TESTING THE LAW OF ONE PRICE

BY

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1. Introduction

In the realm of international economics, the Law of One Price (LOOP) stands as a foundational concept that underpins our understanding of global trade and market integration. LOOP posits that identical goods should command the same price in different markets, irrespective of geographic boundaries or political jurisdictions (CFI Team, n.d.). Its implications extend beyond economic theory, shaping trade policies and impacting the decisions of

businesses and governments worldwide.

The significance of LOOP lies in its potential to foster a seamless global marketplace where arbitrage opportunities are minimal, and prices harmonize across borders. This research paper explores the subject of achieving LOOP through convergence of prices, which has been a subject of attention and controversy in international economics. For testing the LOOP, the data from Metro Cash and Carry is examined, which enables the comparison of prices in the major cities of Astana and Almaty in Kazakhstan, as well as Moscow and Saint-Petersburg in Russia.

The evidence backing the convergence of prices throughout different locations stems from the utilization of expansive datasets and methodological advancements, including the adoption of panel data and time series data. In this thesis, the paper indicates evidence of price convergence over time and

contributes to prior research. Despite confirming convergence, the slow pace of convergence in international markets remains a persistent puzzle, which is similar to the results of the study. A closer look at the rate of price convergence will be taken in this paper, using the panel data of almost 900 identical products for examining the relationship between variables over time for these four locations. Additionally, the panel data helps to control for both entity-specific effects (fixed effects) and time-specific effects, which can enhance the precision

of statistical analysis and provide more insights into how changes in one variable affect another.

The research paper uses regression model for studying price convergence, driven by the careful application of the benchmark paper methods. Through this exploration, the Law of One Price (LOOP) is tested within the same chain of stores in different locations. The motivation for the thesis paper is to test if the LOOP holds in Kazakhstan, looking at the two biggest cities – Astana and Almaty, and testing the same thing considering the exchange rate between Russia and Kazakhstan, for market integration and price convergence within one chain of supermarkets – Metro Cash and Carry.

2. Background

The Law of One Price (LOOP) is an economic principle stating that when prices are denominated in the same currency, identical goods should be priced consistently across various markets. The LOOP implies that the exchange rate between two currencies should reflect the ratio of price levels for a specified basket of goods and services in the respective countries. Frequently, LOOP

serves as a tool for assessing the credibility of the Purchasing Power Parity (PPP) theory, which states that exchange rates should adapt to equalize the prices of identical goods across diverse countries. The convergence to the LOOP implies that cross border arbitrage opportunities are eliminated, and markets become more integrated.

The paper "Market integration and convergence to the Law of One Price: evidence from the European car market," by P.K. Goldberg and F. Verboven in 2003, serves as a benchmark study for this thesis. In this paper, the authors investigate whether prices in the European car market align with the principles of the Law of One Price (LOOP), both in its relative and absolute forms. The authors attribute the robust support for the convergence hypothesis in their data to the ongoing process of market integration within Europe. This means that prices for identical cars tend to come closer together as markets become more integrated. The authors use a comprehensive panel data set of car prices to analyze how the process of European integration influenced price dispersion across different countries within Europe. Their findings reveal a strong tendency towards

convergence to both the absolute and relative versions of Purchasing Power Parity (PPP).

While the results regarding the absolute version of the LOOP are less definitive, the authors still find substantial evidence of convergence in both the

absolute and relative interpretations of LOOP. This suggests that, to some extent, prices for the same cars are equalizing across European markets. To gain insights into the factors driving this convergence, the authors conduct a detailed analysis of the European car market at a micro-level. They explore the sources of market segmentation and assess how measures aimed at promoting market integration relate to actual price convergence. In summary, the paper concludes that the process of integration in Europe's car market has had a discernible impact on reducing price differences across countries, as evidenced by the tests of the Law of One Price.

The reference paper by Goldberg (2005) examines two approaches to studying the convergence of car prices in the European market. The first approach in the paper seeks to understand how long-term price differences persist and calculates the speed at which prices come together in line with the Law of One Price (LOOP). The focus of this thesis revolves around the second approach, which involves a dynamic panel regression model. This model includes lagged price differentials as explanatory factors. The analysis primarily focuses on Belgium as the benchmark country and emphasizes the examination of price differences between bilateral trading partners. In this context, if the coefficient on

past period prices is negative, it signifies that price disparities are diminishing over time, and this challenges the hypothesis of a unit root. The findings in the

paper provide support for the idea that there is convergence towards both the relative and absolute versions of the Law of One Price (LOOP). However, the evidence for the absolute version of LOOP is less straightforward. In summary, the paper concludes that the process of integration in the European market has played a role in reducing price differences, but significant variations in prices across countries persist.

The paper discusses the advantages of micro-level analysis in investigating the relationship in the European car market. The micro-level analysis allows authors to look closer to the relationship between market integration and price convergence at a very detailed level, which allows them to draw more precise conclusions about the nature and extent of price convergence in the European car market. In the analysis for this thesis, the micro-level analysis is conducted.

