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INTERREGIONAL INTEGRATION OF WHEAT MARKETS IN KAZAKHSTAN

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ABSTRACT

Reliable marketing opportunities in both interregional and international trade along with relatively low transportation [and transaction] costs are essential to profitability of wheat production. In this study we have investigated one aspect of the quality of marketing and trade opportunities in the Kazakh wheat sector, that is the extent and nature of integration among regional wheat markets. We applied threshold cointegration technique to assess the co-movement between time series of elevator prices at three grain-trading (and producing) spots in the northern and central parts of the country.

Results suggest that markets of two northern grain trading spots (Petropavlovsk and Kokshetau) are closely connected with each other while their connection with Karaganda in central Kazakhstan is much weaker. Here, levelling out of price gaps through arbitrage trade only occurs after a threshold of considerable extent has been surpassed.

JEL: C22, Q13

Keywords: Kazakhstan, Price transmission, Market integration, Threshold cointegration.

ZUSAMMENFASSUNG

Eine wichtige Voraussetzung für die Wirtschaftlichkeit der Getreideproduktion sind verlässliche Vermarktungswege, die interregionalen und internationalen Handel zu relativ geringen Transport- und Transaktionskosten zulassen. Die Studie behandelt die Integration regionaler Weizenmärkte miteinander und beleuchtet damit, wie reibungslos Getreidehandel zwischen diesen Regionen möglich ist. Mit Hilfe von Verfahren der threshold cointegration analysis werden Zusammenhänge in den Preisentwicklungen zwischen drei wichtigen Handelsplätzen in Nord- und Zentralkasachstan untersucht.

Die Märkte der beiden nördlichen Marktorte Petropavlovsk und Kokshetau stehen in enger Verbindung zueinander, während sie wesentlich unabhängiger von den Marktentwickungen im zentralkasachischen Karaganda sind. Ein Ausgleich von Preisunterschieden zwischen den nördlichen Märkten und Karaganda findet erst statt, wenn diese Unterschiede einen beträchtlichen Schwellenwert (threshold) übersteigen.

JEL: C22, Q13

Schlüsselwörter: Kasachstan, Preistransmission, Marktintegration, Kointegration.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller test
AIC	Akaike Information Criteria
CI	Cointegration
ECM	Error Correction Model
ECT	Error Correction Term
FAO	Food and Agriculture Organization of the United Nations
FCC	Food Contract Corporation
FOB	Free On Board
GDP	Gross Domestic Product
I (0)	Integrated of order zero
KCSO	Kazakh Central Statistical Office
LM	Lagrangian Multiplier test
LOP	Law of One Price
ML	Maximum Likelihood
OLS	Ordinary Least Squares
TECM	Threshold Error Correction Model
USD	United States Dollars
USSR	Union of Soviet Socialistic Republics
VECM	Vector Error Correction Model

1 INTRODUCTION

Kazakhstan is among the 20 largest wheat producers and 10 largest exporters in the globe. Agriculture accounts for 8 % of Kazakh GDP and wheat production accounts for 30 % of agricultural GDP. Although production risks due to climatic factors are high, natural conditions for growing grains are favourable and render wheat production highly competitive in international comparison (BOKUSHEVA and HEIDELBACH, 2004).

One critical factor in the development of this important sector of the Kazakh economy is the degree of markets functioning. Reliable marketing opportunities in both interregional and international trade along with relatively low transportation (and transaction) costs are essential to profitability of wheat production and hence to the growth perspectives of the sector.

Studies on agricultural markets in Kazakhstan describe the structure of supply, demand, the trade sector, and analyse the development of trade margins. (LONGMIRE and MOLDASHEV, 1999; AHMAD and BRASLAVSKAYA, 2003). However, these studies did not undertake a rigorous statistical analysis of integration of those markets. At the same time there exist significant amount of literature on the integration of agricultural markets in other transition countries. ROZELLE et al. (1997) analyse how market liberalisation in China between 1988 and 1995 was reflected in interregional integration of rural markets. GOODWIN et al. (1999) as well as KOPSIDIS and PETER (2001) analysed spatial market integration in the Russian Federation.

This discussion paper investigates one aspect of the quality of marketing and trade opportunities in the Kazakh wheat sector, that is the nature of integration among regional wheat markets. If regional markets are integrated, i.e. they are linked to each other, then deficit and surplus situations tend to be levelled out by arbitrage trade. This is to say that the prices for wheat in any two locations should not differ (persistently) by more than the cost of transfer of that wheat between these two locations. Excess price gaps in that sense are expected to be alleviated by arbitrage, – by shipment of wheat from the low-price-region to the high-price-region, – so that prices converge. As long as arbitrage can take place, price shocks in one region will be buffered and price co-movement between regions can be observed to some extent. However, there is evidence in many transition economies (and not only there) suggesting that arbitrage is restricted. Possible causes are regional market power in the transportation or warehouse sector, insufficient price information systems (lacking market transparency) and risks regarding reliability of market partners or unhindered physical transfer.

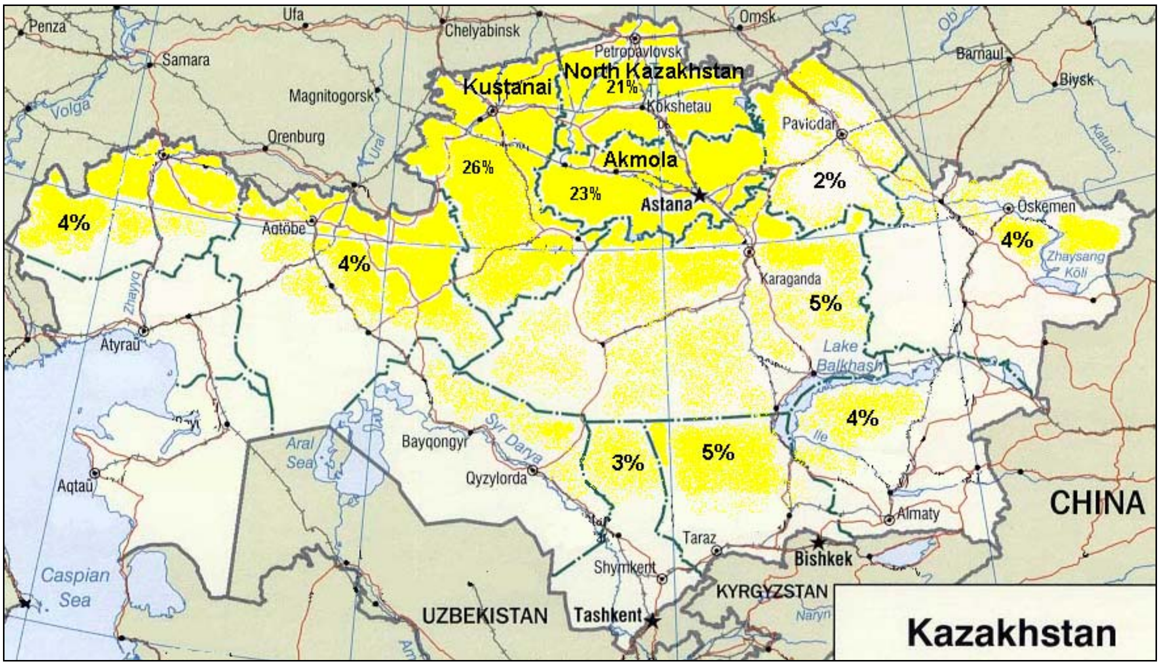
The study aims to detect how well regional markets in Kazakhstan are integrated. We apply threshold cointegration techniques to assess the co-movement between time series of elevator prices at three grain-trading (and producing) spots in the northern and central parts of the country. First, an overview of the Kazakh wheat sector characterising the structure of production, marketing and trade patterns is given in section 2. In addition descriptive analyses on inter-oblys wheat price relationships are provided. They form a link between the characterisation of the market structure and the subsequent model-based approach. The general range of analytical approaches to testing market integration as well as an introduction to the threshold cointegration approach is given in section 3. Section 4 describes the data source and the applied model and estimation procedure. The discussion paper concludes with the policy implications derived from the findings of the study (section 5). The empirical analysis is confined to a sample of three major market spots and hence it gives only an extract of the complete picture of spatial wheat market integration in Kazakhstan. However, the discussion paper describes a pilot study that explores the empirical relevance of the research question as well as the applicability and interpretability of the selected approach in the given context.

