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HOW TO WITHSTAND UNCERTAINTY IN RUSSIAN WHEAT MARKET

N.M. SVETLOV

(Russian Academy of National Economy and Public Administration)

The study develops a finite difference dynamic simulation model of the Russian market of wheat for the purpose of agricultural policy analysis. The distinctive feature of the model is that it does not simulate prices in the absence of an active policy, taking the historical prices as input data instead. By doing so the model avoids discrepancy between modeled and actual prices that is inherent to all models that deal with variable prices. Hence, the model can only be applied for retrospective analysis that is commonly sufficient for policy analysis applications. Another distinction is a parameter of market perfection, which can vary from zero (absolutely fragmented market) to one (the perfect market). During the analysis of commodity and purchase interventions, the average domestic price of wheat is calculated as a weighted average of the historical price and intervention price using the parameter of market perfection as weight.

The paper reports three cases of state policy applicable to the grain market: first, purchase and commodity interventions that are exercised outside a fixed price corridor; second is similar to the first but the price corridor is allowed to vary once a year depending on the market conjuncture; third is the producers' price loss coverage with a fixed reference price. It is demonstrated that the strictly defined rules of intervention allow decreasing variation coefficient of wheat price by 1 to 2.5 per cent points in comparison to the historic monthly data of years 2007-2015. So, it is concluded, that the existing policy is not as efficient as it could be.

The interventions are ineffective as means of income support for producers and cost control for households. Simulations demonstrate that the price loss coverage can add up to 2.1% to the producers' revenues, while the interventions increase their revenues less than by 1% at best. Other advantages of the price loss coverage are their fairness (all producers have equal access to coverage payments, while the benefits from interventions depend on access to the exchanges where the interventions take place) and certainty of the effect (it does not depend on the unknown parameter of market perfection).

The study suggests that the only reason to exercise this instrument is its theoretically expected positive influence on the investment climate via controlling over the price volatility. However, it is doubtful in the view of relatively large fragmentation of the Russian market of wheat, which hampers the efficiency of the policy. The price loss coverage, although generating larger costs for the state budget, secures the incomes of grain producers at the cost of failing to protect consumers from excessively high prices and to make the prices of wheat more predictable for investors.

Key words: *wheat, agricultural policy, policy analysis, simulation model, purchase interventions, commodity interventions, price regulation, price loss coverage, Russia.*

1. Introduction

Many centuries grain markets failed to equalize supply and demand in a long run without someone having to die from hunger. The production process lasting a year or half a year at best in conjunction with unpredictability of yields makes price signals too late to adjust the production. Nowadays the presence of imperfections in the grain markets are evident from eventual trade disparity among different importers from the same country [10] and from dependence of wheat prices on financial markets rather than on yields [19]. These imperfections can heavily stress family budgets and demotivate investors, rousing the need for regulatory policies.

Such policies are driven by contradictory goals. To secure the population of grain producers, the regulator would protect the domestic grain market with high tariffs and push grain prices up by all means. To avoid malnutrition of the poor and diminished demand on non-food products from households, it would do opposite. To prevent the market from persistent oversupply or shortage, the regulator must let the prices follow market conjuncture. To attract investors in the grain production and related businesses, it is necessary to diminish price variation. The art of the trade policy in the grain market is to withstand the severest problems at the cost of minimal harm. To keep the harm under control, it is desirable to simulate the expected situation in the market in the case that a certain trade policy is applied.

The prior aim of this paper is to introduce a policy analysis technique that allows quantifying impacts of purchase and commodity interventions in the grain market. In terms of the framework developed in [6], this study assesses selected arguments of social welfare function that relate to the grain sector of agriculture. The applied technique is retrospective what-if simulations.

Furthermore, the paper investigates three different policy instruments aimed primarily at protecting target classes of market agents from excessively low and, possibly, high prices of grain. Two studied instruments are based on the concept of price corridor. In the first case, the corridor is semi-fixed: it is intended not to change in the future (more strictly, sufficient reasons for changing it are too rare to focus on them here). Such policy provides higher certainty in the long run. In the second case the corridor boundaries are allowed to vary yearly. This policy fits the best to the existing Russian legislation on grain market regulation. The third instrument is similar to that introduced in the USA by Act [23]. It compensates to the producers the difference between the reference price set by the regulator and actual market price when the latter is lower. Such policy does not affect prices directly.

The urgency of this study is evident from the conclusion of [3] that, although the Russian legislation requires the grain market to be regulated, the actual implementation of the instruments that are enforced by the law [9, § 14] fails to facilitate the aims declared ibidem. The same conclusion follows from the research report [25, ch. 5.6].

As for now, the model is calibrated to the Russian market of wheat and the reported results relate to wheat only. Hereafter the paper narrates about wheat with no reference to other cereals. The model and the methodology as a whole is applicable, though, to a national market of any kind of grain, subject to the assumption that the amount of storage space that is reserved for this kind is either known or defined in the scenario setting.

2. A review of grain market policy analyses

The aim of this section is to outline a «methodology space» of grain policy analyses and to justify the position of this study in that space. Although the literature on grain policy analyses is rich, it commonly addresses specific policy instruments and applies a specific measurement, thus having limited relevance to this study. The relevant studies, which are based on a modeling framework and relate to intrusions into grain markets, are commonly represented in working papers and technical reports. They define four branches of the applied methodologies: econometric modeling, e.g. [17], partial equilibrium framework [16, 21], system dynamics framework [11, 22] and optimal planning [18].

Working paper [16] presents a spatial partial equilibrium model, which is used to analyze the effect of grain policy changes on the markets of EU members. Specifically, three options are analyzed: abolition of monetary compensatory amounts, 10% cut in support prices for grains and 10% tax on fodders that could substitute grain. The PhD dissertation by Robledo [17], which is largely influenced by the seminal paper [7], develops an econometric model of the USA wheat market. The aim of Robledo's study is to contribute in developing a forecasting framework that could elucidate the future of wheat markets, assuming some statistical properties of their dynamics invariant. Although the dissertation focuses on econometric techniques of estimating parameters of simultaneous equations representing a seasonal nonstationary process, it contains an extensive literature review of earlier experience with grain market policy analyses. Due to Robledo's work, this section can be focused, with some exclusions, on later studies.

Paper [11] uses a system dynamics model to access the influence of the expanding biofuel use of cereals on the global food market and, particularly, on the global market of grain. Oil price subsystem is essential part of the model, meanwhile cereals price indices are exogenous. By assumption, the oil market is disequilibrium: the supply and demand are not required to match, so the oil price is a function of both. The model allows simulating the impact of external factors (like climate change or shrinking farmland) on food security, thus focusing at risk analysis tasks. Therefore, it does not represent functioning of specific policy instruments. The model is intended to be used at the projection phase of policy making. It helps politicians to select policy instruments for further discussion and analysis.

