Modeling Producer Price Index and Consumer Price Index Pre and Post Coronavirus Pandemic

Sara Aliabadi
Northeastern Illinois University

Alireza Dorestani
Northeastern Illinois University

Consumer Price Index (CPI) and Producer Price Index (PPI) should move together because the cost of inputs is the most important determinant of the selling prices. However, our results, using monthly data from November 2009 to August 2023, show that they do not. At the micro level, to examine whether the increase in gap between PPI and CPI is the result of increase in indirect expenses or increase in profit margin, we limit our analyses to only one industry that is more prone to artificial price increases. The main purpose of our study is to investigate whether the rise in selling prices post the Coronavirus Pandemic period is the increase in input prices or unjustifiable greed. Our results show that companies in our selected industry were enjoying the rise in their revenues and earnings during Coronavirus Pandemic period.

Keywords: modeling, producer price index, consumer price index, coronavirus, pandemic

INTRODUCTION

Our research is an interdisciplinary study that include economics and accounting fields. The economics portion (macro level) deals with modeling Producer Price Index (PPI) and Consumer Price Index (CPI), while the accounting portion (micro level) deals with the case of pharmaceutical companies. We have collected data for PPI and CPI from the U.S. Bureau of Labor Statistics, and data for pharmaceutical companies from the Compustat database. We start with arguing that the PPI and CPI should move together because the cost of inputs is the most important factor for determining selling prices. PPI is an index that represents the average cost of inputs used in final selling price of products and services. Companies use inputs to produce goods and services. Companies start with the costs of their inputs and then add a percentage to cover their indirect expenses as well as their profits. Therefore, we should expect these two indexes, CPE and PPI, move together and show the same behavior during any time period. In short, the main purpose of our study is to investigate whether the rise in prices is the natural consequence of higher input prices or companies unreasonable price increases.

To assess the expectation that PPI and CPI move together, we use monthly data from November 2009 to August 2023 to find the best-fitted time series models for both PPI and CPI. Our results show that the best fitted model for PPI is an ARMA (5,5) model, while an ARMA (3,2) is the best fitted model for CPI. To find the best-fitted model, we ran different models and chose the one with the lowest Akaike Information Criterion and Schwarz Criterion scores to achieve the maximum efficiency. From comparison of the best fitted model for PPI and CPI, we conclude that the PPI and CPI do not show the same behavior and do not move together in a consistent way. That is, we conclude that the gap between PPI and CPI is not stable and changes during our selected period. The gap becomes larger starting from the beginning of the Coronavirus Pndemic period.

LITERATURE REVIEWS

The Following Is a Summary of Selected Prior Studies on the Producer Price Index and Consumer Price Index

Zieschang (2000) investigates four frameworks of price indices including Consumer Price Index (CPI), Producer Price Index (PPI), Export (XPI) and Import Price Index (MPI). in the system of economic statistics—the Producer Price Index (PPI), the Consumer Price Index (CPI), and the Export and Import Price Indices (XPI and MPI). He starts with providing basic mathematics of different price indices and briefly touches the Purchasing Power Parity as well as indices of employee wage and compensation including the Employment Cost Index (ECI).

Ellis and Price (2003) posit that in current free market economy prices are tied to consumer behavior. However, they argue that, even at the domestic level, the prices of imported products can affect pricing even though there exist some theoretical ambiguity as well as the problem of identification. Using the techniques of Cointegration together with the use of producer price data, they attempt to cope with these problems. In addition, they have documented some evidence for the existence of two long-run relationships. The first one deals with mark up demand relationship, and the second one deals with long-run equilibrium price relationship that include both domestic and foreign prices. They argue that a single-equation model may not necessarily be applicable for other indexes.

Kovacs (2003) he posits that calculation of Consumer Price Index is biased throughout the word. He refer to the 1.1 percentage point biased in CPI documented in the United States between years 1990 to 1995. As a result of this bias, many economic decisions made using the calculated CPI were not the optimal ones. He tries to investigate empirically the possible roots of these biases between 1991 and 2000 using Hungarian data. They concluded that the possible causes of bias are change in the country's political regime, change in calculation methodology, and researchers' misclassifications.

Gautier (2006) investigates the behavior of Producer Price Index (PPI) in France and other EU country members. They describe the research done by a group of European economists known as the Inflation Persistence Network (IPN) that performed a joint research on the persistence of inflation in the European countries. The IPN uses three data sources to perform its analyses theoretically and empirically. The tree data sources that they used were Producer Price Index, Consumer Price index, surveys of firms' price setting procedures, and aggregated area-wide price indices. He concluded with describing the patterns and policy implications inflation persistence. He provide more insight on the behavior of price setting procedures for the period from 1994 to 2005. Lastly, he raise some concerns about the method used to calculate Producer Price Index.

Vermeulen et. al. (2007) document the methodologies used in calculation of Producer Price Index in six European countries including Belgium, France, Germany, Italy, Portugal, and Spain. They used evidence available in other studies from those countries as well as new evidence they collected. They used monthly Producer Price index and followed six facts that other researchers used in similar studies. They collect evidence from available studies on each of those countries and provide new evidence. First, they posit that the change in PPI is infrequent. Second, they observed the heterogeneity in price change frequencies. Third, they argued that the ranking of price changes are similar among different countries. Fourth, they found no evidence of declining rigidity. Lastly, they concluded that the size of price changes are more than the size of inflation rate. They also concluded that CPI is less flexible than PPI.

