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# Extreme Price Risk on the Market of Soybean Meal[3]

**Abstract.** The price of soybean meal in Poland is related with the price quoted on the Chicago Board of Trade (CBOT). The aim of this study was to assess and compare extreme price risk on the market of soybean meal in Poland and on the market of futures contracts for soybean meal and soybean, quoted on the CBOT. For this purpose analyses were conducted on daily price series for soybean meal ex quay port of destination Gdynia as well as historical time series for daily closing quotes for futures contracts for soybean meal and soybean at the CBOT, from 23 February 2012 to 8 July 2015. Extreme risk was assessed using two measures: value at risk and expected shortfall, applying the extreme value theory. Results of analyses indicate a higher level of extreme price risk on the market of futures contracts for soybean meal and soybean. For both contracts we observe an asymmetry of the risk profile for the long and short positions in these contracts. No marked asymmetry in the risk profile was observed on the market of soybean meal in Poland.

**Key words:** soybean meal, futures contracts for soybean meal, extreme value theory, extreme price risk, value at risk, expected shortfall, Poland

## Introduction

Since the beginning of the 21st Century, we have been observing an increase in world prices for oil seeds, including soybean and its processing products. This is caused by the growing competition on the market of oil raw materials between the food and biofuel sectors among main importers (China, EU, India). These prices undergo huge fluctuations caused by variation in yields, fluctuations of USD exchange rates in relation to other currencies and speculation in the financial markets [Rosiak 2014]. Fluctuations in prices are also significantly influenced by the increasing demand for high-protein raw materials generated by the development of animal production, as well as the crisis caused by BSE and the related ban on the use of meat and bone meal in animal feeding, introduced in many countries. At a high and constantly increasing share of soybean meal in the total ground grain meal production, the world market for protein concentrates is becoming increasingly dependent on soybean [Dzwonkowski, Bodył 2014]. The price for Hi-Pro soybean meal (a by-product of oil extraction from GM soybean) in Poland is connected with the CBOT price. The price ex quay Gdynia for Hi-Pro soybean meal comprises the CBOT quote price plus CIF (cost of transport, cost of loading and unloading, storage, insurance, etc.).

Currently in Poland, soybean meal is the basic component of balanced feeds for poultry and pigs. To meet its feed demand Poland imports annually approx. 2 million tons of GM soybean meal. On the feed market standardised soybean meals are available, with

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crude protein content of 42, 44 or 48%. Soy protein is readily available and its amino acid composition is advantageous from the point of view of animal nutrition. However, it is an expensive protein component, thus in feeds for older animals it may be replaced by other components, e.g. rapeseed meal, cake, seeds of native legumes or oil crops and extracts [Zaworska, Kasprowicz-Potocka 2014]. In the Amended Act on Animal Feeds, from 1 January 2017, a ban will be introduced in animal nutrition on the use of genetically modified feed and genetically modified organisms for fodder purposes [Act on Animal Feeds 2006]. It is estimated that after the Act enters into force, banning the use of feeds from genetically modified plant production, costs of poultry meat will increase by 10-15% and egg prices will increase by approx. 10-12%. Implementation of the ban on the use of GM soybean in feed production and animal nutrition will greatly diversify prices. At present, in Poland over 77% of feed protein are imported and only approx. 23% are produced in Poland. A similar problem is observed in the entire European Union, where almost 70% of protein feeds are duty-free imports, mainly from North America [Zaworska, Kasprowicz-Potocka 2014]. As much as 80% of world soybean production originates from three countries: the USA, Brazil and Argentina. China is a definite leader in the production of soybean meal, with its production increasing 3.5-fold over the last 12 years (from 15.6 million to 51.5 million tons in the season of 2012/13), with approx. 75% of meal produced from imported seed. The USA is the second largest soybean meal producer, with the annual production of approx. 35 million tons. Argentina and Brazil are also leading soybean meal producers – within the last three years the production of soybean meal was 26-27 million tons each, with greater dynamics in recent years observed for its production in Argentina. This is connected with the dynamic development of GM soy production, as well as the state policy promoting exports of processed products (lower export taxes on oil and soybean meal than on soybean seeds) [Dzwonkowski, Bodył 2014].

