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Assessment of Price Volatility in Euro Area, Germany and France

Andrzej JĘDRUCHNIEWICZ – Dawid BRÓDKA***

Abstract

The aim of this study is the assessment of the applicability of the Austrian School theory in explaining products' price volatility at particular stages of structure of production. This assessment was based on the authorial model and the usage of statistical tests. Empirical verification of Austrian School theories is rare in economic literature. The test method used in this study fills the gap in the price volatility research. Proposed approach was not used in regards to the Austrian School theory before. The data analysis of the years between 2010 – 2017 indicated an existence of statistically significant differences in price volatility within various stages of production structure in all analyzed economies, including the euro area, Germany and France. In the analyzed years price volatility of goods was higher at stages of production structure more distant to final consumer goods. The exception was lower price volatility on capital goods stage compared to consumer goods in euro area and French economy.

Keywords: *prices, price volatility, production structure, Austrian school*

JEL Classification: C46, E31, E51

Introduction

One of the most characteristic phenomena of contemporary market economies is high volatility of prices. In the long-run, it is mostly related to business cycle and its phases. The business cycle constitutes an important problematic aspect of many economic schools of thought (Snowdon and Vane, 2005; Kaletsky, 2010). Price volatility is especially significant from the point of view of both policy makers and market participants. Knowledge in this field enables for more

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effective decision making and planning. Price volatility analyses conducted on the macroeconomic level are related mostly to the effects of monetary policy. Mainstream economists use aggregated categories such as average price level. In most cases, average price level concept is depicted by using consumer price index. An alternative approach is proposed by Austrian School. Austrians[1] reject research based on aggregated categories, pointing out that it can lead to omitting important aspects of economic processes. By using the theory of structure of production and heterogeneous capital goods, austrians stress out the importance of analyzing price volatility from the point of view of particular sections of the economy.

The aim of this study is the assessment of the Austrian business cycle theory (ABCT) to explain products' price volatility at different stages of structure of production. This aim will be accomplished by verifying two hypotheses resulting from theory developed by this school. The first hypothesis states that particular stages of production differ in terms of price volatility. The second hypothesis states that price volatility of goods is higher at more distant stages of production compared to those closer to final consumer goods stage.

The methodology of the Austrian School significantly differs from the approach of the mainstream schools of economics. The matter of empirical verification of hypotheses is still discussed in Austrian School. The majority of economists stick to the traditional standpoint and question its sense. However, the group referring to Hayek's point of view believes that testing the hypotheses is reasonable (cf. Mulligan, 2006; Bismans and Mougeot, 2009; Luther and Cohen, 2014). The hypotheses adopted in this study will undergo an empirical verification with the use of authorial model based on Austrian School literary output and statistical tests. Such approach was not used in Austrian School literature before.

1. Price Volatility in the Austrian School Theory

The Austrian business cycle theory (ABCT) was created by Mises (1912; 1934) and Hayek (1929; 1931), while nowadays it is developed by Skousen (1990), Garrison (2001), Huerta de Soto (2009), Salerno (2012), among others. It seems to be a good alternative to the mainstream economic schools theories as it analyses and explains the processes happening in the particular phases of business cycle.

According to the Austrian School theory, the business cycle is a characteristic phenomenon of the modern economy based on fiat money system and fractional-

[1] Nowadays this term applies to all economists indentifying themselves with austrian school of economics, not necessarily of austrian descent.

-reserve banking. The main reason for cyclical fluctuations is the central bank policy. The economic cycle begins with monetary policy easing (Mises, 1949; Garrison, 2001). The market interest rate drops below the natural rate (Rosen and Ravier, 2014). This encourages businesses and consumers to increase their lending. This results in an increase in money supply (Hülsmann, 2011). This is connected to the problem of "the place" where new money appears in the economy causing so-called Cantillon effect (Cantillon, 1755; Rothbard, 2006). According to the economists of the Austrian School the new supply of money is not evenly distributed. The largest portion of the new loans not backed by voluntary savings are obtained by entrepreneurs for production and investment purposes (Salerno, 2012). The loans for purchases of consumer goods do not increase much.

