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Recent Long-Term Management of Relation Across Czech-Republic Price Indices and Exchange Rates

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Abstract:

Purpose: *This article examines the data related to four nominal variables to illustrate their long-term joint evolution, emphasizing the process of coordinating economic agents to adjust economic decisions when inflation accelerates, and the impulse on other markets, in particular the foreign exchange market. The article appears as relevant to the extent that the long-run common evolution of the nominal variables is indicative of a kind of indexation. The article is relevant to confirm some economic interaction of agents and markets in the framework of a monetarist economic mechanism. With the co-integration approach we bear out common trends in the time series used as an assertion of the coherence in the adjustment between a set of nominal variables.*

Design/Methodology/Approach: *We run a set of co-integration techniques embedding three prices indices and the nominal exchange rate for the Czech Republic. We run the augmented Dickey Fuller test for bearing out long-run relationships between pair of sequences and for asserting the same order of co-integration across the four sequences. As recently developed, we conduct a multivariate strategy for bearing out the existence of at least one co-integration vector, resorting to the Johansen rank test. Later, the Error Correction Model demonstrated the short run dynamics, supporting the idea that the Consumer Price Index CPI explained by the dynamics of the model, adjusted to the equilibrium in the next period.*

Findings: *The co-integration technique pursued the identification of common stochastic trends in four Czech time series. We confirmed the stationarity of the four variables in first differences, confirming a convergence to a long run equilibrium. When applying the Error Correction Model, we born out the adjustment mechanism towards the long run equilibrium, when any short rung shock affected the structure of the model. When confirming the common long-run trends in the indices and the exchange rate, the variables in questions loom as reliable predictors of the objectives of macroeconomic stabilization.*

Practical Implications: *The article provides support for the close long-run evolution of nominal variables, as a set of indicators of the evolution of the mechanism of prices in the economy. The conclusions endorse the use of nominal tools in pursuing the nominal stabilization of the economy. The conclusion reinforces the relevance of alternative prices indices and the exchange rate as predictors of the behavior of headline inflation. Our*

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conclusions can serve as a support for the tracking of alternative variables to anticipate the stabilization path.

Originality/Value: *This article emphasizes the connection between nominal time series during a period marked by an unusual inflation upsurge, and the subsequent phase of monetary tightening and convergence towards lower inflation rates. The discussion is very relevant to the extent that amid a process of indexation of nominal variables, the economy is looking for a nominal anchor able to give credibility to economic policy. In such terms in Czech Republic the economic policy has transmitted some signals of a restrictive monetary policy and fiscal adjustment intended to stick the expectation of the economic agents, eager to find a nominal anchor.*

Keywords: *Cointegration, Error Correction Model, inflation, long-term management, Czech Republic.*

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1. Introduction

The process of predicting accurately the behaviour of prices is worthy for the policy makers in order to formulate the monetary policy, even more in times of full implementation of the inflation target strategy. In this article we work with some determinants of the consumer price index, in order to elucidate the long run equilibrium relationship across variables.

There are several reasons for analysing the long term equilibrium behaviour between the Producer Price Index (PPI) and the Consumer Price Index (CPI). In recent times, the incorporation of more global intermediation activities can affect the PPI and, in consequence, the equilibrium conditions in both sequences of prices. Furthermore, any misalignment across indices can convey inefficiencies in the implementation of the monetary policy (Thalassinos *et al.,* 2022).

In pursuing this analysis of integration, the structure of the article is arranged as follows: the introduction describes the antecedents of the international discussion. The second part develops the econometric strategy, and finally the conclusions are proposed.

In this analysis of equilibrium, the cointegration procedure is the most suitable strategy for drawing the best long run analysis of variables, and the Error Correction Model assesses the short run shocks, and the subsequent return to equilibrium. In such terms the combined regression-time series model, provide clues and the conclusions can be used as effective forecasting tool of economic policy. As Shang and Yinxi (2019) assert, in the case of strong co-movements in both indices, in practical terms, the distinction between the two indicators would be irrelevant.

Our system is composed by three prices indices and the exchange rate, in the vein of the studies intended to explain long term equilibrium relationship in the time series giving some clues to the monetary policy. The inclusion of the exchange rate is related to the traditional studies stressing the pass through as a widespread framework for analysing the relevance of the transmission from exchange rate to inflation.