Loupias and Sevestre (2010) estimate a Probit model to explain the change and magnitude of the change in PPI in French manufacturing sector. They used data from 1998 to 2005 for their model estimation. They concluded that the main cause of the change in PPI is the change in prices of intermediate products. They also concluded that firms react to the change in PPI indexes of related industries. Two other factors that they found responsible for the change are change in labor cost and change in the level of production. They also found that the unconstrained dynamic estimation model is preferable to the alternative model (the mode that depends on the state). Lastly, they observed an asymmetry in direction of the change. That is, when costs increase, firms react more to upward changes than they do to downward changes.

McCormack (2013) discusses the differences between PPI and CPI. He posits that the differences are methodological. That is, there are definitional and conceptual difference between these two indexes. He argues that the implications of these two indexes are different. While the PPI is used to calculate the read growth of Gross Domestic Products (GDP), the CPI is used to adjust the cost of goods and services in consumer baskets. Because of the above mentioned implications and uses, there exist definitional differences such as difference in compositions of good and services included in the basket, and the basket as well as the types of prices included in the basket.

Ahn et. al. (2016) investigate how change in prices of imported inputs affect the prices of domestic product. The approach they used was to use sector level prices and other information to analyze the input output model. They used an error correction model and concluded that the domestically produced goods are increased by seventy percent in Korean companies when imported input prices increase, but the rate for European companies are around hundred percent. Compare to the estimation models used in prior studies, they argue that their model can better estimate the degree of change in prices of domestic products because of change in prices of imported products.

Bilgin and Yilmaz (2018) investigate how the inflationary shocks in producer price affect manufacturing companies during the period beteen1947 and 2018 in the United States. They framework they used was based on the Diebold-Yilmaz Connectedness Index. This framework uses a vector autoregressive approach to decompose the observed variance. They concluded that, across industries, there is a Granger Causality link between input inflationary prices and output prices. They posit that the link is stronger when the economy observe supply side shocks, such as during global crude oil crises, and the link is weaker during the demand side shocks, such as during 2008 great recession. They also concluded that the tariff imposed by Trump in the first half of 2018 was responsible for increase in the system wide inflation connectedness in tariff-targeted industries such as machinery, fabricated and basic metals.

Du Et. al. (2019) investigate the relation between Producer Price Index and Consumer Price Index by using a Vector Error Correction (VEC) model. Using the VEC model, they find a long run equilibrium between these two indexes. They argue that there is a reciprocal relationship between CPI and PPI. That is, the PPI affects CPI, and at the same time, the CPI affects PPI. They also posit that the PPI affect itself both in short run and long run. Their results show that the relationship between current CPI and previous CPI is negative while the relationship between current CPI and precious PPI is positive.

Wei and Xie (2019) argue that for monetary policy the target should be PPI inflation and not CPI inflation only if these two indexes do not more together. They posit that the two inflations were moving together in the last century, but from the begging of the current century the association between PPI inflation and CPI inflation has decline strongly. They also concluded that since 2000, they has been a structural change in production all over the world. They use a multiple stage model for multiple countries to investigate the association between PPI inflation and CPI inflation. They have documented their expectations using available macroeconomics data. To confirm their findings, they have applied estimators such as the Least Squares Dummy Variables and Arellano-bond.

Li Et. al. (2019) use Johansen co-integration test to develop a vector-error-correction model to investigate the association between PPI and CPI. Consistent with prior studies, they concluded that in long run equilibrium, there is a co-integration association between these two indexes. They concluded there is a reciprocal relationship between PPI and CPI. That is, to some extent, PPI affects CPI, and at the same time and to some extent, CPI affects PPI.

Özpolat (2020) highlights the importance of producer price index and consumer index in calculation the change in prices of goods and services as well as the overall condition of macro economy; however, he posits that in most countries in Eastern Europe, the central banks gives priority to CPI in calculating price changes. He uses data from 1992 to 2017 from countries in the Eastern Europe to investigate the association between CPI and PPI. He concluded that in long run there is a casual relationship between these two indexes. As a policy implication, he recommends that central bank to use both PPI and CPI in achieving price stability. He also posits that change in input prices will ultimately lead to increase in output prices.

Morris (2021) investigate the trend between the CPI core and basic CPI in India to detect possible errors in calculation of CPI core. He raise concerns about the use of erroneous CPI core in significant polices such as monetary policy and targeting inflation. He argue that the Reserve Bank of India (RBI) have been using the CPI targeting approach since 2014, and in earlier years (2011 – 2014) the RBI used this approach even though it did not openly announce the approach. He argues that when an economic regime attempts to cut inflation when it is high, or attempts to increase inflation when it falls below the target, they regime must use accurate information with no biases. He posits that a regime uses the core CPI to target the inflation because the core CPI changes with lag and is less volatile in short run, while the non-core CPI, such as prices of fuel and food, is more volatile and quickly changes because of supply-side shocks. They posit that even though non-core inflation is not the target, its effects on core inflation through changes in expectations of consumers should be taken into account.