Literature in Russian mainly analyses the specific forms of state intrusion into the grain market that are enforced by Russian legislation, yet avoiding, as a rule, models and simulations. Avarsky, Prolygina et al. [4] warn about overvaluing commodity and purchase interventions as means of state policy in the grain market. They conclude that the role of intervention is to inform agents on the expected price levels; coordinating actual demand with what they call "necessary demand" and supply with "necessary supply"; securing producers and consumers from price volatility. Altukhov [1], using annual data on difference between minimal and maximal producers' prices of wheat for the period 1993…2013, comes to the conclusion that the state hardly helps matching supply and demand in the Russian grain markets. He suggests, in fact, that the state would organize a system that will either complement or substitute markets in sending signals to producers about what kind and amount of grain to produce and what agreements to enter. Implementation of this suggestion seems to require a fundamental revision of Russian legislation, including Civil Code. Referring to Canada Grains Council as a prototype of the basement of such system, the author requires, however, that the governmental body should possess final responsibility on the market situation. Meanwhile, the Canadian experience suggests that governmental bodies participate in the Grains Council as members rather than supervisors.

Paper [5] is closely interlinked with this study, as it addresses formation of intervention fund. It concludes that the existing practice of the state interventions in the grain markets in Russia is characterized by weak dependence of prices on the scale of intervention activities. This observation is explained by insufficient methodological support of interventions, gaps in the legislation and dysfunctional monitoring system. As a result, the paper reads, the Ministry of Agriculture prescribed the size of specific lots instead of the amount of the overall intervention. In contrast, Demianov [8] assesses the interventions as relatively effective. However, he does not specify the assumed aim of the interventions, regarding to which they are effective. His analysis extends to the amounts of interventions and focuses on the fact that, as a rule, the United Grain Company, a state's agent in the market, bought the grain at the prices that were close to their starting levels. Karlova [12] investigates the impact of Russian grain export embargo in 2010/2011 marketing year. She comes to the conclusion that commodity intervention can be a sufficient alternative to the export embargo. Moreover, as she notes, the embargo seems to conserve the existing lack of export infrastructure in Russia.

The studies [18, 22] are rare cases of using modeling framework among the Russian grain policy analyses, yet they do not present computable models. The former monograph develops an optimal planning model aimed at ex ante analysis of state development programs in agriculture with respect to the sectoral point of view, including grain sector. As for the latter, theoretic considerations based on the analysis of feedback loops in the model sketch imply the conclusion that the impact of a policy aimed at increasing domestic grain prices on the amount of production is ambiguous, unless decreasing production costs are secured (for instance, via high competition among producers).

The conclusion follows that the Russian regulatory practice, as well as its analysis, lacks computable judgments. International experience provides tools for such judgments, which, however, do not cover specific analytical tasks that emerge in the Russian case. To span them, system dynamic models like [22, 15] seem relevant. Yet, in order to avoid unneeded complexity, it is possible to use exogenous prices when possible (like cereals price indices in [11]). Another option is to sacrifice the classical system dynamics in favor of the finite difference approach.

3. Methodology

3.1. The model in brief

Figure 1 displays the structure of the model in more details. On the figure, parallelograms represent input data and boxes denote the results of some computation. The arrows expose the relations between variables, which can also be interpreted as data flows in a computation process. Double cross over an arrow denotes one month delay and triple cross denotes one year delay. Each variable is a 1×108-vector of data covering January 2007 to December 2015. Excluding "modeled net export", all supply and demand variables measure domestic supply and demand.

The distinction of the simulation model developed for the purpose of this study is using, when possible, exogenous prices that span unobserved factors altogether. The policy is only enabled to draw (under certain conditions) the domestic price closer to a target level. This way the model avoids large gaps between projected and true prices, which often cause doubts about the usability of various market simulations. The cost of these advantages is that the model can only be applied for retrospective simulations. It is unable to make projections. Moreover, it does not capture indirect influence of analyzed policies on prices via production, exports etc.

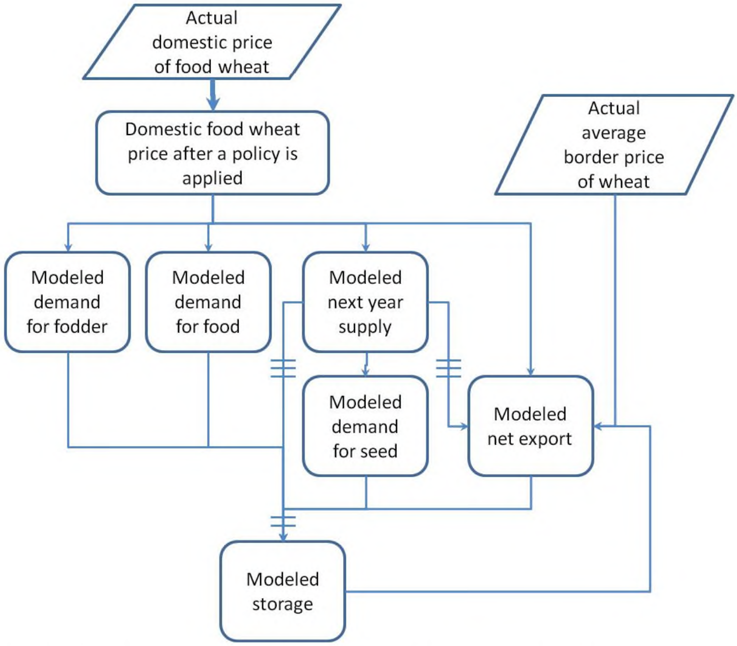

Fig. 1. A sketch of the simulation model of Russian wheat market

As it can be seen from the figure, the market of wheat is assumed to be a non-equilibrium market, like the oil market in [11]. The supply may not match the overall demand. The gap between the supply and demand is absorbed by the storage. If the storage is out of the capacity then the (remaining) gap increases or diminishes the net export.

The model does not distinct the storage of wheat producers and that of other agents. So, it is not possible to compute the exact revenue of the wheat producers by the given month. On this reason, the model is pessimistic about this revenue, assuming that the incremental storage is not yet marketed.

The policy impact is imposed by the bold arrow from «actual domestic price of food wheat» to «domestic food wheat price after a policy is applied». The simplest algorithm that could be associated with this arrow is setting excessively high or low prices to an allowed maximum or minimum, while the prices that fall into these borders remain unchanged. In a similar way the model can be easily enriched with the capability to model the impact of tariffs by including a multiplier (which can be conditional) between the «actual average border price of wheat» and «modeled net export». To model the impact of price loss coverage as it is defined in [23], the supply is derived from «domestic food wheat price after a policy is applied» and the demand from «actual domestic price of food wheat».

Based on the variables that are present on the figure, the comparative policy indicators are calculated as differences or ratios between e.g. the modeled wheat supply in the presence and absence of the studied policy. It is also possible to calculate the cost of the policy for taxpayers. The next subsection describes the currently implemented analytical capacity of the model in details.

3.2. The model in formulae

The model presented below is a base version that is not enabled to model export tariffs and price loss coverage.

Sets

$U = \{D; R; Z\}$ is a set of *indices* of time series groups: D indexes time series in the absence of any policy, R time series affected by the analyzed policy instrument and Z supplementary time series.

