and conclusion remarks are rendered in section three and section four respectively.

107 **2. Material and Theoretical concept**

108 **2.1 Material**

109 The theoretical concept of the study is based on the use of the producer price indexes of
110 pharmaceutical items: multivitamin, vitamins nutrients and hematinic (V-N-H), other vitamins
111 (other-V), antidepressant, and antidiabetic. The indexes of the aforementioned pharmaceutical
112 materials were retrieved from the Federal Reserve Economic Data, FRED (2020)¹. In addition, the
113 employed world pandemic uncertainty index (denoted as WPU) and economic policy uncertainty
114 index (denoted as EPU) were retrieved from the world pandemic index (2020) and FRED (2020)
115 respectively. The aforementioned dataset covers the period of June 2001 to February 2020.

116 **2.2 Theoretical Concept**

117 In Table 1, the descriptive statistics of the employed aforementioned materials are presented. With
118 223 observations, the volatility is observed to be highest in index of antidiabetic, and followed by

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

119 antidepressant, EPU, other vitamins, V-N-H, WPU, and lastly by multivitamins. Therefore, we
120 proceed to employ the Diebold Yilmaz spillover index approach (Diebold & Yilmaz, 2012).

121

122 **Table 1: Statistical Inference**

123 **Common Statistics**

	WPU	V-N-H	OTHER-V	MULTIVATMINS	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
Std. Dev.	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	68405.62	20.27080	22.68026	19.00809	52.93633	28.78807	23.10812
<i>Probability</i>	<i>(0.00000)</i>	<i>(0.00004)</i>	<i>(0.00001)</i>	<i>(0.00008)</i>	<i>(0.00000)</i>	<i>(0.000001)</i>	<i>(0.00001)</i>
Observations	223	223	223	223	223	223	223

124

125 **Note:**

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127 **2.2.1 Spillover effect approach**

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

$$132 \quad y_t = \sum_{i=1}^p \Phi_i y_{t-i} + \varepsilon_t \quad (0, \Sigma) \quad (1)$$

133 such that

$$134 \quad y_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i} \quad (2)$$

135 is the moving average of the covariance stationary process and $y_t = (y_{1t}, y_{2t}, \dots, y_{Nt})'$ is $N \times 1$ vector
 136 of the individual return and volatility series. Also, Φ is $N \times N$, ε is the vector of disturbance that
 137 are assumed to be independent (not necessarily identically) distributed over time such that $A_i = \Phi_1$
 138 $A_{i-1} + \Phi_2 A_{i-2} + \dots + \Phi_p A_{i-p}$. A_0 is the identity matrix with $N \times N$ dimension, and $A_i = 0$ for all $i <$
 139 0 .

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

$$143 \quad \theta_{ij}^g(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h e_i)^2} \quad (3)$$

144 Such that the variance matrix of the error vector is Σ , σ_{jj} is the standard deviation of the error term
 145 for variable j , e_i is the selection vector with $1 = ith$ element and $0 = otherwise$. Then, the diagonally
 146 centralized elements (the own variance shares of shocks to variable y_i) is the fraction of the H-
 147 step-ahead error variance in forecasting y_i , given that $i = 1, 2, \dots N$. Also, the off-diagonal (cross
 148 variance shares or spillovers) are the fractions of the H-step-ahead error variances in forecasting
 149 y_i that are due to shocks to y_j , given that $j = 1, 2, \dots N$ and i is not equal j . Furthermore, to use the
 150 full information, each entry of the variance decomposition matrix is normalized by taking the row
 151 sum such that

$$152 \quad \theta_{ij}^g(H) = \frac{\theta_{ij}^g(H)}{\sum_{j=1}^N \theta_{ij}^g(H)} \quad (4)$$

153 where $\sum_{j=1}^N \theta_{ij}^g(H)$ (sum of the contributions to the variance of the forecast error) is not equal to
 154 1, but $\sum_{j=1}^N \tilde{\theta}_{ij}^g(H) = 1$ and $\sum_{i,j=1}^N \tilde{\theta}_{ij}^g(H) = N$