Weerakoon Et. al. (2021) define PPI as average selling price of domestically produce goods and services during a period. They posit that many analyses performed to investigate the association between PPI and Consumer Price Index (CPI). They use PPI data from 2014 to 2020 of textile manufacturing sector of Sri Lanka to develop a time-series model that best fits data. They used data for 81 companies in their analyses. After observing the unit root in their primary analyses, they use the change in PPI in their analyses. They compared eight time-series models and chose the best model based on the Akaike–information criterion (AIC). They also examined the possibility of the Granger Causality, but they found no evidence of the causality. They concluded that the best-fitted model is a vector error correction model (VECM).

Feygin (2022) develops a time-series model to determine the monthly changes in PPI and CPI as inflation indices, and mentions its risk management implications for low-income households living in urban area such as New York City. He suggests creating an inflation insurance fund that in both up cycle and low cycle inflation can provide large benefit to low-income households. He argues that existing models to forecast inflation fail to properly explaining the behavior of historical data. He also argues that the existing classification of inflation to core and non- core, and cyclical and a-cyclical fails to explain dependencies of many macro level indices. He argue that his model is more useful in risk management during periods of high inflation that can reduce returns and increase the volatility of portfolios. He also argues that his model can better manage the risk of high inflations for low-income households who spend more on items such as energy, food, and shelter.

Williams (2023) posits that the inflation rate in the United States is now at its highest level for decades, citing the distortion in supply chain and shortage of core commodities as important driving forces. He mentions that prior studies documented that the main reason for the high inflation is the transfer of increase in production costs incurred by producers to consumers; however, he cannot quantify and support prior findings, and the results are not the same at the aggregate level. He used the augmented Phillips curve estimation tool to break down PPI into certain commodity prices to disaggregate the PPI pass through coefficients, and found that the short run pass through rate of aggregate PPI is about seven percent. He also used a VARX tool to conduct the Toda-Yamamoto test and find causality between PPI and CPI in both directions. Lastly, he argues that many models with disaggregate PPI time-series provide more accurate forecasts compare to the basic model.

Williams (2023) posits that it a commonly knowledge that producer price inflation is the most important factor for consumer price inflation; however, he argues that data over an extended period do not support this common knowledge, so called cost-push inflation theory. To support his argument, he used different time series models such as causality test, regression analysis, impulse response functions, and structural break. He concludes that the rate of pass-through from PPI to CPI is between 7% and 12%, but he found that during significant periods, the direction is in both ways. He also finds that the magnitude of pass-through is different from states to states. In states in which PPI leads CPI, the level of pass through is small but consistent, and in states in which there is no causal direction, the level of pass-through is large but has shorter lives. He believes his findings have many implications for market participants and policymaker to better forecast inflations and reduce its negative consequences.

He (2023) posits that it is a well--known hypothesis that the shortage in labor market is a leading factor for observed higher prices. The test this hypothesis, she examined the association between wage inflation and consumer price inflation at the level of industry for the period from 2016 to 2022. She used PPI instead of CPI because she argues that, PPI data are available at the industry level. She also used the Quarterly Census of Employment and Wages to calculate the shortage in labor market. She mentions that we need more work before reaching valid conclusions.

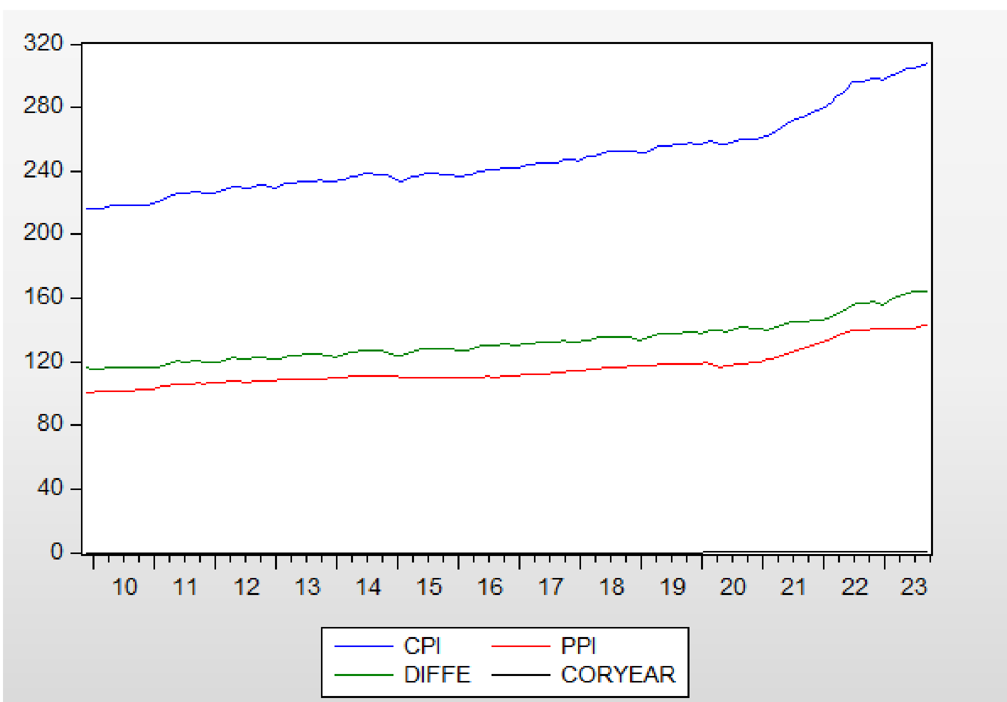
As we show in the above summary, the research on the relationship between PPI and CPI is rare, so we believe our study can be an important addition to the pool of existing literature in this area. We should emphasize that we have conducted an interdisciplinary study between economics and accounting fields, which is highly recommended by the Association to Advance Collegiate Schools of Business (AACSB) accreditation organization.