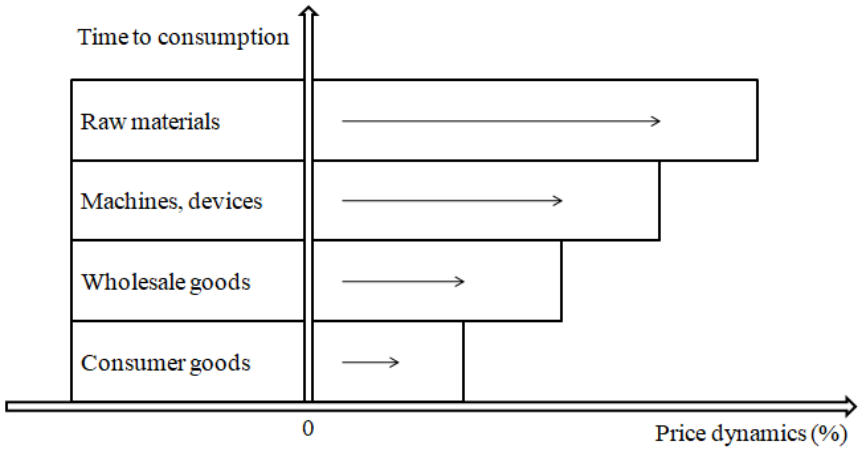
Additional influx of money changes the time structure of production of goods targeted for consumers. The structure of production itself consists of stages arranged according to the technical and temporal process of producing and selling final goods. This concept has significant consequences for the course of the business cycle. The basis for the analysis of changes in the structure of production is the austrian capital theory originally created by E. von Böhm-Bawerk. According to the theory capital goods are heterogeneous goods used at every stage of consumer goods production. These stages and their outputs are all in different distances away from final consumer goods. All capital goods are intermediate goods; their quantity and variety determines the length and width of the production structure (Garrison, 2001). The more capital-intensive production the more complex the structure. The larger the amount of capital the longer the production time. The waiting time for increased consumption is also prolonged. The theory of the Austrian School states that the necessary condition for more final goods is the extension of production time. "The fact that roundabout methods of production lead to greater effects than direct methods is one of the most important and fundamental assumptions in the whole theory of production" (Böhm-Bawerk, 1891, p. 20).

Entrepreneurs cannot distinguish whether new money constitutes actual savings or was created by the banking system (Fillieule, 2007; Hayek, 1975). Increasing value of loans not backed by voluntary savings initiates multiple mistakes on producers' side based on false information resulting from the expansionary monetary policy (Shostak, 2013). In the growth phase of the cycle, businesses start lengthening and widthening the production structure (creating new stages and expanding the already existing ones respectively). Changes in production volume and prices at particular stages are not uniform (Zahringer, 2012). At the beginning of the cycle, the demand at initial stages (those most distant from the consumer) is growing with the highest dynamics. Consequently, at the final stages,

the increase is minimal. It results from the fact that according to the entire technical process of producing the final good, raw materials and machinery must be produced at first as this stage provides capital goods for all subsequent stages. The creation of new production stages is a technical process. Therefore, the greatest entrepreneurial opportunities come from the stages associated with production of unprocessed goods at the beginning of the production structure (Zelmanovitz, 2011). The goods produced at these stages also serve the longest in the entire production process. The dynamic growth in demand causes the largest increase in production and prices observed at these initial stages. It is also strengthened by the increase in real wages of employees who become less competitive than capital goods due to Ricardo effect. The price increase at other stages is proportional to the degree of their distance from the consumer. This is illustrated in Figure 1 where an exemplary production structure is shown. New production methods result in increased productivity and reduced unit cost of production.

F i g u r e 1

Prices Dynamics during the Expansion Phase of the Cycle



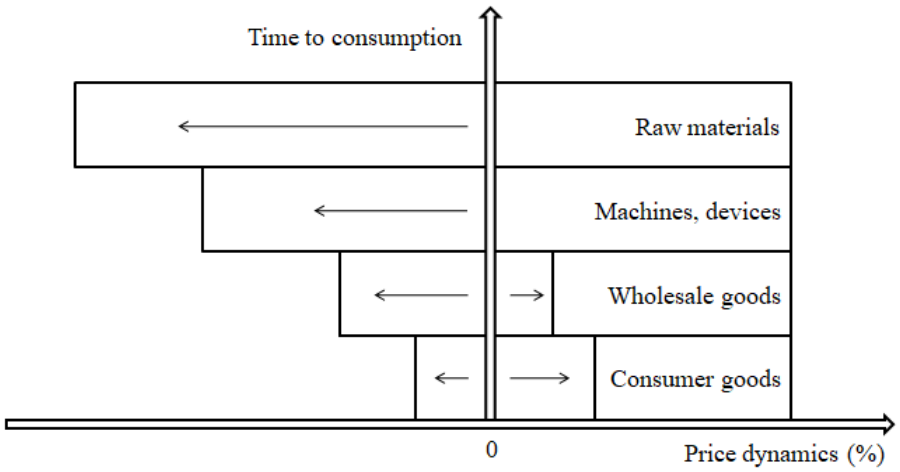
Source: Own elaboration based on (Skousen, 1990).

The change in monetary policy lengthens the time structure of production, but it does not lengthen the time structure of consumption (Huerta de Soto, 2009). Therefore, in the final part of the expansion phase, the growth in prices of consumer goods is higher than in investment goods. This results in a higher profitability of companies producing closer to the consumers than at stages more distant from them. In this situation, the entrepreneurs limit the demand for goods produced at stages distant from the consumer (Tempelman, 2010). This decrease is also strengthened by higher profitability of labor as compared to capital goods.

