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Article — Published Version

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Journal of New Economy

Provided in Cooperation with:

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Suggested Citation: Chezha, Giorgi; Perekhozhuk, Oleksandr; Glauben, Thomas (2021) : Measuring oligopsonistic power in the Kazakh grain processing industry: Empirical evidence from the General Identification Method, Journal of New Economy, ISSN 2687-0002, Ural State University of Economics, Yekaterinburg, Vol. 22, Iss. 3, pp. 6-27,
<https://doi.org/10.29141/2658-5081-202122-3-1>

This Version is available at:

<https://hdl.handle.net/10419/243124>

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Measuring oligopsonistic market power in the Kazakh grain processing industry: Empirical evidence from the General Identification Method¹

Abstract. The issues of market structure, pricing behaviour and market power are of great interest to research, industry and society. In recent years, Kazakhstan has become one of the largest wheat producers and exporters on international markets. This paper provides empirical evidence for measuring and identifying oligopsonistic market power in the Kazakh grain processing industry based on the well-known methodological approach in the New Empirical Industrial Organization (NEIO) literature – the General Identification Method (GIM). Using a regional-level panel data set covering the period 2000–2011, two estimation methods, the Nonlinear Three Stage Least Squares (N3SLS) and the Generalized Method of Moments (GMM), were applied to estimate a structural model consisting of a nonlinear system of simultaneous equations. The main result of this empirical analysis is that the market behaviour of Kazakh grain processors in the wheat purchase market is rather competitive. The tests of the market power parameter imply that there was no exercise of oligopsony power. The market power parameter obtained was statistically close to zero, suggesting that grain processors do not have sufficient oligopsonistic market power to influence purchase prices in the Kazakh wheat market during the study period.

Keywords: market power; oligopsony; grain processing industry; New Empirical Industrial Organization (NEIO); General Identification Method (GIM); Kazakhstan.

For citation: Chezha G., Perekhozhuk O., Glauben T. (2021). Measuring oligopsonistic market power in the Kazakh grain processing industry: Empirical evidence from the General Identification Method. *Journal of New Economy*, vol. 22, no. 3, pp. 6–27. DOI: 10.29141/2658-5081-2021-22-3-1

Received June 18, 2021.

¹ This paper is based on various chapters of Giorgi Chezha's Ph.D. dissertation, which was supervised and reviewed by Prof. Dr. Dr. h. c. Thomas Glauben and co-reviewed by Dr. Oleksandr Perekhozhuk [cf. [Chezha, 2019](#)].

Introduction

Over the last two decades, Kazakhstan has become one of the top exporters of wheat and wheat flour in the world. FAO statistics from 2000 to 2019 consistently place Kazakhstan among the top ten wheat exporting countries with exports of 3.07 million tonnes in 2000 and 5.38 million tonnes in 2019. Today, Kazakhstan is the second largest exporter of wheat flour in the world, exporting 2.39 million tonnes in 2016 and 1.57 million tonnes in 2019¹.

As Kazakhstan transitioned from a planned economy to a market economy in the 1990s, its grain sector, agricultural production and industrial processing underwent a severe crisis that lasted into the 2000s. According to the data provided by the Committee on Statistics of Ministry of National Economy of the Republic of Kazakhstan (CSMNERK)², after a sharp decline in 1991–1995, average annual wheat flour production increased from 1.57 million tonnes in 1995–2001 to 2.97 million tonnes in 2002–2011³. However, in contrast to the almost doubling of wheat flour production, the number of processing plants in the Kazakh grain processing industry⁴ declined, especially after 2005.

According to a Business Media Group report, a concentration and consolidation process has been accelerated in the grain processing industry in recent years⁵. Companies merge and small processors are leaving the industry and market. According to statistical data of the Information and Computing Center of the Agency of the Republic of Kazakhstan on Statistics (ICCARKS), the number of grain processors decreased from 438 in 2005 to 301 at the end of 2011. The decrease in market participants may indicate that the remaining smaller number of companies control larger market shares, resulting in a higher degree of market concentration and enhanced market power.

The above descriptive evidence suggests that Kazakh processors may exercise oligopsony power in wheat purchasing. Issues of market structure, pricing, competition, and market power in the Kazakh grain supply chain are important topics for a broad audience that includes agricultural policy makers, researchers and all market participants (grain producers, processors and consumers). This paper predominantly focuses on two research questions: Is the market behaviour of Kazakh grain processors competitive in

¹ FAOSTAT. (2018, 2021). Food and Agriculture Organization Corporate Statistical Database. <http://www.fao.org/faostat/en/#data>.

² Before 2014 the Committee was named the Agency of the Republic of Kazakhstan on Statistics.

³ Statistical yearbook “Industry of Kazakhstan and its regions”, various issues. The Committee on Statistics of Ministry of National Economy of the Republic of Kazakhstan, Astana. (in Russ.)

⁴ The grain processing industry includes two related branches of economic activity classified by NACE “10.6 – Manufacture of grain mill products, starches and starch products” and “10.9 – Manufacture of prepared animal feeds”. NACE is an acronym derived from the French “Nomenclature statistique des activités économiques dans la Communauté européenne” meaning in English the “Statistical classification of economic activities in the European Community” (see EUROSTAT. <https://ec.europa.eu/eurostat/>).

⁵ Business Media Group. (2011). The report on the market research in industry with NACE 10.61 “Production of the milling industry”. LP “Business Media Group”, Almaty.

the wheat purchase market? And are they able to influence and determine the wheat purchase price? In addition, this paper aims to elaborate and apply the General Identification Method (GIM) as a robust methodological approach for the econometric analysis of the degree of oligopsony power of grain processors in the Kazakh grain supply chain. In doing so, it fills the research gaps in empirical research on transition economies and makes an important contribution to empirical research in the field of the New Empirical Industrial Organization (NEIO).

This paper is organized as follows. The next section looks at the Kazakh grain processing sector. Section 3 provides a brief literature review and introduction to the GIM. Section 4 addresses the theoretical framework and the empirical model of oligopsonistic market power. Section 5 describes the panel data set used for model estimation. Section 6 presents and discusses the main results of the empirical model used to measure and test the degree of oligopsonistic market power in the Kazakh grain supply chain. The final section summarises the empirical results, draws conclusions and presents recommendations for further research.