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

$$156 \quad S^g(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^N \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^N \tilde{\theta}_{ij}^g(H)} \times 100 = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^N \tilde{\theta}_{ij}^g(H)}{N} \times 100 \quad (5)$$

157 But, the Total directional spillover exhibits two indicators: “To others” and “From other”. Then,
 158 the directional spillover index from others is computed as

$$S_i^g(H) = \frac{\sum_{j=1}^N \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^N \tilde{\theta}_{ij}^g(H)} \times 100 = \frac{\sum_{j=1}^N \tilde{\theta}_{ij}^g(H)}{N} \times 100 \quad (6)$$

159

160 While the directional spillover index to others is calculated as

$$S_i^g(H) = \frac{\sum_{j=1}^N \tilde{\theta}_{ji}^g(H)}{\sum_{i,j=1}^N \tilde{\theta}_{ji}^g(H)} \times 100 = \frac{\sum_{j=1}^N \tilde{\theta}_{ji}^g(H)}{N} \times 100 \quad (7)$$

161

162 Moreover, the difference between the ‘to other’ and ‘from others’ indicators is calculated using

$$S_i^g(H) = S_i^g(H) - S_i^g(H) \quad (8)$$

163

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

$$S_{ij}^g(H) = \left\{ \frac{\tilde{\theta}_{ji}^g(H)}{\sum_{i,k=1}^N \tilde{\theta}_{ik}^g(H)} - \frac{\tilde{\theta}_{ij}^g(H)}{\sum_{j,k=1}^N \tilde{\theta}_{jk}^g(H)} \right\} \times 100 = \left\{ \frac{\tilde{\theta}_{ji}^g(H) - \tilde{\theta}_{ij}^g(H)}{N} \right\} \times 100 \quad (9)$$

165

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

171 **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	90.9	3.5	0.9	0.1	1.4	3.1	9.1
V-N-H	0.2	81.0	7.4	2.8	7.6	0.9	19.0
OTHER-V	0.4	29.3	54.1	13.4	1.9	0.9	45.9
MULTIVATMINS	2.7	14.3	1.6	79.7	0.2	1.4	20.3
ANTIDIABETIC	0.1	0.2	0.4	0.4	95.5	3.4	4.5
ANTIDEPRESSANT	6.7	0.5	0.1	5.2	1.6	85.9	14.1
Contribution to others	10.1	47.8	10.5	21.9	12.8	9.8	113.0
Contribution including own	101.1	128.8	64.5	101.6	108.3	95.6	(18.8%)