As a research work "Persistence in Law-of-One-Price Deviations: Evidence from Micro-Data" authored by Mario J. Crucini and Mototsugu Shintani (2008) shows, an examination is undertaken regarding the anticipation that, over an extended duration, the pricing of a commodity denominated in a common currency should ultimately revert to a uniform level across diverse locations, aligning with the theoretical framework of absolute convergence. However, the authors direct their focus towards ultimate consumer prices of retail commodities as opposed to the origin and destination prices of standardized

traded goods. Considering this perspective, the authors posit that conditional convergence is likely to be more prevalent than absolute convergence. The presented empirical substantiation by Crucini and Shintani (2008) reinforces the proposition that disturbances giving rise to temporary deviations from a location-specific mean in the relative pricing of a commodity are transitory rather than enduring. This empirical observation holds true both within the confines of individual nations and across distinct countries. Consequently, the pivotal inquiry stemming from these empirical observations pertains to the degree of persistence manifested by these temporary deviations. Thus, although prices exhibit a tendency to converge over the long term, ephemeral disruptions may introduce transient deviations from this anticipated pattern.

In their seminal work, "Persistence in Law-of-One-Price Deviations: Evidence from Micro-Data," Mario J. Crucini and Mototsugu Shintani (2004) delve into the existing microeconomics literature concerning the frequency of price adjustment across 71 countries with 245 goods prices. The authors highlight the scarcity of empirical evidence on micro-price dynamics at the international level. The authors initiate their investigation by conducting tests of unit roots in Law-of-One-Price (LOOP) deviations on a cross-country basis, pooling data across various locations. Notably, they face the challenge of a small number of time series observations (T = 11) for each real exchange rate, rendering conventional panel unit root tests inapplicable. This methodological

constraint underscores the complexity and limitations associated with analyzing micro-price

dynamics internationally. Crucini and Shintani's study (2004) underscores the need for nuanced approaches in addressing the intricacies of LOOP deviations, especially when dealing with limited time series data. Their acknowledgment of the challenges posed by small sample sizes and aggregation biases contributes valuable insights to the broader discourse on the dynamics of prices across different economic entities.

The Error Correction Method (ECM) in panel data regression considers this dependence by allowing for a dynamic interaction between entities through the error correction mechanism. Estimating the general ECM in panel data involves addressing the challenges associated with panel data, such as dealing with unobserved heterogeneity, endogeneity, and potential issues related to the number of entities and time periods. The general structure of an ECM involves expressing the change in the dependent variable as a function of its lagged values, the lagged values of other relevant variables, and an error correction term. Therefore, when conducting a regression for the thesis, we included lagged values, due to impossibility of unit root test, which may not extend beyond the time series domain to account for both cross-sectional and time dimensions. The inclusion of lagged values suggests that the model is capturing not only the short

term dynamics of the series but also the potential long-term equilibrium relationship among the variables.

3. Data and Summary Statistics

The data for the thesis paper was kindly provided be the management of one of the biggest retail chains Metro Cash & Carry Kazakhstan. The data is observed monthly for 2016 and 2017, summing to 24 months of observations for 893 products that are present in the four different stores – in Astana, Almaty, Moscow, and Saint Petersburg. The raw data was not filled for every month, indicating the changes only in the given period. While filling up the data, total observations increased almost twice, from 45,198 to 92,400. The final panel data is completed with multiple observations for each product over time, as a result a larger sample size is attained, which can lead to more precise parameter estimates.

The data is structured as a panel data, since it was crucial for the analysis to control for both entity-specific and time-specific effects, making the regression results more robust and providing a better understanding of how price changes are influenced by various factors. The product identifier "ean_no" represents different products, and the fixed effects model helps account for the unique characteristics or unobserved factors associated with each product. The

variable “time”, which ranges from 1 to 24 and represents each month from January 2016 to December 2017, serves as a time indicator. The "time" variable allows to track price changes for each product over different time periods. The longitudinal panel data dimension enables the examination of price evolution, including the identification of trends, seasonality, and patterns, while also facilitating the

assessment of price dynamics in diverse product categories with due consideration to their unique attributes.

The analysis is initiated by computing the natural logarithm of product prices in each city (lnp10, lnp11, lnp14, lnp15). This transformation to log-scale data serves multiple purposes. Initially, it simplifies the understanding of percentage fluctuations in price since a shift in the logarithm corresponds directly to a percentage alteration in the initial price. Additionally, when conducting regression tests, log-transformed data is favored because it frequently demonstrates more uniform variance, adhering to the assumption of homoscedasticity crucial for various statistical models. All the prices in the dataset are already in Kazakhstani Tenge (KZT) since the data is sourced from Metro in Kazakhstan. This ensures consistency in the currency used for the analysis. There is an exchange rate that indicates how the Kazakhstani Tenge (KZT) changed concerning 1 Russian Ruble over time. This is essential when

making cross-border price comparisons, as it adjusts for changes in the relative value of currencies, allowing for meaningful comparisons between the two countries.

The analysis starts by comparing prices in Astana (the benchmark) and Almaty within Kazakhstan. The average price of products across these two cities is calculated. This step is crucial to understand price variations within the same country and identify any significant price differences between the two cities. Then, the minimum and maximum prices for each product for each specific

month and year is computed. These variables are important for understanding the price range for each product in each month and for identifying potential outliers. A new variable devKZ that calculates the price deviation between the maximum price in Almaty (maxprice11) and the minimum price in Astana (minprice10) for each product in each specific month and year is created. The next variable reldevKZ is created, which computes the relative price deviation in Kazakhstan. It's calculated as the ratio of the previously calculated devKZ to avgprice_KZ. This relative deviation allows to assess how significant the price difference is relative to the average price in Kazakhstan. Then cleaning the data starts for the observations, where relative deviation of prices is more than 1 and less than 1, since it would mean that these observations are outliers (possibly large deviations) or the maximum prices in Almaty can be less than the minimum price in Astana, creating a negative relative deviation of prices. These

products are seasonal, rare, some might be irregular.