THE GAP BETWEEN PPI AND CPI:

As we discussed earlier, the difference between CPI and PPI is used to cover indirect expenses and profits. We hypothesize that the share of profit is larger than that of indirect expenses, and the gap becomes larger in favor of profit after the Coronavirus Pandemic has started. To test our hypothesis at the micro level, we chose all companies in the pharmaceutical industry because, we believe, this industry is more prone to over pricing compare to companies in other industries.

To achieve our goal, we first draw monthly PPI, CPI, and their differences from November 2009 to August 2023 in the following figure (Figure 1). As this figure shows, the gap between PPI and CPI is becoming wider when the time passes. We can observe that the slope of the difference curve becomes steeper after 2020 when the Coronavirus pandemic started.

FIGURE 1
CHANGE IN PPI, CPI, AND THEIR DIFFERENCES



To quantify our observation, we have first prepared the descriptive statistics for our data (Table 1) as well as correlation matrix (Table 2). The descriptive statistics show mean, median, maximum, minimum, standard deviations, as well as the measures of skewness for Consumer Price Index (CPI), Producer Price Index (PPI), the difference between CPI and PPI, as well as a dummy variable for Coronavirus Pandemic years (CORYEAR), which is equal to one after the start of the Coronavirus Pandemic and zero otherwise.

TABLE 1
DESCRIPTIVE STATISTICS FOR ALL GOODS AND SERVICES

	CPI	PPI	DIFFE	CORYEAR
Mean	248.4475	115.6574	132.7901	0.269461
Median	241.4280	111.3000	130.5490	0.000000
Maximum	307.7890	143.2110	164.5780	1.000000
Minimum	215.9490	100.2000	115.4870	0.000000
Std. Dev.	23.47028	11.14019	12.46400	0.445014
Skewness	0.968150	1.139862	0.814753	1.039213
Kurtosis	3.189358	3.405370	3.031826	2.079964
Jarque-Bera	26.33811	37.30689	18.48346	35.94899
Probability	0.000002	0.000000	0.000097	0.000000
Sum	41490.74	19314.79	22175.95	45.00000
Sum Sq. Dev.	91441.76	20601.25	25788.31	32.87425
Observations	167	167	167	167

TABLE 2
CORRELATION MATRIX FOR ALL GOODS AND SERVICES (ALL ARE HIGHLY SIGNIFICANT)

Correlation Probability	CPI	PPI	DIFFE	CORYEAR
CPI	1.000000 -----			
PPI	0.993651 (0.0000)	1.000000 -----		
DIFFE	0.994931 (0.0000)	0.977300 (0.0000)	1.000000 -----	
CORYEAR	0.821339 (0.0000)	0.819978 (0.0000)	0.813731 (0.0000)	1.000000 -----

MODELING PPI

We argue that in a perfect world, CPI must follow the PPI, so their differences should stay the same by the passage of time; consequently, we should come up with the same time series model to present their behavior. First, we have tested the potential candidate models for PPI. Table 3 shows the related statistics and commonly used model selection criteria for the candidate models for PPI. As shown in this table, the selected candidates for modeling PPI are AR (6), ARMA (5, 5), ARMA (3, 3), ARMA (3, 2), ARMA (3, 1), and ARMA (2, 1). As Table 3 shows, the model selection criteria, Alaike Information Criterion, Schwarz Criterion, and Hannan-Quinn Crierion choose ARMA (5, 5), and also the sum of squared residuals is the smallest among different models, Consequently, ARMA (5, 5) best represents the behavior of PPI. Table 4 represents other statistics for ARMA (5, 5).

TABLE 3
COMPARISON OF CANDIDATE PPI MODELS

PPI	Adjusted R-squared	S.E. of regression	Sum squared resid	Prob(F-statistic)	Akaike Info Criterion	Schwarz Criterion	Hannan-Quinn Criter
AR (6)	0.998652	0.371974	21.30818	0.000000	0.902520	1.036494	0.956919
ARMA (5,5)	0.999014	0.323704	15.71759	0.000000	0.753446	0.982156	0.846306
ARMA (3,3)	0.998678	0.386439	23.29628	0.000000	0.984810	1.136023	1.046197
ARMA (3,2)	0.998685	0.385487	23.33021	0.000000	0.973473	1.105784	1.027186
ARMA (3,1)	0.998693	0.384343	23.33968	0.000000	0.961814	1.075224	1.007854
ARMA (2,1)	0.998746	0.382160	23.36736	0.000000	0.945718	1.039837	0.983924