2 WHEAT SECTOR IN KAZAKHSTAN

2.1 Primary production

Wheat is produced in all but one *oblyses*[1] of Kazakhstan (Map 2.1). Kazakhstan with diverse climate conditions produces spring as well as winter wheat varieties. Southern regions of the country produce mostly winter wheat varieties, while northern regions produce spring wheat varieties. 70 % of wheat produced in Kazakhstan comes from three north and north-central regions, Akmola oblys, Koustanay oblys, and North Kazakhstan oblys (Source: KAZAKHSTAN STATISTICS AGENCY, 2003).

Map 2.1: Distribution of wheat production in Kazakhstan



Source: KAZAKH STATISTICS AGENCY, 2004.

Wheat is a traditionally commercial crop in Kazakhstan. In the USSR times Kazakhstan used to supply most of the Soviet Republics with its wheat. Nowadays, forty percent of produced wheat in Kazakhstan is being sold for export to neighbouring countries in the former Soviet Union. (FAO, 2005)

After gaining independence in 1991 Kazakhstan started transformation from a central-command economy to a market-oriented one. Disruption of the USSR market had an adverse impact on the Kazakh grain sector and as a result the production level during the past 12 years has drastically declined. In 2004 Kazakhstan produced 9.6 million tons, which is half of what was produced in 1992. The decline in production was associated with a decrease in the production area from 13.7 mln hectares in 1992 to 10.5 mln hectares in 2004. The average yield also dropped down to 900 kg/ha in 2004 from 1300 kg/ha in 1992. (FAO, 2005)

Changes in the institutional environment have also contributed to the decrease in wheat production. During the first years of independence large-scale 'kolkhozes' and 'sovkhozes' were privatized, and many small and medium-scale farms appeared. Later on, due to high market and production risks many farmers united and formed big-scale production cooperatives, very

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[1] Oblys stands for the Kazakh administrative regions. There are 14 oblys in total in Kazakhstan.

often on the base of former 'kolkhozes'. However, other farmers (peasant farmers) decided to run their business independently[2]. Nowadays, about half of total wheat supply is being produced in farmers' unions (production cooperatives). Peasant farms produce 45 % of Kazakh wheat. (Source: KAZAKHSTAN STATISTIC AGENCY, 2003)

Farmers' unions (production cooperatives) usually operate in larger scale, while the peasant farmers in medium and small scales. Farmers' unions (production cooperatives) in Akmola oblys have on average 3400 ha, in Koustanay oblys 1500 ha, and in North Kazakhstan oblys 2900 haof wheat cultivated area, while peasant farms in Akmola oblys have 882 ha, in Koustanay oblys 773 ha, and in North Kazakhstan oblys 469 hain average. (Source: KAZAKHSTAN STATISTIC AGENCY, 2003)

With regard to land productivity, peasant farms are usually more productive than the large-scale cooperatives. On average, one Kazakh peasant farmer harvested 1.4 tons per hain 2001, while the cooperatives on average yield 1 ton/ha. Such pattern can be noted in all regions of Kazakhstan. The highest yield that peasant farms got in 2001 was 2.4 t/ha in Southern Kazakhstan, while the highest yield in cooperative farms in the same year was observed in Eastern Kazakhstan as 1.6 t/ha.

Though peasant farms are more productive and most promising in terms of increasing wheat production, there are, however, constraining factors that they face, such as poor access to machinery, fertilizers, and markets.

2.2 Marketing infrastructure

Kazakhstan has inherited a well-developed wheat-marketing infrastructure from the former years of the Soviet Union, comprising of elevators, rail stations, and roads. In the first years after gaining independence a number of elevators has been privatized by newly established farmers' unions, corporations, and cooperatives.

There are approximately 80 elevators spread across Kazakhstan, with a majority of them located in the wheat-producing regions, Northern Kazakhstan, Koustanay, and Pavlodar. On average one elevator's capacity is little more than 100 thousand tons, with the range of the largest capacity of 300 thousand tons, and the smallest of 60 thousand tons. The total capacity of all Kazakh elevators to store grain is estimated as approximately 4 million tons (own calculations based on food-grain corporations' data available online). There is also a significant number of bread making and grain processing factories in the country, which consume 4 million tons of produced grains per year. Another 2 million tons of grain are being left for seed use, and 4 million tons being exported annually (Source: FAO, 2002).

In general, changes in wheat trade and prices occur seasonally, with low prices at the harvest period, and higher prices otherwise. Most of the total wheat trade volume occurs on forward contracts. Grain prices are set according to the grain quality, capacity of the elevator, and season among other factors.

The level of the price for wheat on domestic markets heavily depends on the export price, particularly on the export price to Russia and Ukraine. In 2003 both Russia and Ukraine,

[2] The government of Kazakhstan officially names these entities peasant farms. However, most of them are commercially oriented farms.

when suffering from drought, have imported half of the wheat produced in Kazakhstan. As a result, grain prices in Kazakhstan skyrocketed.[3]

Though wheat prices in Kazakhstan have grown on average for the recent couple of years, and farmers start getting high prices for the product, there is still some evidences of price discrimination among the farm types, and failure of local markets to entirely transmit the changes (increase) in export/elevator/flour prices to similar changes at the farm-gate level, and as result of this leading to disintegration of regional markets. AHMAD and BRASLAVSKAYA (2003) indicate that peasant farmers often discriminated by grain traders and offered low prices.

The structure of wheat production, marketing, and utilisation in Kazakhstan must be assumed to have influenced the pattern of regional prices. We now report on descriptive analyses focusing on such pattern. The results motivate the model based analysis that will follow.

2.3 Wheat price patterns in Kazakhstan

To get an impression of the pattern of regional wheat prices we looked at average farm gate wheat prices by oblys that the Kazakh Central Statistical Office (KCSO) publishes on a monthly basis. These data represent the volume and quality composition typical for the respective oblys. Therefore, price comparisons over oblyses have to be interpreted with care. One particular difference is that in the north (oblyses North-Kazakhstan, Akmola, and Kustanai) farms produce soft wheat while in southern oblyses, the share of hard wheat – traded at higher prices – is larger. Another difference is that the average volume of individual deals is much larger in the north, where average farm sizes are a multiple of southern oblyses. However, it cannot be concluded a priori in what direction this size differences affect prices.

Figure 2.1 shows the price development (in USD/ton) in 12 oblyses for the period from January 2000 to July 2004.[4] This plot does not reveal details but three characteristics can be identified from it: First, general price trends are reflected in almost all oblyses: A moderate increase can be observed through 2000 and 2001, a decrease in 2002 and a strong increase in 2003 and 2004 including a jump in the second half of 2003. The trend is positive with an average annual increase of over 14 percent which exceeds the corresponding inflation rate of the US Dollar by more than 4 times.

Second, prices in some oblyses are typically above average while in other oblyses prices below average were usually observed. Figure 2.2 shows the stylised pattern. Considering the (unweighted) mean over oblyses as the national average, in the five oblyses marked dark, prices were on average more than 2 % below that average. The gaps ranged between -2.1 % for East-Kazakhstan and -8 % in Almaty oblys. For the surplus regions in the North (North Kazakhstan and Akmolar produce 44 % of Kazakh wheat supply) this conforms with expectations while it surprises with regard to the southern deficit regions in which only small quantities of relatively high quality durum wheat is produced. A possible explanation for the low prices in these regions is the relatively inefficient infrastructure (e.g. elevator and transport technology) predominant in southern oblyses that involves large marketing margins at the cost of producers with low market power. The high price regions Kysylorda (17 % above average), South Kazakhstan (+ 7 %) and West Kazakhstan (+ 4 %) have a wheat deficit situation which is consistent with the high prices.