To see what range of price is acceptible, the summary statistics for the avgprice_KZ variable is generated. It provides details about the distribution of the average product price in Kazakhstan. The 99th percentile of data is up to 12,856.25 KZT, which we took as a point to which we draw the scatter plot. This

limitation helped to save the visualization from the distortion with outliers.

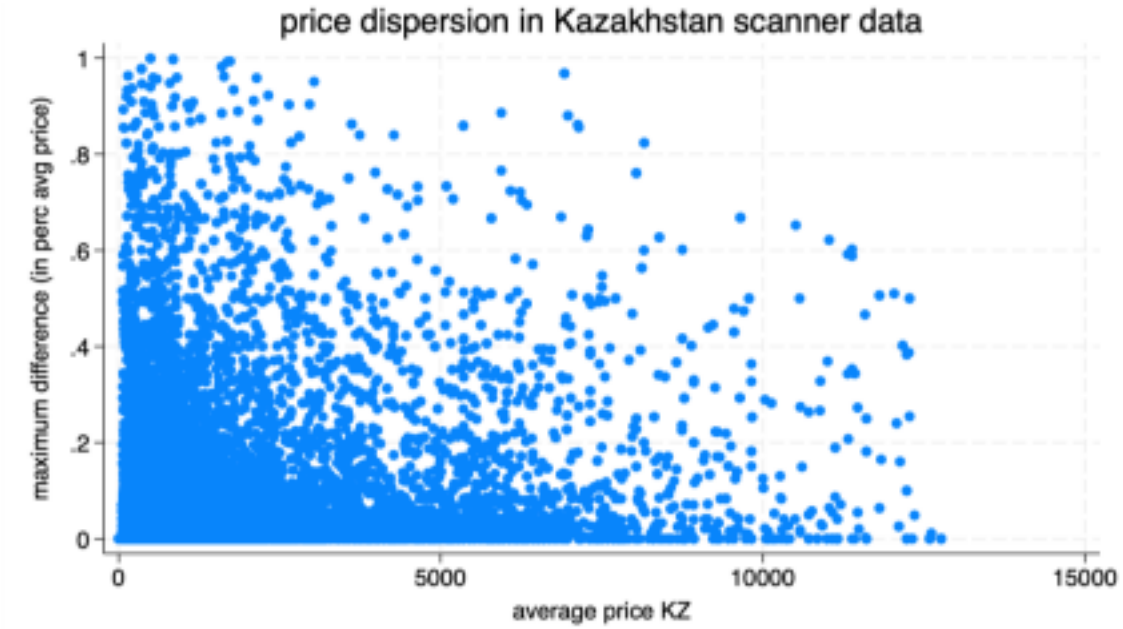

Figure 1. Price Dispersion Astana & Almaty

On the x-axis, there is the average product price of Kazakhstan (avgprice_KZ), which indicates the pricing range of products. The y-axis represents the relative price deviation (reldevKZ), indicating how much

Almaty's prices differ from Astana's within Kazakhstan. These values between 0 and 1 are positive values, which signify that Almaty's maximum price exceeds Astana's minimum price, other options are dropped for not being relevant.

This scatter plot unveils intriguing insights. Towards the lower end of average prices, notable price variations exist between Astana and Almaty. Factors such as transportation costs, variations in demand, and localized market conditions could be contributing to these disparities. Products with lower average prices appear to be more susceptible to such influences, resulting in more significant price divergences between the two cities.

As the x-axis is traced towards higher average prices, the y-axis values, indicating price deviations, gradually diminish. This pattern suggests that as the average price of products in Kazakhstan increases, the degree of price deviation between Astana and Almaty tends to lessen. It's plausible that these factors, which exert a substantial impact on lower-priced items, become less influential as average prices rise. Consequently, products with higher average prices may experience fewer price disparities due to their reduced susceptibility to local market conditions.

Figure 2. Price Dispersion Moscow & Saint-Petersburg

The same process has been done to Moscow and Saint-Petersburg brunches, comparing the prices within Russia only. Here, in contrast with the previous scatter plot, the 99 percentile of data is up to 24,621.45 kzt, which indicates that the same products in Russia are way expensive. In summary, this

scatter plots provide a visual representation of how price disparities in Kazakhstan and Russia fluctuate in relation to the average product price of the relevant country. It underscores that price discrepancies are more conspicuous among lower-priced products and tend to attenuate as the average prices increase, possibly reflecting variations in market dynamics and cost structures. These observations offer valuable insights for analyzing the law of one price within the context of Kazakhstan and Russia.

The article by Parsley and Wei (1996) focuses on the convergence to PPP

within the United States, providing insights into the dynamics of price convergence without the influence of trade barriers or currency fluctuations. It emphasizes the faster convergence for larger price differences and the impact of geographical distance on convergence rates within a single country. In our analysis, within country analysis also shows very similar trends.

Intercountry analysis between Russia and Kazakhstan is done through taking the average prices for cities within each country. Since the data was taken from Metro Kazakhstan, the prices were already in KZT. Summing the prices, we had an average of 15,806.7 KZT for two cities in each country. The same tests as previous were conducted, where the difference in the prices were seen. Due to differences in prices in two countries, the convergence to the LOOP is not clearly detected as for each country seperately.