TABLE 4
SUMMARY STATISTICS FOR ARMA (5, 5) FOR PPII

METHOD: ARMA MAXIMUM LIKELIHOOD
Included Observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.268658	0.061603	4.361126	0.0000
PPI(1)	1.640177	0.049963	32.82774	0.0000
PPI(2)	-0.083077	0.095680	-0.868282	0.3866
PPI(3)	-0.130315	0.074609	-1.746646	0.0827
PPI(4)	-1.155214	0.111879	-10.32560	0.0000
PPI(5)	0.725862	0.056225	12.90998	0.0000
MA(1)	-0.469410	11.48492	-0.040872	0.9675
MA(2)	-0.582821	10.21747	-0.057042	0.9546
MA(3)	-0.804312	21.41677	-0.037555	0.9701
MA(4)	0.833007	29.96299	0.027801	0.9779
MA(5)	0.236525	9.550570	0.024766	0.9803
SIGMASQ	0.097022	1.257665	0.077145	0.9386

R-squared	0.999082	Mean dependent var	114.8551
Adjusted R-squared	0.999014	S.D. dependent var	10.30979
S.E. of regression	0.323704	Akaike info criterion	0.753446
Sum squared resid	15.71759	Schwarz criterion	0.982156
Log likelihood	-49.02909	Hannan-Quinn criter.	0.846306

F-statistic	14833.33	Durbin-Watson stat	2.002409
Prob(F-statistic)	0.000000		

Table 3: Comparison of Can Table 3: Comparison of Candidate Models for PPI
didate Models for PPI

MODELING CPI

Table 5 shows the related statistics and commonly used model selection criteria for the potential models for CPI. As shown in this table, the selected potential models are AR (6), ARMA (5, 5), ARMA (3, 3), ARMA (3, 2), and ARMA (3, 1). As Table 5 shows, the model selection criteria, Alaike Information Criterion, Schwarz Criterion, and Hannan-Quinn Crierion choose ARMA (3, 2), and also the sum of squared residuals of this model is among the smallest ones. Consequently, ARMA (3, 2) best represents the behavior of CPI. Table 6 represents other statistics for ARMA (3, 2).

TABLE 5
COMPARISON OF POTENTIAL CPI MODELS

CPI	Adjusted R-squared	S.E. of regression	Sum squared resid	Prob(F-statistic)	Akaike Info Criterion	Schwarz Criterion	Hannan-Quinn Criter
AR (6)	0.998801	0.730181	82.10733	0.000000	2.251456	2.385431	2.305855
ARMA (5,5)	0.998895	0.714500	77.08700	0.000000	2.271320	2.480972	2.356442
ARMA (3,3)	0.998937	0.726960	82.44154	0.000000	2.252453	2.403666	2.313840
ARMA (3,2)	0.998941	0.725453	82.62620	0.000000	2.241502	2.295216	1.983876
ARMA (3,1)	0.998950	0.722411	82.45664	0.000000	22.29542	2.341788	2.274418

METHOD: ARMA MAXIMUM LIKELIHOOD

TABLE 6
SUMMARY STATISTICS FOR ARMA (5, 5) FOR PPII

Included Observations: 164

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.029156	0.928299	3.263124	0.0014
CPI(1)	0.947251	0.076764	12.33984	0.0000
CPI(2)	0.197805	0.086129	2.296629	0.0230
CPI(3)	-0.159176	0.068757	-2.315048	0.0219
MA(1)	0.657064	0.078657	8.353513	0.0000
MA(2)	-0.033776	0.062069	-0.544175	0.5871
SIGMASQ	0.503818	0.047648	10.57374	0.0000

R-squared	0.998980	Mean dependent var	247.3795
Adjusted R-squared	0.998941	S.D. dependent var	22.29542
S.E. of regression	0.725453	Akaike info criterion	2.241502

Sum squared resid	82.62620	Schwarz criterion	2.373813
Log likelihood	-176.8032	Hannan-Quinn criter.	2.295216
F-statistic	25633.43	Durbin-Watson stat	1.983876
Prob(F-statistic)	0.000000		

Even though by eyeballing we can see that the gap between CPI and PPI became wider after the start of the Coronavirus Pandemic (Covid-19) period, we have statistically tested this observed phenomenon. Table 7 shows the results.

DEPENDENT VARIABLE: CPI

Method: Least Squares
Included Observations: 167

TABLE 7
SUMMARY OF REGRESSION OUTPUT

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PPI	2.005034	0.029740	67.41815	0.0000
COVID	2.583124	0.696652	3.707909	0.0003
C	15.66882	3.258168	4.809089	0.0000

R-squared	0.988321	Mean dependent var	248.4475
Adjusted R-squared	0.988178	S.D. dependent var	23.47028
S.E. of regression	2.551877	Akaike info criterion	4.729336
Sum squared resid	1067.981	Schwarz criterion	4.785348
Log likelihood	-391.8996	Hannan-Quinn criter.	4.752070
F-statistic	6938.937	Durbin-Watson stat	0.082245
Prob(F-statistic)	0.000000		

CASE OF PHARMACEUTICAL COMPANIES

The above discussions and analyses have revealed that at the macro level, the gap between PPI and CPI is not constant and is becoming wider as the time passes. As indicated earlier in this paper, the CPI is an index for the average selling prices of all goods and services produced in a country. Producers start with PPI which is an index for average cost of inputs used in production of goods and services in a country. In a sustainable and healthy economy, there should be a reasonable difference between PPI and CPI. That is, the difference between PPI and CPI consists of two main components. The first component is the indirect expenses (other than direct expenses or PPI) that firms would incur, and the second component is the profit margin that firms expect to earn. When the difference begins to rise, it indicates that indirect expenses or profit margins are rising. To examine, at the micro level, whether the increase in gap between PPI and CPI is the result of increase in indirect expenses or increase in profit margins, we study pharmaceutical companies. We chose pharmaceutical companies because they are more prone to artificial price increases since (1) they spend extensive money in research and development activities, and (2) their products are mostly necessities for their customers.