Market concentration and structural development in the grain processing industry

While wheat flour production has increased steadily over the last couple of decades, the number of grain processors has decreased significantly. This strongly negative relationship is illustrated in Figure 1 below. The left axis of the figure shows the total production in million tonnes of five processed products: (i) cereal and vegetable flour, mix of fine grindings; (ii) groats, whole meal flour and pellets and other cereal products; (iii) ready feed for farm animals, except flour and lucerne pellets; (iv) rice peeled; and (v) rice semi-milled or milled. The right axis of Figure 1 shows the number of grain processing plants (grain processors) and agricultural entities (grain producers). As a result of the transition process from a planned economy to a market economy, a dual structure developed in Kazakhstan's agricultural sector. According to the statistical publication of CSMNERK, agricultural grain producers of all forms of organizational-legal activities are statistically recorded in two groups: (i) agricultural enterprises and (ii) peasant farms. The total number of agricultural grain producers more than doubled from 2000 (92,800) to 2011 (197,000). The decrease in the number of grain processors and increase in the number of grain producers increased the ratio of producers to processors by almost 2.5 times, from 272 agricultural producers per one grain processor in 2000 to 646 agricultural producers per grain processor in 2011. On average, one grain processing plant was supplied with wheat by 501 agricultural producers. The combination of few demanders (grain processors) and many suppliers (agricultural producers) points to oligopsonistic market structures. A comparison of the number of grain processing plants with the number of agricultural producers (agricultural enterprises and peasant farms) shows that they are not perfectly competitive due to the market structure of the wheat market.

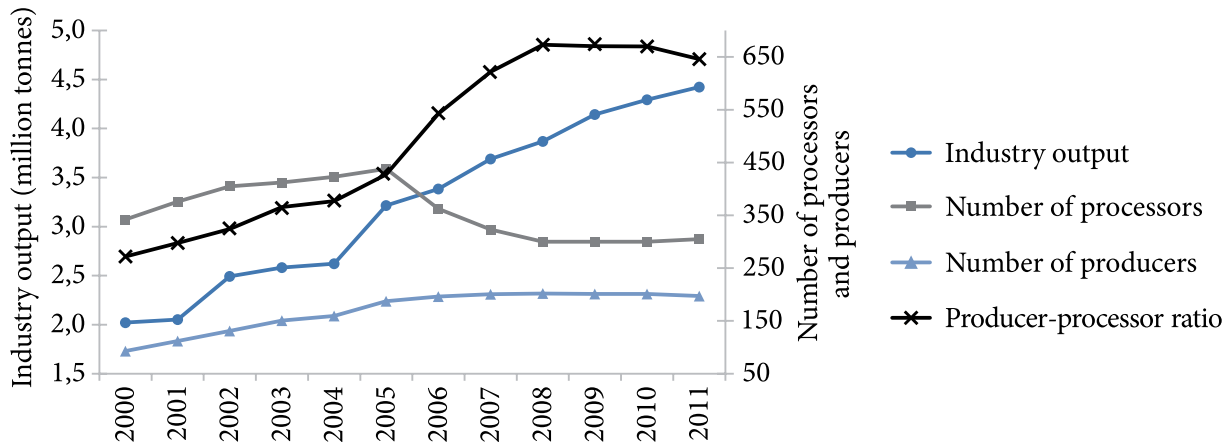


Fig. 1. Grain supply chain development in Kazakhstan¹

The Herfindahl–Hirschman Index (HHI) uses market share data to measure market concentration, with values ranging from 0 (least concentrated) to 10,000 (most concentrated). Statistical data on industry concentration from the US Census Bureau² and the German Federal Statistical Office³ show that the HHI for the US grain and oilseed milling industry (NAICS⁴ code 3112) is 839.0 and the HHI for the German manufacturing of grain mill products, starches and starch products (NACE code 10.6) is 389.8 (cf. Table 1).

However, unlike countries such as the USA or Germany, Kazakhstan lacks official statistical data on the concentration ratios of the grain processing industry. Therefore, we must assume that all grain processing plants in the Kazakh grain industry have equal market shares. Based on this assumption, the Herfindahl–Hirschman Index (HHI*) can be calculated as follows: $HHI^* = 1/n \times 10\,000$, where n is the number of grain processing plants. The HHI* for 2000–2011 ranges between 22.8 and 33.3. This gives an average of 28.1 for the Kazakh grain processing industry. For comparison purposes, we also calculate the Herfindahl–Hirschman Index (HHI*) for Germany and the USA according to the number of companies in the industry. This calculation shows that the HHI* is 117.6 for 85 companies in Germany, 16.8 for 594 companies in the USA, and 32.8 for 305 grain processing plants in Kazakhstan. The calculated HHI* value for Kazakhstan is low compared to Germany, but high compared to the USA. This comparison shows that official statistical data on industry concentration with market shares of companies are needed to calculate the

¹ Source: own illustration based on statistical data provided by ICCARKS and annual data published by CSMNERK in various issues of the statistical yearbook “Industry of Kazakhstan and its regions”. (in Russ.)

² US Census Bureau. (2021). Manufacturing: Subject Series: Concentration Ratios: Share of Value of Shipments Accounted for by the 4, 8, 20, and 50 Largest Companies for Industries: 2012. Survey/Program: Economic Census; TableID: EC1231SR2; Year: 2012; Dataset: ECNSIZE2012. <https://data.census.gov/cedsci/table?q=&y=2012&n=N000.00&tid=ECNSIZE2012.EC1231SR2>.

³ German Federal Statistical Office. (2014). Produzierendes Gewerbe 2003/2004. Konzentrationsstatistische Daten für das Verarbeitende Gewerbe, den Bergbau und die Gewinnung von Steinen und Erden sowie für das Baugewerbe. Fachserie 4 Reihe 4.2.3. Wiesbaden: Statistisches Bundesamt. (in German)

⁴ NAICS is the acronym of the North American Industry Classification System, which is used by federal statistical agencies to classify business establishments by type of economic activity in Canada, Mexico, and the United States of America.

Table 1. Concentration ratios of grain processing industries in Germany, the USA and Kazakhstan

Parameter	Germany	USA	Kazakhstan
Concentration ratios of the:			
4 largest companies	n.a.	50.6	n.a.
6 largest companies	33,8	n.a.	n.a.
8 largest companies	n.a.	64.0	n.a.
10 largest companies	45,6	n.a.	n.a.
20 largest companies	n.a.	77.3	n.a.
25 largest companies	71,0	n.a.	n.a.
50 largest companies	92,4	88.5	n.a.
Value of sales (million US dollars)	7,470.6	101,456.3	n.a.
Number of companies	85	594	305
Value of sales per company (million US dollars)	89.5	170.8	n.a.
HHI (ranges from 0 to 10,000)	389.8	839.0	n.a.
HHI*	117.6	16.8	32.8

Note: n.a. means not available.

Source: own illustration based on statistical data provided by the German Federal Statistical Office and the US Census Bureau.

Herfindahl-Hirschman Index (HHI). However, we can assume that the Herfindahl-Hirschman Index for the Kazakh grain processing industry should be significantly larger than 32.8.