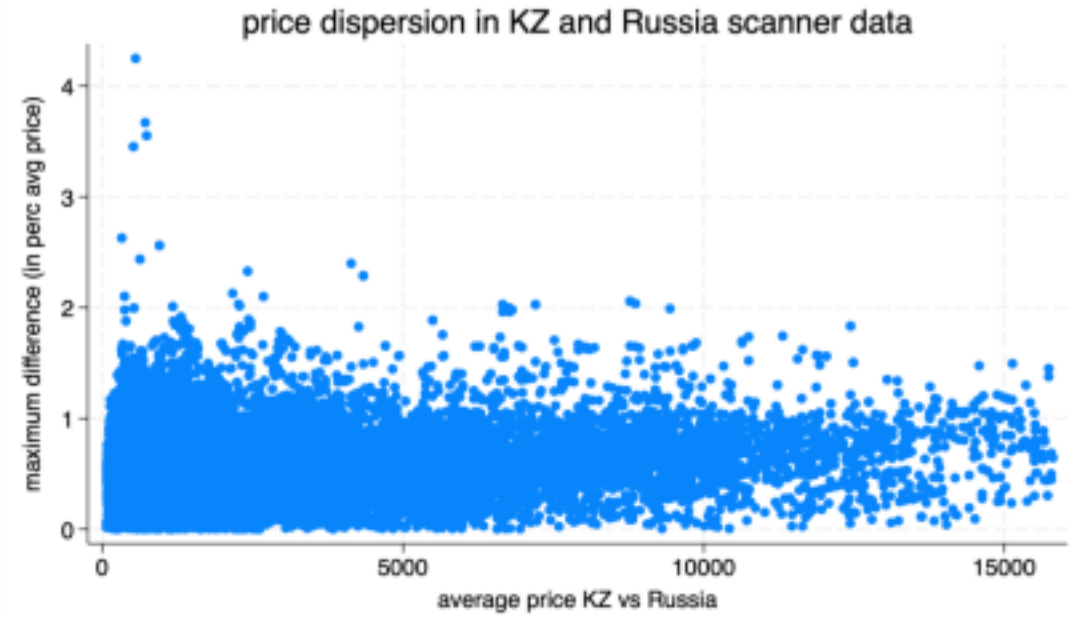

Figure 3. KZ and Russia price dispersion

The prices for Russia seem to be higher several times than the prices in Kazakhstan. Therefore, we take off the outliers (>2 y-axis) and divide relative prices by 2 (reldevKZR/2) to make it comparable to the previous graphs. As seen in the graph, there seem to be a little evidence of convergence as the prices go up.

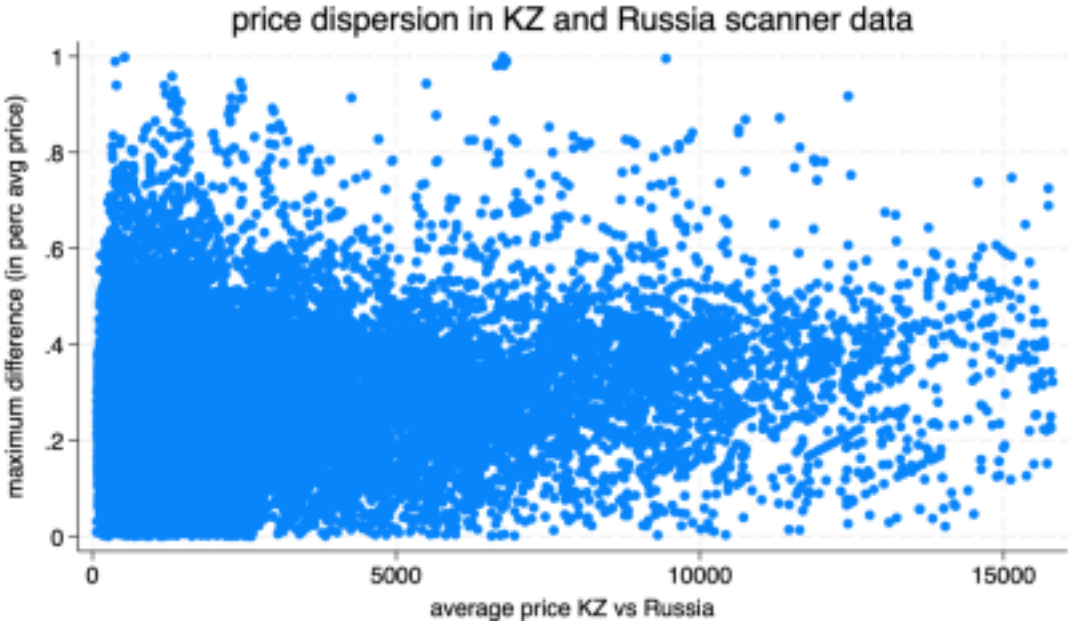

Figure 4. KZ & Russia price dispersion modified version

4. Regression Results

In this analysis, a convergence model is employed through regression to explore the dynamics of prices in Almaty concerning their convergence or divergence relative to the benchmark city of Astana. Initially, our primary focus is on the market conditions within Kazakhstan (KZ), then we also look at the two cities (Moscow and Saint Peteresburg) in Russia using the same method to see changes in prices within country and identify if they converge with time.