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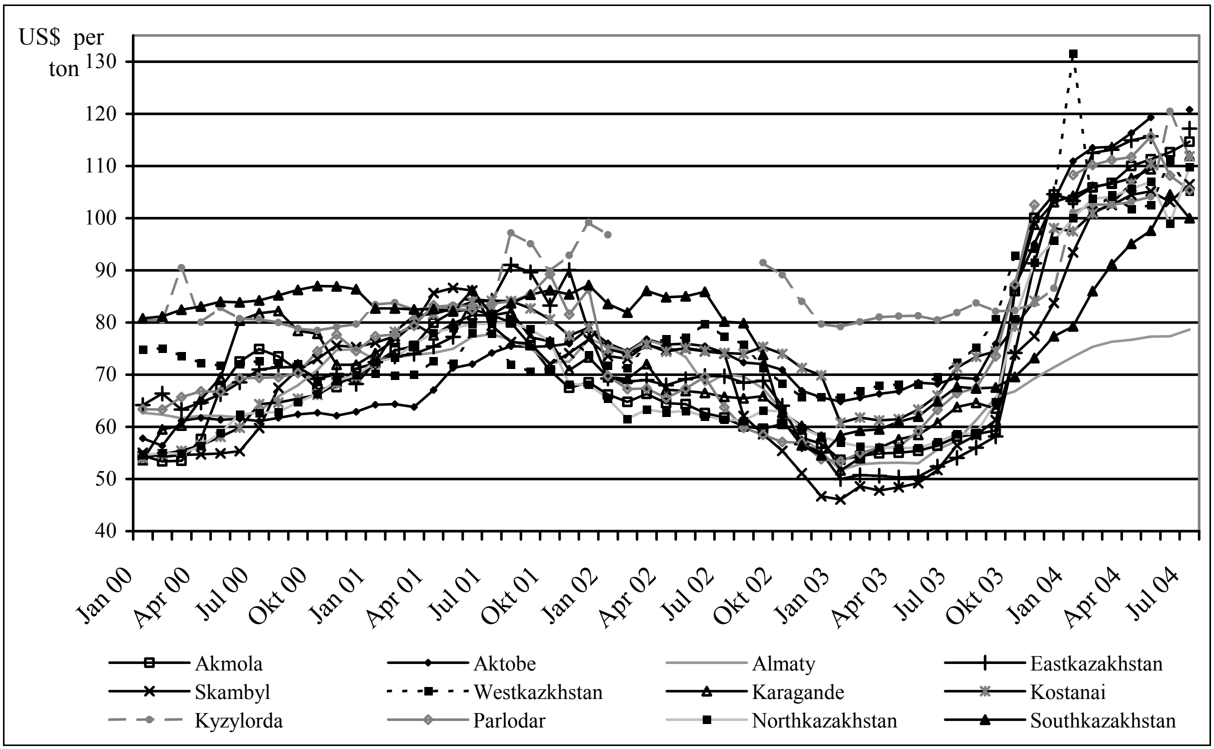
3 From November 2003, average wheat farm-gate prices in the southern Russian regions neighbouring Kazakhstan ranged from 130 to 160 USD/ton and stayed in this range until July 2005, when prices felt to 110 USD/ton on average. (MINISTRY OF AGRICULTURE, RUSSIAN FEDERATION, 2005)

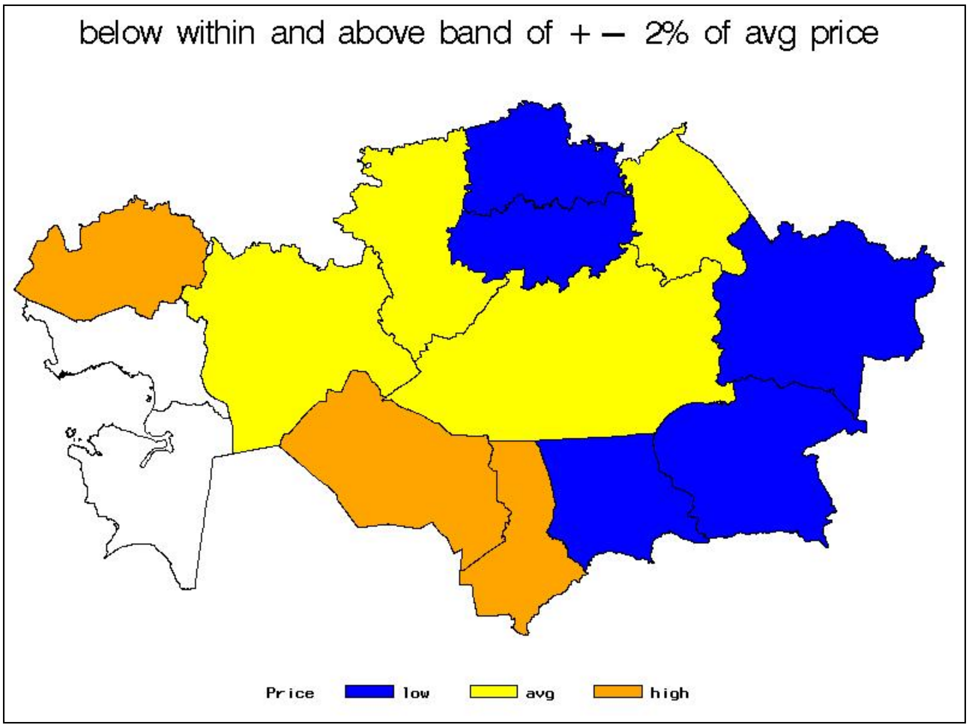
4 For Atyrau and Mangghystau where wheat production is negligible, no price data were reported.

Figure 2.1: Wheat prices Kazakhstan, by oblys, 2000-2004



Source: Price data obtained from KCSO, in 2004.

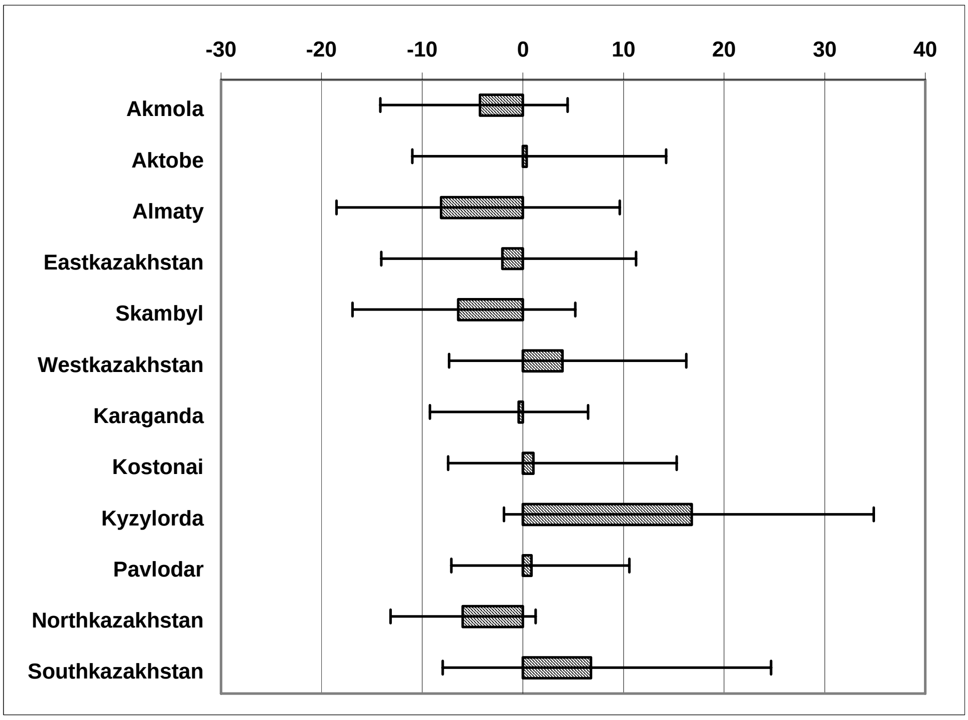
Figure 2.2: Interregional differences between average relative prices



Source: Price data obtained from KCSO, in 2004.