According to the United States Department of Agriculture (USDA), in 28 EU countries the demand for soybean meal in the season of 2014/2015 lasting till the end of September, in comparison to the previous season, will increase to 29.74 million tons, i.e. by 7% (by 1.3 million ton). Over a successive time period from October 2015 to September 2016 the demand for soybean meal in the EU will increase by another 800 thousand tons (by 3%) to 30.54 million tons. Demand for soybean meal will also increase in the USA and Brazil. In the season of 2014/2015 in the USA it will amount to 28.21 million tons, to increase in the season of 2015/2016 to 29.03 million tons. In turn, in Brazil demand is expected to reach 14.98 million tons and 15.45 million tons, respectively. The increase in the world production of soybean meal in the season of 2014/2015 is forecasted to be 13.16 million tons (by 7%) to 202.63 million tons and in the season of 2015/2016 the world production is expected to be 211.0 million tons [www.farmer.pl].

The observed changes in price trends on the soybean market have a critical effect on the stability of economic conditions, operations of enterprises involved in processing of this raw material as well as producers in the agri-food sector. Fluctuations of market prices increase exposure of all these entities to price risk, and thus influence the stability of their income. The aim of this paper is to assess and compare extreme price risk on the market of soybean meal in Poland and on the market of futures contracts for soybean meal and soybean quoted on the CBOT. Extreme risk was measured based on quantile measures of risk, i.e. value at risk and expected shortfall. These measures were determined applying the extreme value theory. A review of studies, in which the extreme value theory was used to measure risk on agricultural commodity markets, is presented in [Morgan, Cotter and Dowd 2012; Van Oordt, Stork and De Vries 2013].

## Material and research method

Empirical studies were conducted using daily price series for Hi-Pro soybean meal ex quay Gdynia [www.agrolok.pl] and historical time series for CBOT daily closing quotes of futures contracts for soybean meal and soybean [www.stooq.pl] for the period from 23 February 2012 to 8 July 2015. The time series of daily closing quotes of futures contracts were created based on the most active series of contracts. Analyses were conducted on prices of Hi-Pro soybean meal expressed in USD/t and PLN/t. On the basis of soybean meal prices and prices of futures contracts for soybean meal and soybean daily logarithmic percentage increments (rates of return) were calculated according to the formula: $r_t = 100\ln(P_t / P_{t-1})$, where $P_t$ denotes the price of a commodity or a futures contract for a commodity in period $t$.

Extreme price risk on the market of soybean meal and soybean was estimated based on two quantile risk measures, belonging to the group of downside risk measures: value at risk and expected shortfall. These measures were determined based on the extreme value theory.

Downside risk measures are used to measure risk in the negative concept and they measure potential loss. The most frequently applied measure of risk is Value at Risk (VaR). It is defined as such a volume of loss in the value of investment (a financial instrument, commodity or the entire portfolio) that the probability of its occurrence or exceedance within the assumed period of time is equal to the pre-specified level of tolerance. Formally VaR is presented as [Jajuga et al. 2001]:

$$P(P_t \le P_{t-1} - VaR) = \alpha, \tag{1}$$

where: $P_t$ – value of an investment, instrument, commodity in period $t$, $\alpha$ – assumed level of tolerance. Loss may also be determined in percent, which makes it possible to compare risks. If $r_t$ denotes a logarithmic percentage rate of return from an instrument, commodity in period $t$, VaR is defined according to the formula:

$$P(r_t \le -VaR) = \alpha. \tag{2}$$

VaR for the long position in a financial instrument or commodity generating a loss, when the price of this instrument or commodity decreases, for the level of tolerance $\alpha$ is an opposite number to the quantile of the distribution of returns:

$$VaR_{\alpha,t+1} = -F_{r_t}^{-1}(\alpha), \tag{3}$$

where: $F_{r_t}^{-1}(\alpha)$ is a $\alpha$ -quantile of the distribution of returns $r_t$. For the short position in a financial instrument or commodity, generating losses, when the price of this instrument or commodity increases, it is a $1-\alpha$ -quantile of the distribution of returns $r_t$:

$$VaR_{1-\alpha,t+1} = F_{r_t}^{-1}(1-\alpha). \tag{4}$$

However, value at risk does not specify how big losses may be when they exceed value at risk. Expected Shortfall (ES) is a measure of risk informing on the volume of these losses. This measure is defined as the expected value of loss on condition the loss is greater than value at risk.