$S = \{G, Y, B, F, S, I, X, P, M\}$ is a set of *indices* of time series within a group defined by an index from set U. Here G indexes the stored wheat, Y wheet production, B, F and S wheat used as food, fodder and seed, symbol I indexes the amount of market intervention fund, X net export of wheat, P domestic price of flour wheat, M the share of the intervention sales (purchases) in the domestic market of wheat (excluding seed). The series indexed with symbols G and I are measured in thousand tons (hereafter a ton is a metric ton amounting 1000 kg). Those indexed with Y, B, F, S and X are in thousand metric tons per month and with P in rubles per metric ton. The subset $S_1 \in S$ is defined as $\{B, F, S, X\}$.

$N = \{A, C, D, E, H, J, K, L\}$ is a set of *indices* of output variables of the model. Most of the indexed variables represent annual average increments in comparison to the absence of state intrusion: A of domestic sales of wheat by its producers, C of revenues from (net) export of wheat, D of wheat used for food, E of net export of wheat; H of wheat producers' revenues (from both domestic and export sales), J of gross margins from (net) exporters of wheat, K of consumers' expenses. L indexes the annual average of state budget expenses caused by the modeled policy. The variables indexed with A, C, H, J, K and L are measured in billion rubles per annum deflated to December 2014, while D and E are in million tons per annum.

$T = \overline{0;107}$ is an ordered set of indices that index months of the modeled period: zero relates to January 2007 and 107 to December 2015. $M = \overline{0;11}$ is an ordered set of months of a year, where 0 relates to January.

Variables

A scalar x_{svt}, where $s \in S$, $v \in U$, $t \in T$, is an observation t from time series v belonging to group s. Output variables are denoted y_n, where $n \in N$.

Parameters

$\alpha_0 \ldots \alpha_5$ are parameters of the net export equation.
β and η are parameters of the domestic demand function of wheat for food use.
γ and δ are parameters of the domestic demand function of fodder wheat.
ε and ζ are parameters of the domestic wheat supply function.
ρ is an average spending of seed per unit of harvested wheat.
τ is a storage loss of wheat per annum (fraction).
λ_m is a share of a yearly gross yield that is harvested in month $m \in M$.
μ_m is a share of a yearly seed spending that falls on month $m \in M$.

[1]2007 is the first year when the production of wheat was influenced by the law [9].

Scenario parameters

c is a storage capacity available for wheat (thousand tons).

f is a price ratio of fodder wheat to wheat for food use.

g is a price ratio of wheat for seed to wheat for food use.

h is a gross yield of wheat in 2007 (thousand tons).

a is a gross amount of stored wheat by $t = 0$ (thousand tons).

b is an intervention fund amount by $t = 0$ (thousand tons).

p_t and w_t are a domestic producer price of food wheat and a border price of wheat in month $t \in T$, rubles per metric ton.

q_t and r_t are lower and upper reference prices of food wheat in month t, rubles per metric ton.

d is a retail margin.

$\psi \in [0;1]$ is a market perfection parameter. Zero means that third parties totally ignore the intervention price, while one means a perfect market, such that all agents accept the intervention price as the best option.

Operators

Operator $\underline{T(t)}$ defines the set (which may be empty) of all month indices from set T that relate to the complete civil year preceding month $t \in T$. $\overline{T(t)}$ returns a set (possibly empty) of all month indices from set T that relate to the complete civil year that includes month $t \in T$. Finally, $m(t) = t \setminus 12$, where backslash denotes a modulo operator, returns the number of month t within a civil year.

Equations

1) Current wheat storage:

$$x_{\mathrm{G}v0} = a, \quad v \in V;$$
$$x_{\mathrm{G}vt} = (1-\tau)\cdot\left(x_{\mathrm{G}vt-1} + x_{\mathrm{Y}vt} - \sum_{s\in S_1} x_{svt-1}\right), \; v \in V, t \in T \setminus \{0\}.$$

2) Supply of harvested wheat:

$$x_{\mathrm{Y}vt} = \lambda_{m(t)}\cdot h, \quad v \in V, t \in T, t < 12;$$
$$x_{\mathrm{YR}t} = \lambda_{m(t)}\cdot\varepsilon\cdot\left(\frac{1}{12}\cdot\sum_{\theta\in \underline{T(t)}} x_{\mathrm{PR}\theta}\right)^{\zeta}\cdot\kappa_t,\; x_{\mathrm{YD}t} = \lambda_{m(t)}\cdot\varepsilon\cdot\left(\frac{1}{12}\cdot\sum_{\theta\in \underline{T(t)}} p_\theta\right)^{\zeta}\cdot\kappa_t, \quad t \in T, t \ge 12,$$

where κ_t reflects acutal weather in the civil year to which month t belongs as a ratio of wheat production in this year to average wheat production over 2007-2015.

3) Using wheat for food: $x_{\mathrm{BR}t} = \beta x_{\mathrm{PR}t}^{\eta}, \; x_{\mathrm{BD}t} = \beta p_t^{\eta}, \; t \in T.$

4) Using wheat as fodder: $x_{\mathrm{FR}t} = \gamma x_{\mathrm{PR}t}^{\delta}, \; x_{\mathrm{FD}t} = \gamma p_t^{\delta}, \; t \in T.$

5) Sowing: $x_{\mathrm{S}vt} = \rho\cdot\mu_{m(t)}\cdot\sum_{\theta\in\overline{T(t)}} x_{\mathrm{Y}v\theta}, \; v \in V, t \in T.$

6) Current market intervention fund of wheat:

$$x_{\mathrm{IR}0} = b; \;\; x_{\mathrm{IR}t} = (1-\tau)\cdot\Big(x_{\mathrm{I,R},t-1} - \sum_{s\in S_1} x_{s,\mathrm{R},t-1} + \sum_{s\in S_1\setminus\{\mathrm{X}\}} x_{s,\mathrm{D},t-1} + x_{\mathrm{X,Z},t-1}\Big), \;\; t\in T\setminus\{0\}.$$

7) Net export of wheat:

$$x_{\mathrm{X}ut} = \min\begin{cases} \max\begin{cases} \alpha_0 + \alpha_1 x_{\mathrm{Y}ut} + \alpha_2 x_{\mathrm{Y},u,t-1} + \alpha_3 x_{\mathrm{Y},u,t-2} + \alpha_4 w_t + \alpha_5 x_{\mathrm{P}ut} \\ x_{\mathrm{S}ut} + x_{\mathrm{Y}ut} - \sum_{s\in S_1\setminus\{\mathrm{X}\}} x_{sut} - c \end{cases} \\ x_{\mathrm{S}ut} + x_{\mathrm{Y}ut} - \dfrac{x_{\mathrm{I}ut}}{1-\tau} - \sum_{s\in S_1\setminus\{\mathrm{X}\}} x_{sut} \end{cases}, \;\; t\in T, u\in U,$$

where $x_{\mathrm{PD}t} = x_{\mathrm{PZ}t} = p_t, t\in T,\;\; x_{s\mathrm{Z}t} = x_{s\mathrm{R}t}, s\in S\setminus\{\mathrm{P}\}, t\in T$ and the symbols with time indices outside the set T are zeroes.