The fall in the demand for investment goods triggers the recession phase of the cycle. The main reason for the recession is the discrepancy between the artificially expanded structure of production compared to the actual consumption structure (Skousen, 1990). The inability to finance capital-intensive production processes forces companies to abandon them. The time structure of production becomes shortened. It involves the liquidation of some of the stages of consumer goods production. This process is the strongest at the initial stages of the structure. Along with the shortening of the production structure narrowing comes as well. This results in a decline in production at the remaining stages and emergence of a new production structure in the economy compared to the pre-recession structure. Austrians also stress the importance of relative price changes. In the recession phase, production and prices change inversely as compared to the growth phase. The fall in prices of goods from initial stages (e.g. raw materials) is relatively (often also absolutely) the most significant. The price dynamics of the final goods are the smallest (Figure 2) and are most commonly characterized by small absolute increases.

F i g u r e 2

Price Dynamics during the Recession



Source: Own elaboration based on (Skousen, 1990).

The period of economic recession is the time when entrepreneurs give up and admit that they have made investment mistakes. The structure of production becomes adjusted to consumer decisions. A certain amount of time is always needed to reorganize the structure in the economy. ”The period of depression is, therefore, a necessary period for recovery of the economy” (Rothbard, 2008, p. 410).

2. Research Methodology

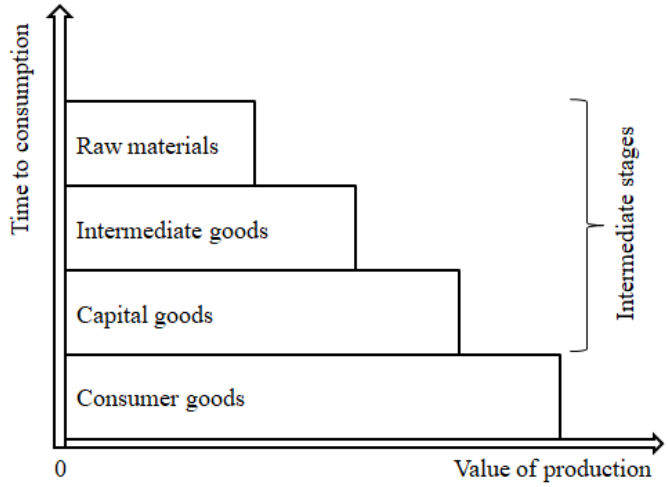
Along with changes in production volume within the business cycle, prices of goods at each stage of production structure change at different rates. Austrians stress that the analysis of price changes cannot focus on macroeconomic categories because their global and average values do not fully reflect the processes taking place in particular sectors of the economy (Cochran, 2011). Austrians consider analyses based solely on official inflation index (CPI) to be counterproductive and base their own analyses on relative prices which correspond to the stages of production structure.

In order to examine price volatility according to the Austrian School theory a production structure model containing four production stages was used. For each stage, the following price indices correspond: 1. raw materials – energy price indices; 2. intermediate goods – price indices of intermediate goods; 3. capital goods – price indices of capital goods; 4. final goods – price indices of consumer goods and services (Figure 3). Raw materials are at the beginning of the production structure and final goods are at the end. In theory, we could deduct many more stages. The adopted model results from the limitations in data availability. The proposed simplifications were considered acceptable for the purposes of the study and do not affect its reliability.

As the theory points out, the main reason for business cycles is expansionist monetary policy of the central bank. In order to establish the relationship between supply of money and price volatility in examined economies Granger causality was used (Charemza and Deadman, 1997).

Figure 3

The Adopted Model of Production Structure



Source: Own elaboration.

In our research, a number of statistical tests was adopted. The tests revolve around the problem of homogeneity of variances of our price indices samples and their populations. Using the tests, we were able to draw statistically significant conclusions about the differences in variance of tested indices and their respective stages of production. On the basis of tests results and their *p-values* we were able to determine if price volatility differed throughout the different stages of production of given economy.

The procedure of the statistical analysis of the volatility of used price indices was as follows:

1. The graphical assessment of the density charts of tested samples for given economy.

2. The Shapiro-Wilk normality distribution test.

The normality of the distribution of the tested samples is one of the key issues of the conducted analysis. Shapiro-Wilk test is characterized by high power and allows for mitigating the risk of using inappropriate methods further (Razali and Wah, 2011). The result of the test informs about the need to apply statistical procedures robust to possible failure in assuming normal distribution. *P-value* below 0.05 for calculated test statistic was equivalent to rejection of the hypothesis about the normality of the distribution for a given sample of price indices.

3. Brown-Forsythe and Fligner-Killeen tests for homogeneity of variances.

Both tests are robust to non-normal distribution types. The tests are characterized by high power and simplicity of use (Denkowska et al., 2009). The combination of both tests of homogeneity of variance enables greater reliability which allows for more accurate examination of the research hypothesis regarding the differences in price volatility between different stages of production structure. Following hypotheses were tested:

- $H_0^{HV}: \sigma_1^2 = \sigma_2^2 = \sigma_3^2 = ... = \sigma_g^2$,
- $H_1^{HV}: \sigma_i^2 \neq \sigma_j^2$ for at least one pair (*i, j*).

P-value below the level of significance for given statistic was equivalent to rejecting null hypothesis assuming homogeneity of variance of all production stages (confirming differences in price volatility in given economy).