In the Czech Republic previous studies already have focused on this analysis of convergence across indices Khan (2018), Babecká-Kucharčuková (2009), Josifidis *et al.* (2009) and Dorestani and Arjomand (2006). Specifically, there is a clear effect from the exchange rate to three kind of prices, imports, producer prices and consumer prices (Thalassinos *et al.,* 2015). The pass throw is especially strong on the imports obviously, but on producer price as well, to the extent that there is one important composition of foreign goods and services in it (Hajek and Horvath, 2015).

This focused effect on the PPI is asserted by Khan *et al.* (2018) emphasising one additional clue: the pass throw tends to be powerful in small economies, in open systems with wide international transactions, and with a volatile monetary policy.

The relationship between the prices at production level and the CPI becomes an objective of analysis suitable for the typical contrasts verifying long run relationships, and the test for causality of Granger. In fact, the retailing sector adds value in a subsequent stage after the upstream stage at the producer level. In the context of the production chain, the CPI receives the effect of the price of raw materials at the production level (Tiwari, 2012).

The producers commonly contract with retailers and they do not sell to consumers directly. The price in consumer markets relies on contractual relations which depend on the structure at the wholesale and the consumer levels. In such terms, the whole sale margins increase when the retail segment becomes less competitive (Pallis and Katsouli, 2003)

The cause-effect between the upstream and downstream indices seems ambiguous, because the direction of causality could be either way: from wholesale prices to consumer prices or vice versa. In fact, as long as an index is very intricate in terms of its individual components, the study of overall indices becomes complex.

In fact, the composition of both indices conveys some considerations. As long as the PPI is composed not only by intermediate goods but also some by finished goods, the variation in producer prices of intermediate goods may take a bit longer to reverberate the CPI, whilst the effect of finished goods may transmit quickly (Arby and Ghouri, 2016; Jindrichovska *et al.*, 2020).

The indices compositions in terms of good and services becomes relevant for the final result of the index itself, and for imparting information to policy makers. Yunjong *et al.* (2023) discovered that both sectors conveyed increased volatility into the inflation measurement before 1990. However, in the subsequent years, most of the variability consists in the contribution of the services sector.

As long as the Producer Price Index pertains to an upper level of commercialization, has a straightforward effect on the Consumer Prices Index, whose focus is the final transactions involving directly the consumer. In this view is assumed that retail prices incorporate the previous cost increments occurred at the wholesale segment of production.

In most cases, the PPI is assumed as accurate predictor of Consumer Price Index, considering that the former is capturing the production conditions of groups as crude materials, intermediate goods, and finished goods. However, there some caveats in the methodological construction of indices, to the extent that the PPI is mainly composed by domestic goods, whilst the construction of the CPI takes a more comprehensive basket of goods and services (Sidaoui, 2010).

This aspect about the composition of baskets becomes relevant to the extent that it exists empirical evidence about the link between the higher volatility in inflation to price of services. In addition, there are indications that goods and services inflation have differentiated responses to monetary policy (Yunjong *et al.*, 2023). In fact, in times of predominance of inflation targeting strategies, a clear prediction about the behaviour of prices and the availability of more information make more efficient the formulation of economic policy (Ryczkowski, 2021).

Clearly, the effect towards a downstream level ends up to be very relevant and this is the most general causation applied. This is quoted as the production chain view (Dorestani and Arjomand, 2006), or is described as a cost-push process. Whilst Khan *et al.* (2018) assert that upon verifying the cointegration between indices, the PPI can be used for monitoring the future path of CPI.

However, the inverse causality is plausible as well, mainly because the wages adjustment affecting the labor intervening in the production the upper level of production (at the producer level) (Özpolat, 2020). Other plausible reason is because the producers unfold a strategy of mark up or because workers develop a mechanism of indexation looking for a compensation facing an unanticipated inflation (Neeraj and Anuradha, 2016).

Accordingly, Arby and Ghouri (2016) identify a demand-pull shock influencing the CPI at the first stage which finally reverberates the upstream prices. In a such context, the retailer changes the final prices but modify their pattern of purchases from wholesalers and producers, suggesting a transmission form CPI to wholesale and producer prices.