Third, although significant gaps between long-term-means of prices show that there are typical high-price and typical low-price regions respectively it should be realised that the price ranking implied by this does not describe a stable situation. The plot over time in figure 2.1 shows that prices in South Kazakhstan for instance have been above average for most of 2000 through 2002 but they were lower than in any other oblys (except Aktobe) in 2004. Figure 2.3 visualises this aspect in more detail. The hatched bars represent the mean percentage price gap between the respective oblys and the national average price (unweighted average of oblys specific prices). The thin black lines however represent the volatility of such price gaps over time: Even if the lowest and the highest ten percent of observations are disregarded (because there might be outliers due to measurement errors among them) the spread between low (relative) price periods and high (relative) price periods is huge. In none of the oblyses prices were consistently below or consistently above average.

Figure 2.3: Deviation from national average price: Mean over time and range



Source: Own computations from KCSO data.

Considering that short term deviations can be expected to have been "corrected" within the period of a month which the time series is based on, this means that prices in different oblyses seem to move quite independently: Not even the ordering remains approximately constant over time. This finding motivates to have a closer look on the price co movement which will be covered in the remaining part of this paper.

3 Assessing market integration: Methodological approach

3.1 Overview of approaches

Most of the existing studies on spatial market integration belong to either of two groups of approaches.[5] The first group investigates the probability of markets to observe the so-called spatial arbitrage condition, i.e. the condition that the price gap between two locations does not

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5 Fackler and Goodwin (2001) provide a thorough and detailed coverage of definitions of various terms that are used interchangeably in market integration studies, such as Law of one price (LOP), spatial arbitrage, spatial market integration, and spatial market efficiency. They review a wide range of studies and used methodologies.

exceed costs of transfer of the good in question between those locations. These studies apply switching regression models (SPILLER and HUANG, 1986; SEXTON et al., 1991) and in later years parity bounds models (BAULCH, 1997). The probability (or frequency) of spatially distinct markets to comply with the spatial arbitrage condition is interpreted as a (continuous) measure of the degree of market integration. The ability to reflect market integration on a gradual scale rather than as a dichotomous property is emphasised by the proponents of the method. Also, exogenous information on transaction costs can be utilised in these approaches.[6] On the other hand, the only information considered on compliance with the spatial arbitrage condition at any moment is the dichotomous (yes/no) information; the dynamics of adjustment towards that state are not being addressed with this approach.

The other group of studies particularly focuses on the dynamic aspects of market integration. It considers the degree of co-movement of prices collected in different locations which is seen as an indicator of market integration. Earlier works proposed to measure market integration by the size of correlation (and regression) coefficients between prices of identical products in different markets (locations). Being estimated from nonstationary time series, the validity of these simple coefficients as a measure of market integration had to be denied (ARDENI, 1989). However the basic idea was retained as advanced time-series models and tests appeared (cointegration and error correction models, among others). These models account for potential non-stationarity and if with their help one detects stable equilibrium relationships between price series from different market locations, this is usually interpreted to imply market integration. There is, however, no one-to-one correspondence between the statistical concepts cointegration/ no-cointegration and the economic concepts well-functioning/dysfunctional markets: The driving force presumed to maintain interregional price equilibrium is arbitrage trade. It is triggered as soon as price deviations become too large and reduces them by levelling out differences in scarcity between locations. A desirable economic framework is concluded in these cases which is characterised by favourable or at least sufficient institutional preconditions for a well functioning market. There is however, at least one other interpretation of close spatial price relationships: It is that prices in different locations are controlled by the same agent, e.g. by a cartel or an official market regulation system that guarantees intervention purchases by a public authority in different locations at a uniform fixed price. This would also cause price co-movement, but without well functioning trade and hence without the economic benefits that are usually associated with it. Likewise, the rejection of cointegration is often interpreted as a sign for lacking conditions for a well functioning market. However, also this conclusion is not necessarily stringent. As long as prices do not diverge by more than the unavoidable transaction costs incurred with arbitrage trade, it is just natural that price formation in spatially distinct markets is completely independent. It would be unjustified in such case to allege that markets do not work properly and that potential gains from trade are foregone.

Cointegration analysis of horizontal price transmission was found useful in many studies on grains, livestock, and other agricultural products on data from both developed and developing (transitional) economies. Important to note that the degree of market integration typically varies between developing (transitional) and developed economies. The degree of markets integration is likely to be higher in developed economies than in developing (and transitional) economies. There could be several reasons for that. Among them is less developed marketing infrastructure in developing countries, as well as asymmetric access to information on markets and prices, political constraints, etc. In this respect, studies that investigated market integration in developed economies are more concerned about the speed and asymmetry in price adjustment

[6] BAULCH (1997) used data on transportation costs as the proxy to transaction costs to derive the parity bounds within which the arbitrage condition holds.

between the regional markets (GOODWIN and PIGGOTT, 2001). However, in the case of developing (and transitional) economies, the cointegration analysis tool aims at revealing whether market integration occurs at all, at providing policy implications based on the results of the analysis, and, ideally, even at extending to the analysis of factors affecting market integration (or better to say factors that affect the regional market disintegration, or why prices fail to transmit between the regional markets). (ISMET et al., 1998; GONZALEZ-RIVERA and HELFAND, 2001).

Similar, in this study we check whether pairs of price series from different Kazakh oblyses are cointegrated. Though cointegration analysis has become standard textbook material, we will briefly describe the given bivariate case in order to emphasise a couple of aspects that are particularly important in this study.

3.2 Linear cointegration

Pairs of nonstationary time series are cointegrated if they have the same order of integration and if they have a stable long term linear relationship. For two series *x* and *y* such relationship means that we can find a linear combination among the series that is stationary. The residuals *e* of a linear regression among the series *x* and *y*

$$y_t = \mu + \beta x_t + e_t \tag{3.1}$$

will then form a stationary time series, i.e. a series with constant (zero) mean and variance.[7] Empirically this is usually accepted if the (absolute value of the) first order autoregressive coefficient of the series is significantly smaller than one.

The parameters μ and β form the cointegration vector and characterise the nature of the long term relationship between the price series. Cointegration does not make sure that the series are not or do not drift "far apart from each other". Aside from some constant gap μ between them also continuous divergence over time is not ruled out. The definition only requires that the price gap grows in a proportional manner (with β unequal to one), i.e. with a constant ratio between absolute price changes in both markets. If, as it is frequently done, logs of the price series are studied, the divergence is disproportional but restricted to maintain a constant ratio between *relative* price changes, i.e. with a constant elasticity.[8]

For stochastic time series to obey a stable long term relationship requires some "driving force" that prevents the series from drifting too far apart. GRANGER (1981) has shown that time series that are in fact cointegrated, necessarily have also a so called error correction representation which explicitly focuses on the adjustment process maintaining the equilibrium:

$$\Delta y_t = b_0 + \sum_{i=1}^{n} c_i \Delta y_{t-i} + \alpha (y_{t-1} - \beta x_{t-1}) + v_t \; ^{9} \tag{3.2}$$

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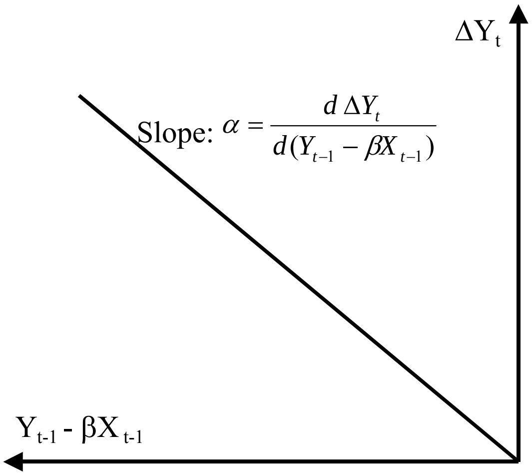
7 An equivalent condition requires stationarity of the residuals of the inverse regression, specifying $x_t = \overline{\mu} + \overline{\beta} y_t + \overline{e}_t$.