Of further significance is the price development within the grain supply chain, especially after the intervention in 2008 when a wheat export ban was introduced. Figure 2 shows the price trends for wheat, wheat flour, and wheat bread for the period 2000–2011 in the Kazakh grain supply chain. The price trends are largely parallel to the price spikes in 2008. Although the government ban on wheat and meslin exports on April 15, 2008 lasted only five months, it nevertheless affected the entire supply chain and caused all prices in the grain supply chain to increase. After the export ban was lifted and export markets reopened, only wheat and wheat flour prices fell, while bread prices remained unexpectedly high. This may be due to the government's economic goal of securing and stabilising food prices in Kazakhstan¹.

As shown in Figure 2, the linear trend for wheat (agricultural producers), wheat flour (grain processors), and wheat bread (consumers) is not strictly parallel throughout the period from 2000 to 2011, while the linear trend for wheat bread (consumers) is simultaneously increasing. These price dynamics suggest that some of the market players may benefit from the mark-ups. Indeed, Oskembayev and Turabayev [2014] concluded that prices evolve asymmetrically along the Kazakh grain supply chain, while Pomfret [2007, p. 18] reported price disparities and distortions in the Kazakh grain market. The OECD

¹ Government Resolution of the Republic of Kazakhstan of April 15, 2008, no. 343 "On introducing amendments and additions to the Order of the Government of the Republic of Kazakhstan of July 10, 2003, no. 681".

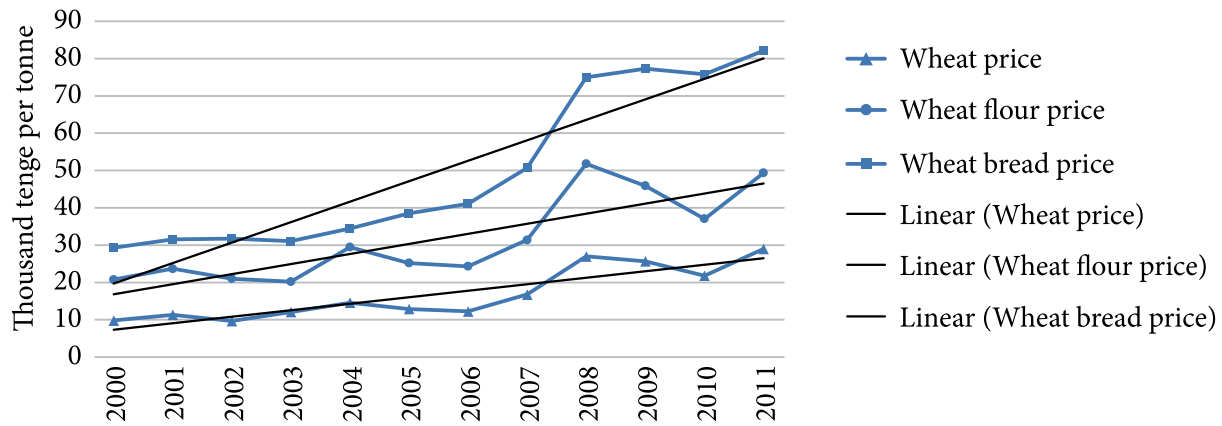


Fig. 2. Price trends in the Kazakh grain supply chain, nominal prices (2000 = 100 %)¹

report on agricultural policies in Kazakhstan showed that infrastructural inefficiencies resulted in increased transactional costs for agricultural grain producers². Swinnen [2009, p. 728] reported on local authorities still intervening in agricultural commodity markets in a variety of ways. In this context, the grain sector is characterized by market imperfections and high inefficiencies caused by high transaction costs and undeveloped infrastructure.

Literature review on the General Identification Method

The General Identification Method (GIM), along with other New Empirical Industrial Organization (NEIO) approaches and methods, provides a methodological framework for estimating market power as a structural model. It allows simultaneous estimations of a system of equations on input and output markets and provides the possibility to estimate market power using only the demand or supply functions and optimality condition.

The GIM was initially introduced by Bresnahan [1982] who proved that testing for market power can be undertaken even without a production or cost function and that it can be identified by exogenous shifters affecting price and quantity. Lau [1982] further developed the model, showing that it is possible to estimate the degree of competitiveness based on industry level price and output quantity data.

Several studies have used this method to test for oligopsony power in agri-food markets. There are empirical studies that used the GIM approach and did not find any statistical evidence for market power. Deodhar and Sheldon [1997] investigated the world soymeal market for imperfect competition and found no sign of market power. Hyde and Perloff [1998] investigated retail beef, lamb, and pork markets in Australia and likewise found no sign of market power. Muth and Wohlgenant [1999] examined the US beef packing industry, but did not find any evidence of oligopsony. Mérel [2009] applied

¹ Source: own illustration based on annual data published by CSMNERK in various issues of the statistical yearbooks "Prices in agriculture, forestry and fisheries in the Republic of Kazakhstan" and "Prices in industry and tariffs for production services in the Republic of Kazakhstan. (in Russ.)"

² OECD (2013). OECD Review of Agricultural Policies: Kazakhstan 2013. OECD Publishing, p. 21. <http://dx.doi.org/10.1787/9789264191761-en>.

the GIM approach for market power analyses in the French Comté cheese market and found that the hypothesis regarding competitiveness was not rejected.

There are many empirical studies that have been applied by agricultural economists based on the econometric application of the GIM approach and have found strong empirical evidence of market power in agri-food markets. Buschena and Perloff [1991] analyzed the Philippine coconut export market and found econometrically that the gap between price and marginal costs doubled over the analyzed period, indicating market power existence in the industry. Lopez and You [1993] tested the Haiti coffee market for oligopsony power and found that coffee grain producers suffered from lower prices than they would have received had the market been competitive. Steen and Salvanes [1999] found short-term market power on the French fresh salmon market; Anders [2008] revealed market power on the German meat market. O'Donnel et al. [2007] investigated the Australian multiple-input, multiple-output grains, and oilseeds sector and found that some of the food manufacturers exerted oligopsony market power while purchasing agricultural products, such as wheat, barley, oats, and triticale. Zheng and Vukina [2009] concluded that US pork packers exercise oligopsonistic market power on the spot market for live hogs. Perekhozhuk et al. [2015; 2017] analyzed oligopsony power in the Ukrainian dairy industry and found strong statistical evidence for market power. The GIM has therefore been shown to have been successfully applied to analyses of oligopsony market power.

The GIM approach provides the possibility to estimate market power with merely the demand or supply functions and optimality condition. Nonetheless, the GIM approach is limited in assumptions regarding functional specifications and fixed proportions technologies. The following section demonstrates the theoretical framework and empirical model of this approach.