In any case, the co-moves between prices indices are not constant across the time. Shang and Yinxi (2019) have describe a stylized fact in terms of a reduction in the PPI alongside with a slight increase in the CPI. Facing this scenario, the monetary policy inspired in the PPI information, ends up to be more expansionary than in other cases. In fact, during the past century the correlation between the two indices demonstrated to be closer. Just recently, the enlargement of the international productive process conveyed any kind of divergence between PPI and CCI.

One plausible explanation to this reduction in the correlation between the two indices can be ascribed to the enlargement of the international production chain. Besides, the simultaneous increase in the market competition drives a reduction in the mark-up margins of manufacturing firms, relatively to services conveying a relative divergence across PPI and CPI (Shang and Yinxi, 2019).

Regarding the relationship between exchange rate and CPI, there is evidence of a clear mechanism of pass throw in the Czech Republic, although the effect on the diverse group of goods and service turned out to be neatly differential. Besides, there is evidence about a non-symmetric effect in the upward or downward movements of the exchange rate.

In the analysis of the pass throw process, it has been concluded recently that the movements are not transmitted fully, because they dissipate along the diverse chain processes. The effects are fully straightforward on some groups as energy and other commodity prices. This is the reason because in our model appears two proxies of this sequences.

Normally, the prices arise alongside with devaluation, but they demonstrated to be stickier in appreciation episodes (Hájek and Horváth, 2015). In any case, the exchange rate effect must be analysed in the context of an inflation targeting strategy, which started in 2012, giving more flexibility to exchange rate. In a such regime, several studies conferred a higher pass throw on PPI than on CPI (Khan *et al.*, 2018).

2. Econometric Strategy

As discussed above, the estimation of the long run dynamics between price indices is relevant specially during periods characterised by an upsurge in inflation, as a procedure for detecting the prediction capacity of the referred time series. The

results turn out to be indicative for purposes of economic policy and for designing a path of price stabilization and achievement of goals.

We pursue to identify the behavior of long-run stochastic trend of a set of prices indices and the nominal exchange rate. Our econometric strategy is timely, due to the recent outburst in inflation at an international level, and the decisive effort by the economic authorities to resume the price stabilization.

We apply the traditional analysis of cointegration intended to elucidate the long run equilibrium behavior of time series. Our co-integration model is tractable, as it considers a set of variables that demonstrate to be determinant in the path of domestic prices. These nominal variables change dynamically and receive feedback from the behavior of other ones, making up a dynamic system. We perform the estimations under the spirit of Engle and Granger tradition, assuming constancy in the estimated parameters (Schmidt and Karsten, 2022).

This traditional procedure inspired in Engle and Granger (1987) has been widely applied in studies of long term equilibria analysis, including the analysis of the short run adjustment in case of transitory disequilibria. In this vein of the co-integration studies recent applications has been applied.

The last stage in our procedure is the run of the Granger Causality between pairs of time series, defining one variable which precedes the other one. Ina such terms, the causal variable can help forecast the effect variable.

In this vein of cointegration studies, modern techniques in the analysis of stationary series implement time-domain descomposition intended to handle the fluctuations of macroeconomic and financial series (Morana, 2024). Other approaches incorporate any expectation concept in the estimations, because the influence of forward looking predictions improves the forecast of other macroeconomic variables as unemployment, in new works working in the context of the Phillips curve (Goulet, 2024).

We assume a common path in the long-run behavior of our set of nominal variables which can guide the monetary policy decisions. The purpose is to demonstrate the strength of dependence between price indices and exchange rates. Previous research has applied a similar econometric strategy, applying co-integration analysis. Khan *et al.* (2018) uses an expenditure-switching model incorporating the PPI, the CPI, using the exchange rate as controlling variable.

For the U.S. Dorestani and Arjomand (2006) investigate the relationship between CPI and PPI in first difference, performing unit root and cointegration tests, and conclude that their estimated model circumvents the problem of spurious regression, and after all, it is possible to assume an influence from PPI to CPI.

Neeraj and Anuradha (2016) apply the Granger causality technique to the indices in India, using specific CPI and the wholesale price index supporting a bijective causality, however, they assert the strongest causality from the WPI to the CPI, which is explained by supply shocks in the economy. Sidaoui *et al.* (2010) use the Mexican indices in a cointegration technique and an Error Correction Model estimation, and bear out the strong predictive content from the PPI to the CPI, and analyse the convergence to equilibrium in the long run between both time series, identifying a short run upsurge in inflation, as a deviation from the permanent equilibrium.