To set up this convergence model, we first create a new variable, `lnprice_ik`, which measures the disparity between the natural logarithms of prices for product i in Almaty (lnp11) and Astana (lnp10). The utilization of the natural logarithm of prices is a well-established practice in economic analysis, chosen for its capacity to enhance data interpretability and facilitate the effective handling of percentage changes. Subsequently, the dataset is checked for being organized chronologically by sorting it based on the year and month. This temporal arrangement is crucial for conducting robust time-series data analysis, ensuring that the observations are appropriately sequenced over time. To establish a time dimension, we generate a variable named `time`. This is accomplished by employing the `egen` function to group observations based on the combined values of year and month. This time variable is instrumental for time-series data analysis and supports our panel data approach, enabling the examination of data across various entities, in this case, products, over time.

The `xtset` command is then employed to configure the dataset as a panel dataset, with product identification number (ean_no) serving as the panel identifier and “time” as the time variable. This step is pivotal in preparing the data for panel data analysis, a framework well-suited for studying how products evolve over time. Another variable, `dlnprice_ik`, is generated to represent the first difference in the `lnprice_ik` variable, which is the lagged level of the

natural logarithm of the price variable. Essentially, this variable quantifies the change in the price differential between Almaty and Astana from one time period to the next.

The subsequent step involves a regression analysis. The regression involving the first difference of the natural logarithm of price variable (dlnprice_ik) regressed on its lagged values (l1.dlnprice_ik, l2.dlnprice_ik, l3.dlnprice_ik, l4.dlnprice_ik) and the lnprice_ik variable along with its lagged value (l1.lnprice_ik) is run. This regression is pivotal in our convergence model, offering valuable insights into historical and current price divergences over time. The purpose of this regression is to investigate how past and current price disparities (represented by dlnprice_ik) are related to each other over time and to explore the dynamic relationships between these variables. Each of these lagged variables allows you to assess how past price differences influence the current price difference. By including multiple lags, both short-term and longer-term effects are accounted on the dynamics of price convergence or divergence between Almaty and Astana. It's an essential component of the convergence

model and can provide valuable insights into the evolution of price differences between Almaty and Astana in Kazakhstan.

Furthermore, fixed effects are incorporated in this regression, pertaining to the panel variable `ean_no`. These fixed effects account for time-invariant attributes unique to each product, enabling the focus on the impact of changes in

our independent variables on the convergence or divergence of prices. Also, it controls for unobservable, time-invariant factors specific to each product. This reduces the risk of omitted variable bias, making the regression results more reliable.

All tables employ very similar type of regression analysis. A short description for each regression:

- Simple regression: y= dlnprice_i(product)k(country) and x= l.lnprice_ik. • Simple regression full model: all variables are included in this regression without fixed effects.
- Fixed effects: the regression with all variables that are intended to be included with fixed effects. From this on, every regression in the next columns is with fixed effects.
- Controlling for months: monthly dummies are added with fixed effects. • Controling for year: year dummy is added with fixed effects. • Controlling for both: both months and year dummies are included in the regresion with fixed effects.

- ECM – Error correction model for dlnprice_i and its lags, using monthly and yearly dummies with fixed effects.

Table 1. Astana and Almaty regression results

VARIABLES	Simple regression dlnprice_i k	Simple reg full model Fixed effects dlnprice_i k	Controllin g for months dlnprice_i k	Controllin g for year For both dlnprice_i k	months&yea r ECM dlnprice_i k	months&yea r dlnprice_i k

	dlnprice_ik	dlnprice_ik				
L.lnprice_ik	-0.078***	-0.040***	-0.118***	-0.579***	-0.601***	-0.623***
	(0.002)	(0.002)	(0.005)	(0.030)	(0.030)	(0.031)
L.dlnprice_ik	-0.168***	-0.192***	-0.069**	-0.051	-0.037	-0.535***
	(0.007)	(0.008)	(0.031)	(0.031)	(0.032)	(0.022)
L2.dlnprice_i k				-0.059***	-0.062***	-0.014
				(0.006)	(0.007)	(0.027)
L3.dlnprice_i k					-0.009	-0.000
					(0.027)	(0.025)
L4.dlnprice_i k						-0.000
						(0.027)
L5.dlnprice_i k						-0.271***
						(0.025)
L6.dlnprice_i k						-0.396***
						(0.027)
2.month	-0.008	-0.005	-0.008	0.000	0.055***	0.058***
	(0.010)	(0.010)	(0.011)			
3.month	0.011	0.016	0.008	0.010)	(0.010)	(0.011)
4.month	0.023**	0.030***	0.011	(0.011)	(0.011)	(0.012)
5.month	0.018	0.028**	0.004	(0.011)	(0.011)	(0.012)
6.month	0.002	0.024**	-0.008	(0.009)	(0.010)	(0.011)
7.month	-0.000	0.023**	-0.010	(0.009)	(0.010)	(0.011)
8.month	0.007	0.031***	-0.003	(0.009)	(0.010)	(0.011)
9.month	-0.005	0.020**	-0.016	(0.009)	(0.010)	(0.011)
10.month	-0.008	0.017*	-0.016	(0.009)	(0.010)	(0.011)
11.month	-0.002	0.025**	-0.009	(0.009)	(0.010)	(0.011)
12.month	0.001	0.028***	-0.006	(0.009)	(0.010)	(0.010)
2017.year	0.024***	0.034***	0.001	(0.005)	(0.006)	(0.006)
Constant	0.004***	0.002***	0.004***	0.027***	0.017***	-0.009
	(0.000)	(0.000)	(0.000)	(0.007)	(0.003)	(0.010)
						(0.011)

Observations	38,696	22,819	22,819	4,145	4,145	4,145	4,145
R-squared	0.035	0.055	0.216	0.488	0.489	0.493	0.416

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The stars indicate the level of statistical significance of the coefficients. Three stars (***) indicate a significance level of 0.1% (highly significant), two stars (**) at 5%, and one star (*) at 10%. Coefficients that are statistically significant suggest that there is a robust relationship between these variables.