8 To comply with the notion of market integration prices in spatially distinct markets may not drift too far apart. Cointegration is hence not sufficient, and, to meet this condition, (in this example) the cointegration parameter β may have to be restricted to unity. On the other hand, this rules out the realistic idea of nonproportional transaction costs which can be caused by nonconstant tariffs, risk premia, brokerage fees etc.

9 In this representation the constant μ of the cointegrating relationship (3.1) was removed from the cointegrating vector because it is not identified given an additional constant in the ECM. In that sense (3.2) is a reduced form equation in which the parameter b_0 represents both constants at the same time.

Error correction models relate the changes in the observed series Δy_t to the error correction term $(y_{t-1} - \beta x_{t-1})$, i.e. the deviation from equilibrium in the preceding period. The parameter α reflects the strength of the error correction mechanism, i.e. it characterises to what extent a deviation from the equilibrium relationship in the previous period triggers a change of *y* in the present period and hence pulls the series back towards the equilibrium. In that sense it measures the speed of adjustment. A correct specification according to the assumed data generating process requires to include deterministic and autoregressive components in the model.[10] The error correction mechanism is illustrated in figure 3.1. The constant slope of the function, represented by the parameter α, indicates the linear relationship between the past period's divergence from equilibrium $y_{t-1} - \beta X_{t-1}$ (or y_{t-1}-μ-βx_{t-1} to be exact) and the present period's adjustment from the part of the variable *y*: $\Delta Y_t = y_t - y_{t-1}$. The higher the slope the quicker *y* adjusts to reduce any given divergence from equilibrium. The linearity of the error correction mechanism implies that even very small deviations from the equilibrium relationship will always lead to an adjustment process in each of the two considered markets.

Figure 3.1: Linear error correction mechanism



Source: MEYER, 2003.

Expression (3.2) refers to the single-equation approach suggested by ENGLE and GRANGER (1987). It considers only one dependent variable in the model. JOHANSEN (1988) has developed a multivariate system of equations approach, which allows for simultaneous adjustment of both or even more than two variables.

JOHANSEN's approach is widely used also in many bivariate studies as it has some advantages to the single equation approach. First, the multivariate system of equations approach is more efficient than the single equation approach, i.e. it allows to estimate the cointegration vector with smaller variance. The second advantage of the multivariate approach is that in the simultaneous estimation it is not necessary to presuppose exogeneity of either of the variables. In the case of two dependent variables the vector ECM has the following form:

$$\begin{bmatrix} \Delta y_t \\ \Delta x_t \end{bmatrix} = \begin{bmatrix} b_0 \\ b_1 \end{bmatrix} + \sum_{i=1}^{n} \begin{bmatrix} c_i^{y,y} & c_i^{y,x} \\ c_i^{x,y} & c_i^{x,x} \end{bmatrix} \begin{bmatrix} \Delta y_{t-i} \\ \Delta x_{t-i} \end{bmatrix} + \begin{bmatrix} \alpha_y \\ \alpha_x \end{bmatrix} \left(\begin{bmatrix} \beta_1 & \beta_2 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} \right) + v_t \qquad (3.3)$$

10 An analogous Error Correction Model indicates changes in the other variable, x_t (instead of y_t) as a function of deterministic variables, autoregressive components, and the deviation from equilibrium.

Parameters b_i and c_i are estimated and n is set according to information criteria in order to account appropriately for the dynamic structure of the underlying data generating process. In the adjustment term $\begin{bmatrix}\alpha_y \\ \alpha_x\end{bmatrix}\left(\begin{bmatrix}\beta_1 & \beta_2\end{bmatrix}\begin{bmatrix}y_{t-1} \\ x_{t-1}\end{bmatrix}\right)$ each period's deviation from equilibrium is represented by the scalar $\begin{bmatrix}\beta_1 & \beta_2\end{bmatrix}\begin{bmatrix}y_{t-1} \\ x_{t-1}\end{bmatrix}$ and the speed of adjustment of each of the series by the parameters α_y and α_x. JOHANSEN's multivariate equations approach offers two tests for cointegration based on the estimated parameter matrices. These are the trace test (or reduced rank test) and the maximal eigenvalue test and we refer to the literature for details.

3.3 Threshold cointegration

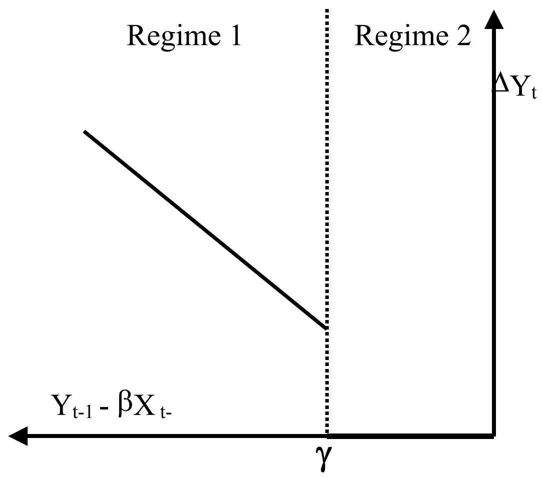
In the context of spatial market integration the force that prevents prices from drifting far apart is arbitrage. Sellers ship their product from low-price regions to places where they can receive higher prices. Buyers tend to acquire goods from places with prices that are lower than in their own place. This re-balancing of supply and demand tends to reduce interregional scarcity- and hence price-differences. However, gains from arbitrage can only be made if price gaps exceed the transaction (transport-) costs incurred. This means that price adjustment through arbitrage will only take place if the price gap exceeds a certain threshold level given by transaction costs. As long as they are below that level no systematic error correction will take place. In the error correction model (3.3) the adjustment parameters α_y and α_x will then be zero. This is represented by a Threshold Error Correction Model (TECM) (BALKE and FOMBY, 1997; GOODWIN and PIGGOTT, 2001; HANSEN and SEO, 2002; MEYER, 2003). In general, in these models the short term adjustment behaviour is not constant but it differs between distinct regimes. The regimes are characterised by different sets of adjustment parameters α (and potentially deterministic and autoregressive parameters) and the size of the error correction term $ECT_{t-1} = \begin{bmatrix}\beta_1 & \beta_2\end{bmatrix}\begin{bmatrix}y_{t-1} \\ x_{t-1}\end{bmatrix}$ determines in each period which regime is in effect:

$$\begin{aligned}
\begin{bmatrix}\Delta y_t \\ \Delta x_t\end{bmatrix} &= \begin{bmatrix}b_0 \\ b_1\end{bmatrix} + \sum_{i=1}^{n}\begin{bmatrix}c_i^{y,y} & c_i^{y,x} \\ c_i^{x,y} & c_i^{x,x}\end{bmatrix}\begin{bmatrix}\Delta y_{t-i} \\ \Delta x_{t-i}\end{bmatrix} + \begin{bmatrix}\alpha_y^{1} \\ \alpha_x^{1}\end{bmatrix} ECT_{t-1} + v_t \qquad \text{if } ECT_{t-1} \le \gamma \ (\text{Regime 1}) \\
\begin{bmatrix}\Delta y_t \\ \Delta x_t\end{bmatrix} &= \begin{bmatrix}b_0 \\ b_1\end{bmatrix} + \sum_{i=1}^{n}\begin{bmatrix}c_i^{y,y} & c_i^{y,x} \\ c_i^{x,y} & c_i^{x,x}\end{bmatrix}\begin{bmatrix}\Delta y_{t-i} \\ \Delta x_{t-i}\end{bmatrix} + \begin{bmatrix}\alpha_y^{2} \\ \alpha_x^{2}\end{bmatrix} ECT_{t-1} + v_t \qquad \text{if } ECT_{t-1} > \gamma \ (\text{Regime 2})
\end{aligned} \tag{3.4}$$

When ECT_{t-1} is smaller than or equal to the threshold value γ the speed of adjustment of the series y and x towards equilibrium is given by α_y^1 and α_x^1 respectively. When the ECT_{t-1} exceeds the γ, the parameter set of regime 2 (α_y^2 and α_x^2) is in effect.