In this document, we try to apply similar approach building a co-integration system using relevant indices for the Czech Republic and the exchange rate. We consult the information of the Czech Statistical Office for the prices indices, and the Central Bank (ČNB) tables for the time series of exchange rate.

On a monthly basis, the period of analysis spans since January 2018 until April 2024, covering two relevant stages in the macroeconomic policy: the global upsurge in inflation and the subsequent stage of stabilization. The series are handled on a monthly basis and are transformed into logarithmic states, because as usual, this transformation gives smoothness to time series and lessens the risk of heteroskedasticity (Lederman and Xu Lixin, 2007).

The variables included in the analysis are the consumer price index (cpi), the productor price index (ppi), the price index for Housing, water, energy and fuel (housingenergy), and the exchange rate versus the Euro (e). The source of data for the first ones is the Czech Statistical Office (ČSÚ), and for the last one is the Czech Central Bank (Česká národní banka). The descriptive statistics appear on the table 1. For each time series we gathered 76 monthly observations and the estimates were run using STATA.

Table 1. *Descriptive Statistics*

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
cpi	76	122.0632	16.51104	104.4	151.4
ppi	76	118.0961	18.76187	98.7	148.4
e	76	127.2355	22.0203	103.7	168.1
housingenergy	76	25.31857	.8711384	23.438	27.268

Source: *Authors' calculations.*

Indeed, we work with a set of relevant variables. Shang and Yinxi (2019) assert that the models of welfare typically worked by the central banks, defines a welfare maximizing objective function modelling the PPI, the output gap and the real exchange rate.

The starting point in the recognition of variables is the analysis of the stationarity properties of the prices indices used and the exchange rate. After confirming that the

variables were nor stationary at level, we proceeded to apply the tests of Dickey Fuller and Perron using the set of time series in first differences.

The results appear in Tables 2 and 3. We can endorse the assertion that all variables have the same order of integration. So, all variables confirmed to be non-stationary in levels, however, they end up to be stationary in first differences, therefore all our sequences of time series are integrated I (1).

This conclusion dealing with the variables at level is quite common in the economic time series. The typical feature of this class of variables is their smoothness, making their movements similar to long swings with no regularity. Given this feature this kind of variables at level are not suitable within the statistical analysis, because the condition to proceed the analysis is the confirmation of the stationarity propriety.

However, in the context of the cointegration theory the linear combination of two non-stationary variables, turns out at the end to be stationary. It means that when measuring the distance between both time series, a stationary series is generated, providing an indication of cointegration (Granger, 2003)

Table 2. *Dickey Fuller Tests for Unit Root. Time series in First Differences*

	Test Statistics	**1%**	**5%**	**10%**
d.lcpi	-7.625	-3.546	-2.911	-2.590
MacKinnon approximate p-value for Z(t) = 0.0000				
d.lppi	-6.815	-3.546	-2.911	2.590
MacKinnon approximate p-value for Z(t) = 0.0000				
d.le	-7.580	-3.546	-2.911	2.590
MacKinnon approximate p-value for Z(t) = 0.0000				
d.lhouseenergy	-9.413	-3.546	-2.911	2.590
MacKinnon approximate p-value for Z(t) = 0.0000				

Source: *Econometric Estimation.*

3. The Model

We must define the cointegrating equation, where the residuals represent the linear combination of variables. To test the cointegrating process, we used the Dickey–Fuller contrast applied to the residuals of the original regression at level, previously conducted following the model in eq. 1, where {Yt} and {Zt} are a pair of time series:

$$Y_t = \beta_0 + \beta_1 Z_t + e_t (1)$$

This test responds to the definition:

$$\Delta \hat{e}_t = a_1 \hat{e}_{t-1} + \varepsilon_t (2)$$

Given that {ê} represents the stationary sequence of deviations from long-run equilibrium, if these deviations demonstrate to be stationary, the original sequences in levels {Yt} and {Zt} are cointegrated of order (1,1). We assume that the linear combination of two non-stationary variables at level becomes stationary, leading to the conclusion that such a linear combination represents a long-run steady-state equilibrium.