Tools for the assessment of extreme risk are supplied by the Extreme Value Theory (EVT). Two approaches are used in this theory to model extreme values. The first approach is based on the Block Maxima Model (BMM), estimating the distribution of extremes. The other approach is applied more frequently and it is based on the Peaks over Threshold Model (POT), estimating the tail of the distribution of returns. The tail of the distribution of returns is modeled using the Generalized Pareto Distribution (GPD), while the beginning of the tail is specified by the determination of the threshold value. Modeling only tails of distribution and not the entire distribution facilitates a more accurate estimation of tails of distribution. The POT model makes it possible to present analytically VaR and ES measures.

In the Peaks over Threshold model [McNeil 1999; Morgan, Cotter and Dowd 2012] the starting point for consideration is provided by the conditional distribution of peaks of the random variable $X$ of a certain threshold value $u$ defined according to the formula:

$$F_u(x) = P(X - u \le x | X > u) = \tfrac{F(x+u)-F(u)}{1-F(u)}, \tag{5}$$

where: $F$ is an unknown distribution function of random variable $X$. According to the Pickands-Balkema-de Haan theorem, for a sufficiently large $u$ the distribution function $F_u$ has a limiting distribution, which is a generalized Pareto distribution with the distribution function:

$$G_{\xi,\beta}(x) = \begin{cases} 1-(1+\xi x/\beta)^{-1/\xi}, & \xi \ne 0 \\ 1-\exp(-x/\beta), & \xi = 0 \end{cases}, \tag{6}$$

where: $\beta > 0,\ x \ge 0$ for $\xi \ge 0$ and $0 \le x \le -\beta/\xi$ for $\xi < 0$. This distribution has two parameters: $\beta$ – the scale parameter, $\xi$ – the shape parameter determining the thickness of the tail. Positive values of the shape parameter denote the occurrence of thick (heavy) tails, which is connected with an increased probability of extreme returns. In turn, negative values of the shape parameter mean that the distribution has thinner tails than the normal distribution. Most typically parameters of the distribution function for the Pareto distribution is estimated using the maximum likelihood method. This estimation requires a selection of a threshold value $u$, which affects the obtained values of estimators. An excessive high threshold value $u$ will result in few observations exceeding threshold $u$, which will be manifested in high variance, while a too low value will cause a great estimator bias. From formulas (5)-(6) we obtain the distribution function of variable $X$:

$$F(x) = (1 - F(u))G_{\xi,\beta}(x-u) + F(u), \ x > u . \tag{7}$$

Next we replace value $F(u)$ with an empirical estimator $\hat{F}(u) = 1 - N_u / n$, where $n$ is the number of observations and $N_u$ is the number of exceedances $u$. Then we obtain the following estimator of the distribution function $F$:

$$\hat{F}(x) = 1 - \frac{N_u}{n}\left(1 + \hat{\xi}\frac{(x-u)}{\hat{\beta}}\right)^{-1/\hat{\xi}} . \tag{8}$$

After $x$ is determined from equation (8), VaR may be noted for the short position using the following formula:

$$VaR_{1-\alpha} = u + \frac{\hat{\beta}}{\hat{\xi}}\left(\left(\frac{n}{N_u}\alpha\right)^{-\hat{\xi}} - 1\right), \tag{9}$$

where: $\alpha$ is the level of tolerance for VaR. In order to determine VaR for the long position, calculations need to be made for rates of return multiplied by minus one.

Using the Peaks over Threshold model we may also present expected shortfall for the short position using the formula [McNeil 1999; Morgan, Cotter and Dowd 2012]:

$$ES_{1-\alpha} = \frac{VaR_{1-\alpha}}{1-\hat{\xi}} + \frac{\hat{\beta} - \hat{\xi}u}{1-\hat{\xi}} . \tag{10}$$