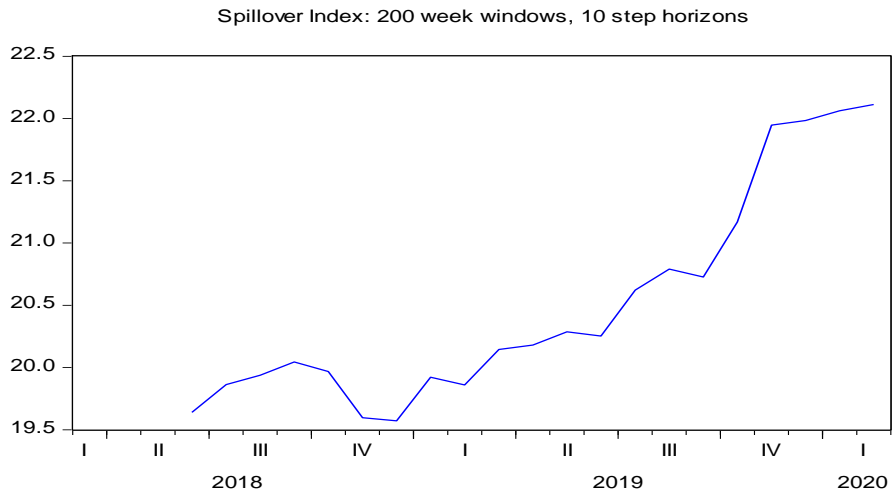
172 **With Pandemic (Panel B)**

	WPU	V-N-H	OTHER-V	MULTIVATMINS	ANTIDIABETIC	ANTIDEPRESSANT	From Others
WPU	98.4	0.6	0.3	0.1	0.4	0.2	1.6
V-N-H	16.3	69.4	5.5	1.9	6.1	0.8	30.6
OTHER-V	24.4	23.6	40.3	9.3	1.6	0.8	59.7
MULTIVATMINS	2.1	13.5	1.4	81.3	0.2	1.6	18.7
ANTIDIABETIC	58.2	0.2	0.6	0.1	39.9	0.9	60.1
ANTIDEPRESSANT	14.5	0.3	0.2	5.6	1.7	77.6	22.4
Contribution to others	115.5	38.3	8.0	17.0	10.0	4.3	193.1
Contribution including own	213.9	107.7	48.3	98.3	50.0	81.9	(32.2%)

With both Pandemic and Economic Policy Uncertainties (Panel C)

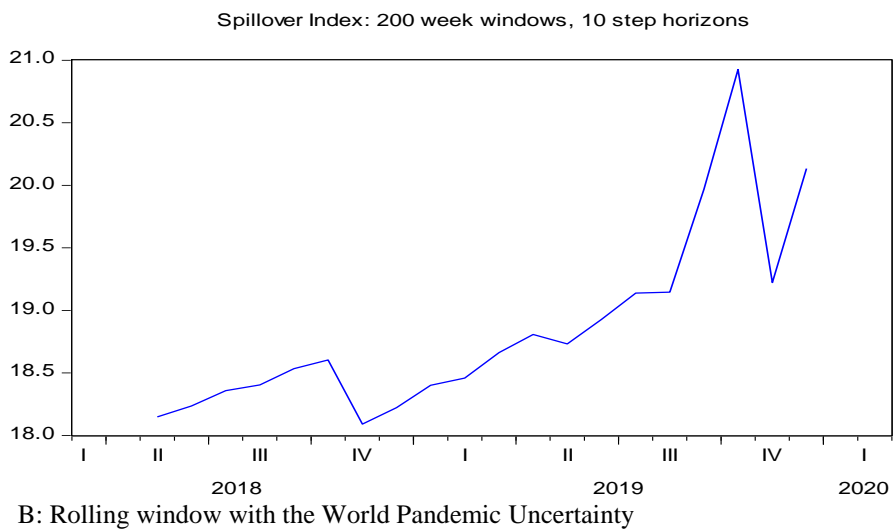
	WPU	V-N-H	OTHER-V	MULTIVATMINS	EPU	ANTIDIABETIC	ANTIDEPRESSANT	From Others
WPU	98.3	0.6	0.4	0.1	0.0	0.4	0.2	1.7
V-N-H	20.0	66.6	5.1	1.8	0.1	5.7	0.8	33.4
OTHER-V	23.9	23.8	40.1	9.4	0.5	1.5	0.8	59.9
MULTIVATMINS	1.0	13.4	1.8	81.6	0.6	0.2	1.4	18.4
EPU	91.1	1.3	0.1	0.2	6.9	0.4	0.1	93.1
ANTIDIABETIC	57.0	0.2	0.6	0.1	0.2	40.9	0.9	59.1
ANTIDEPRESSANT	8.3	0.5	0.0	5.5	3.6	1.5	80.6	19.4
Contribution to others	201.2	39.8	8.1	17.1	5.0	9.6	4.2	285.0
Contribution including own	299.5	106.4	48.2	98.7	11.8	50.6	84.8	40.7%