Figure 3.2. illustrates this for the case where in regime 2, i.e. close to the equilibrium, there is no significant adjustment process whereas an error correction mechanism is in effect when the deviation from equilibrium is relatively large, i.e. ECT_{t-1} is below the threshold γ (regime 1).

Figure 3.2: Threshold error correction mechanism



Source: MEYER, 2003.

In empirical applications the threshold value usually has to be estimated. Our empirical study follows BALKE and FOMBY (1997) who suggest a sequential approach to test for threshold cointegration. First we test in bivariate models for cointegration. Second, for those pairs of price series that are found to be cointegrated we test for the presence of a threshold value that separates significantly different error correction mechanisms.

4 DATA AND EMPIRICAL ESTIMATION

4.1 Data sources

Data have been compiled from the online database of "AgroInfrom" initiative of TACIS, Ministry of Agriculture of Kazakhstan, and Kazakhstan Statistics Agencies. Data comprises weekly observations of elevator-level wheat prices in three market spots of Kazakhstan, Petropavlovsk (PET), Kokshetau (KOK), and Karaganda(KAR).[11] Observations were available for the period from March 1998 to December 2004. Missing values were interpolated, replacing with the values observed in the last period when the variable was nonmissing.[12]

Characteristics and descriptive statistics of price series are given in Table 4.1. Price series are given in USD per ton. The minimum values for all series were observed in August-September, 2002, and maximum prices in February-April, 2004.

Before proceeding with the analysis, we transformed all the series into the natural log form as is common practice in many comparable studies. This transformation helps to account for *relative* price variation during periods of different price levels in a sufficiently balanced manner.

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[11] It was initially planned to consider additional market locations within the country, in order to find out to what extent the LOP applies also between locations with less frequent wheat trade. Lack of price data prevented to perform conclusive analysis so that we concentrated on the mentioned major market spots.

[12] GOODWIN and PIGGOTT (2001) replaced missing values using cubic spline interpolation.

Table 4.1: General characteristics and descriptive statistics of price series in three locations of Kazakhstan, USD/ton, 1998:03-2004:12

	Petropavlovsk	Kokshetau	Karaganda
N of observations	356	355	355
Mean	81.09	83.68	91.18
Std. Dev	32.38	29.35	27.16
Minimum	44	52	58
Maximum	164	176	165

Source: Own computations based on data of AGROINFORM, 2005.

4.2 Results

First, we have checked whether the three pairs of locations (PET-KOK, PET-KAR, and KOK-KAR) are characterised by co-integration between the observed wheat price series. Augmented Dickey-Fuller unit-root tests (ADF) of the individual price series (in levels and first differences) indicated that each series is I(1), or integrated of order one. (Table 4.2)

Table 4.2: Results of ADF test for unit roots on Kazakh price series in levels and first differences (Specification: With constant and two lagged differences)

Series	ADF test statistic	
	Level	1st difference
Petropavlovsk	-1.72	-12.45*
Kokshetau	-1.10	-11.47*
Karaganda	-1.49	-10.26*

Source: Own computations based on data of AGROINFORM, 2005.

Note: * – Statistically significant at 1 % level. Critical value is -3.43.

JOHANSEN's both reduced rank and maximal eigenvalue tests for significance of the cointegration vector were used for the three pairs of series. Table 4.3 presents the estimated eigenvalues, the results from trace tests, maximal eigenvalue tests, and the estimated linear long-run cointegration relationships between the series. Both of JOHANSEN's tests rejected the hypothesis of no cointegration in two pairs of series, Petropavlovsk-Kokshetau, and Kokshetau – Karaganda. In contrast, for Petropavlovsk-Karaganda both trace and maximal eigenvalue tests did not give evidence of an existing cointegration relationship between the series. This is consistent with some reports indicating that Karaganda is more involved in trading wheat with southern regions rather than the two northern regions which are focused on here. For the cointegration vectors reported in Table 4.3 the original β vector was normalised to one of its elements so to express one of the prices in terms of a multiple of the other price plus a constant.

Table 4.3: Test for cointegration and estimated long-run linear cointegration relationship

Pair	λ_1	λ_{max}	λ_{trace}	Long-run cointegration relationship
Petropavlovsk – Kokshetau	0.121	45.56*	46.88*	Price (Petrop) = - 0.52 + 1.10*Price(Koksh)
Petropavlovsk – Karaganda	0.027	9.85	12.20	Price (Petrop) = - 0.91 + 1.17*Price(Karag)
Kokshetau – Karaganda	0.046	16.82*	20.08*	Price (Koksh) = -1.13 + 1.24*Price(Karag)

Source: Own computations based on data of AGROINFORM, 2005.

Notes: * – Statistically significant at 5 %. Critical values (OSTERWALD-LENUM, 1992) at 5 % for (n-r) = 2 the Maxi mal Eigenvalue test is 15.67; and for the trace test is 19.96.

While cointegration between two of the pairs of price series implies a connection between the respective markets, the classical notion of market integration and the law of one price does not necessaryly apply here. The cointegration coefficients β_2 (1.10 and 1.24) substantially differ from unity which implies that, according to the model, the absolute price gap between the locations linearly increases with rising prices. However, we attribute the apparent significance of these linear coefficients to the limited price range covered by the data and hence do not see it as a reason to preclude market integration. We rather focus on the positive results of the cointegration tests themselves.

Next, using the information on the long-run cointegration relationship the short-run dynamic Vector Error Correction Model (VECM) was estimated for each pair of series that was found to be cointegrated. Estimating the VECM allowed to find the values of the α parameters, i.e. parameters of the speed of adjustment towards equilibrium. The estimated equations (with Eicker-White standard errors in parentheses) are as follows.[13]

(4.1) For Petropavlovsk and Kokshetau:

$$\begin{bmatrix} \Delta P_t^{Petr} \\ \Delta P_t^{Kok} \end{bmatrix} = \begin{bmatrix} -0.074 \\ (0.035) \\ 0.039 \\ (0.014) \end{bmatrix} + \begin{bmatrix} 0.134 & 0.076 \\ (0.135) & (0.115) \\ 0.063 & 0.060 \\ (0.107) & (0.098) \end{bmatrix} \begin{bmatrix} \Delta P_{t-1}^{Petr} \\ \Delta P_{t-1}^{Kok} \end{bmatrix} + \begin{bmatrix} -0.145 \\ (0.065) \\ 0.072 \\ (0.029) \end{bmatrix} \left[ECT_{t-1} \right] + \begin{bmatrix} e_t^{Petr} \\ e_t^{Kok} \end{bmatrix}$$

(4.2) For Kokshetau and Karaganda:

$$\begin{bmatrix} \Delta P_t^{Kok} \\ \Delta P_t^{Kar} \end{bmatrix} = \begin{bmatrix} 0.010 \\ (0.009) \\ 0.040 \\ (0.009) \end{bmatrix} + \begin{bmatrix} 0.027 & 0.043 \\ (0.095) & (0.082) \\ -0.015 & 0.073 \\ (0.099) & (0.098) \end{bmatrix} \begin{bmatrix} \Delta P_{t-1}^{Kok} \\ \Delta P_{t-1}^{Kar} \end{bmatrix} + \begin{bmatrix} 0.008 \\ (0.008) \\ 0.036 \\ (0.008) \end{bmatrix} \left[ECT_{t-1} \right] + \begin{bmatrix} e_t^{Kok} \\ e_t^{Kar} \end{bmatrix}$$

From equations (4.1) and (4.2) of special interest are the speed of adjustment parameters, i.e. ECT parameters.[14]

The speed of adjustment coefficient in (4.1) indicates that prices in Petropavlovsk adjust relatively fast to disequilibrium between the prices in Petropavlovsk and Kokshetau. Since we are considering logarithms of prices, the parameter value of 0.14 should be interpreted as an elasticity. It says that a one percent deviation from equilibrium (observed price in Kokshetau exceeds by one percent that theoretical price which would be observed if equilibrium was perfectly met) results in a 0.14 percent price change in Kokshetau towards equilibrium.[15] Prices in Kokshetau as well as in both locations of the relation Kokshetau – Karaganda adjust much slower. Prices in Karaganda adjust faster to changes in the equilibrium price relationship between Kokshetau and Karaganda than prices in Kokshetau do. Both cases indicate that prices in Kokshetau adjust slower to changes in prices in the other two locations.

