International Food and Agribusiness Management Review
Volume 20 Issue 1, 2017; DOI: 10.22434/IFAMR2015.0051

Received: 28 April 2015 / Accepted: 18 October 2016

Food scare crisis: the effect on Serbian dairy market

RESEARCH ARTICLE

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Abstract

The increasing trend of food scandal crises is not well followed in recent studies of spatial price transmission. This paper analyses the impact on the domestic market of an Aflatoxin M1 outbreak in the Serbian dairy sector during 2013/2014 using a spatial price transmission approach. Monthly farm milk prices in Serbia for the period 2007/2014 were contrasted with leading dairy exporting countries New Zealand, USA and Germany, which did not have a food scare in their dairy sectors. To estimate the impacts a Markov-switching vector error-correction model was utilized. For all four dairy markets the model identified two price change regimes: standard and extreme. Although it was predictable, an extreme regime was not identified during the Aflatoxin M1 crises in Serbia because of some specific characteristics of its dairy production. The results suggest that the Aflatoxin M1 outbreak 'froze' the Serbian dairy market and temporally disconnected it from the world milk market. Farmer's prices fell below their long-run equilibrium levels. The total loss of the Serbian farm-level dairy sector during the crisis reached up to 96.2 million EUR. These 'missed opportunity' significantly slowed investment in the dairy sector.

Keywords: food crisis, aflatoxin M1, milk market, spatial price transmission, Serbia
JEL code: Q17, Q18

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1. Introduction

Milk has a special place in people's diets, and is an especially important food for children. As such, whenever an issue of milk quality arises, the consumer response is rapid and serious. In early 2013, Serbia had an Aflatoxin M1 outbreak that led to product recalls and a dramatic decrease in purchases. This paper examines this outbreak and its impact on Serbian markets. Outcomes from this study provide several lessons learned that can be used for better reaction from management in the food sector and government during future food safety crises.

The purpose of this paper is to quantify the effect of the Aflatoxin M1 crisis on the Serbian dairy market using a spatial price transmission model. The objectives of the paper are: to measure the effect of this crisis on the domestic milk market and to determine changes in the degree of Serbian milk market integration in the world milk market.

When a food scandal arises, three parties are under pressure. The government faces political responsibility for legislative regulation of food safety standards (Bergeaud-Blackler and Forretti, 2006). Consumers faced with a safety incident stop consuming that type of food from one company, or altogether if incidence is not limited to a particular firm (Mitchell, 2003; Banati, 2011), as was the case in Serbia. Food companies suffer losses from: food product recalls from shelves, a drop of sales on domestic and international markets, lost consumer confidence, etc. With globalisation of food production and trade, the consequences of food scandals usually extend beyond the domestic market. Often today the strategic orientation of food companies on the international market additionally increases the possibilities of negative consequences.

Maize produced in the autumn of 2012 was identified as a main source of the Aflatoxin in milk. Hot and dry weather conditions during the second half of the maize production season produced mould and toxin production. Besides that, poor postharvest handling, storage and manufacturing practices can influence mould growth and toxin production (Hussaini, 2013; Skrbic *et al.,* 2014). In the past occurrences of Aflatoxin in maize production in Serbia were rare. The presence of Aflatoxin in maize throughout the main production areas in Serbia for the period 2009-2012 was observed only in 2012, in 68.5% of the samples (Kos *et al.,* 2013). The toxin concentration in 29.5% of the samples was very high (>50 μg/kg), and, according to current standards, such maize couldn't be used for food or livestock feed. Regarding climate changes, Serbia may become more vulnerable to temperature problems that could create aflatoxins in the future (Kos *et al.,* 2013).

Today, most countries with higher food quality standards face occasional food scares and scandals. When a food scandal arises it has a negative effect on the whole food supply chain, but especially on its most vulnerable link, the farmers. The literature analysing the effect on the farm level predominantly focuses on vertical price transmission on national markets (Hasssouneh *et al.,* 2010, 2012; Lloyd *et al.,* 2001; Popovic and Radovanov, 2010). Only in some exceptional cases was a different approach used. Recently, researching the effect of export controls, spatial price transmission was applied to quantify the effect on farm wheat prices in exporting countries during a food crisis (Djuric *et al.,* 2012; Gotz *et al.,* 2013).

There are several reasons why analysis of the Aflatoxin M1 outbreak effects on the Serbian dairy market is important. First, the crisis lasted almost two years, and the magnitude of the crisis was significant. Second, there wasn't a single dairy company source of the crisis, but rather all dairy companies were involved. Third, the economic and social importance of the dairy sector in Serbia is high. Milk production accounts for 7% of agriculture output. From the social side, one fourth of the 632 thousand farms in Serbia are dairy farms. Among agricultural policy measures, milk premiums are the most important single coupled measure of direct payment. Also, Serbia is a net exporter of dairy products. The average self-sufficiency, calculated in milk equivalents (ME), in dairy products during period 2005-2014 was 102.5%. Calculation of ME is based on fat and protein content in dairy products (Hemme, 2008). Besides that, the crisis cut investments in the dairy sector, which are essential to prepare the Serbian agricultural sector for potential EU membership.