4. Miao-Gel-Gastwirth symmetry of distribution test.

Test was carried out before the Fligner-Policello test, which requires that both compared distributions should be symmetrical. Miao-Gel-Gastwirth test is characterized by non-parametricity and lack of assumptions as to the knowledge of distributions' medians from which the tested samples were drawn (Miao, Gel and Gastwirth, 2006).

On the basis of *p-value* for the obtained statistics and the adopted level of significance it was checked whether the null hypothesis concerning the symmetry of the price index distribution of given stage of production for given economy can be adopted. In the absence of rejection of the null hypothesis for given pair of production stages it was possible to use Fligner-Policello test on a given set of data.

5. Fligner-Policello rank test.

In order to check the assumption regarding the equality of distributions' medians from which the samples used in the Ansari-Bradley test come from the Fligner-Policello rank-sum test was used (SAS, 2018). The test allows to check the null hypothesis concerning the equality of medians of the two distributions based on statistical samples derived from them. The advantages of the test are its non-parametricity, the lack of assumption about equality of the distribution functions of the compared distributions and the lack of assumption about the equality of variance. Fligner and Policello propose a use of the statistic based on the results of the place of the analyzed observations.

For the test statistic, *p-value* is calculated. Values below the assumed significance level inform about a significant shift in the location of compared distributions resulting from the lack of equality of the medians. In the case of this study, rejection of the null test hypothesis meant that there is no way to conduct the Ansari-Bradley test for a given set of data.

6. The Ansari-Bradley's test.

This test is used to measure differences in dispersion (variability) of distributions (Ansari and Bradley, 1960). The test allows to examine the significance of scale differences between two distributions. We used the test to verify the hypothesis of greater price volatility at the stages of the production structure more distant from consumer goods than at the stages closer to final goods.

Ansari and Bradley propose the use of scale parameter (θ) given as:

$$G(u) \equiv F(\theta u) \tag{1}$$

where $G(u)$ and $F(u)$ are distribution functions of two *independent* statistical samples.

The study adopted a zero and an alternative hypothesis in the following form:

- $H_0 : \theta \leq 1$
- $H_1 : \theta > 1$

P-value below the level of significance was equivalent to accepting an alternative hypothesis, which points out to a greater dispersion of distribution $G(u)$

thus confirming higher price volatility in the lower production stage in case of this research.

One of the problems that arises when using the Ansari Bradley test is the limited possibility to test more than two statistical samples simultaneously. The solution that was adopted in the course of the study was the application of the test for all possible pairs of price indices. Such a procedure was also applied in relation to tests validating the assumptions of the Ansari-Bradley test. By analyzing stages according to their sequence in the production structure, it was possible to determine whether more distant stages are characterized by greater volatility than stages closer to consumer goods. The rejection of the null test hypothesis for a given data set lead to a confirmation of the second research hypothesis.

3. Data Characteristics

The study of price volatility in the euro area as well as German and French economies was based on data from 2010 – 2017. Research available on this topic points out that all of examined economies were characterized by economic fluctuations. Business cycles were highly synchronized (Belke, Domnick and Gros, 2017; Kunovac, Mandler and Scharnagl, 2018).

In order to measure the phenomenon, price indices data was assigned to particular stages of each economy production structure. All indices data come from Eurostat. This allowed for making adequate comparisons between the studied economies. The adjustment of empirical data to the created model is consistent with the specification of individual aggregates included in the indices of the Main Industrial Groups (European Commission, 2007).

Analyzed price indices inform about the monthly y/y change in the level of prices at a given stage of the structure of production. Data is presented at monthly intervals. For each of the economies 96 observations were recorded for each of the production stages which allowed for obtaining 384 observations per economy. In total, 1152 price indices were analyzed. It should be added that the study did not require organizing data in the form of time series as indices were not analyzed chronologically in the subsequent phases of the business cycle (cf. Jędruchniewicz, 2013; 2015).

In the study of differences in price volatility the Ansari-Bradley test was used. Its usage requires the statistical samples to be independent. The collected data comes from different populations. This means that this condition is met.

All calculations were performed in R. In most of the carried out tests, the significance level of 0.05 was used. Any significance level change was indicated in the description of the analysis.