8) Presence of state in the market (excluding seed):

$$x_{\mathrm{MR}t} = \frac{x_{\mathrm{BR}t} + x_{\mathrm{FR}t} + x_{\mathrm{XR}t} - x_{\mathrm{BD}t} - x_{\mathrm{FD}t} - x_{\mathrm{XD}t}}{x_{\mathrm{BD}t} + x_{\mathrm{FD}t} + \max(x_{\mathrm{XD}t}, 0)}.$$

9) Domestic price after a policy is applied:

$$x_{\mathrm{PR}t} = \min\begin{pmatrix} p_t\cdot(1-x_{\mathrm{MR}t})\cdot(1-\psi) + r_t\cdot\big(x_{\mathrm{MR}t} + (1-x_{\mathrm{MR}t})\cdot\psi\big), \\ \max\big(p_t, p_t\cdot(1+x_{\mathrm{MR}t})\cdot(1-\psi) + q_t\cdot\big(-x_{\mathrm{MR}t} + (1+x_{\mathrm{MR}t})\cdot\psi\big)\big) \end{pmatrix}, \;\; t\in T.$$

10) Mean annual increment of revenues from domestic sales of wheat:

$$y_{\mathrm{A}} = \frac{1}{9\cdot 10^6}\cdot\Big(\sum_{t\in T} x_{\mathrm{PR}t}\big(x_{\mathrm{BR}t} + f\cdot x_{\mathrm{FR}t} + g\cdot x_{\mathrm{SR}t}\big) - \sum_{t\in T} p_t\big(x_{\mathrm{BD}t} + f\cdot x_{\mathrm{FD}t} + g\cdot x_{\mathrm{SS}t}\big)\Big).$$

11) Mean annual increment of revenue from (net) exported wheat:

$$y_{\mathrm{C}} = \frac{1}{9\cdot 10^6}\cdot\sum_{t\in T} w_t\cdot\big(x_{\mathrm{XR}t} - x_{\mathrm{XD}t}\big).$$

12) Mean annual increment of consumption of wheat for food purposes:

$$y_{\mathrm{D}} = \frac{1}{9000}\cdot\sum_{t\in T}\big(x_{\mathrm{BR}t} - x_{\mathrm{BD}t}\big).$$

13) Mean annual increment of net wheat export: $y_{\mathrm{E}} = \dfrac{1}{9000}\cdot\sum_{t\in T}\big(x_{\mathrm{XR}t} - x_{\mathrm{XD}t}\big).$

14) Average annual increment of producers' revenues from sales of wheat:

$$y_{\mathrm{H}} = \frac{\sum_{t\in T} x_{\mathrm{PR}t}\big(x_{\mathrm{BR}t} + f\cdot x_{\mathrm{FR}t} + g\cdot x_{\mathrm{SR}t} + x_{\mathrm{XR}t}\big) - \sum_{t\in T} p_t\big(x_{\mathrm{BD}t} + f\cdot x_{\mathrm{FD}t} + g\cdot x_{\mathrm{SS}t} + x_{\mathrm{XR}t}\big)}{9\cdot 10^6}.$$

15) Average annual increment of the exporters' gross margin:

$$y_{\mathrm{J}} = \frac{1}{9\cdot 10^6}\cdot\Big(\sum_{t\in T} x_{\mathrm{XR}t}\cdot\big(w_t - x_{\mathrm{PR}t}\big) - \sum_{t\in T} x_{\mathrm{XD}t}\cdot\big(w_t - p_t\big)\Big).$$

16) Average annual incremental expenses of ultimate consumers of wheat for food use:

$$y_{\mathrm{K}} = \frac{1+d}{9 \cdot 10^6} \cdot \left(\sum_{t \in T} x_{\mathrm{BR}t} \cdot x_{\mathrm{PR}t} - \sum_{t \in T} x_{\mathrm{BD}t} \cdot p_t \right).$$

17) State budget spending due to the analyzed policy:

$$y_{\mathrm{L}} = \frac{1}{9 \cdot 10^6} \cdot \sum_{t \in T \setminus \{0\}} x_{\mathrm{PR}t} \cdot \left(x_{\mathrm{IR}t} - (1-\tau) \cdot x_{\mathrm{I,R},t-1} \right).$$

3.3. Parameterization of the model

Although the model is relatively simple, it is not possible to estimate all its parameters at once from the available empirical data. The obstacle is the presence of dynamic chaos in the dependence of endogenous variables on the estimated parameters. So, it is necessary to decompose the parameterization procedure at the expense of probable missing or distorting some interaction effects.

The applied parameterization strategy is a compromise between the reliability of the model and feasibility of the whole research project. The sources of parameter estimates are ordered as follows: the highest priority is given to relevant estimates that are already available in the literature; statistical estimates from the relevant data are ordered the second; the third turn is assigning to a parameter the value that adjusts a modeled total or average of some indicator over the modeled period to the historical value (the pre-condition is that this total or average must not depend on the fourth and consequent turn parameter estimates); the fourth turn is expert approximation based on incomplete data and, finally, the fifth turn is including a parameter into a scenario setting. An important advantage of the retrospective simulation is that we can deal with the available observations as with a finite population rather than a sample. So, as far as the statistical model used for the estimations is valid, we can think of the estimated parameters as they are precise (yet insufficient for any other population).

The first turn parameterization procedure is applied to parameters η, δ, ζ and τ. Both η and δ are set equal to the value of elasticity of demand for wheat on the producer price in Russia obtained from the calibration procedure of the partial equilibrium model reported in [21]. The elasticity of supply of wheat on the producer price, which is assigned to ζ, is also obtained from that procedure. Parameter τ is set to a pessimistic (upper biased) proxy, namely the standard rate of loss of wheat stored in bulk during one year [2].

The second turn parameterization involves ρ, λ_m, $\alpha_1 \ldots \alpha_5$. To estimate ρ, we divide the average wheat seed rate per hectare reported in [2] by the average historical yield of wheat per hectare during the modeled period. Estimates of λ_m are directly calculated from the data available in [13, 14]. Parameters $\alpha_1 \ldots \alpha_5$ are obtained via maximum entropy (ME) estimation from the incomplete linear model

$$\xi_t = \alpha + \alpha_1 \upsilon_t + \alpha_2 \upsilon_{t-1} + \alpha_3 \upsilon_{t-2} + \alpha_4 w_t + \alpha_5 p_t + \varepsilon_t, \quad t \in T \setminus \{0,1\}, \qquad (1)$$

where ξ_t is net export of wheat in month $t \in T$ (in thousand metric tons) as reported by Federal Custom Service of the Russian Federation; υ_t is an estimated amount of wheat harvested in month t; ε_t is a residual and the remaining symbols are defined in the previous subsection. For each t the value of υ_t is calculated as gross yield in the year to which the month t belongs (as reported by the Federal statistics agency of the Russian Federation, hereafter Rosstat) multiplied by $\lambda_{m(t)}$. ME estimation is tolerant to incomplete models and diminishes the harm from high correlation between p_t and w_t (actually it turns out that the estimate of α_4 is zero). The following prior assumptions are used while the estimation: the prior distribution of parameters $\alpha_1 ... \alpha_3$ is uniform between 0 and 1; the prior distribution of $\tan(\alpha_4)$ is uniform between 0 and $\pi/2$, $\tan(\alpha_5)$ is a priory distributed uniformly between $-\pi/2$ and 0; $\tan(\alpha/1000)$ and $\tan(\varepsilon/1000)$ are a priory distributed uniformly between $-\pi/2$ and $\pi/2$. Tangents appear here in order to overcome the requirement of ME estimator that all the parameters and residuals must be distributed over a finite domain. Spearman rank correlation between ξ_t and $\xi_t - \varepsilon_t$ is 0,785. Using prior assumptions makes ME estimations somewhat subjective. However, the influence of these assumptions on the estimates is limited, as sensitivity tests have shown.