Methodological framework for the econometric analysis of oligopsonistic market power

Consider the Kazakh grain supply chain in which grain processors purchase grain as a raw material (M) for processing from agricultural producers. Assume that an inverse agricultural supply function faced by the grain processors can be given by:

$$W_M = f(M, \mathbf{S}), \quad (1)$$

where W_M denotes the price of grain purchased by grain processors, M such as grain raw material, and \mathbf{S} is the vector of non-agricultural shift factors, such as fuel, pesticides and fertilizers, and machinery (tractors) utilized by agricultural producers.

We assume further that grain processors produce a homogeneous output Y (wheat flour and other cereal foods) in a manufacturing process using one agricultural input M along with several non-agricultural inputs represented by vector \mathbf{Z} . Then the production function of the grain processor can be represented in the following way:

$$Y = f(M, \mathbf{Z}). \quad (2)$$

Considering the equations (1) and (2), the profit maximising problem of grain processors can be defined accordingly:

$$\Pi = Pf(M, \mathbf{Z}) - W_M \cdot M - \mathbf{W}_Z \cdot \mathbf{Z}, \quad (3)$$

where P is the output price of grain processors and \mathbf{W}_Z is a vector of prices of non-agricultural inputs. After differentiating the processors' profit maximisation problem (3) with respect to W_M and suitable rearranging, the first-order condition (FOC) for estimating oligopsony power can be represented in the following way:

$$W_M \left(1 + \frac{\phi}{\varepsilon}\right) = Pf_M, \quad (4)$$

where $\varepsilon = (\partial M / \partial W_M)(W_M / M)$ is the own-price elasticity of supply for grain, f_M is the marginal product of grain and ϕ is the conjectural elasticity measuring the degree of oligopsony power. Ranging between 0 and 1, ϕ indicates how competitive the market is. For $\phi = 0$, the market is perfectly competitive, for $\phi = 1$ it is monopsonistic. Accordingly, the estimates between the extremes represent the structure of the oligopsonistic market, thus indicating the degree of oligopsonistic market power Kazakh grain processors have, i. e. how much market power they have when purchasing grain.

With regard to an empirical application of this oligopsony model, we assume that W_i and V_j describe the output and input prices faced by agricultural producers, and A designates the quasi-fixed input factor agricultural land expressed as grain-sown area. Following Perekhozhuk et al. [2007; 2015] we assume that the inverse grain supply function (1) can be written as a truncated second-order approximation to a general transcendental logarithmic function:

$$\begin{aligned} \ln M = & \beta_0 + \sum_i \beta_i \ln W_i + \sum_j \varphi_j \ln V_j + v_A \ln A + \delta_T T + \\ & + \sum_i \beta_{iT} \ln W_i T + \sum_j \varphi_{jT} \ln V_j T + v_{AT} \ln A T + \frac{1}{2} \delta_{TT} T^2, \end{aligned} \quad (5)$$

where W_i ($i = M, E, C, P$) is the price of grain delivered from agricultural producers to the processing industry (W_M), the price for wheat exported from Kazakhstan to international markets (W_E), the price received for cattle (W_C), and the price received for potatoes (W_P), and V_j ($j = P, T, F, S$) is the input prices of pesticide-fertilizers (V_P), tractors (V_T), fuel (V_F), and workers' salaries (V_S) paid by the agricultural producers.

To maintain homogeneity of degree zero, the following parameter restrictions are implemented in the model:

$$(i) \sum_i \beta_i + \sum_j \varphi_j = 0 \text{ and } (ii) \sum_i \beta_{iT} + \sum_j \varphi_{jT} = 0. \quad (6)$$

Own-price elasticity and cross-price elasticities can be estimated by the partial derivatives of the supply function (5) with respect to output and input prices, respectively in the following ways:

$$\frac{\partial \ln M}{\partial \ln W_i} = \beta_i + \beta_{iT} T \quad (7)$$

and

$$\frac{\partial \ln M}{\partial \ln V_j} = \varphi_j + \varphi_{jT} T. \quad (8)$$

Similarly, elasticities for the quasi-fixed factor sown area (A) of the translog supply function (8) can be derived as follows:

$$\frac{\partial \ln M}{\partial \ln A} = v_A + v_{AT} T. \quad (9)$$

The rate of autonomous technological change in the grain supply can be obtained in the following way:

$$\frac{\partial \ln M}{\partial T} = \delta_T + \sum_i \beta_{iT} \ln W_i + \sum_j \varphi_{jT} \ln V_j + v_{AT} \ln A + \delta_{TT} T. \quad (10)$$

The derivation of the empirical model is based on the study of Perekhozhuk et al. [2017] with adjustments to the Kazakh grain industry¹. According to Christensen, Jorgenson and Lau [1973], the production function (1) can be specified in a transcendental logarithmic (translog) form as follows:

$$\ln Y = \alpha_0 + \sum_{r=1}^3 \alpha_r \ln X_r + \frac{1}{2} \sum_{r=1}^3 \sum_{n=1}^3 \alpha_{rn} \ln X_r \ln X_n + \gamma_T T + \frac{1}{2} \gamma_{TT} T T + \sum_{r=1}^3 \gamma_{rT} \ln X_r T, \quad (11)$$

where $\alpha_{rn} = \alpha_{nr}$. X_r and X_n represent production factors used to process grain, $r, n = (M, L, K)$ with M, L, K indicating grain inputs, labour employed and capital utilized in the grain processing industry, respectively. Time trend variable T is used to capture the technical change factor.

From the translog-production function (11), the marginal product of grain expressed in the equation (4) above can be given as follows:

$$f_M = \left(\alpha_M + \sum_{n=1}^3 \alpha_{Mn} \ln X_n + \gamma_{MT} T \right) \frac{Y}{M}, \quad n = M, L, K. \quad (12)$$

Submitting the derived marginal product (12) into the FOC equation (4) and rearranging the expression with the market power parameter from left to right gives the following equation for measuring the degree of oligopsonistic market power in the Kazakh grain processing industry:

¹ Turning to the aspect of specifications, the applied functions vary depending on the market and data analyzed. Appelbaum [1982], Lopez [1984], Schroeter [1988], Schroeter and Azzam [1990], Azzam [1997], and Morrison Paul [2001] applied generalized Leontief cost functions, whereas Azzam and Pagoulatos [1990], Bakucs et al. [2009; 2010], Perekhozhuk et al. [2013; 2015; 2017], and Scalco, Lopez and He [2017] relied on translog production functions. Translog revenue and profit functions were used by Hockmann and Vöneki [2009], and Quagrainie et al. [2003], respectively.

$$W_M = \left(\alpha_M + \sum_{n=1}^3 \alpha_{Mn} \ln X_n + \gamma_{MT} T \right) P \frac{Y}{M} / \left(1 + \frac{\phi}{\varepsilon} \right). \quad (13)$$

Substituting the own-price elasticity for grain supply obtained in the equation (7) into the equation (13) will lead to the following derivation:

$$W_M = \left(\alpha_M + \sum_{n=1}^3 \alpha_{Mn} \ln X_n + \gamma_{MT} T \right) P \frac{Y}{M} / \left(1 + \frac{\phi}{\beta_M + \beta_{MT} T} \right). \quad (14)$$

Following Bresnahan [1982] and Lau [1982], the degree of oligopsonistic market power (ϕ) can be identified econometrically with the General Identification Method (GIM) using a simultaneous two-equations structural model. The empirical model consists of two equations, where the first equation for supply function (1) is represented by a truncated translog supply function (5) and the second equation for the first-order condition (4) is represented by a nonlinear relation (14).