For our analyses, we have used a sample of 94 pharmaceutical companies listed on NYSE. Our data includes the period between 2009 and 2022. Table 8 shows descriptive statistics of data for these companies.

As this table shows, our sample includes both small and large companies with total revenue ranging from $9.3 million to $18.2 million, cost of goods sold ranging from $3.9 million to $6.5 Million, and total operating expenses ranging from $8 million to $15.1 million.

TABLE 8
DESCRIPTIVE STATISTICS FOR PHARMACEUTICAL COMPANIES

	REVE	CGS	TEXP	NEIN
Mean	12046.25	4485.816	10084.33	1342.508
Median	11421.63	4215.168	9645.940	1213.180
Maximum	18180.40	6517.422	15051.36	2383.784
Minimum	9321.916	3843.644	7968.326	871.6001
Std. Dev.	2650.641	773.1262	2128.601	435.2809
Skewness	0.870838	1.597206	0.911604	0.976927
Kurtosis	2.898958	4.596367	2.972957	3.328109
Jarque-Bera	1.775458	7.439048	1.939480	2.289700
Probability	0.411589	0.024246	0.379182	0.318272
Sum	168647.5	62801.42	141180.7	18795.11
Sum Sq. Dev.	91336643	7770413.	58902256	2463102.

Table 9 shows the regression output for revenue as a dependent variable and cost of goods sold and total operating expenses as independent variables. As this table shows, the ANOVA results as well as coefficients of independent variables are highly significant, indicating that these variables are important factors explaining the revenue.

DEPENDENT VARIABLE: REVE

Method: Least Squares

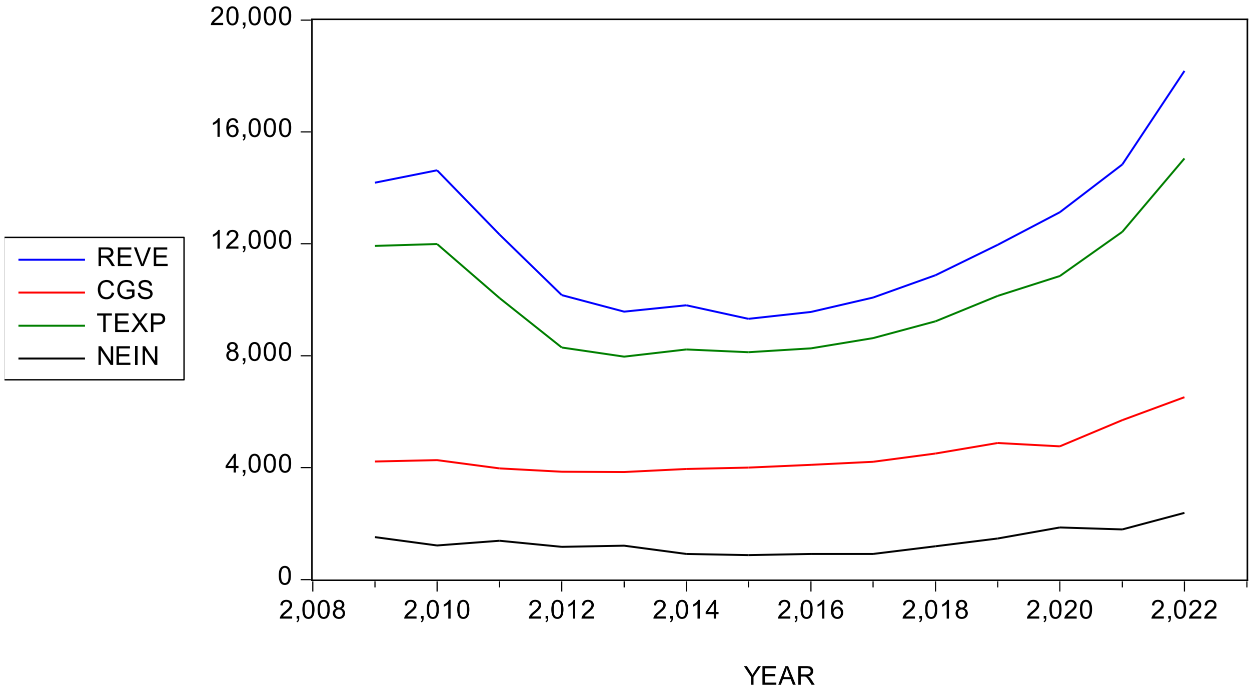
TABLE 9
REGRESSION OUTPUTS FOR PHARMACEUTICAL COMPANIES

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CGS	-0.242910	0.103640	-2.343777	0.0371
TEXP	1.303092	0.045796	28.45425	0.0000

R-squared	0.994982	Mean dependent var	12046.25
Adjusted R-squared	0.994564	S.D. dependent var	2650.641
S.E. of regression	195.4275	Akaike info criterion	13.51982
Sum squared resid	458303.0	Schwarz criterion	13.61111
Log likelihood	-92.63874	Hannan-Quinn criter.	13.51137
Durbin-Watson stat	0.921133		

Figure 2 shows the change in Average Revenue, Cost of Goods Sold, Operating Expenses, and Net Income for Pharmaceutical Companies for fourteen years from 2009 to 2022. As this figure shows, pharmaceutical companies were enjoying the rise in their revenues and net income during the Coronavirus Pandemic period (2020 to 2022), ignoring the widening gap between their revenues and their cost of goods sold and other expenses.