The results drawn for Kazakhstan show the clear evidence of convergence. Table 1 describes all the regression results for Astana and Almaty

cities. In the first column we have variables names, then the regression results start with simple regression, where we include only the lagged level of the natural logarithm of the price variable (l.lnprice_ik) in the regression. The coefficient for l.lnprice_ik is negative and significant. In the next column, where we include all other variables, the coefficients for lnprice_ik and its lagged values (lagged 1) are all negative and statistically significant (p-value=0). This implies that fluctuations in the natural logarithm of price differences (lnprice_ik) and its preceding values are linked to variations in dlnprice_ik, highlighting a connection between past and present price divergences. The coefficient for dlnprice_ik (lagged 4) is nearly zero and lacks statistical significance, suggesting that the fourth lag of dlnprice_ik does not exert a significant influence on the current value of dlnprice_ik.

Based on the regression results, the coefficient on the past period prices represented by `lnprice_ik` (Lagged 1) is negative and statistically significant, it indeed signifies that price disparities are diminishing over time. This is a crucial observation, as it challenges the hypothesis of a unit root, which would imply that price disparities remain constant or grow over time. In other words, the results of the regression suggest that, over time, prices in Almaty are moving closer to prices in Astana, which is consistent with the idea that the principle of the Law of One Price is being upheld. This convergence is observed in both

relative terms (price disparities are decreasing) and absolute terms (prices are moving closer together).

The r-squared improved compared to the previous regression, and now approximately 21.59% of the variability in the dependent variable, dlnprice_ik, is explained by the independent variables in the model. This is a moderate level of explanatory power. The coefficient for lnprice_ik (Lagged 1) is negative and highly significant (p-value 0.000), indicating that past changes in natural logarithm of price differences are associated with current changes in dlnprice_ik. This implies a robust connection between historical and present price divergences. Consistent with prior findings, the coefficients for dlnprice_ik (Lagged 1, Lagged 2, and Lagged 3) remain negative and highly significant (p values 0.000), suggesting a strong influence of past dlnprice_ik values on the current figure.

The next 3 columns control for time dummies – months, years, and both. The r-squared significantly goes up here due to control for seasonal effects and yearly effects. The basis year is 2016 in our dataset, and as a basis month was taken January. When both year and month dummies are added, r-squared is at the highest, which is 49.3%. And throughout all of these inclusions to the regression, we observe a negative coefficient fot the lagged natural logarithm of the price variable (l.lnprice_ik). The coefficient becomes more negative starting

from the simplest regression, to the model with time dummies, starting from the coefficient of -0.078 to -0.623 under 1% significance level for all parts.

The data provides clear evidence of a substantial negative correlation between previous price disparities, considering both natural logarithms and first differences, and the current price disparities. This suggests a trend of diminishing price divergences over time, underscoring the improvement in convergence when fixed effects are incorporated.

Since the regression is a part of the error correction model, the inclusion of it seemed logical as the last step. An error correction model that considers both monthly and yearly factors. Seasonal and yearly patterns play a significant role in the variation of the dependent variable, as evidenced by the coefficients on the month and year dummies. In time series analysis, it's often essential to work with stationary variables. If your variables are non-stationary, the differences (or changes) may be more appropriate for modeling. The ECM includes both the levels and first differences of the variables, helping to address non-stationarity

issues. The coefficients of the ECM represent the speed of adjustment back to the long-term equilibrium after a shock. In the table, a significant ECM coefficient (for example, 0.535***) suggests that around 53.5% of the disequilibrium is corrected within the next period. The ECM column shows that the first lag is negatively significant, indicating that previous price changes have

a notable and opposite effect on current price changes. The ECM model's significant and negative coefficient confirms that the dependent variable corrects towards its long-term equilibrium at a relatively rapid pace. The lagged variables show that past prices have an impact on current prices, with the effect decreasing as the lag increases, which is also a positive sign for the LOOP.

The results suggest that past and current price disparities are strongly related. The strong statistical significance of most coefficients adds confidence to these findings. Compared to the results within Kazakhstan, in Russia, all lagged coefficients of ‘dlnprice_ir’ are negative and highly significant (p-value=0).

Same process for regression model is done for Russian cities Moscow and Saint Petersburg. The outcomes of the regression analysis furnish valuable insights into the evolution of price differences between two cities of each country over time. It considers both current and past price levels, along with the potential influence of product-specific fixed effects. These findings are pivotal for the examination of the law of one price and the determination of whether prices in Kazakhstan and Russia are moving towards convergence or divergence.