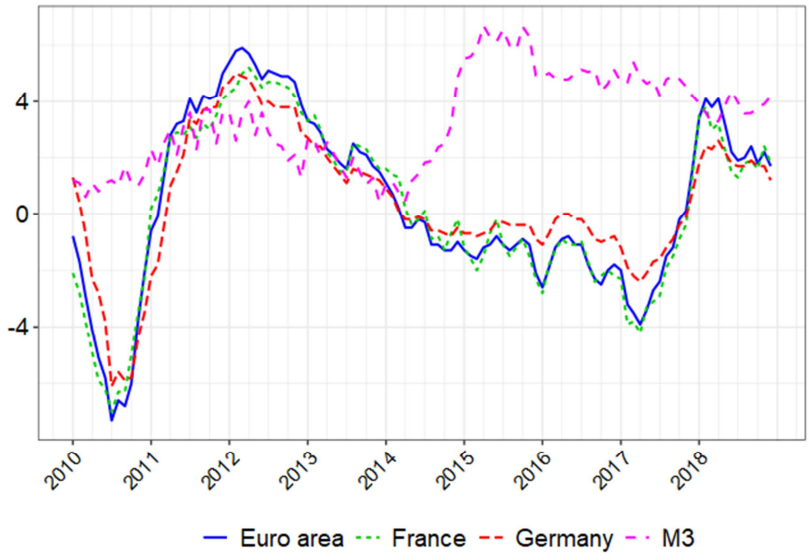
4. The Study Results

4.1. Supply of Money and Prices. Granger Test

Before investigating the relationship between European Central Bank M3 money supply and producer price changes in euro area, Germany and France a stationarity analysis of the data was conducted. Graph 1 represents the data used. Graphical analysis suggests that the data lacks stationarity, which is also confirmed by using Augmented Dickey-Fuller (ADF) test. Raw data cannot be used for Granger causality test. To neutralize nonstationarity of the data first order differencing was used. Transformed data was again examined using ADF test which confirmed stationarity for given significance level. All time series were order 1 integrated. It was then possible to use them in further analysis.

G r a p h 1

Monthly M3 Money Supply Change of ECB and Producer Price Changes in Euro Area, France and Germany (y/y)



Source: Own elaboration based on EBC and Eurostat data.

In order to conduct Granger causality test between M3 aggregate change (cause) and price changes (effect) an autoregressive distributed lag (ADL) model was used:

$$\pi_t = \alpha_0 + \sum_{j=1}^{k} \alpha_j \pi_{t-j} + \sum_{j=1}^{k} \beta_j \Delta M3_{t-j} + \varepsilon_t \qquad (2)$$

where

π_t – price change in period,

$\Delta M3_{t-j}$ – money supply change in t-j,

α, β – model parameters,

ε_t – random variable.

The model was adopted by using the method of least squares for euro zone, Germany and France. Statistical test results pointed out to the lack of autocorrelation and non-homoscedasticity of random variable for all economies. Linear restriction test (Fisher-Snedecor test) allowed the determination of the existence of causality. Granger causality test confirmed that producer price changes in the euro area were caused by money supply changes (depicted by measuring M3 aggregate monthly y/y changes).

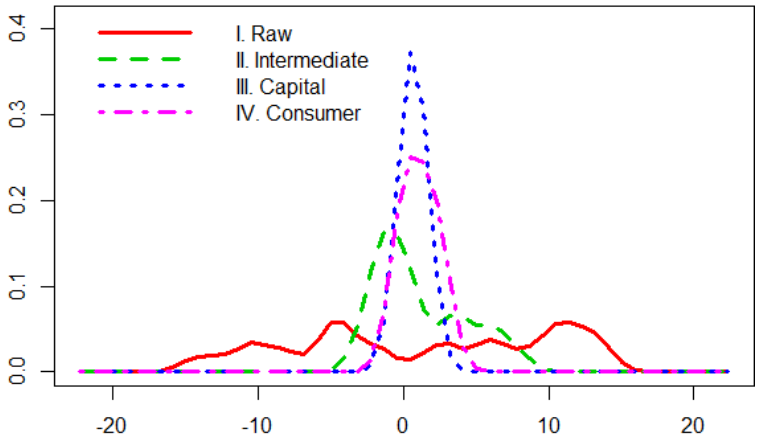
At the same time, money supply changes were not caused by producer price changes. Same was confirmed for Germany. For France however, Granger causality tests did not confirm the relationship between money supply and price changes. In spite of that, we decided to proceed with the research, as price changes in France very much resembled those in euro area as a whole.

4.2. Price Volatility in the Euro Area

According to the presented research methodology the empirical analysis begins with the assessment of the normality of price indices distributions. Graph 2 presents aggregated density of price indices distributions for all stages of the structure of production in the euro area economy.

Graph 2

The Density of Price Indices Distributions for Euro Area



Source: Own elaboration based on Eurostat data.

The graphical analysis is only an illustrative element but on its basis it is possible to determine the adequacy of the method selection in the form of non-parametric tests due to the lack of fulfillment of the assumption regarding the normality of the studied distributions.

Failure to meet the assumption about the normality of price indices distributions can be confirmed in a precise manner by the results of the Shapiro-Wilk test (Table 1). *P-value* of the test for all stages of the structure of production scores values below the adopted significance level.

T a b l e 1

The Results of Shapiro-Wilk Normality Test for the Euro Area

Stage of the structure	I	II	III	IV
P-value	0.0002402	1.124e-05	0.01696	0.001833

Source: Own elaboration based on Eurostat data.

On the basis of the results of tests of homogeneity of variances (Tables 2 and 3) statistically significant differences in variance of price indices were observed for all possible combinations of production stages in the euro area (cf. Bródka and Chciałowski, 2017). The results for the euro area confirm the first research hypothesis stated in the introduction of the study. This is in line with the theory of the Austrian School regarding different price volatility of goods produced at particular stages of the structure of production in the business cycle.