The third turn is applied to parameters α_0, β, γ, ε. Initially it was intended to set these parameters to such values that modeled export, supply by producers, demand for food and fodder over the nine years would match the corresponding totals of the historical data. However, this strategy was found to result in unrealistic dynamics with excessive amounts of export or import in some years. The likely reason is that part of the market is not observable by Rosstat. Particularly, the supply of wheat by producers seems underreported. On this reason, the values of these parameters are chosen with respect to fit quality indicators, giving the highest priority to fitting the net export.

Estimates of μ_m are obtained at the fourth turn as shares of area sown (on average) in month $m \in M$ in the whole area sown during a year. They are approximated (informally) from the data on gross sown areas of winter and spring wheat and typical time for sowing both kinds in different wheat regions of Russia.

The estimates of the fifth turn are intended to vary while simulations. Of them, the parameters listed below remain unchanged while the simulations that are presented in this paper: c (set to 2/3 of the overall grain storage capacity reported in [24, p. 117]), f (calculated from available price data over the studied period), g (assumed), h (taken from the actual data of 2007), a (discussed below), b (taken from the actual data), d (assumed), p_t and w_q (set to their historical values).

Parameter a needs a special discussion. The data on wheat storage by the beginning of the civil year provided by Rosstat do not match the data on subsequent consumption and net export. If the data were true, the reported storage would completely run out by summer. So, the amount of wheat storage is evidently underestimated by Rosstat due to the underreported supply by producers that is mentioned above. So, having all the parameters but a either estimated or calibrated and assuming no state intrusion into the market, parameter a is assigned a value that results in small but yet positive modeled seasonal minimums of the storage.

As measure of fit quality we use the mean absolute percentage error (MAPE) for values $\sum_{t \in T(\upsilon)} x_{\mathrm{YD}t}$, $\sum_{t \in T(\upsilon)} x_{\mathrm{BD}t}$ and $\sum_{t \in T(\upsilon)} x_{\mathrm{FD}t}$, where $\upsilon \in \{0;12;24;\ldots;96\}$.

MAPE is a sufficient measure because the variables that relate to wheat production and usage are positive and their variation is moderate. Sum over year is inasmuch as only annual historical data about wheat production and usage are available. The obtained values of MAPE are 8,61% for production, 11,68% for food usage and 16,06% for use for fodder.

Fit imperfection of net export, which may be negative, is measured by $\frac{\sum_{t \in T} |x_{\mathrm{XD}t} - w_t|}{\sum_{t \in T} w_t} \cdot 100$. This value is comparable to MAPE and can be used with variables that can be negative providing that their average is positive and variation is moderate. Measured this way, the fit imperfection of net export is 35,00%. It is noticeable that the bias of overall export is 1,28%. Such a small bias is reached at the expense of large biases (circa 10%) of production and usage. The large biases, however, should be attributed rather to the quality of the historical data than to the quality of the model.

4. Evidence

The results that are reported below are based on the selected scenarios, which avoid both lacks and overflows of the intervention fund, attempt to minimize growth of the intervention fund storage and maximize the impact on domestic prices of wheat. Starting simulation from 2007, when the intervention fund was only 1.7 million tons, it is not possible to eliminate its growing trend without spending it fully in some periods.

4.1. Fixed price corridor

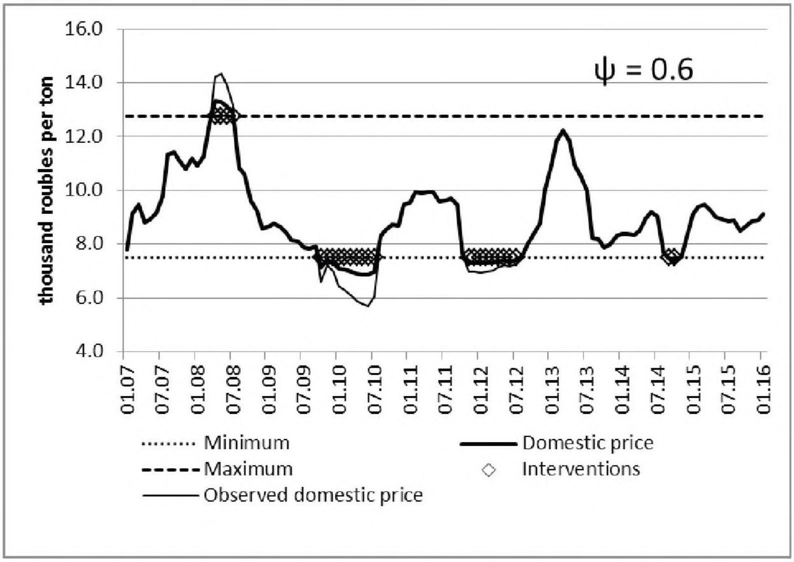

Figure 2. Impact of interventions on domestic price of wheat: fixed price corridor

The reported scenario is following: a = 26.3 million tons, b = 1.7 million tons, q_t = 7500 rubles per ton and r_t = 12750 rubles per ton, where $t \in T$.

Figure 2 demonstrates the impact of interventions on prices assuming $\psi = 0.6$. Under the scenario assumption the maximum market price would be 13331 rubles per ton (exceeding r by 4.6%) instead of historical 14334 (by 12.4%). The minimal price would be 6856 (8.6% below q) instead of 5690 (24.1%). This effect would cost to the taxpayers 5.4 billion rubles. The intervention fund would vary between 756 and 4953 thousand tons during the studied period.

Figure 3 displays measurable costs and benefits of the policy across all possible values of ψ. Households, exporters and the state budget bear the costs of the policy, while producers benefit when $\psi > 0.05$. However, none of the effects exceed 1% to the «no policy» scenario, with an exclusion of the exporters' margin that fall by 3.4%. The direction of the effects is quite sensitive to small changes in the scenario, but the effects remain marginal throughout all studied scenarios that can be thought about as realistic. With an exclusion of the revenues from exports at low ψ, larger ψ increases the effects.