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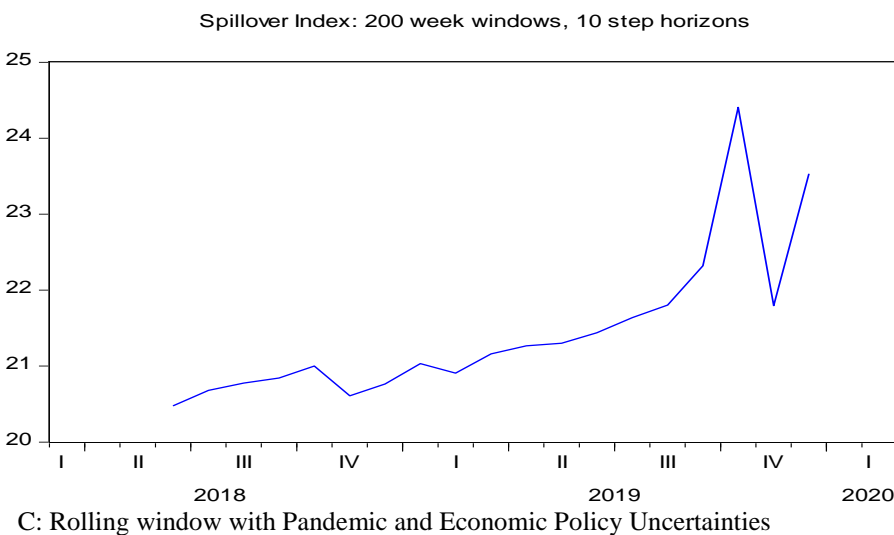


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Figure 1: A, B and C are respective visual evidence of

182 **3. Findings and discussion**

183 By employing the step-step procedures (equation 1 to 9) above, the approach is employed for three
184 different categories: (1) using the EPU (result in panel A of Table 2), (2) using the pandemic
185 uncertainty index (result in panel B of Table 2), and (3) employing with both the EPU and WPU
186 (result in panel C of Table 2). In the panel A, where the EPU was employed with the PPI of the
187 pharmaceutical materials, the total spillover index that signifies the total transfer of information
188 among the variable is 113.0%. However, with the inclusion of the EPU, the total spillover index
189 increased to 193.1% (see panel B). This implies that the uncertainty caused by the world pandemic
190 is capable of causing the spread of higher level of uncertainty as compared with the uncertainty
191 caused by economic policy (EPU).

192 In specific, as seen in panel B of Table 2, the world pandemic uncertainty contributes 115.5%
193 shock to other element of the estimation. In this context, antidepressant receives the highest shock,
194 followed by vitamins nutrients and hematinic (V-N-H) with 38.3% and multivitamins (5.6%). In
195 addition, these elements also received the three largest shock from others. Furthermore, the result
196 of the panel C (Table 2) provides an additional supporting evidence. This result implies that when
197 both EPU and WPU are employed along with the pharmaceutical compounds, the contribution of
198 shock from the WPU to other elements now increased to 201.2%. In this case, vitamins nutrients
199 and hematinic (V-N-H) and multivitamins receives the highest shocks with respective values of
200 39.8% and 17.1%. More importantly, the total spillover index (transfer of shock among the
201 estimated elements) now increased to 285.0%. This is an indication that world pandemic
202 uncertainty such as the COVID-19 is capable of contributing a significant amount of shock to the
203 production of pandemic-related medications.

204 **4. Concluding Remark**

205 This study examined the potential and magnitude of shock associated with production of immune-
206 related pharmaceutical products or compounds especially in the context of COVID-19 pandemic.
207 Considering that the severity of COVID-19 has been largely linked with the sufferers' immune
208 system and evidence of underlying illness, the industrial production of immune-related
209 pharmaceutical drugs such as the multivitamin, vitamins nutrients and hematinic (V-N-H),
210 antidepressant, and antidiabetic is expected to increase during the pandemic. As such, the current
211 study examined the spillover effect arising from the world pandemic uncertainty and economic
212 policy uncertainty to the producer price indexes of pharmaceutical items: multivitamin, vitamins
213 nutrients and hematinic (V-N-H), other vitamins (other-V), antidepressant, and antidiabetic in the
214 United States. The result posited that the uncertainty arising from the world pandemics such as the
215 COVID-19 in the United States is responsible for high shock in the producer price index of all the
216 examined pharmaceutical items. The study further showed that the shock arising from the world
217 pandemic uncertainty is significantly higher than that of the economic policy in the United States.

218 By implication, if the United States is interested in curbing the adverse effect of inflation associated
219 with the immune-specific pharmaceutical compounds, the government should foster policy that
220 target the COVID-19 scenario in the United States. With such effective policy, potential surge in
221 inflation in the pharmaceutical industry can be curbed, thus reducing the burden the consumers.

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