T a b l e 2

The Results of Homogeneity of Variance Tests for the Euro Area

Stages tested	All stages	I, II, III	II, III, IV
P-value for the Brown-Forsythe test	< 2.2e-16	< 2.2e-16	< 2.2e-16
P-value for the Fligner-Killeen test	< 2.2e-16	< 2.2e-16	< 2.2e-16

Source: Own elaboration based on Eurostat data.

T a b l e 3

The Results of Homogeneity of Variance Tests for Each Pair of Stages for the Euro Area

Stages tested	I & II	I & III	I & IV	II & III	II & IV	III & IV
P-value for the Brown-Forsythe test	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16	1.479e-10	7.048e-13
P-value for the Fliger-Killeen test	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16	1.704e-09	1.812e-11

Source: Own elaboration based on Eurostat data.

Based on the results of symmetry of distribution test for the euro area (Table 4), it should be concluded that almost all (except for the second stage) distributions of price indices are characterized by symmetry.

T a b l e 4

The Results of the Miao-Gel-Gastwirth Symmetry Distribution Test for the Euro Area

Stage of the structure	I	II	III	IV
P-value	0.586	< 2.2e-16	0.316	0.446

Source: Own elaboration based on Eurostat data.

Table 5 contains the results of the Fligner-Policello test and Ansari-Bradley test for the euro area. Based on the test results it should be stated that stage I was characterized by greater price volatility than stages III and IV, which confirms the second research hypothesis. In the case of stages III and IV, the results of the Ansari-Bradley test are statistically significant only if a lower level of significance (i.e., 0.01) is adopted. The results of the test for these stages do not confirm the theory of the Austrian School that the volatility of product prices increases along with the increase of the distance from final goods stage. *P-value* equal to 1 indicates lower price volatility at stage III than at stage IV. The tested theory indicates that it should be the other way round. In the remaining cases, "–" means that the assumptions allowing the given test to be performed have not been met.

T a b l e 5

The Results of the Fligner-Policello and Ansari-Bradley Tests for the Euro Area

Stages tested	I & II	I & III	I & IV	II & III	II & IV	III & IV
P-value for the Fligner-Policello test	–	0.6401	0.8112	–	–	0.0251
P-value for the Ansari-Bradley test	–	< 2.2e-16	< 2.2e-16	–	–	1

Source: Own elaboration based on Eurostat data.

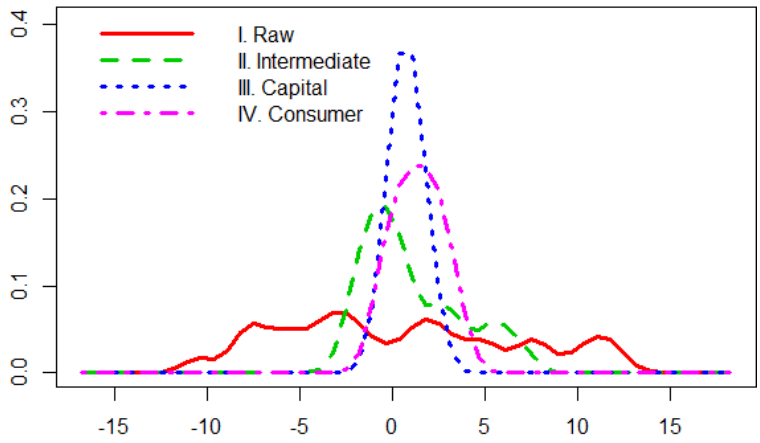
The pace of price changes in the economy depends on many factors. In a given period, a combination of certain causes and conditions may lead to a different formation of price volatility than in the theory of the Austrian School (cf. Jędruchniewicz, 2013; 2015). Lower volatility of prices of investment goods (stage III) than prices of consumer goods and services (stage IV) in the euro area may result from: lower demand of enterprises regarding post-crisis investments, different pace of investment (and thus price changes) in various countries in the euro area, high pace of technical progress, lack of exclusion of durable goods purchased by households from the consumer price index, situation on particular international markets. Other causes include supply shortages on agricultural markets caused by negative climate change effects, shrinking of agricultural land, increase in biofuels production and energy, increase in demand for resource-intensive food which further accelerated intensity of agricultural land usage. All these factors intensified price volatility in food and agricultural sectors.

4.3. Price volatility in the German Economy

The first single country on the example of which price volatility was analyzed was Germany, the largest economy in the European Union. The results of the graphical analysis from Graph 3 indicate that the data from the German economy will also require the use of nonparametric methods in the further study.

Graph 3

The Density of Price Indices Distributions for Germany



Source: Own elaboration based on Eurostat data.

The data from Table 6, where the normality of the distribution of price indices groups was assessed, indicate that all indices are characterized by the lack of normality of probability distributions. Statistical tests confirmed the results of the initial graphical assessment.

Table 6

The Results of Shapiro-Wilk Normality Test for Germany

Stage of the structure	I	II	III	IV
P-value	0.0051	1.919e-06	0.0136	0.0041

Source: Own elaboration based on Eurostat data.