In the cointegration process, the relevant coefficient is a1. In eq. 2, if we cannot reject Ho: a1=0, we assert that the residual series contains a unit root. Under the null hypothesis assumption, the sequences {Yt} and {Zt} are not cointegrated (Enders, 2014).

When there is uncertainty that the term εt in eq. 2 is white noise, a common procedure is to apply the augmented Dickey–Fuller test as shown in eq. 3. There, the model incorporates the first differences of errors lagged backward, and the test is used alternatively when there are clues of serial autocorrelation (Enders, 2014). The model follows this definition:

$$\Delta \hat{e}_t = a_1 \hat{e}_{t-1} + \sum_{i=1}^{n} a_{i+1} \Delta \hat{e}_{t-i} + \varepsilon_t (3)$$

When conducting a multivariate analysis of co-integration, the Johansen technique consults the λtrace and λmax to quantify the number of cointegrating vectors to confirm linear combinations between rows in the matrix (Enders, 2014). In the Johansen test, we identify the rank in the π matrix as follows:

In eq. 4, the π matrix elucidates the cointegrating properties, as the number of stationary relationships corresponds to the number of cointegrating vectors. The rank

$$\Delta X_t = \pi X_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta X_{t-1} + \varepsilon_t (4)$$

of π signifies the number of independent rows and the quantity of cointegrating relationships.

Each sequence within the set of time series, including CPI for stational goods, the money supply, the exchange rate, and the interest rate, consists of 76 monthly observations. The econometric routines were run using STATA. The observation of the drifts at level in all sequences reveals a set of integrated variables with no evidence of stationary properties.

However, end up to be stationary at first difference. Regarding the criticism of the Dickey–Fuller stationarity test, we are confident in this procedure for detecting unit roots.

However, as an additional measure, we also apply the Phillips–Perron test, given its robustness to autocorrelation and heteroscedasticity in the disturbance process of the equation defining the test. All variables in differences are tested, and all of them reject the null hypothesis about the existence of a one-unit root (Table 3).

Alongside with the contrast of Dickey Fuller, we applied the Phillips – Perron test in order to assert the stationarity of variables used in the econometric strategy.

Table 3. *Phillips - Perron Tests for Unit Root*

	Test Statistics	**1%**	**5%**	**10%**
d.lcpi Z(rho)	-70.392	-19.332	-13.492	-10.84
Z(t)	-7.689	-3.546	-2.911	-2.590
	MacKinnon approximate p-value for Z(t) = 0.0000			
d.lppi Z(rho)	-63.075	-19.332	-13.492	-10.844
Z(t)	-6.941	-3.546	-2.911	-2.590
	MacKinnon approximate p-value for Z(t) = 0.0000			
d.le Z(rho)	-58.662	-19.332	-13.492	-10.844
Z(t)	-7.521	-3.546	-2.911	-2.590
	MacKinnon approximate p-value for Z(t) = 0.0000			
d. .lhousingelectricity (rho)	-76.107	-19.332	-13.492	-10.844
Z(t)	-9.516	- 3.546	-2.911	-2.590
	MacKinnon approximate p-value for Z(t) = 0.0000			

Source: *Econometric Estimation.*

The implementation of the two previous tests is a crucial stage for endorsing the property of equal order of integration in all-time series. Sharing the same order of integration is a condition for asserting the common stochastic trends in our variables.

The following step in the analysis is the confirmation that all of our time series are cointegrated, it means they share the same stochastic trend in the long run. So, the condition for continuing is contrasting the hypothesis of non-cointegration using the residuals of the OLS regression at level. The linear combination of time series ends up to be stationary.

The augmented Dickey–Fuller test, applied in this way imparts about the stationary properties of the residuals emanating from the co-integration equation. The information drawn from the test is a clue about the existence of a linear combination

of variables with properties of stationarity, driving the system convergent towards the equilibrium. When implementing the augmented Dickey Fuller test, we apply the contrast but, adjusting properly the critical values during the definition of the decision criteria. Interpreting Table 4, we confirm the stationarity of our nominal set of sequences (McKinnon test's critical values at 10%). Therefore, we can proceed with our co-integration analysis using the selected variables.