The derived structural model of market power was estimated using two estimation methods: the Nonlinear Three Stage Least Squares (N3SLS) and the Generalized Method of Moments (GMM). Due to the regional level data set, the econometric model also considered regional dummy variables.

Data sources and descriptive statistics of the model

The annual data used for the analysis were obtained from the various publications of CSMNERK. The data set combined data provided in various issues of statistical year-books on different Kazakh sectors and regions including: “Industry of Kazakhstan and its regions”, “Regions of Kazakhstan”, “Agriculture, forestry and fishery in the Republic of Kazakhstan”, “Prices in agriculture, forestry and fishery in the Republic of Kazakhstan”, “Prices in industry and tariffs for production services in the Republic of Kazakhstan”, “Prices on consumer market in the Republic of Kazakhstan”, and “Balance of resources and utilization of main agricultural products of the Republic of Kazakhstan”. However, despite this broad range of information, the compilations did not provide the complete set of data needed for the econometric analysis, especially at the regional level. Therefore, data were also added from ICCARKS.

The analysis was based on regional-level data from 14 regions of Kazakhstan (Akmola, North Kazakhstan, Atyrau, Aktobe, East Kazakhstan, Karaganda, Mangystau, South Kazakhstan, Kostanay, Almaty, Pavlodar, West Kazakhstan, Jambyl, and Kyzylorda) and the two cities Almaty and Astana. Since grain production and processing industries were not significantly represented in the cities, the statistical data of both cities were integrated into the data of the Almaty and Akmola regions, respectively.

The panel data set combines 14 time series covering the period from 2000 to 2011 and 14 regions of Kazakhstan and contains 168 observations in total. The study period was determined by the data availability of the 14 model variables collected from various agricultural and industrial statistical sources in Kazakhstan.

Table 2 summarises the complete variable set used in the GIM, including variables for estimating supply function (5) and the FOC (14).

Table 2. Descriptive statistics of the model variables used for the GIM

Variable	Definition	Units	Min.	Max.	Mean	Source
Q	Aggregated output quantities of the grain processing industry	Metric tonne	493.0	1025995.0	230910.5	CSMNERK a
P	Output price of the grain processing industry	Tenge*/kg	3.7	81.3	22.5	CSMNERK a
M	Grain input quantities used by the grain processing industry	Metric tonne	701.0	1202969.0	301280.1	CSMNERK b, d
K	Capital utilized by the grain processing industry	Thousand tenge	1781.0	1495909.0	218409.4	ICCARKS
L	Labour employed in the grain processing industry	Employees	16.2	2299.0	831.3	ICCARKS
W_M	Producer price for wheat delivered to the grain processing industry	Tenge/ metric tonne	4053.7	35955.0	15678.7	CSMNERK c
W_E	Wheat export price	Tenge/ metric tonne	12634.9	62476.5	21394.3	GTA
W_C	Cattlepriceindex(2000=100%)	Percent	99.2	501.3	202.1	CSMNERK c
W_P	Priceforpotatoes(2000=100%)	Tenge/ metric tonne	11151.0	70000.0	31483.7	CSMNERK c
V_P	Price index of pesticides and fertilizers (2000 = 100 %)	Percent	98.6	251.4	133.4	CSMNERK c
V_T	Price index of tractors (2000 = 100 %)	Percent	100.0	253.9	133.0	CSMNERK c
V_F	Priceindexoffuel(2000=100%)	Percent	100.0	600.1	233.2	CSMNERK c
V_S	Average salary of workers employed in agriculture	Tenge	3619.0	50847.0	18537.0	CSMNERK e
A	Total grain-sown area	Thousand ha	0.1	4537.1	1058.8	CSMNERK d

Note: *The Tenge is the currency of Kazakhstan.

Source: own calculations based on the panel data obtained from CSMNERK, ICCARKS and GTA¹. Letters a, b, c, d, e refer to the various issues of the following statistical yearbooks by CSMNERK: a. Industry of Kazakhstan and its regions (in Russ.); b. Regions of Kazakhstan (in Russ.); c. Prices in agriculture, forestry and fisheries in the Republic of Kazakhstan (in Russ.); d. Agriculture, forestry and fishery in Kazakhstan Republic (in Russ.); e. Remuneration of labour in the Republic of Kazakhstan (in Russ.).

¹ Global Trade Atlas - Global Trade Information Services, Inc. (GTA). Online database: www.gtis.com/gta.

The aggregated production quantities of grain processors summarise production quantities of five products of the Kazakh grain processing industry collected from the industry statistical data, which is calculated in metric tonnes as the aggregated output quantity of the grain processing industry (Q). This model variable joins the observations for fodder and flour production, since in many cases grain processors purchase the same input – wheat – for processing and further production of milling products. Therefore, industry output comprises the total production of processed grain products and the corresponding price of processors' output products (P). Quantities and prices for inputs and outputs are reported in aggregated form for both sectors. In detail, output quantities (Q) for grain processors include the five following products: (i) cereal and vegetable flour, mix of fine grindings; (ii) groats, whole meal flour and pellets and other cereal products; (iii) ready feed for farm animals, except flour and lucerne pellets; (iv) rice peeled; and (v) rice semi-milled or milled.

The aggregated output values of all products manufactured by grain processors were collected from various issues of the statistical yearbook “Industry of Kazakhstan and its regions”. Although the statistical data series on the industry output value of the grain processing industry was not included in the model itself, it was used to calculate the average output price of the industry. Accordingly, the average price for aggregated grain processor outputs (P) was calculated by dividing the aggregate output value by the output quantity of the grain processing industry (Q).