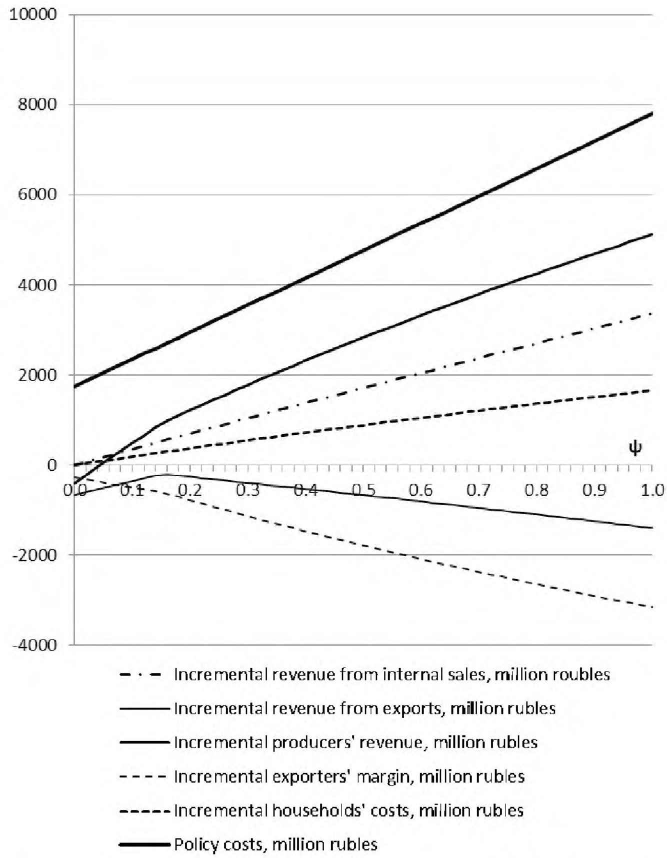

Figure 3. Effects of the fixed price corridor on revenues and costs

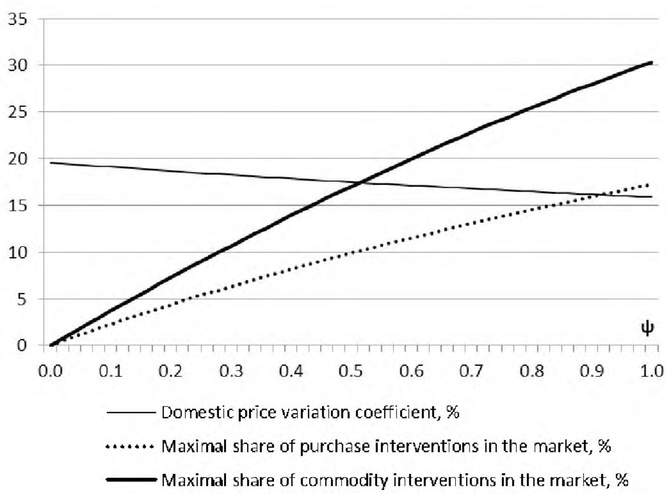

Figure 4. Intrusion of the state in the domestic market of wheat and its impact on price volatility: fixed price corridor

When the situation in the market requires interventions, the participation of the state in the market is quite substantial amounting (at $\psi = 0.6$) to 20.0% of sales in the case of commodity interventions and 11.5% of purchases during purchase interventions, as illustrated by Figure 4. These interventions allow reducing price variation coefficient along the studied period from 19.7% to 17.1%.

4.2. Floating price corridor

For the floating price corridor policy, the reported scenario is $a = 26.3$ million tons, $b = 1.7$ million tons, $r_t = 2_{q_t}$ and

$$q_t = 6000 \cdot \left(\frac{w_{t-1}}{\overline{w}}\right)^{0.486} \cdot \left(\frac{x_{\mathrm{YR}t}}{x_{\mathrm{YR}t-1}}\right)^{-0.469} \cdot \left(\frac{x_{\mathrm{GR}t-1}}{x_{\mathrm{GR}t-2}}\right)^{-0.467},$$

where $\overline{w}$ is an average export price of wheat during the studied period.

This formula is a model of a floating price corridor that is advisable for being used in the real policy, providing that $x_{\mathrm{YR}t}$ is replaced by the forecasted gross yield of wheat. The parameters in the formula, with the exclusion of the scale coefficient, are GME estimates of a model of the domestic wheat price as a power function of the same arguments as the power function in the formula above depends on. The background of the formula is that the regulator reacts on changes in the world market price, "forecasted" (expected in the period t) gross yield and last year stock addition.

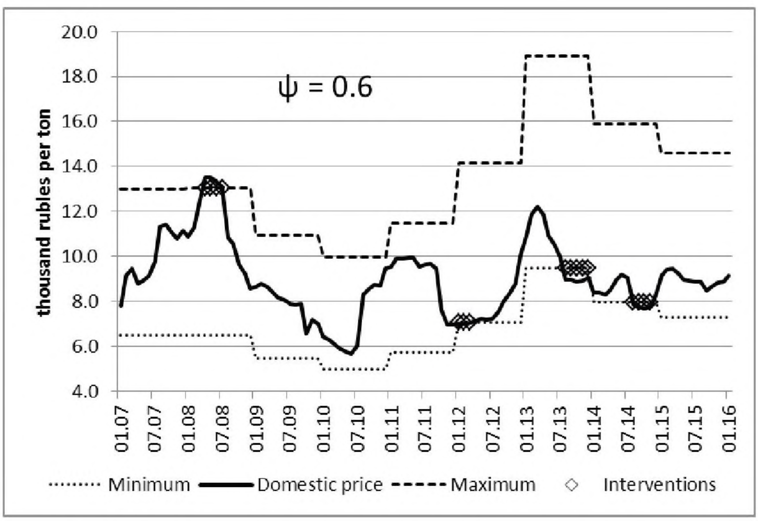

Figure 5. Domestic prices of wheat under the floating price corridor policy

Figure 5 shows that the floating corridor avoids a long period of purchase interventions in 2010 (compare to Figure 2) in favor of a shorter period in 2013. Overall state intrusion in the market decreases (compare Figures 6 and 4) at the cost of lower control over the price variation coefficient: at $\psi = 0.6$ it decreases by 1.04 per cent points versus 2.55 points in the previous case.

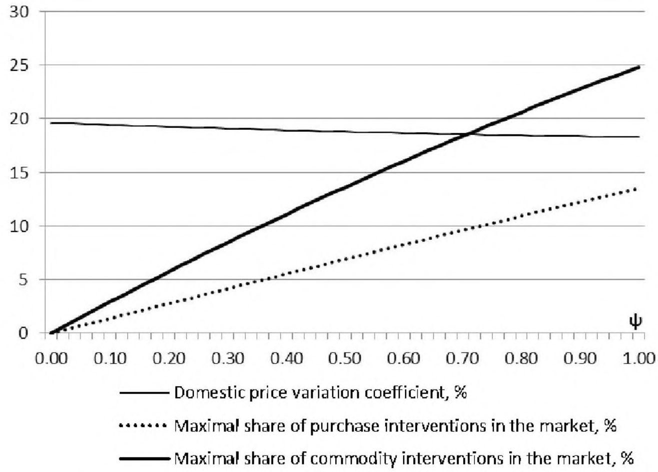

Figure 6. Intrusion of the state in the domestic market of wheat and its impact on price volatility: floating price corridor