## Results

In the first stage of the study the series of logarithmic percentage increments were prepared for prices of soybean meal (SM_PLN, SM_USD) and futures contracts for soybean meal (SM_F) and soybean (S_F). Descriptive statistics of the generated series and values of the Jarque-Bera test are presented in Table 1. Arithmetic means for logarithmic increments for prices of soybean meal and futures contracts for soybean meal and soybean were close to zero and did not differ significantly from zero at the 5% significance level (*t*-test). The greatest volatility, measured by the range and standard deviation, was found for logarithmic increments for prices of futures contracts for soybean meal, which indicates their strong dynamics. Logarithmic increments for prices of soybean meal showed a lower level of volatility than logarithmic increments for prices of futures contracts for soybean meal and soybean. In the next stage of the study it will be verified whether levels of extreme price risk also vary. Skewness was not statistically significant at the significance level of 5% for logarithmic increments for prices of soybean meal (the D'Agostino test). Negative skewness was observed for logarithmic price increments of futures contracts for soybean meal and soybean. This indicates an asymmetry in the risk profile for the short and long positions in these contracts. In the case of all analysed series of logarithmic price increments the values of kurtosis were significantly greater than three at the significance level of 5% (the Anscombe-Glynn test). This shows that the distributions of price increments for soybean meal, contracts for soybean meal and soybean had thick tails. This means that extreme values in the increment series appear more frequently than in the normal distribution. Moreover, values of kurtosis for logarithmic increments for prices of futures contracts for soybean meal and soybean were much greater than those of kurtosis for logarithmic increments for prices of soybean meal. The hypothesis on the normal distributions for the analysed logarithmic price increments was rejected based on the Jarque-Bera test. Thus it is advisable to model logarithmic increments of the analysed prices using distributions including thick tails and skewness.

Table 1. Descriptive statistics of logarithmic increments for prices and values of the Jarque-Bera test (J-B) for soybean meal, futures contracts for soybean meal and soybean

| Statistics | SM_PLN | SM_USD | S_F | SM_F |
|---|---|---|---|---|
| Maximum | 6.02 | 5.99 | 5.23 | 5.47 |
| Minimum | -4.89 | -4.41 | -12.54 | -16.23 |
| Mean | 0.0211 | -0.0031 | -0.0294 | 0.0034 |
| Standard deviation | 1.32 | 1.27 | 1.40 | 1.78 |
| Skewness | -0.01 | 0.08 | -1.06 | -1.02 |
| Kurtosis | 4.47 | 4.94 | 11.24 | 11.91 |
| J-B | 73.30 | 128.83 | 2560.30 | 2957.99 |

Source: the authors' calculations.

Since the price of soybean meal in a Polish port is composed of the CBOT price plus CIF (cost of transport, cost of loading and unloading, storage, insurance, etc.), dependencies between these prices were also investigated. The Granger causality was also verified. Changes in prices of futures contracts for soybean meal are Granger causes for changes in prices of soybean meal in PLN ex quay a port in Poland (the Granger test with the Wald statistic: 190.27, lag order 1, the series stationarity required in the Granger test was found using an augmented Dickey-Fuller test). This means that increments in prices of soybean meal ex quay a Polish port may be more accurately forecasted if we include the appropriately lagged increments in prices of CBOT contracts for soybean meal. Values of Pearson's linear correlation coefficients for logarithmic increments for prices for soybean meal ex quay Gdynia (SM_PLN, SM_USD) and logarithmic increments for prices of CBOT futures contracts for soybean meal (SM_F_C) are presented in Table 2.

Table 2. Pearson's linear correlation coefficients of logarithmic increments for prices for soybean meal and futures contracts for soybean meal

| Specification | SM_PLN | SM_USD | SM_F_C |
|---|---|---|---|
| SM_PLN | 1 | | |
| SM_USD | 0.86 | 1 | |
| SM_F_C | 0.47 | 0.53 | 1 |

Source: the authors' calculations.

Price series of contracts for soybean meal were fitted to the series of prices for soybean meal, including closing quotations of the previous day. The strongest positive correlation was obtained for logarithmic increments for prices for soybean meal in PLN and USD. The correlation between logarithmic increments for prices for soybean meal ex quay Gdynia and increments in CBOT futures prices was moderate.