In terms of processor inputs, quantity (M) indicates the amount of grain supplied to processors; the purchased grain price is represented by the average wheat price (pM). As for non-agricultural inputs, three main production factors were included in the econometric analysis: labour (L), capital (C), and electricity (E). At this point, it must be emphasized that it was not possible to acquire all necessary information for the electricity variable, as parts of the statistical data were either incomplete or not reliable. Furthermore, since electricity costs represent only 3 % of the total cost structure¹, the variable was excluded from the econometric analysis to avoid bias in the estimate. Regional statistics on two model variables for capital cost and labour input in the Kazakh grain industry were provided by ICCARKS upon request.

In addition to the delivery quantities and prices of wheat sold for processing, cross prices are also needed to estimate the agricultural supply function for wheat. The cross-prices of four major inputs of agricultural producers were also identified in the literature and collected from various issues of the statistical yearbooks “Prices in industry and tariffs for production services in the Republic of Kazakhstan”. These were: (i) average salary of workers employed in agriculture (V_S); (ii) price index of tractors (V_T); (iii) price index of pesticides and fertilizers (V_P); and (iv) price index of fuel (V_F). In addition to these price variables, other factors affecting the price and quantity of the wheat grain supplied to the processors are also considered. Three other agricultural prices were included in

¹ These empirical findings are confirmed by Kazakh grain experts [Gan, 2014].

the estimation of the supply function: wheat export price (W_E), cattle price (W_C) and potato price (W_C). This is because the wheat export and animal feeding industries, together with the processing industry, are the important distribution channels for agricultural grain producers. Hence, the prices in those industries can compete with the processors' purchasing price and impact the grain flow within the distribution channels including the quantity delivered to the processors. The potato price index is included in the analysis due to its potential to be a substitute crop to grain produced on arable lands. In other words, grain producers can switch to potato production if it is more profitable. Some variables suffered from missing values and they are either imputed by interpolation method or replaced by national level observations. One example of this is potato price data missing for the Atyrau, Kyzylorda and Mangystau regions for the whole period and for the West Kazakhstan and Jambyl regions for the years 2000 and 2003.

All price data used for the analysis were deflated by the Consumer Price Index (CPI). Consumer Price Index data were collected from the statistical yearbooks "Prices on consumer market in the Republic of Kazakhstan". To exclude the inflation factor in price development, prices from 2000 served as the base year for deflation. The annual data on total grain sown area (A) were collected from various issues of the statistical yearbooks "Agriculture, forestry and fishery in the Republic of Kazakhstan".

Estimation results

The GIM model consists of a nonlinear system of two simultaneous equations, an equation for supply function (SF) and an equation for first order conditions (FOC). The grain supply function (5) is specified as a truncated translog function and hence an estimated supply function, and the variables are used as exogenous variables along with the time trend interaction terms. The equation for first order conditions (FOC) incorporates the parameters for marginal product (12) derived from the transcendental logarithmic (translog) production function (11) and the parameters of own-price elasticities derived from the truncated translog function (5). Regional dummies are also used to capture the regional effect in the grain supply and the FOC.

The structural model is estimated applying two estimation methods: the Nonlinear Three Stage Least Squares (N3SLS) and the Generalized Method of Moments (GMM) using the statistical software SAS¹. The estimates of the full model with regional dummies are presented separately in the Appendix. In total, 53 parameters are estimated, out of which 34 parameters belong to the SF and 19 parameters to the FOC. Furthermore, two model parameters are shared by both the SF and the FOC. Of the 53 estimated parameters, 30 parameters are statistically significant in the case of the N3SLS and 36 parameters in the case of the GMM (cf. Appendix). The GMM estimation results show better statistical significance of the estimated parameters of the market structure model for the balanced panel data set of statistical data at the region level.

¹ SAS. (2008). SAS/ETS User's Guide, Version 9.2, Cary, NC: SAS Institute Inc.

Table 3 shows selected estimation results for the structural model without considering the regional dummy variables. Both estimation methods, the N3SLS and the GMM for the full structural model, seem to provide satisfactory results, with an overall reasonable goodness of fit for the two structural equations.

Table 3. Estimation results for the GIM

Parameters	N3SLS		GMM	
	Estimate	t-ratio	Estimate	t-ratio
β_0	17.642*	1.67	20.719**	2.12
β_M	-0.532***	-2.66	-0.493***	-3.09
β_C	-0.948	-1.49	-0.957**	-2.03
β_E	-0.849**	-2.01	-1.075***	-3.95
β_P	0.448	1.19	0.572*	1.85
φ_P	-1.976**	-1.98	-2.197***	-2.98
φ_T	1.459	1.14	1.340	1.33
φ_F	0.859	1.55	0.894**	2.02
φ_S	0.074	0.15	-0.072	-0.18
ν_A	0.677***	2.79	0.695**	2.5
δ_T	0.272	0.25	0.011	0.01
β_{MT}	0.085***	2.72	0.081***	3.12
β_{CT}	0.013	0.21	0.020	0.46
β_{ET}	0.114**	2.05	0.133***	3.85
β_{PT}	-0.077	-1.56	-0.099**	-2.15
φ_{PT}	0.253**	2.31	0.262***	3.04
φ_{TT}	-0.279**	-2.21	-0.306***	-2.96
φ_{FT}	-0.122*	-1.81	-0.096*	-1.85
φ_{ST}	-0.073	-1.11	-0.040	-0.68
ν_{AT}	0.002	0.59	0.003	0.87
δ_{TT}	0.016	0.92	0.011	0.68
α_M	-0.548**	-2.15	-0.494**	-2.23
α_{MM}	0.127***	3.42	0.135***	4.93
α_{ML}	-0.067	-1.28	-0.071*	-1.76
α_{MK}	-0.021	-1.09	-0.030**	-2.39
α_{MT}	0.013*	1.67	0.013**	2.07
ϕ	-0.007	-0.60	-0.004	-0.47
Objective Value	1.15	-	0.30	-
R-squared:				
SF	0.97	-	0.96	-
FOC	0.79	-	0.78	-
Durbin – Watson:				
SF	1.40	-	1.44	-
FOC	1.71	-	1.71	-

Notes: The values in parentheses are asymptotic standard errors. The superscripts ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Source: own estimation.

The R-squared and the adjusted R-squared show almost the same value of 0.97 and 0.96 for the supply function (5), and 0.79 and 0.76 for the FOC (14), respectively. The Durbin – Watson (DW) test is applied to test for serial autocorrelation. The DW statistics obtained by the N3SLS range from 1.40 to 1.71. Almost similar values are observed for the GMM method, where the difference with the N3SLS is small and provides a high estimate of the model explanation.

Considering the transcendental logarithmic (translog) function form of the supply function (5) and the production function (11), the estimated parameters of the truncated translog supply function (5) and of the marginal product of the grain processing industry expressed in equations (4) and (14) above were used to estimate the own-price and cross-price supply and production elasticities, and technical change in wheat supply. Table 4 summarises the estimated test results for these economically interpretable model parameters.