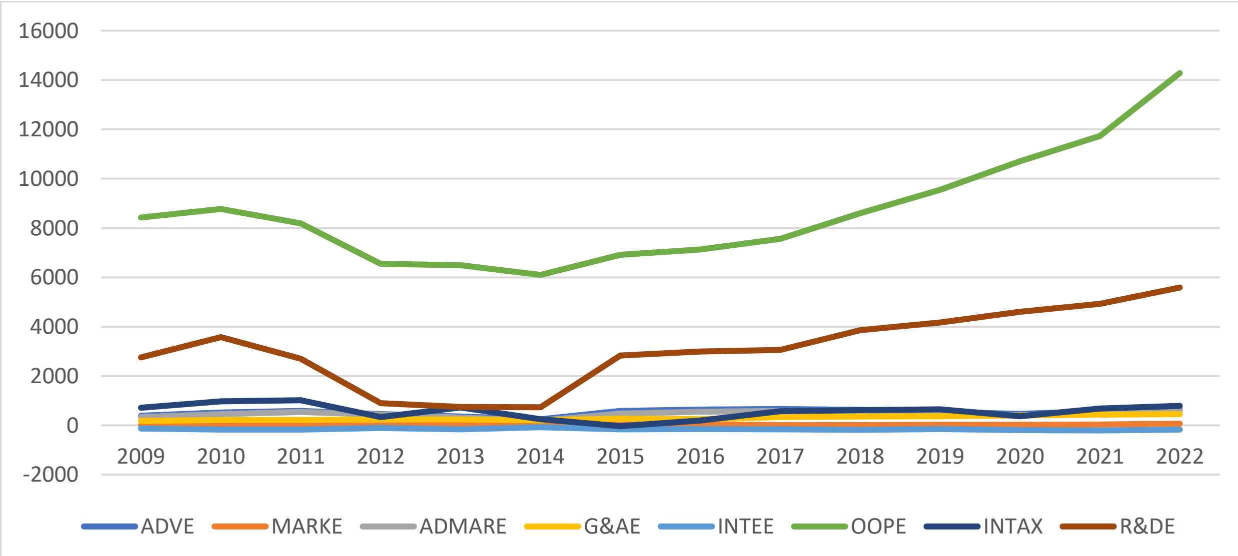
FIGURE 2
CHANGE IN AVERAGE REVENUE, COST OF GOODS SOLD, OPERATING EXPENSES, AND NET INCOME FOR PHARMACEUTICAL COMPANIES



REVE = Average Revenue
CGS = Cost of Goods Sold
TEXP = Operating Expenses
NEIN = Net Income

In the next step, we have analyzed the change in operating expenses during the same period (2009 to 2022). Figure 3 shows the pattern of change in major components of operating expenses such as advertising expenses, marketing expenses, general and administrative expense, other operating expenses, interest expenses (minus interest revenues), and income tax expenses. As this figure shows, the change in almost all expenses are moderate, except for other operating expenses. Other operating expenses are rising and usually companies do not provide full disclosure for this type of expenses in their financial statements, so we could not investigate them.

FIGURE 3
CHANGE IN COMPONENTS OF OPERATING AND NON-OPERATING EXPENSES OF PHARMACEUTICAL COMPANIES



ADVE =Advertising Expenses
MARKE = Marketing Expenses
ADMARKE= Sum of Advertising and Marketing Expenses
G&AE = General and Administrative Expenses
INTEE = Interest Expenses
OOPE = Other Operating Expenses
INTAX = Income Tax Expenses

CONCLUSIONS AND POLICY IMPLICATIONS

As we discussed earlier, Consumer Price Index (CPI) and Producer Price Index (PPI) should move together because the cost of inputs is the most important determinant of the selling prices. PPI is an index that represents the average cost of inputs used in final selling price of products and services. Companies use inputs to produce goods and services. Companies start with the costs of their inputs and add a percentage to cover their indirect expenses as well as their profits. Therefore, we should expect these two indexes, CPE and PPI, move together and show the same behavior during any time period. However, our results, using monthly data from November 2009 to August 2023, show that CPI and PPI do not move together, and the time series models representing these two indexed are not the same.

The best fitted model for PPI is an ARMA (5,5) model, while an ARMA (3,2 is the best fitted model for CPI. We selected two models based on the commonly used selection criteria in time-series analyses, criteria such as Akaike Information Criterion and Schwarz Criterion. In other words, we conclude that the gap between PPI and CPI not only changes during our selected period, but also the gap becomes wider starting from the beginning of the Coronavirus pandemic period.