In the next stage of this study, parameters of the generalized Pareto distribution for the left and right tails of distribution were estimated for logarithmic increments for prices of soybean meal and futures contracts for soybean meal and soybean. Results of these estimations together with standard errors are presented in Table 3. Calculations were made for the threshold at 90% (meaning that the greatest 10% of positive and negative logarithmic increments for prices was regarded as extreme observations). In the case of logarithmic increments for prices of soybean meal the values of the shape parameter for the right tail are greater than for the left tail. This means that the right tail of distribution for logarithmic increments for prices of this commodity is thicker than the left, and that probability of extreme losses is greater for the short rather than the long positions. However, it needs to be added here that the obtained estimations for parameters are burdened with relatively large errors. In turn, in the case of futures contracts for soybean meal and soybean, left tails of distribution for logarithmic price increments are thicker than the right. The thickest tails of distribution for logarithmic price increments were observed for the left tails in the case of futures contracts for soybean meal and soybean. Values of estimated parameters to a considerable extent depend on the assumed threshold value in the POT model.

Table 3. Estimates of parameters of the generalized Pareto distribution with standard errors in brackets

| Specification | Left tail | | | Right tail | | |
|---|---|---|---|---|---|---|
| | $u$ | $\hat{\xi}$ | $\hat{\beta}$ | $u$ | $\hat{\xi}$ | $\hat{\beta}$ |
| SM_PLN | -1.4981 | -0.2906 | 1.2205 | 1.6412 | 0.1117 | 0.6649 |
| | | (0.0972) | (0.1752) | | (0.1464) | (0.1217) |
| SM_USD | -1.4064 | -0.3416 | 1.2842 | 1.5726 | 0.1905 | 0.6057 |
| | | (0.1268) | (0.2104) | | (0.1473) | (0.1108) |
| S_F | -1.6098 | 0.2545 | 0.7515 | 1.5944 | -0.0357 | 0.7339 |
| | | (0.1342) | (0.1280) | | (0.1276) | (0.1229) |
| SM_F | -2.0078 | 0.2624 | (0.8519) | 1.9982 | -0.3524 | 1.4590 |
| | | (0.1215) | (0.1366) | | (0.1048) | (0.2128) |

Source: the authors' calculations.

Measures of extreme price risk were determined for economic entities in the long and short positions on the market of soybean meal and soybean, i.e. for the left and right tails of distribution for logarithmic increments for prices of soybean meal and futures contracts for soybean meal and soybean. Although estimations of parameters in the generalized Pareto distribution depend to a considerable extent on the assumed threshold value, the estimations of extreme risk are generally relatively stable. In this study, the threshold value was assumed at 90%. Measures of extreme risk were estimated using 814 and 849 logarithmic price increments for soybean meal and futures contracts for soybean meal and soybean, respectively. Calculations were made for four levels of tolerance: 0.005, 0.01, 0.025 and 0.05 are presented in Table 4.

Table 4. Estimates of the value at risk and expected shortfall for the generalized Pareto distribution

| VaR | Left tail | | | | Right tail | | | |
|---|---|---|---|---|---|---|---|---|
| $\alpha$ | 0.005 | 0.01 | 0.025 | 0.05 | 0.005 | 0.01 | 0.025 | 0.05 |
| SM_PLN | 3.95 | 3.56 | 2.90 | 2.27 | 4.01 | 3.40 | 2.65 | 2.13 |
| SM_USD | 3.82 | 3.46 | 2.84 | 2.21 | 4.02 | 3.33 | 2.55 | 2.03 |
| S_F | 4.99 | 3.96 | 2.86 | 2.18 | 3.68 | 3.22 | 2.59 | 2.10 |
| SM_F | 5.89 | 4.71 | 3.44 | 2.66 | 4.70 | 4.30 | 3.60 | 2.90 |
| ES | Left tail | | | | Right tail | | | |
| $\alpha$ | 0.005 | 0.01 | 0.025 | 0.05 | 0.005 | 0.01 | 0.025 | 0.05 |
| SM_PLN | 4.34 | 4.04 | 3.53 | 3.05 | 5.01 | 4.34 | 3.51 | 2.94 |
| SM_USD | 4.15 | 3.89 | 3.43 | 2.96 | 5.30 | 4.47 | 3.51 | 2.88 |
| S_F | 7.14 | 5.77 | 4.29 | 3.38 | 4.31 | 3.87 | 3.26 | 2.79 |
| SM_F | 8.40 | 6.81 | 5.10 | 4.04 | 5.07 | 4.78 | 4.26 | 3.74 |

Source: the authors' calculations.