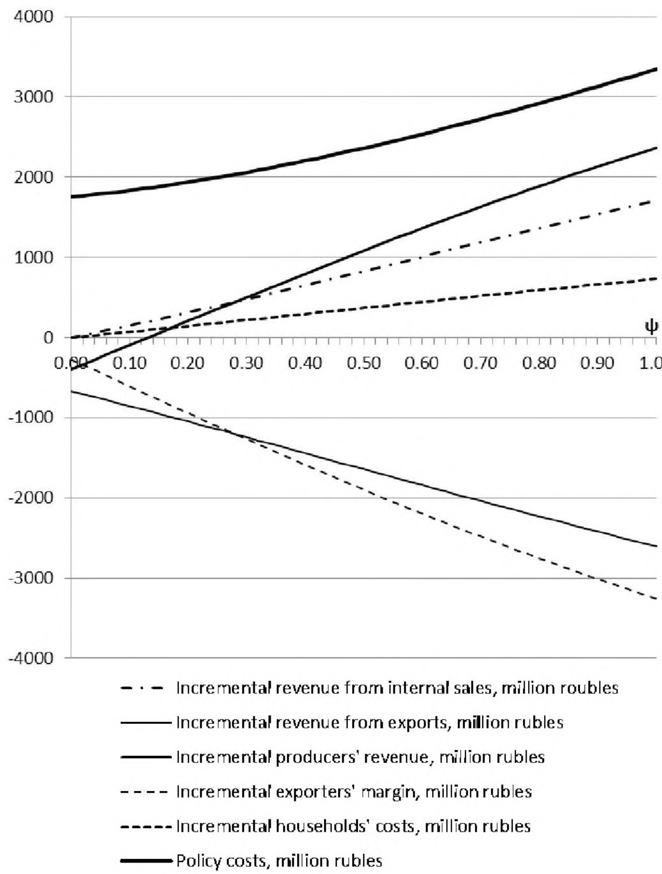

Figure 7. Effects of the floating price corridor on revenues and costs

In this scenario the list beneficiaries of the policy remains the same as in the case of fixed price corridor (see Figure 7). The only reservation is that ψ must exceed 0.13 in order to let the producers benefit from the policy. In general, the magnitude of the effects is smaller than in the previous case as a consequence of a shorter duration and smaller amount of interventions. Another consequence is lower variation of the intervention fund: it does not fall below 992 thousand tons, thus diminishing the risk of using it up, and does not exceed 2986 thousand tons, reducing budget payments for the storage.

4.3. Price loss coverage

The reported scenario is following: a = 26.3 million tons, b = 1.7 million tons and q = 7500 rubles per ton. Intervention fund does not exist. Parameter ψ does not matter, as the state does not operate in the market. Figure 8 displays the periods when the state covers price loss to the producers under the scenario conditions.

The price loss coverage stimulates production during the periods when the policy is active. As a result, the production increases a little (0.7% growth throughout the nine years). This effect pushes the export to grow (by 0.3%). As the growth occurs (under this particular scenario) in the periods when the gap between the domestic and border price is a bit larger than usual, the exporters' margin grows by 0.4%. The total of producers' revenue and price loss coverage exceeds their revenue under «no policy» by 2.1%, demonstrating the strongest producer support effect among all the reported cases. However, the state misses the income from commodity interventions. As a consequence, the policy costs amount to 7.79 billion rubles per annum, which is the largest value among the three cases. For the producers the effective price variation coefficient, compared to the «no policy» scenario, reduces by 2.49 per cent points down to 17.20%, while for other agents it remains 19.69%. So, the producers experience nearly the same effect as it would emerge in the case of fixed price corridor at ψ = 0.6. It is important, however, that in the case of price loss coverage this effect does not depend on the unknown parameter ψ.

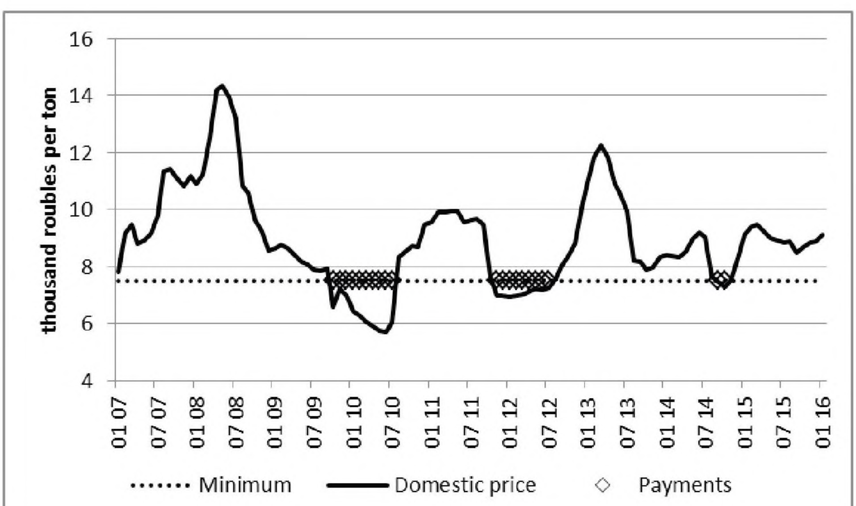

Figure 8. The cases of price loss coverage payments (fixed reference price)

5. Conclusions and discussions

Our study supports the conclusions of [1, 3, 5] that the existing practice of interventions in the wheat market scarcely attains the goals declared in [9] and disagrees with [8], where an opposite judgment is proclaimed. As the selected cases presented above prove, interventions are able to decrease the variation of wheat price by 1 to 2.5 per cent points (at $\psi = 0.6$) in comparison to the historical data due to smoothing price peaks.

In general, interventions fail to serve as an income securing tool. Their effect on incomes, as well as on households' costs, is marginal. So, regardless to the advantages and disadvantages of different ways to exercise interventions, this instrument should only be used, as far as this study suggests, to improve investment climate in the related sectors of the national economy: facing lower price risk, the investor may be satisfied by a lower rate of return. A special study is required to estimate this effect and to decide whether or not it worth the costs of the policy.

The tradeoff between the fixed and variable price corridor is due to the budget costs and the size of intervention fund (causing extra loading on infrastructure) on one hand and the impact on the investment climate on another hand. The fixed corridor brings more certainty into the market but requires more efforts from the government to carry out the policy.

The obtained results should be interpreted with respect to the spatial aspect of the problem. Due to large territory and the lack of infrastructure, Russian markets of wheat are weakly integrated. As a result, the implementation of the analyzed intervention schemes may cause problems. For instance, a commodity intervention may not meet sufficient demand at the specific exchanges where the intervention is performed, meanwhile in the remaining part of the country the price will remain higher than the declared intervention price. Another issue is that the state's agent may fail to timely deliver the wheat sold while a commodity intervention from the place where it is actually stored. These two cases can be formally captured by selecting lower value of ψ. Moreover, instead of help in finding an equilibrium, purchase interventions can worsen the existing market distortion. E.g., supose a lack of wheat supply at the specific exchanges where the state's agent exercises a purchase intervention. In such case the buyers that compete with the state's agent on these exchanges will pay higher prices than the purchase intervention price (otherwise they will fail to buy at all), meanwhile outside these exchanges the prices will remain as low as they would be in the absence of interventions. Finally, a risk of arbitrage against the state interventions arises in the situation when the intervention fund is about to be exhausted or, contrarily, overfilled.