Table 4. *Engle-Granger Cointegration Tests*

	Critical Values	**1%**	**5%**	**10%**
	Test Statistics			
Z(t)	-3.929	-4.891	-4.248	-3.923

Note: *Critical values for MacKinnon test are: -4.70 (1%); -4.18 (5%) and 3.89 (10%).*
Source: *Econometric Estimation.*

The augmented Dickey–Fuller test is contrasted with the residuals drawn from the OLS regression of indices. In this fashion, we can verify if the linear combination of non-stationary variables, ends up to stationary itself. The definition of the null hypothesis is proposed in terms of the non-stationarity of these residual series.

The Dickey–Fuller contrast applied to the residuals of the co-integrating equation, along with the Engle and Granger tests, reject the null hypothesis of a unit root in the residuals. This provides strong evidence of the presence of common stochastic paths and a linear combination. In accordance with the results of the test applied on the residuals and according the MacKinnon Critical values, we can assert that the hypothesis of non-cointegration is rejected at a 10% level of significance.

3.1 The Johansen's Rank Condition and the Multivariate Cointegration

Our previous strategy asserted the existence of cointegration relationship in our set of data. In such terms, although the Engle–Granger technique confirmed the common stochastic trends in the variables, we consider useful to tackle the application of Johansen rank condition as a comparison of the two procedures.

When conducting a multivariate analysis of co-integration, the Johansen technique consults the λtrace and λmax to quantify the number of cointegrating vectors to confirm linear combinations between rows in the matrix (Enders 2014). In the Johansen test, we identify the rank in the π matrix as follows:

$$\Delta X_t = \pi X_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta X_{t-1} + \varepsilon_t \quad (4)$$

In equation 4, the π matrix elucidates the cointegrating properties, as the number of stationary relationships corresponds to the number of cointegrating vectors. The rank

of π signifies the number of independent rows and the quantity of cointegrating relationships.

Table 5. *Johansen tests for cointegration*

Trend: none				**Number of obs = 74**	
Sample: 74				**Lags = 2**	
Maximum Rank	**Parms**	**LL**	**eigenvalue**	**Trace statistics**	**5% Critical Value**
0	20	958.38557	.	48.0612	47.21
1	27	967.88365	0.22640	29.0651*	29.68
2	32	976.78082	0.21374	11.2707	15.41
3	35	982.36101	0.13999	0.1103	3.76
4	36	982.41618	0.00149		

Source: *Econometric Estimation.*

According to Table 5, the most relevant information pertains to the case when the rank is assumed 0 (r=1). The decision criterion is defined by the comparison the trace statistics and the 5% critical value. In such terms, since 48.0612 surpasses the 5% critical value of the λtrace statistic (47.21, we are enabled to reject the null hypothesis of no cointegrating vectors, therefore the contrast gives us the certainty about the existence of one or more cointegrating vectors.

This finding is very relevant to the extent that in cointegrated set of prices indices, the observation of one single index suffices for capturing the price stability (Özpolat, 2020), a definitive process to keep in mind. On the other hand, the pass through effects typically lasts within a year. Besides, this effect also depends on the policy interventions in the foreign exchange market and its duration (Hajek and Horvath, 2015).

In any case, the exchange rate policy is more and more ineffective as long as the capital markets is more open, and the systems are deregulated (Kurihara, 2012). In other empirical works the authors did not find any evidence about predictive content from the PPI to CPI, with the subsequent suggestion of disregard the former one as a guide for the monetary policy (Khan *et al.*, 2018).

The confirmation of common trends in our model provides any additional clue for the economic policy, providing a kind of coherence for the monetary policy. This result is relevant, to the extent that in other cases, when the influence from the the exchange rate on each index is differential, the goals of economic policy, can be achieved for one index but missed for the other (Akdi *et al.*, 2006).

Khan *et al.* (2018) demonstrate a straightforward pass throw from the exchange rate on the Czech indices, finding in addition a long lasting effect, once the effect is internalized by the model.

Some findings emphasize the relevant information embedded in the PPI when is incorporated in the central bank models, and such exceling role increases with the most complex process of commercial intermediation occurs in the economy (Shang and Yinxi, 2018).

3.2 The Short-Run Model and the Error Correction Model

Upon establishing the cointegrating properties of the time series, we can explore the behaviour of equilibrium for gaining a predictive power about the short-run and long run relationships across sequences. Now we will proceed to embed the short run dynamics into the trends pertaining to the long run path of the model. In this way we can predict the behaviour and return to equilibrium of any transitory deviation.