Results of analyses indicate a greater level of extreme price risk on the market of CBOT futures contracts for soybean meal than on the market of soybean meal in Poland. The greatest price risk measured by the value at risk and expected shortfall is found for the long position in the futures contract for soybean meal. The economic entity at the long position in this contract is exposed to the risk of loss resulting from the decrease in contract value of 5.89% or greater during a day with the probability of 0.005, while in the case of soybean meal it is the risk of loss at 3.82-3.95% or greater. This means that losses at these levels or greater may occur once in 200 days. The level of extreme risk for futures contracts for soybean meal and soybean is greater for long positions than for short positions at low levels of tolerance. This confirms earlier observations concerning properties of the analysed distributions of logarithmic price increments. The occurrence of asymmetry in the risk profile for long and short positions in CBOT futures contracts for soybean was indicated by Morgan, Cotter and Dowd [2012] in their analyses conducted on weekly data. In the case of soybean meal for the level of tolerance of 0.005 the values of VaR and ES indicate a slightly greater risk for the entity at the short position.

## Concluding remarks

The aim of this study was to assess and compare extreme price risk on the Polish market of soybean meal and futures contracts for soybean meal and soybean. Extreme risk was measured using two measures: value at risk and expected shortfall, applying the extreme value theory.

Results of the conducted analyses indicate a lack of normal distributions for logarithmic price increments in the case of soybean meal and futures contracts for soybean meal and soybean, as well as the occurrence of thick tails. Presented results confirm the potential frequent occurrence of large disadvantageous price fluctuations. Thus it seems justified to model distributions of logarithmic price increments using the POT model originating from the extreme value theory. An advantage of the application of such an approach is connected with modeling only tails of distribution and not the entire distribution, which facilitates more accurate estimation of distribution tails. Changes in prices of CBOT futures contracts for soybean meal are Granger causes for changes in prices of soybean meal ex quay a Polish port. However, measures of risk and extreme risk indicate differences in the level of price risk for soybean meal ex quay a Polish port and CBOT quotes. A greater risk and extreme price risk are observed on the market of futures contracts for soybean meal. For both contracts, i.e. those for soybean meal and soybean, risk at the long position is considerably greater than at the short position. On the market of soybean meal ex quay a Polish port no marked asymmetry was observed in the risk profile.

## Literature

Act of 22 July 2006 on Animal Feeds (the Journal of Laws no. 144, item 1045, with later amendments).

Dzwonkowski W., Bodył M.R. [2014]: Zmiany zapotrzebowania na białko paszowe w kontekście rozwoju produkcji, Zeszyty Naukowe SGGW w Warszawie, *Problemy Rolnictwa Światowego*, vol. 14, no. 1, pp. 13.

Jajuga K., Kuziak K., Papla D., Rokita P. [2001]: Ryzyko wybranych instrumentów polskiego rynku finansowego, *Rynek terminowy*, no. 11, pp. 133-140.

McNeil A.J. [1999]: Extreme Value Theory for risk management, Mimeo ETZH Zentrum, Zurich, pp. 1-22.

Morgan W., Cotter J., Dowd K. [2012]: Extreme measure of agricultural risk, *Journal of Agricultural Economics*, vol. 63, no.1, pp. 65-82.

Van Oordt M.R.C., Stork P.A., De Vries C.G. [2013]: On agricultural commodities' extreme price risk, DNB working paper, no. 403, pp. 1-27.

Rosiak E. [2014]: Krajowy rynek rzepaku na tle rynku światowego, Zeszyty Naukowe SGGW w Warszawie, *Problemy Rolnictwa Światowego*, vol. 14, no. 1, pp. 89-90.

Zaworska A., Kasprowicz-Potocka M. [2014]: Czy rośliny strączkowe uprawiane na terenie kraju mogą stać się alternatywą dla drogiej soi. [Available at]: http://www.portalhodowcy.pl/hodowca-drobiu/324-numer-102013/3546-czy-rosliny-straczkowe-uprawiane-na-terenie-kraju-moga-stac-sie-alternatywa-dla-drogiej-soybean. [Access: June 2015].

www.agrolok.pl. [Access: July 2015].

www.farmer.pl. [Access: July 2015].

www.stooq.pl. [Access: July 2015].