The price loss coverage, although lacks legislative base for its implementation, has a different focus. It does not have a direct impact on prices in the market, while its indirect influence on the prices via stimulating larger output is hardly sensible. So, it is not intended to attract more investors in wheat production and the sectors connected with it. Their major purpose is to support the economy of grain producers, diminish risk of bankruptcies among them and prevent the capital and labor outflow from the sector. Given this purpose, the price loss coverage demonstrates important advantages in comparison to interventions. First, it releases the state from taking care of the asset which requires a sophisticated management. Second, it does not face the problems listed in the previous paragraph. Third, it does not provoke lobbying various changes in the intervention rules that would allow insiders to benefit at the expenses of taxpayers. Fourth, it never supports producers at the expense of consumers and v.v., like intrusions into the market do. Fifth, it secures fairness in distribution of benefits among producers, while interventions provide larger benefits to those producers who have easier access to the exchange market. Sixth, its efficiency does not depend on whether the market is perfect or not and cannot be questioned due to the uncertain parameter ψ. Finally, this instrument diminishes price distortions[2], thus being compatible with WTO trade policies. However, the price loss coverage is more expensive for taxpayers than the policies based on interventions. Another disadvantage is a higher price volatility and the risk of price shocks. is a tradeoff for.

Financing the studied policies can be a difficult task, especially when fair market prices of grain remain very low for a long period. Normally, if the costs of purchase interventions exceed the budget limits, the state's agent that perform interventions may easily get loans for this purpose, because the intervention fund can serve as reliable collateral. Insofar, there is no need for a guarantee from the state. However, it is possible that the market price falls for decades below the price at which the intervention fund was formed. Such case would force the agent into bankruptcy, and the banks will require the increased interest rate in the view of such situation. The possible solution could be to establish a financial fund which would accumulate regular annual contributions from the state budget in order to cover excess financial outflows during either large scale purchase interventions or a demanding price loss coverage.

All these considerations lead to the conclusion that, despite the potential profitability, commodity and purchase interventions lack reliability, simplicity, transparency and fairness. The only reason to exercise these instruments is its theoretically expected positive influence on the investment climate via controlling price volatility. However, it is doubtful in the view of relatively large fragmentation of the Russian market of wheat (ψ is likely to be lower than in well-developed national wheat markets). The price loss coverage, although generating larger costs for the state budget, secures the incomes of grain producers at the cost of failing to protect consumers from excessively high prices and to make the prices of wheat more predictable for investors.

6. Acknowledges

I express my gratitude to Prof. Dr.V. Uzun who suggested the idea of the retrospective simulations, outlined the basic structure of the simulation model described above (particularly, proposed using actual prices while simulations) and intensively discussed the progress of the study; Dr.N. Shagaida for discussions concerning the analyzed scenarios and the results of simulations; Prof. Dr.A. Radygin and Prof. Dr.S. Sinelnikov-Muryliov for valuable suggestions on presenting the results.

[2]This advantage can be debated considering the imperfections inherent to the grain markets (as Section 1 reads), and the presence of multiple equilibriums in agricultural markets [20].

Appendix. Parameter values and indicators of validity

Table

Parameter values

Parameter	Unit	Value	Parameter	Unit	Value
α_0	thousand ton	2735.4	λ_8	–	0.2
α_1	–	0.031	λ_9	–	0.1
α_2	–	0.051	μ_4	–	0.5
α_3	–	0.044	μ_8		0.2
α_4	ton/ruble	0	μ_9	–	0.3
α_5	ton/ruble	–0.227	c	thousand tons	78078
β	–	139581.3	f	–	0.898
η	–	–0.490	g	–	2
γ	–	91177.5	h	thousand tons	49368
δ	–	–0.490	a	thousand tons	26272
ε	–	1700.7	b	thousand tons	1714
ζ	–	0.388	p_t, w_t	rouble/ton	historical data of 2007-2015
ρ	–	0.150	q_t	rouble/ton	scenario
τ	–	0.00095	r_t	rouble/ton	scenario
λ_6	–	0.5	d	–	0.25
λ_7	–	0.2	ψ	–	scenario

The parameters that are not listed in this table are zeroes.

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КАК ПРОТИВОДЕЙСТВОВАТЬ НЕОПРЕДЕЛЁННОСТИ РОССИЙСКОГО РЫНКА ПШЕНИЦЫ

Н.М. СВЕТЛОВ

(Российская академия народного хозяйства и государственной службы)

В целях анализа аграрной политики разработана конечно-разностная динамическая имитационная модель российского рынка пшеницы. Особенность модели – отказ от имитации цен в отсутствие действия мер анализируемой политики: в этом случае используются фактические данные о ценах. Благодаря этому в модели не возникает расхождение между фактическими и модельными ценами, характерное для всего класса моделей с эндогенными ценами. В связи с этим модель может применяться только для ретроспективного анализа, чего, как правило, достаточно при анализе политики. Ещё одна особенность – присутствие в модели параметра, характеризующего качество рынка, варьирующего от нуля (абсолютно фрагментированный рынок) до единицы (рынок совершенной конкуренции). При анализе политики товарных и закупочных интервенций цена пшеницы на российском рынке рассчитывается как средневзвешенная фактической и интервенционной цен с учётом данного параметра.

Рассмотрены три примера политик, применимых к рынку зерна. Первый предполагает, что товарные и закупочные интервенции проводятся при выходе цены за пределы фиксированного коридора. Второй аналогичен первому, но коридор цен пересматривается ежегодно с учётом конъюнктуры рынка. Третий предусматривает компенсацию ценовых потерь производителей по отношению к фиксированному уровню цены. Показано, что чётко определённые правила интервенций обеспечивают снижение коэффициента вариации цен пшеницы на 1…2,5-процентных пункта в сравнении с фактическими данными за 2007-2015 гг. Таким образом, фактически проводившаяся политика не достигает максимально возможной эффективности воздействия на цены.

Интервенции неэффективны в качестве меры поддержания дохода производителей и снижения расходов домохозяйств. Компьютерные эксперименты показывают, что компенсация ценовых потерь обеспечивает прибавку 2,1% к выручке производителей, в то время как интервенции увеличивают выручку не более чем на 1%. Кроме того, компенсация ценовых потерь справедливее (все производители имеют равный доступ к компенсационным выплатам, что недостижимо в случае интервенционных закупок), а их эффект стабилен вне зависимости от качества рынка (которое не поддаётся надёжной оценке).

Согласно исследованию, единственное основание для использования интервенций – теоретически ожидаемое положительное влияние на инвестиционный климат вследствие снижения волатильности цен. Однако этот эффект может быть слишком слабым вследствие сравнительно высокой фрагментации российского рынка пшеницы, снижающей эффективность интервенций. Компенсация ценовых потерь, требующая бóльших бюджетных затрат, чем интервенции, гарантирует доходы производителей зерна, однако не может защитить потребителя от чрезмерного роста цен и неспособна сделать цены более предсказуемыми для инвесторов.

Ключевые слова: *пшеница, аграрная политика, анализ политики, имитационная модель, закупочные интервенции, товарные интервенции, регулирование цен, компенсация ценовых потерь, Россия.*

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Николай Михайлович Светлов, доктор экономических наук, ведущий научный сотрудник Центра агропродовольственной политики Российской академии народного хозяйства и государственной службы при Президенте Российской Федерации, тел.: +7(499)956-9557; e-mail svetlov-nm@ranepa.ru

Svetlov Nikolai Mikhailovich, doctor of economic sciences, leading researcher at the Centre for Agricultural and Food Policy of Russian Academy of National Economy and Public Administration. Phone: +7(499)956-9557; e-mail: svetlov-nm@ranepa.ru