When there is any guarantee about the cointegration relationship across variables, we can draw several conclusions in terms of the model's dynamic intertemporal adjustment. In fact, according (Granger, 2003), this ECM gives to the cointegration procedures its full practical usefulness.

In doing so, we regress the variables in first differences, but inserting as regressor the residual of OLS estimation at level. This regression provides the cointegration parameters and generate the shock or the error to be embedded in the ECM.

Our model output appears in the table 6. The change in the consumer price index is explained in terms of the first differences of the regressors, and the lag of the error estimated in the regression at level. We assume the representation theorem, and assert that our ECM generates data which has the propriety of being co-integrated as well. For this purpose, we estimate the ECM model following the specification used by Moreno (2002) who analyses the exchange rate behavior.

$$\Delta lcpi_t = \alpha + \sum_{i=1}^{n} \delta_i dlppi_i + \sum_{i=1}^{n} \beta_i d1e_i + \sum_{i=1}^{n} \varphi_i dlhou\sin gelectricity_i + \Psi u_{t-1} + n_t \quad (7)$$

In compliance of the Granger's representativity theorem, the data which is coming up from the error correction model is assumed to be stationary (Granger, 2003). In fact, during the econometric procedure was confirmed the common behavior of time series in the long run. However, when a short run shock emerging from the residuals is applied into the model, the system will come back to its equilibrium after some time.

The econometric results are relatively very good for the error correction equation. All variables are generally significant and the mathematical signs are consistent. The results of ECM describe an interesting dynamic, and portraits the long term equilibrium adjustment of the structure of data. The error correction model is a source of information about the prediction of the model behavior.

On the other hand, there is a very significant influence of the PPI, and the Price of the group housing and energy on the headline inflation. The significance of the error correction term (Error) portraits a correction in our cointegrating system towards long run equilibrium. In such terms, the error correction term is the driver of a temporary deviation in the inflation rate, until the long-run system's equilibrium relationship is achieved again (Sidaoui, 2010).

Interpreting the terms of the estimated short-term adjustment coefficients, we can say that it shows the fraction of theandand deviation of the actual variable from its long-term equilibrium level that is corrected each month. It demonstrates a relatively quick process of adjustment. The model indicates an adjustment towards equilibrium by 12.5% in the next period, when the there is a short run divergent shock. It means that the shock's effects are purely transitory regarding the long run path of the model.

Table 6. *Error Correction Model: lcpi. Lppi, le, lhhousingelectricity*

	Source	**SS**	**df**	**MS**		
	Model	**.006208821**	**4**	**.001552205**		
	Residual	**.000767494**	**70**	**.000010964**		
	Total	**.006976315**	**74**	**.000094275**		
D.lcpi	**Coef.**	**Std. Err.**	**t**	**P>|z|**	**[95%**	**Conf.**
lppi						
D1.	.2867485	.0387754	7.40	0.000	.2094134	.3640837
le						
D1.	-.0752789	.0315192	-2.39	0.020	0.020	-
lhhousingelectricity						
D1.	.2548736	.022213	11.47	0.000	.2105711	.299176
Error						
L1.	-.1254161	.0425543	-2.95	0.004	-.210288	-.040544
cons	.0018064	.0004126	4.38	0.000	.0009835	.0026294

Source: *Econometric Estimation.*

3.4 The Causality of Granger

According to Granger (2003) the analysis of causality conveys two principles, the cause precedes the effect and the cause is strongly effective for forecasting the effect, and contains information that is missing in another variable. The procedure is contrasted using one F statistics in order to test the null hypothesis that {Y} time series does not Granger cause {Z}.

For our theoretical discussion is very important to determine the sense of the Granger causality, provided the relevant implications for the purpose of economic policy. The contrast about causality will clarify which variable contributes to forecast the behaviour of another variable.