On the basis of homogeneity tests of variances for Germany (Table 7 and 8) for the adopted level of significance, it should be stated that there are statistically significant differences in the variance of price indices distributions examined in the structure of production of the German economy in all possible combinations of stages. The example of the German economy, same as the example of the euro area, confirms the first research hypothesis.

T a b l e 7

The Results of Homogeneity of Variance Tests for Germany

Stages tested	All stages	I, II, III	II, III, IV
P-value for the Brown-Forsythe test	< 2.2e-16	< 2.2e-16	< 2.2e-16
P-value for the Fligner-Killeen test	< 2.2e-16	< 2.2e-16	< 2.2e-16

Source: Own elaboration based on Eurostat data.

T a b l e 8

The Results of Homogeneity of Variance Tests for Each Pair of Stages for Germany

Stages tested	I & II	I & III	I & IV	II & III	II & IV	III & IV
P-value for the Brown-Forsythe test	2.454e-14	< 2.2e-16	< 2.2e-16	3.303e-14	5.073e-07	6.75e-12
P-value for the Fligner-Killeen test	4.917e-13	< 2.2e-16	< 2.2e-16	6.135e-14	3.696e-06	3.792e-10

Source: Own elaboration based on Eurostat data.

Based on the symmetry distribution test results for Germany (Table 9), it should be assumed that stages I, III and IV are characterized by symmetry of their population's distributions. This is indicated by the *p-value* below the adopted significance level. However, the lack of symmetry occurs in stage II.

T a b l e 9

The Results of the Symmetry Distribution Test by Miao-Gel-Gastwirth for Germany

Stage of the structure	I	II	III	IV
P-value	*P-value*	0.256	< 2.2e-16	0.31

Source: Own elaboration based on Eurostat data.

Based on the results of the tests from Table 10, it should be stated that stage I is characterized by a greater volatility of prices than stages III and IV, which partially confirms the second research hypothesis. In the case of stage III and IV, the Ansari-Bradley test was impossible to conduct due to the insufficient *p-value* for the results of Fligner-Policello test indicating the inequality of medians. As before, the "–" sign means that the assumptions allowing the given test to be performed have not been met.

T a b l e 10

The Results of the Fligner-Policello and Ansari-Bradley Tests for Germany

Stages tested	I & II	I & III	I & IV	II & III	II & IV	III & IV
P-value for the Fligner-Policello test	–	0.4235	0.0932	–	–	0.0008
P-value for the Ansari-Bradley test	–	< 2.2e-16	< 2.2e-16	–	–	–

Source: Own elaboration based on Eurostat data.

In the case of the German economy, same as in the euro area, statistical tests that were possible to perform indicate that in the analyzed years 2010 – 2017, the theory of the Austrian School regarding the pace of price changes at the stages of the structure of production during cyclical fluctuations was confirmed. According to the theory, the prices of raw materials should be more volatile in relation to the prices of consumer goods. The German economy was less affected by the recent crisis than other EU countries. However, it is also characterized by cyclicality which has an effect on significant differences in price volatility between sectors.

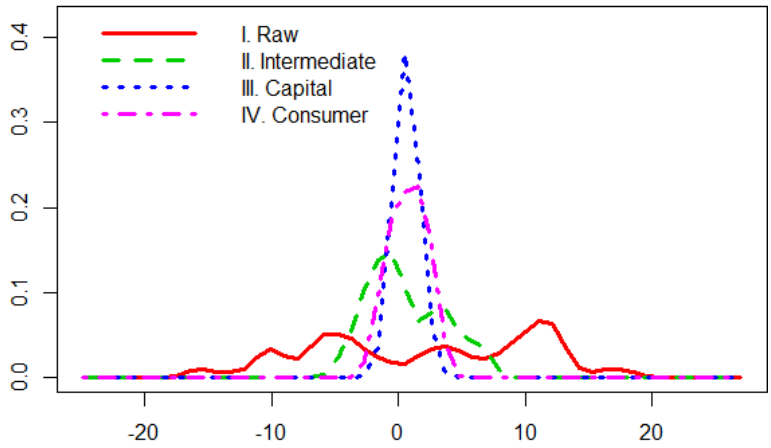
4.4. Price Volatility in the French Economy

The second single country on the example of which price volatility assessment was performed was France. The economy of this country is the second largest in the European Union. The production volume at specified stages of the structure of production is therefore high.

The aggregated charts of density of price indices distributions for all stages of the French economy structure of production are presented in Graph 4. Graphical analysis is only a visual assessment. However, as in previous cases, the adequacy of the selection of nonparametric methods in the conducted analysis can be noticed. This is confirmed by the results of the Shapiro-Wilk test from Table 11, where *p-value* for the test results for all stages records is below the significance level of 0.05. This confirms that the assumption about the normality of the discussed distributions is not met.

Graph 4

The Density of Price Indices Distributions for France



Source: Own elaboration based on Eurostat data.

T a b l e 11

The Results of Shapiro-Wilk Normality Test for France

Stage of the structure	I	II	III	IV
P-value	0.002181	0.0009201	0.04315	0.0001639

Source: Own elaboration based on Eurostat data.