The main focus of this paper is to measure the degree of oligopsony power in the Kazakh grain processing industry. The estimated parameter of market power θ is close to zero in both the N3SLS and the GMM, and is statistically insignificant. However, considering the negative signs for the estimated market power parameter, which is unexpected from a theoretical point of view, several Wald tests were applied to test the null hypothesis that the estimated parameter θ is statistically zero cannot be rejected. Consequent estimations and a discussion are provided in Table 5.

Table 4 reveals the estimated elasticities of own- and cross-price elasticities of wheat supply, the rate of technical change in wheat supply, and the production elasticities of wheat input. The estimates of the own-price elasticity for raw materials (wheat input) of the grain processing industry (ϵ_{MM}) are almost the same and are 0.023 and 0.033 for both estimators, the N3SLS and the GMM, respectively. However, the GMM estimator estimates are statistically significant at the 10 % significance level, while the N3SLS estimator is not. These results show that supply of wheat delivered to the grain processing industry is very inelastic, i.e. a change in the price of wheat does not change the quantity delivered to the grain processing industry.

The cross-price supply elasticities for cattle (ϵ_{MC}) are statistically significant for both estimators and reveal nearly the same values, with -0.866 for the N3SLS and -0.825 for the GMM. The estimated values indicate that wheat supply is very sensitive to changes in cattle prices. The theoretical explanation for the negative sign of the cross-price supply elasticity for cattle and its elastic supply is that higher prices for cattle should lead to an increase in cattle production and thus an increase in grain purchases by this sector. Consequently, an increased flow of grain to cattle production results in a lower quantity supplied to the grain processing industry.

The estimates of the cross-price supply elasticities for wheat exports (ϵ_{ME}) differ little at -0.105 for the N3SLS and -0.208 for the GMM. However, the estimates of the GMM estimator are statistically significant at the 10 % significance level, while the N3SLS estimator

Table 4. Supply function elasticities

Parameters	N3SLS		GMM	
	Coefficient	t-Stat	Coefficient	t-Stat
Supply elasticities w.r.t.:				
Own-price of wheat grain ($\varepsilon_{MM} = \partial \ln M / \partial \ln W_M$)	0.023	(0.73)	0.033*	(1.86)
Cross-price of cattle ($\varepsilon_{MC} = \partial \ln M / \partial \ln W_C$)	-0.866**	(-2.36)	-0.825***	(-2.97)
Cross-price of wheat exports ($\varepsilon_{ME} = \partial \ln M / \partial \ln W_E$)	-0.105	(-0.71)	-0.208**	(-2.06)
Cross-price of potatoes ($\varepsilon_{MP} = \partial \ln M / \partial \ln W_P$)	-0.051	(-0.28)	-0.073	(-0.56)
Cross-price of pesticides ($\eta_{MP} = \partial \ln M / \partial \ln V_P$)	-0.334	(-0.71)	-0.493	(-1.59)
Cross-price of tractors ($\eta_{MT} = \partial \ln M / \partial \ln V_T$)	-0.356	(-0.60)	-0.650	(-1.44)
Cross-price of fuel ($\eta_{MF} = \partial \ln M / \partial \ln V_F$)	0.068	(0.22)	0.267	(1.04)
Cross-price of salary ($\eta_{MS} = \partial \ln M / \partial \ln V_S$)	-0.399	(-1.04)	-0.331	(-1.11)
Quasi-fixed sown area ($v_{MA} = \partial \ln M / \partial \ln A$)	0.694***	(2.74)	0.716**	(2.45)
Technical change rate ($\delta_{MT} = \partial \ln M / \partial T$)	0.378	(0.32)	0.082	(0.08)
Production elasticities w.r.t. the input of:				
Materials (wheat input) ($\rho_{YM} = \partial \ln Y / \partial \ln X_M$)	0.377***	(7.15)	0.400***	(10.07)

Notes: The values in parentheses are asymptotic standard errors. The superscripts ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Source: own estimation.

is not. The negative cross-price supply elasticities for wheat exports imply that exported wheat is a substitute for wheat delivered to the grain processing industry. In other words, higher wheat export prices can lead to declining volumes of wheat delivered to processors.

The estimated negative values of the cross-price supply elasticities of wheat with respect to the price of potatoes suggest a substitution relationship between potatoes and wheat, so that, as expected, there is a decision interdependence between wheat and potato production. However, these estimates are not statistically significant for either estimator.

The supply elasticities of the quasi-fixed factor for sown area (v_{MA}) have almost the same values with 0.694 and 0.716. This is statistically significant for both the N3SLS and the GMM estimators at the 1 % and 5 % significance level, respectively. As expected, the elasticities for the quasi-fixed factor have a positive sign, indicating that a larger sown area leads to a higher quantity of wheat delivered to grain processors. Furthermore, the estimated supply elasticities for wheat with respect to sown area indicate an elastic supply of wheat and thus show that there seems to be a potential to expand wheat production in Kazakhstan.

With respect to technical change, the main finding of this paper is that no technical change in wheat supply occurred during the study period from 2000 to 2011. The estimates for the rate of autonomous technical change in wheat supply (δ_{MT}) show positive signs for both estimators, but they are not statistically significant.

Furthermore, the production elasticities with respect to wheat used as material input in the grain processing industry (ρ_{YM}) are positive, as expected, and have almost the same values of 0.377 and 0.400. The t-statistics show that they are highly statistically significant at the 1 % significance level for both estimators. It should be underscored that the estimated production elasticities for raw material (wheat input) are relatively small. However, in order to draw a conclusion, the estimation of the translog production function should be included in the analysis.

Finally, Table 5 presents the results of testing the hypotheses with the Wald test and the estimates of the parameter of oligopsonistic market power with the following three null hypotheses: (i) $\theta = 0$; (ii) $\theta = 0.01$; and (iii) $\theta = 0.02$, detecting the true value of the market power parameter. It also summarises the Wald test results with respect to the null hypothesis test (iv) for homogeneity of degree zero in price derived in equation (6) above.

Table 5. Wald test results and estimates

Hypotheses test	N3SLS		GMM	
	t-Statistics	p-value	t-Statistics	p-value
(i) $\theta = 0$	0.37	0.545	0.22	0.637
(ii) $\theta = 0.01$	2.14	0.144	2.87	0.091
(iii) $\theta = 0.02$	5.38	0.020	8.49	0.004
(iv) $\sum_i \beta_i + \sum_j \varphi_j = 0, \sum_i \beta_{iT} + \sum_j \varphi_{jT} = 0$	6.13	0.013	12.93	0.000

Source: own estimation.