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[13] Validity of these results is conditional on the validity of the linear VECM. As we will see later, a threshold specification is more appropriate for the pair Kokshetau – Karaganda. The figures presented here are therefore only used for comparison with the regime specific coefficients from the threshold model (see below).

[14] Note, that first and second lag difference variables possess no economic meaning but had to be included for correct specification of the models so that the errors are well behaved.

[15] This is subject to the qualification in footnote 13.

Several discussions with economists from Kazakhstan revealed that Petropavlovsk is, more than any other wheat market in Kazakhstan, affected by the changes in wheat prices in Russia.[16] Indeed, the geographical location of Petropavlovsk and the fact that the main railway that connects western Russia with Siberia and eastern regions of Russia goes through Petropavlovsk give ground to the assumption of strong connection of wheat prices in Petropavlovsk with Russian wheat markets. The size and power of elevators and the transport fleet in Petropavlovsk by far exceeds the one in the other two locations. This enables trading companies to react quickly whenever arbitrage opportunities arise and initiate and carry out arbitrage trade. This may in part explain the high speed of price adjustment in comparison with the other two locations.

Next we analyse for the two pairs of locations with cointegrated prices whether the adjustment process (represented by the speed of adjustment parameter) is sufficiently characterised by a universal ECT parameter in each equation or whether different adjustment parameters must be assumed for different ranges of the ECT (i.e. that different adjustment regimes are valid depending on the extent of divergence from equilibrium). We test the validity of a threshold model with one threshold, i.e. with two distinct regimes. Applying the search procedure and significance test suggested by HANSEN and SEO (2002) we tested each model for linearity. According to HANSEN's LM test linearity is not rejected for the pair of Petropavlovsk and Kokshetau (see Table 4.4). Th s validates the linear estimates in (4.1) with a unique adjustment parameter. For the pair Kokshetau – Karaganda linearity (as in 4.2) was rejected and a threshold parameter of -0.638 was estimated and proved significant. Transposing this estimate into price terms shows that during the investigated period of time arbitrage trade was triggered when the price in Kokshetau exceeded that one in Karaganda by more than 47 %, i.e. (computed at the average price in Karaganda, see Table 4.1) by more than 43 USD/t [17] (Table 4.4)

Table 4.4: Threshold parameter estimates and threshold cointegration test results

Pair	Threshold Parameter	Hansen's LM test
Petropavlovsk – Kokshetau	-0.020	13.93
Kokshetau – Karaganda	-0.638	22.61*

Source: Own computations based on data of AGROINFORM, 2005.

Note: * – Statistically significant at 5 %. Critical values for Hansen's LM test were derived using bootstrap technique at both residual and fixed regressors' levels each with 5000 replications.

As mentioned earlier we have specified two regimes in our estimation. Thus, the first regime represents the adjustment regime, where agents in two locations trade between each other because of the economically profitable difference in prices between these two locations. The second regime occurs when the difference in prices between the two locations are relatively small for agents to be engaged in the trade. In the pair Kokshetau – Karaganda, where we could establish threshold cointegration, we find a large percentage of observations in the first regime, i.e. arbitrage pulls prices back towards the equilibrium relationship.

[16] Petropavlovsk and Kokshetau are located in one administrative district of the Northern Kazakhstan, with Petropavlovsk being in the north and very close to Russian borders, and Kokshetau being south, right between Petropavlovsk and Karaganda. Karaganda is located in the centre of the country.

[17] The threshold price γ^{USD} in USD/t was computed as $\gamma^{USD} = \left(\exp\left(\gamma^{P}\right) - 1\right) * \overline{p}^{Kar}$, with γ^{P} the threshold parameter, and $\overline{p}^{Kar}$ the mean (over time) price in Karaganda.

In the pair Kokshetau – Karaganda the speed of adjustment coefficient in the Karaganda equation (0.045) was statistically significant in the adjustment regime. The greater magnitude of this speed of adjustment coefficient compared to the one in the Kokshetau equation (0.012) indicates that price adjustment to distortions in price equilibrium occur much faster in Karaganda than in Kokshetau.

(4.3) Kokshetau – Karaganda

Adjustment Regime – $ECT_{t-1} \leq -0.638$

Share of observations – 93 %

$$\begin{matrix} \Delta P_t^{Kok} \\ \Delta P_t^{Kar} \end{matrix} = \begin{bmatrix} 0.013 \\ (0.010) \\ 0.043 \\ (0.012) \end{bmatrix} + \begin{bmatrix} 0.086 & 0.024 \\ (0.078) & (0.082) \\ -0.009 & 0.064 \\ (0.102) & (0.099) \end{bmatrix} \begin{bmatrix} \Delta P_{t-1}^{Kok} \\ \Delta P_{t-1}^{Kar} \end{bmatrix} + \begin{bmatrix} 0.012 \\ (0.009) \\ 0.045 \\ (0.011) \end{bmatrix} ECT_{t-1} + \begin{bmatrix} e_t^{Kok} \\ e_t^{Kar} \end{bmatrix}$$

Non-adjustment Regime – $ECT_{t-1} > -0.638$

Share of observations – 7 %

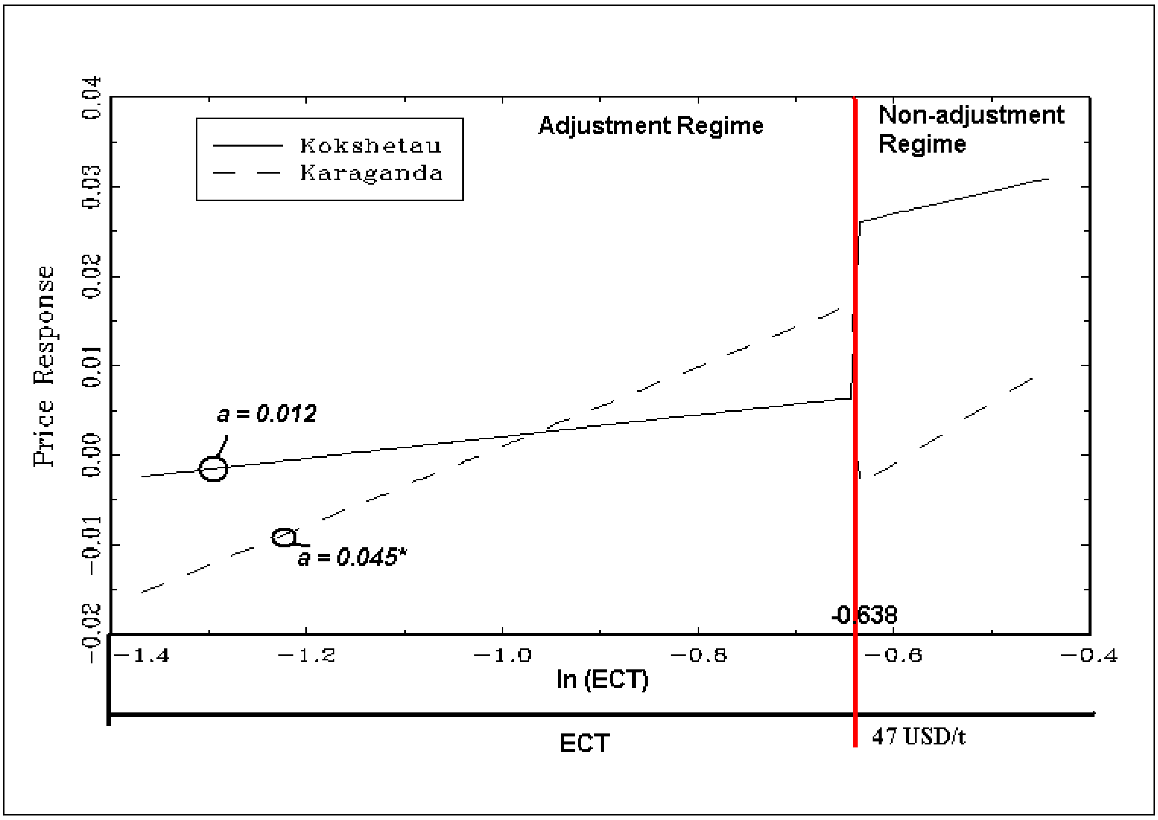
$$\begin{matrix} \Delta P_t^{Kok} \\ \Delta P_t^{Kar} \end{matrix} = \begin{bmatrix} 0.041 \\ (0.036) \\ 0.035 \\ (0.029) \end{bmatrix} + \begin{bmatrix} -1.510 & -0.506 \\ (0.270) & (0.147) \\ -0.011 & 0.096 \\ (0.024) & (0.053) \end{bmatrix} \begin{bmatrix} \Delta P_{t-1}^{Kok} \\ \Delta P_{t-1}^{Kar} \end{bmatrix} + \begin{bmatrix} 0.026 \\ (0.086) \\ 0.068 \\ (0.056) \end{bmatrix} ECT_{t-1} + \begin{bmatrix} e_t^{Kok} \\ e_t^{Kar} \end{bmatrix}$$