Based on The results of homogeneity of variance tests for France (Table 12 and 13), it should be stated that there are statistically significant differences in the variances of the price indices examined in all of the compared stages for the adopted level of significance in the structure of production of this country. The example of the French economy confirms the first research hypothesis.

T a b l e 12

The Results of Homogeneity of Variance Tests for France

Stages tested	All stages	I, II, III	II, III, IV
P-value for the Brown-Forsythe test	< 2.2e-16	< 2.2e-16	< 2.2e-16
P-value for the Fligner-Killeen test	< 2.2e-16	< 2.2e-16	< 2.2e-16

Source: Own elaboration based on Eurostat data.

T a b l e 13

The Results of Homogeneity of Variance Tests for Each Pair of Stages for France

Stages tested	I & II	I & III	I & IV	II & III	II & IV	III & IV
P-value for the Brown-Forsythe test	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16	7.961e-10	< 2.2e-16
P-value for the Fligner-Killeen test	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16	2.153e-08	4.221e-14

Source: Own elaboration based on Eurostat data.

The results of the symmetry test of the distributions from Table 14 indicate the lack of symmetry of distributions for stages II and III for the significance level of 0.05. In the case of this economy, the significance level was reduced to 0.001. As a result, it became possible to accept the hypothesis of the symmetry of all distributions which, however, imposed an obligation to apply the same, lower level of significance in subsequent tests in which data from stages II and III was used.

T a b l e 14

The Results of the Miao-Gel-Gastwirth Symmetry Distribution Test for France

Stage of the structure	I	II	III	IV
P-value	0.588	0.002	0.012	0.742

Source: Own elaboration based on Eurostat data.

The adoption of a lower level of significance allows for conducting the Fligner-Policello median equality test for all possible combinations of price indices. The results of the test are presented in Table 15. All tested pairs of price indices meet the condition of equality of medians, which in turn allowed for conducting the Ansari-Bradley test for each pair.

T a b l e 15

The Results of the Fligner-Policello and Ansari-Bradley Tests for France

Stages tested	**I & II**	**I & III**	**I & IV**	**II & III**	**II & IV**	**III & IV**
P-value for the Fligner-Policello test	0.361374	0.3025728	0.3418743	0.07121921	0.18731	0.388217
P-value for the Ansari-Bradley test	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16	1.244e-11	1

Source: Own elaboration based on Eurostat data.

Based on the results of Ansari-Bradley test, it should be stated that the occurrence of greater price volatility with more distant stages of production from final goods was observed in almost all cases examined (Table 15). This was the case even for pairs from stages II and III, for which test results had to be considered in the context of lower *p-value*. However, the conducted test regarding price volatility between stages III and IV did not confirm the second hypothesis.

The assessment of the results obtained for the French economy is the same as the results obtained for the economy of the euro area. Also in the euro area, the Ansari-Bradley test indicated that goods in stage III of the structure of production are characterized by lower price volatility than in stage IV. In France, the source of this inconsistency between the reality and the theory can be explained by analyzing the reasons already mentioned when this problem was assessed on the example of the euro area economy.

Conclusion

Analysis conducted in this article constitutes a new point of view on price volatility phenomenon in the field of Austrian School and economics. Based on the results we can fully confirm the first research hypothesis – in 2010 – 2017 period statistically significant differences in terms of price volatility were observed in all of the examined economies, namely euro zone, Germany and France.

The second research hypothesis concerning higher price volatility on the production stages further from consumer goods stage was partially confirmed. The data examined in this paper enabled us to perform a limited number of Ansari-Bradley's tests. The results point out to the confirmation of the theory in all

examined cases, apart from higher price volatility on consumer goods stage (IV) compared to capital goods stage (III) in euro zone and France. This might be due to many factors, including insufficient disaggregation of the structure of production or the aggregated data itself.

The research concerning price volatility on a disaggregated macroeconomic level is sparse, especially when it comes to use of Austrian School theory and methods presented. The results of many works are in line with the results concluded in this paper. Skousen (1990), Hughes (1997) and Garrison (2001), states that in US economy price volatility was higher in sectors producing goods further away from consumer stage in the structure of production than in sectors closer to the consumer. Such phenomenon was also confirmed by Jedruchniewicz (2013; 2015), Misztal (2016), Masniak (2016) and Taghizadeh-Hesary, Rasoulinezhad and Yoshino (2019). Analyses conducted in particular branches of the economy confirm high price volatility in sectors producing raw materials (Grudzinski, 2014; Hasan and Ratti, 2015; Szajner, 2017). Others point out to low price volatility in sectors producing consumer goods (Gouel, 2016; Swietlik, 2016). However, research by Bismans and Mougeot (2009) and Luther and Cohen (2014) point out to the inadequacy of Austrian School theories.

All in all the proposed methods can be used not only as a basis for investigating Austrian School's theories but also other fields. The structure of production approach bears much resemblance to the supply chain matters. Different analyses can be conducted on a microeconomic level with the use of proposed approach, where the role of manufacturer, distributor, retailer and consumer can be clearly defined. In theory, similar results should follow there as well.

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