The Wald test results suggest that $\theta = 0$ with a high degree of confidence for both the N3SLS and the GMM. The p-value indicates that the test results for the two null hypotheses (iii) for the degree of market power in the industry ($\theta = 0.02$) and (iv) for homogeneity of degree zero in price ($\sum_i \beta_i + \sum_j \varphi_j = 0, \sum_i \beta_{iT} + \sum_j \varphi_{jT} = 0$) could be rejected even at the 1 % level for both the N3SLS and the GMM estimators. For the study period from 2000 to 2011, the Wald test results confirm the competitive market behaviour in the Kazakh grain processing industry

Conclusion

This paper provides empirical evidence for measuring and identifying market power in the Kazakh grain processing industry using the robust GIM approach. By applying two estimation methods, the N3SLS and the GMM, the market structural model consisting of two equations, the supply function for wheat and the first order conditions for profit maximisation in the industry, is estimated as a nonlinear system of simultaneous equations. By using a balanced panel data set of 168 observations at the regional level for the period 2000–2011, a total of 53 model parameters were estimated.

All econometrically derived elasticities and rates of technical change are theoretically consistent and empirically plausible in terms of microeconomic theory and industrial organization analysis. Therefore, the econometrically obtained results have important policy implications and may give practical reference for the government and policy makers.

The estimated own-price supply elasticities reveal a very inelastic supply for wheat delivered to the industry. This means that a change in the price of wheat does not change the quantity delivered to the grain processing industry. The estimation results indicate that wheat exported abroad is a substitute for wheat delivered to the industry for processing. The cross-price supply elasticities for cattle also show that wheat supply is very sensitive to changes in cattle prices. A higher price for cattle could lead to an increase in cattle production and thus an increase in wheat grain purchases by this sector. Cross-price supply elasticities for potatoes show a substitution relationship between wheat and potato production.

For sown area, the coefficients are positive and highly statistically significant. The elastic supply of wheat with respect to the sown area shows a potential to expand wheat production in Kazakhstan. The model estimates reveal no evidence of statistically significant technical change in wheat supply over the period of study from 2000 to 2011. With respect to factor analysis, the production elasticities of grain production amounted to 0.377 for the N3SLS and 0.400 for the GMM. The elasticities are statistically significant, but they can be considered low.

On the whole, the estimates for the parameter of oligopsonistic market power θ were statistically close to zero, thus indicating that Kazakh grain processors did not have enough bargaining power to influence prices during the study period. The Wald test results for testing the hypotheses with respect to the parameter of oligopsonistic market power confirm the competitive market behaviour in the Kazakh grain processing industry. Hence, it can be concluded that the market for wheat delivered to the grain producing industry is competitive as there is no evidence of oligopsony power.

Appendix. Estimation results of the GIM approach

Parameters	N3SLS		GMM	
	Coefficient	t-Stat.	Coefficient	t-Stat.
β_0	17.642*	1.67	20.719**	2.12
β_M	-0.532***	-2.66	-0.493***	-3.09
β_C	-0.948	-1.49	-0.957**	-2.03
β_E	-0.849**	-2.01	-1.075***	-3.95
β_P	0.448	1.19	0.572*	1.85
φ_P	-1.976**	-1.98	-2.197**	-2.98
φ_T	1.459	1.14	1.340	1.33
φ_F	0.859	1.55	0.894**	2.02
φ_S	0.074	0.15	-0.072	-0.18
v_A	0.677***	2.79	0.695**	2.5
δ_T	0.272	0.25	0.011	0.01
β_{MT}	0.085***	2.72	0.081***	3.12
β_{CT}	0.013	0.21	0.020	0.46
β_{ET}	0.114**	2.05	0.133***	3.85
β_{PT}	-0.077	-1.56	-0.099**	-2.15
φ_{PT}	0.253**	2.31	0.262***	3.04
φ_{TT}	-0.279**	-2.21	-0.306***	-2.96
φ_{FT}	-0.122*	-1.81	-0.096*	-1.85
φ_{ST}	-0.073	-1.11	-0.040	-0.68
v_{AT}	0.002	0.59	0.003	0.87
δ_{TT}	0.016	0.92	0.011	0.68
β_{D2}	-0.124	-0.28	-0.028	-0.06
β_{D3}	1.656***	3.07	1.739***	2.88
β_{D4}	1.725	0.82	2.118	0.85
β_{D5}	0.990*	1.92	1.091**	1.83
β_{D6}	0.104	0.17	0.092	0.12
β_{D7}	-0.065	-0.13	-0.026	-0.05
β_{D8}	0.860**	1.99	0.910**	1.89
β_{D9}	0.918	0.95	1.119	0.98
β_{D10}	0.619***	3.31	0.594***	3.92
β_{D11}	1.314	0.51	1.586	0.53
β_{D12}	-0.137	-0.27	-0.053	-0.1
β_{D13}	0.203	1.2	0.240**	1.83
β_{D14}	1.788**	2.43	1.889***	2.29
α_M	-0.548**	-2.15	-0.494**	-2.23
α_{MM}	0.127***	3.42	0.135***	4.93
α_{ML}	-0.067	-1.28	-0.071**	-1.76
α_{MK}	-0.021	-1.09	-0.030**	-2.39
α_{MT}	0.013*	1.67	0.013	2.07
θ	-0.007	-0.6	-0.004	-0.47
α_{D2}	11636.62***	7.54	11385.6***	7.68
α_{D3}	-67.44	-0.05	-159.47	-0.18

Appendix (concluded)

Parameters	N3SLS		GMM	
	Coefficient	t-Stat.	Coefficient	t-Stat.
α_{D4}	13625.03***	12.08	13023***	8.72
α_{D5}	8746.70***	7.01	8398.26***	10.09
α_{D6}	8216.22***	5.57	8109.65***	9.22
α_{D7}	9268.90***	7.53	8934.08***	10.57
α_{D8}	8396.31***	6.37	8335.75***	9.39
α_{D9}	9590.17***	6.18	9422.37***	7.07
α_{D10}	7889.96***	5.85	7563.81***	9.3
α_{D11}	13422.51***	9.3	12197.5***	7.71
α_{D12}	9886.17***	7.83	9334.11***	11.1
α_{D13}	9922.68***	8.98	9528.95***	11.75
α_{D14}	7221.06***	5.44	6846.1***	5.97
Objective Value	1.15	–	0.30	–
R-squared:				
SF	0.97	–	0.96	–
FOC	0.79		0.78	
Durbin-Watson:				
SF	1.40		1.44	
FOC	1.71	–	1.71	–

Notes: The values in parentheses are asymptotic standard errors. The superscripts ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Source: own estimation.

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