The above discussions and analyses have revealed that at the macro level, the gap between PPI and CPI is not constant and is becoming wider as the time passes. At the micro level, to examine whether the increase in gap between PPI and CPI is the result of increase in indirect expenses or increase in profit margin, we limit our analyses to Pharmaceutical companies that are more prone to artificial price increases as a result of (1) extensive spending in research and development activities, and (2) their products are mostly necessities for their customers. For our analyses, we have used a sample of 94 pharmaceutical companies listed on NYSE. Our data include the period between 2009 and 2022. In the first step, we regressed revenue as a dependent variable against the cost of goods sold and total operating expenses. Our results show that cost of goods sold and operating expenses are important determinants of the revenue.

Our results also show that pharmaceutical companies were enjoying the rise in their revenues and earnings during the Coronavirus pandemic period, from 2020 to 2022, ignoring the widening gap between their revenues and their cost of goods sold and other expenses. In the next step, we have analyzed the change in major components of operating expenses. Including: advertising expenses, marketing expenses, general and administrative expenses, other operating expenses, interest expenses (minus interest revenues), and income tax expenses. Our results show a moderate change in almost all components of operating expenses, except for other operating expenses. In other words, other operating expenses are rising and there is no way for us to determine the reasons for this change because usually companies do not provide full disclosure for these types of expenses in their financial statements. In short, our results do not justify the price increases by pharmaceutical companies.

As our first contribution, we believe that our study is the first interdisciplinary study that has opened a window of opportunities for researcher to do more studies at the micro level to see whether companies in other industries have shown the same pattern, price increases, that we have observed in pharmaceutical companies. As our second contribution, we also believe that our results have implications for policy makers and regulators. We recommend that policy makers and regulators oversee the change in selling prices of different companies in different industries, especially during the unusual periods, such as the one that we observed during the Coronavirus Pandemic period.

REFERENCES

Ahn, J., Park, C., & Park, C. (2016). *Pass-Tough of Imported Input Prices to Domestic Producer Prices: Evidence from Sector-Level Data.* Working Paper. International Monetary Fund, pp. 1–24.

Bigin, M., & Yilmaz, K. (2018). Producer Price Inflation Connectedness and Input-Output Networks. Working Paper, pp. 1–30.

Ellis, C., & Price, S. (2003). *The Impact of Price Competitiveness on UK Producer Price Behavior.* Wording Paper No. 178. Bank of England, pp. 1–33.

Feygin, F. (2022). *A New Model for US Inflation Indices and its Implications for Risk Management and Lower Income Households.* Wording Paper, pp. 1–18.

Gautier, E. (2006). *The Behavior of Producer Prices: Some Evidence from the French PPI Micro Data.* Working Paper. European Central Bank, pp. 1–47.

He, Z. (2023). *Inflation vs Wage by Industry Post Covid-19.* Working Paper, pp. 1–4.

Kovacs, I. (2003). *Biasing Factors of the Consumer Price Index.* Discussion Papers. Institute of Economics. Hungarian Academy of Science. Budapest, pp. 1–26.

Li, S., Tang, G., Yang, D., & Du, S. (2019). Research on the Relationship between CPI and PPI Based on VEC Model. *Open Journal of Statistics*, *9*, 218–229.

Loupias, C., & Sevestre, P. (2010). *Cost, Demand, and Producer Price Changes.* Working Paper. European Central Bank, pp. 1–55.

McCormack, K. (2013). *How Does the Producer Price Index differ from the consumer Price Index? Information Note*. Central Statistics Office, Ireland, pp. 1–3.

Moriss, W.S. (2021). The Error in the CPI Which Precludes its use in Inflation Targeting. *GIM Working Paper Series*, pp. 1–8.

Qzpolat, A. (2020). Causal Link between Consumer Prices Index and Producer Prices Index: An Evidence from Central and Eastern European Countries (CEECS). *ADAM Academy Dodyak Billimier Dergish*, *10*(2), 319–332.

Vermeulem. P., Dias, D., Dossche, M., Gautier, E., Hernando, I., Sabbatina, R., & Stahl, H. (2007). *Price Setting in Euro Areal: Some Stylized Facts from Individual Producer Price Data.* Working Paper. The Banco De Espania, 1–55.

Weerakoon, H.L.A. , Jayawardhana, K.J.U.M., Piyasena, K.N.T., & Hewaarachchi, A.P. (2021). A Time Series Analysis to Forecast Monthly Producer Price Indices of Manufacturing Sector and Textile Manufacturing Subcategory of Sri Lanka. *12th International Conference on Business & Information ICBI*, University of Kelaniya, Sri Lanka. ISSN 2465-6399, pp. 130–140.

Wei, S., & Xie, Y. (2019). The Wedge of Century: Understanding a Divergence Between CPI and PPI Inflation Measures. *NBER Working Paper Series*, pp. 1–62.

Williams, C.J.M. (2023). *A Critical Exploration of United States Producer Price*. Wording Paper, pp. 1–65.

Williams, C.J.M. (2023). *Unraveling Producer Price Inflation Pass-Through: Quantifications, Structural Breaks, and Causal Direction.* Wording Paper, pp. 1–20.

Zieschang, K. (2000). *A Framework for Price Statistics.* Working Paper. International Monetary Fund, pp. 1–45.