Table 7. *Granger Causality Test*

Equation	Excluded	chi2	df	Prob>chi2
lcpi	lppi	12.749	4	0.013
lcpi	lhousingelectricity	19.806	4	0.001
lcpi	le	.49963	4	0.974
lppi	lcpi	7.8079	4	0.099
lppi	lhousingelectricity	26.215	4	0.000
lppi	le	2.227	4	0.694
lhousingelectricity	lcpi	10.639	4	0.000
lhousingelectricity	lppi	19.836	4	0.001
lhousingelectricity	le	2.7234	4	0.605
le	lcpi	12.153	4	0.016
le	lppi	8.9603	4	0.062
le	lhousingelectricity	17.978	4	0.001

Source: *Econometric Estimation.*

Summing up, Table 7 presents the dynamics of causality across variables, reading the likely causality from the second column to the first.

The interpretation of the table is as follows: either the lppi and the lhousingelectricity cause in the Granger sense the logarithm of the lcpi. Next, the lcpi and the lhousingelectricity cause the lppi. The lcpi and the lppi cause in the Granger sense lhousingelectricity. Finally, lcpi, lppi and lhousingelectricity cause le. It means that for our sample of data, the observation of the three indices studied contributes to the forecasting performance of the others.

In such terms, for the purpose of economic policy, either the index at the stage of the Producer, and the Consumer price index for Housing, water, energy and fuel, turn out good predictor of the stability of prices. The impact from imported goods (mostly raw material and energy) is typically higher in producer prices in comparison with CPI. Thus, PPI is openly determined by global shocks in international market commodities, which disrupt severely the price of energy and fuels.

Regarding the role of the other variable included, all price indices demonstrate to cause in the Granger sense the exchange rate, but not vice versa. The particular behaviour of the sequence from the exchange rate to prices indices, can be ascribed to our inclusion of the equivalence Czech crown vs euro. It is widely known that most transactions in the fuel markets are denominated in American dollars.

5. Conclusions

The observation of appropriate indices makes up an efficient strategy to design an assertive monetary policy. The correct choice of the set of available information will provide the criteria for achieving the goals of macroeconomic stabilization.

Conversely, the misunderstanding of the pass throw mechanism can lead to wrong policy decisions, giving rise to disrupting responses (World Bank, 2019). When illuminating results are disposable, the central banks gather overall information for assertive policy formulation. The focus must be posed not only in IPC, but other indicators must be tracked as producer prices, wholesale prices, asset prices, inter alia.

In this article we perform a co-integration method to define the long term equilibrium of our system of variables, and to interpret the sense of the causality across variables. Here we asserted that the prices indices analyzed and the exchange rate share stochastic long term relationships, either when using the univariate, and the multivariate test. In this vein, the Johansen test allow us to test the structure of data, and confirms the existence of at least one cointegration vector.

All variables have the same order of integration and according the traditional tests, demonstrated to be cointegrated. In this way, the technique of cointegration bore out that the fourth variable used, share common stochastic properties in the long run. We specified a cointegration model in order to figure out the cost transfer from producer prices, housing and energy prices, and the exchange rate to consumer prices.

We applied the Augmented Dickey-Fuller (ADF) tests, to dive inside the stationarity proprieties of the time series. The Johansen approach inspired a Multivariate cointegration analysis, using as time series the PPI, CPI, the housing and energy group prices, and the exchange rate. The error correction model describes the dynamic of convergence to log run equilibrium.

The Error Correction Model bears out the quick convergence towards the long-run trend when the system is affected by any short-run shock. The speed of adjustment accounts by a 12.5% towards long run equilibrium. As long as our error correction term is significate, CPI reassume quickly the long term path, when the model is affected by disequilibrium errors with respect to the long run relationship between the system's variables.

The conclusions provided by the cointegration procedure are very useful for the purpose of policy, to the extent that any sequence can be used for predicting the macroeconomic stability in terms of inflation.

The Granger causality test bears out that the three indices are caused mutually in the sense of Granger. According the results, there is causality from the exchange rate to the used indices.

However, vice versa the three indices in fact cause the exchange rate. It means that the monetary policy can use each one of the indices as a good predictor of the stability of prices in the economy. In this fashion, there are more informative indicators for guiding the monetary policy.

One worthy comment emerging from the work of Tiwari (2012) is that the causality from the PPI to the CPI, provides an opportunity to the monetary policy to neutralize or refrain timely, the transmission from the upstream level to the consumer level, through the formulation of a coherent policy stance.

The relevance of this kind of works measuring the co-movements across indices each day is more worthy to the extent that contributes to generate information for a more optimal policy of stabilization.

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