All coefficients for l.lnprice_ir (i – for product, r – for the country) are

negative and significant throughout the whole table. When including the fixed effects, the R-squared is approximately 17.82% of the variability in the dependent variable, ‘dlnprice_ir’, is explained by the independent variables in

the model. This is a moderate level of explanatory power. The adjusted R-squared is lower at 0.0892, suggesting that the model might not benefit significantly from additional variables. The coefficients are still negative, the coefficient of our main interest is more negative when including the fixed effects. When comtrolling for time dummies the R-squared significantly went up, meaning the modle fits well. For Error Correction Model (ECM), we are looking at the four lagged variables of dlnprice_ir, 63.5% of the disequilibrium is corrected in the first lag (first period), then in the subsequent periods, 41%, 25.9%, 15.2% are the speeds at which a dependent variable (dlnprice_ir) returns to equilibrium after a change in other variables. When the coefficients are diminishing and bring the disequilibrium lower, it suggests that adjustments are being made to return to the long-run equilibrium. In the context of the Law of One Price, which posits that in the absence of transportation costs and barriers to trade, the price of an identical good should be the same in different markets, an ECM with diminishing coefficients could indeed be indicative of a convergence towards the Law of One Price. This means that if there were a price difference for the same good in different markets, over time, the prices would adjust and converge towards a common price.

In the context of an Error Correction Model (ECM), the coefficients associated with the error correction terms usually indicate the speed at which

prices adjust to return to their long-term equilibrium. Significantly nonzero and negative coefficients suggest that there is a correction towards equilibrium occurring between periods. This observation aligns with the notion of convergence, as outlined by the Law of One Price.

Table 2. Moscow and SP regression results

	Simple	regression Simple reg	full model Fixed	Controlling effectsfor months	Controlling for year	For both months&year	ECM months&year
VARIABLES	dlnprice_ir	dlnprice_ir	dlnprice_ir	dlnprice_ir	dlnprice_ir	dlnprice_ir	dlnprice_ir
L.lnprice_ir	-0.089***	-0.035***	-0.231***	-0.928***	-0.925***	-0.926***	
	(0.002)	(0.002)	(0.005)	(0.025)	(0.025)	(0.025)	
L.dlnprice_ir	-0.274***	-0.218***	0.061***	0.055**	0.056**	-0.635***	
	(0.006)	(0.007)	(0.024)	(0.024)	(0.024)	(0.016)	
L2.dlnprice_ir	-0.106***	-0.079***	0.089***	0.082***	0.082***	-0.410***	
	(0.006)	(0.006)	(0.021)	(0.021)	(0.021)	(0.018)	
L3.dlnprice_ir	-0.038***	-0.020***	0.075***	0.069***	0.067***	-0.259***	
	(0.005)	(0.006)	(0.018)	(0.018)	(0.018)	(0.018)	
L4.dlnprice_ir	-0.029***	-0.021***	0.017	0.013	0.011	-0.152***	
	(0.004)	(0.004)	(0.014)	(0.014)	(0.014)	(0.015)	
2.month			-0.001	-0.001	-0.001		
			(0.004)	(0.004)	(0.004)		
3.month			-0.000	-0.001	-0.001		
			(0.004)	(0.004)	(0.004)		
4.month			-0.008*	-0.009**	-0.010**		
			(0.004)	(0.004)	(0.005)		
5.month			-0.003	-0.006	-0.005		
			(0.004)	(0.004)	(0.005)		
6.month			-0.008**	-0.013***	-0.009*		
			(0.004)	(0.004)	(0.005)		
7.month			-0.003	-0.009**	-0.002		
			(0.004)	(0.004)	(0.005)		
8.month			-0.001	-0.007*	0.000		
			(0.004)	(0.004)	(0.005)		
9.month			-0.005	-0.012***	-0.009*		
			(0.004)	(0.004)	(0.005)		
10.month			-0.003	-0.012***	-0.010**		
			(0.004)	(0.004)	(0.005)		
11.month			0.002	-0.007*	-0.006		
			(0.004)	(0.004)	(0.005)		
12.month			-0.004	-0.013***	-0.012***		
			(0.004)	(0.004)	(0.005)		
2017.year			-0.007***	-0.012***	-0.013***		
			(0.002)	(0.003)	(0.003)		
Constant	0.004***	0.001***	0.008***	0.057***	0.058***	0.070***	0.016***
	(0.000)	(0.000)	(0.000)	(0.003)	(0.002)	(0.004)	(0.004)
Observations	44,869	28,296	28,296	6,190	6,190	6,190	6,190
R-squared	0.048	0.100	0.238	0.536	0.536	0.539	0.398

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

These findings are significant and provide empirical support for the

hypothesis that there is a convergence towards the Law of One Price, indicating that prices are becoming more similar between the two cities over time. Especially, the coefficients for lagged log prices of product variable (l.lnprice_ir) become more negative and increase their effect on the regression as we add additional variables and time dummies. This has important implications for understanding price dynamics and market integration within the context of Kazakhstan and Russia.

Therefore, Kazakhstani and Russian products' average prices were taken and there has been conducted the same method of regression, to see if the prices of two different countries converge to the Law of One Price (LOOP). Here Kazakhstan's avereage price is a benchmark. The special characteristics of these regression analysis is that we include here the exchange rate too after having simple regression with full set of variables we wanted to include. As usual, we are interested in the lagged level of the natural logarithm of the price variable (l.lnprice_ikzr) for Kazakhstan and Russia average prices to be negative, so it

converge. It does have negative coefficients, though they are not as influential as within country coefficients presented in Table 1 and Table 2. Exchange rates are only significant when we include the fixed effects, monthly dummies with fixed effects, and year dummy with fixed effects. In other cases, it doesn't have any significant effect on the overall rergression.