In the other regime, the parameters of the ECT are not significantly different from zero. It is therefore justified to call it non-adjustment-regime. It is reasonable to associate the threshold parameter with transaction costs and conclude that no arbitrage trade and hence no price adjustment occurs unless that threshold is exceeded.

Figure 4.1 illustrates the price response to the disequilibrium based on the estimates from equations 4.3. The graph shows two regimes with boundary between them where the ECT equals -0.638. The adjustment regime is given in the area left of the threshold, i.e. where ECT is less than the boundary point. The non-adjustment regime is in the area where ECT exceeds the threshold parameter (to the right of the threshold parameter).[18] Slopes of price response curves in each graph and regime represent the speed of adjustment parameters, *a*, for the respective regime from equation 4.3.

[18] A third regime would be a plausible extension to characterise adjustment behaviour beyond the equilibrium, i.e. where divergence from equilibrium has the opposite sign and is large in absolute value. A three regime symmetric threshold model has been used by MEYER (2003).

Figure 4.1: Price response to the ECT, Kokshetau – Karaganda



Source: Own computations based on HANSEN/SEO approach, data of AGROINFORM, 2005.

4.3 Summary of results and policy implications

In our study we analysed movement of wheat prices in three locations, with one being located on the border of Kazakhstan and Russia, another located in the centre of the country and the third located between these two. We find a heterogeneous picture of integration.

Price fluctuations are closely related between the two northern locations (Petropavlovsk and Kokshetau). These are major market spots in Kazakhstan, situated in grain producing regions and possessing elevators and transport facilities as well as processing firms. We can conclude there to be a multitude of market participants on both supply and demand side and the finding of cointegration is likely to reflect a competitive integrated market where any arbitrage opportunities are quickly utilised. Particularly in Petropavlovsk the market situation (and price) adjusts quickly to any divergence from the price equilibrium, i.e. it adjusts even if such divergence and the corresponding potential gain from arbitrage, is only small. Cointegration was also found between price series of Kokshetau and Karaganda. However in this pair of locations, adjustment of divergences from equilibrium is only triggered if the price gap exceeds the considerable extent of 47 percent of the price level in the latter location. This suggests that arbitrage trade is confronted here with particularly high transaction costs, and it is worthwile to identify and potentially mitigate avoidable impediments to trade. For the third pair of locations, no cointegration was found. The identified price co-movement of each of the locations, Petropavlovsk and Karaganda, with Kokshetau is obviously not strong enough to make the price series from these distant locations themselves pass the cointegration test.

Results from threshold VECM indicate that a great percentage of observations reflect the periods of adjustment to the price equilibrium. This implies either a relatively long period of adjustment to price equilibrium (adjustment is relatively slow) or that relatively large fluctuations in prices at local markets happen so often that new arbitrage processes are triggered frequently. Previous studies on price transmission reveal a completely different situation in developed countries: They found only small number of observations in the adjustment regime, while price relationships close to equilibrium prevail (GOODWIN and PIGGOTT, 2001; MEYER, 2003).

The heterogeneity of results among the three observed pairs of locations suggests that the state of the institutional environment for markets differs largely between regions. Parameter estimates and inference in the framework of the described threshold error correction models have lead us to identify research questions of particular policy relevance. The high threshold for instance that needs to be crossed before arbitrage co-ordinates markets in Kokshetau and Karaganda highlights the necessity to look at the particular market situation in both locations to identify what makes transactions more costly than it obviously is between Petropavlovsk and Kokshetau.

Slow (weak) price integration could be due to market power, high cost of transportation, weak market infrastructure among others. Previous studies have emphasised the relevance of market power issues in wheat markets of Kazakhstan (AHMAD and BRASLAVSKAYA, 2003). An FAO study (2003) suggests that there is the situation of an industry with oligopsony and marginal agents. Individual peasant farmers have only access to local markets while large wheat producers sell to production cooperative and farmers' unions where they receive much higher prices for their products than small producers. While this possibility of price discrimination between large and small suppliers does not directly relate to spatial price relations, the indications of market power makes it also possible that also interregional price discrimination exists, i.e. that single agents or cartels have the power to control prices in particular regions and no competitors have a chance to enter. This could be reflected in large interregional price gaps as well as in the absence of price co-movement.

Eventually, the actual cause of price co-movement can not be identified by analysis of price series. Nor can definite conclusions regarding the efficiency of trade and integration of markets be derived from cointegration analysis alone. As this research goes on we will advance the interpretation by collecting information on the market situation in the region itself. Trade relationships with other regions than the ones we have focused on here also need to be considered.

Though this study did not aim to address the analysis of existing policies in Kazakh wheat markets, results support the need for detailed policy analysis with regard to wheat markets in Kazakhstan. Further study might include analysis of FCC price policy and its impact on wheat market integration.

5 CONCLUSIONS

A crucial factor in the development of open markets and trade in the wheat sector of the Kazakh economy is the degree of markets functioning. Reliable marketing opportunities in both interregional and international trade levels along with relatively low transportation [and transaction] costs are essential to profitability of wheat production and hence to the growth perspectives of the sector.

In this study we have investigated one aspect of the quality of marketing and trade opportunities in the Kazakh wheat sector, that is the nature of integration among regional wheat markets. We applied threshold cointegration technique to assess the co-movement between time series of elevator prices at three grain-trading [and producing] spots in the northern and central parts of the country.

From available data it was possible to establish three different pairs of wheat markets. Results give a picture that the degree and nature of integration differs between the three considered pairs of locations. These motivate to focus research on relationships with poorly integrated markets, where impediments to arbitrage trade could be identified and possibly mitigated by appropriate policy.

There were several constraints while doing this study, which did not allow making certain policy implications. First of all, and the most problematic issue at this stage was data availability. Data from the source used have the advantage to be highly specific in location and in product definition and to be of short-termed periodicity. On the other hand, only for the three considered locations the data density was sufficient for the analysis. Data from other sources, e.g. the Statistical Offices data on monthly averages by oblys are not sufficient regarding the covered time span.

However, the chosen approach yielded results that allow give a good example of relations between regional markets, i.e. on market integration as well as the price adjustment processes that entail market integration. Results are well interpretable which supports the usefulness of the approach in the present context.

Further analysis can be extended to both horizontal and vertical levels, the latter focusing on margins in wheat trade and processing. Finally, data on Russian wheat markets that neighbour Kazakhstan would allow analysing the interstate wheat price transmission.

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