Regarding the other parts, they are like the previous results, there is a little evidence for convergence, because different countries often have varying levels of GDP, which can influence the purchasing power of consumers. In wealthier countries with higher GDP per capita, consumers may be willing to pay more for the same good, allowing a chain to charge higher prices. Another reason can be the costs of doing business because it can vary significantly between countries due to differences in labor costs, rent, utilities, local supply chain efficiencies, taxes, and import duties. These factors can cause price discrepancies.

Table 3. Kazakhstan and Russia average prices regression results

VARIABLES	Simple reg dlnprice_ikzr	Simple full dlnprice_ikzr **Exch**	**rate reg** dlnprice_ikzr Fixed	effects exch r dlnprice_ikzr Controllin	g for months dlnprice_ikzr Controlli	n g for year dlnprice_ikzr	Both for months& year dlnprice_ikzr ECM	months& year dlnprice_ikzr
L.lnprice_ikzr				-0.357***	-0.357***	-0.190***	-0.124***	-0.120***
L.dlnprice_ikzr				-0.118***	-0.533***			
				(0.004)	(0.004)	(0.005)	(0.009)	(0.009) (0.009) (0.006)
L2.dlnprice_ikzr				-0.159***	-0.159***	-0.047***	-0.015*	-0.012 -0.010
L3.dlnprice_ikzr				-0.344***				
				(0.004)	(0.004)	(0.005)	(0.009)	(0.009) (0.009) (0.007)
L4.dlnprice_ikzr	-0.047***	-0.019***	-0.019***	-0.313***	-0.533***		-0.093***	-0.093*** -0.015*** 0.000 0.004 0.005
	-0.536***	-0.540***					-0.253***	
	(0.001)	(0.001)	(0.001)	(0.004)	(0.009)	(0.009) (0.009)	(0.004)	(0.004) (0.005) (0.008) (0.008) (0.008) (0.007)
							(0.007)	(0.007)
2.month	-0.054***	-0.054***	-0.007	-0.001	0.002	0.002		
3.month	-0.162***	(0.004)	(0.004)	(0.004)	(0.007)	(0.007)		
4.month								
5.month								
	2.month	-0.012***	-0.012**	-0.010*	(0.005)	(0.005)	(0.005)	
	3.month	-0.000	-0.009*	-0.006	(0.005)	(0.005)	(0.005)	
	4.month	0.006	-0.001	0.001	(0.005)	(0.005)	(0.005)	
	5.month	-0.009*	-0.016***	-0.017***	(0.005)	(0.005)	(0.005)	

6.month -0.022*** -0.028*** -0.032*** (0.004) (0.004) (0.004)
7.month -0.007 -0.019*** -0.016*** (0.004) (0.005) (0.004)
8.month -0.009** -0.026*** -0.021*** (0.004) (0.005) (0.004)
9.month -0.027*** -0.048*** -0.040*** (0.004) (0.005) (0.004)
10.month -0.016*** -0.033*** -0.018*** (0.004) (0.005) (0.004)
11.month -0.021*** -0.036*** -0.018*** (0.004) (0.005) (0.004)
12.month -0.010** -0.032*** -0.012*** (0.004) (0.006) (0.004)
exchange_rk zt (0.002) (0.002) (0.005) (0.005) (0.008)
-0.000 -0.007*** -0.039*** -0.041*** 0.002

2017.year 0.002 -0.021*** 0.003 (0.002) (0.004) (0.002)
Constant 0.026*** 0.008*** 0.009 0.228*** 0.536*** 0.535*** 0.340*** 0.008* (0.001) (0.001) (0.011)
(0.011) (0.027) (0.027) (0.043) (0.004)
80,702 65,590 65,590 65,590 33,238 33,238 33,238
Observation s 33,238

R-squared 0.021 0.126 0.126 0.232 0.335 0.332 0.336 0.254 Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In the framework of an Error Correction Model (ECM), the coefficients linked to the error correction terms provide insights into the pace at which prices adjust to revert to their long-term equilibrium. Within this specific ECM, the coefficient for the initial lag indicates a 53.3% correction toward equilibrium, followed by a diminishing trend with the second lag at 34.3%, the third lag at

25.3%, and the final lag at 16.2%. The consistently negative coefficients diminishing over time suggest an ongoing correction toward equilibrium between periods. This trend again aligns with the concept of convergence as stipulated by the Law of One Price.

5. Conclusion

The evidence of convergence to the Law of One Price (LOOP) is justified by the the regression model and results. The analysis involved a convergence

model, which allowed us to investigate the dynamics of price convergence or divergence over time. We utilized natural logarithms, first differences of price data, fixed effects, as well as time dummies for product-specific characteristics. The regression results provide compelling evidence of price convergence. The negative coefficients on lagged price differences and their statistical significance indicate that past and current price disparities are strongly related. The fact that these coefficients are consistently negative implies that price disparities tend to diminish over time, challenging the hypothesis of a unit root. However, it is important to consider the specific market dynamics, cost structures, and other factors that may influence the observed price disparities. These findings contribute to the understanding of price dynamics in Kazakhstan and in Russia and have implications for economic theories related to the Law of One Price. Further research could explore the specific drivers of price convergence and divergence in more detail.

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