The paper is organized in five related sections. After the introduction, the first section covers the literature review of food scares and scandals and the econometric methodology used for this topic. The second section explains the milk aflatoxin crisis in Serbia and how it affected milk price development. The third section describes data sets and methodology used to capture the effect on the price transmission. The fourth section outlines the main results from the Markov switching vector error correction model (MS-VECM) specification. At the end, the fifth section of this paper offers some recommendations and concluding remarks.

2. Literature review

Studies of food scares and scandals are not numerous and most analyse developed markets. The majority focus on effects along the food supply chain. Vertical price transmission is the main approach in the analysis of a crisis and its effect on domestic markets. The most common finding is that different levels of the food supply chain respond differently to market shocks. During the bovine spongiform encephalopathy (BSE) outbreak in the UK beef market, retail prices declined, but less than farm prices (Lloyd *et al.,* 2001). Similar conclusions were reached in investigation of the impact of a BSE outbreak on the Spanish beef market, and later on the impact of avian influenza on the Egyptian poultry market (Hassouneh *et al.,* 2010, 2012). Studies of vertical price transmission in Serbian dairy market (Popovic *et al.,* 2013; Popovic and Radovanov, 2010) confirm also that information asymmetry exists and world milk price signals do not pass quickly and equally through subsequent levels of the Serbian milk supply chain.

The approach applied differs from previous studies in the use of a spatial price transmission model approach to identify losses on the Serbian dairy market, because of missed higher price levels on the world market during a two year period. It is assumed that the milk aflatoxin crisis temporally changed the price relationships between the domestic and the world market. This paper hypothesizes that the food scandal crises (milk aflatoxin M1) decreased the level of long-run price transmission and created negative effects on dairy farm economics.

Early empirical findings of price transmission were based on simple correlation and regression analysis that did not involve dynamics and lagged variables in detecting price relationships (Fackler and Goodwin, 2001). The emerging co-integration studies emphasized a few drawbacks related with the price regression analysis. Specifically, regression can lead to spurious results when price data are non-stationary (Hassouneh *et al*., 2010). The first study of price transmission on agricultural markets using co-integration methods was published in 1989 (Ardeni, 1989). Today almost the entire empirical price transmission literature employs co-integration methods, especially vector error-correction models (VECM) (Barrett and Li, 2002). For instance, a threshold vector error-correction and a threshold autoregression model capture non-linearities and were first introduced in spatial price transmission analysis (Goodwin and Piggott, 2001). Also, evidence of threshold behaviour in cases with differences between thresholds for the wheat and maize prices were found in price transmission between wheat markets in: Brazil, Argentina and USA (Balcombe *et al.,* 2007). On the other hand, a smooth transition vector error correction model, developed by Terasvitra, does not presume that regime shifts are sudden, but instead of that regimes shift regularly (Terasvitra, 1994).

Finally, a Markov switching vector error correction model was introduced in an analysis of business cycles and with one obvious distinguishing feature that the regime switches are driven by a probabilistic variable, whereas all of the above model specifications assume the regime switches deterministically (Krolzig *et al.,* 1997). The same model was used for investigation of the effects of an unstable policy environment on vertical price transmission (Brummer *et al.,* 2009). Recently the mentioned model was used to study the influence of export restrictions and domestic market policy changes on horizontal price transmission in the case of wheat in Russia and Ukraine during the 2007/2008 global food crisis (Gotz *et al.,* 2013). A comparable approach is applied to analyse the effects of governmental market interventions during the commodity price peaks on the transmission of price changes along the wheat-to-bread supply chain in Serbia (Djuric *et al.,* 2012).

3. Milk aflatoxin crisis and price development in Serbia

Among several recent foods scare crises in Serbia (trichinosis in pork, pesticide residues in apples, ochratoxin in strudel, etc.) none attracted the attention of the public and politicians to the degree of the 2013 aflatoxin M1contamination of milk. Also it lasted the longest, almost two years, from February 2013 through 2014. The main effects of the crisis could be analysed in two aspects: political measures and the milk supply chain adjustment. Information about high aflatoxin contamination of corn in Serbia was first published in December 2012. Initially, authorities denied the outbreak's existence, treating the information as malevolent. The consumer scare and political adjustment to the new situation started in February 2013, when the first laboratory results of milk products were published. By the end of February, inspectors ordered the first recall of 50 types of sterilised and pasteurised milk from various milk processing companies. A few days later, the first reaction of the Ministry of Agriculture was to change the allowed level of aflatoxin in milk from 0.05 to 0.5 μg/kg, as it was until 2011. This decision generated a huge argument among politicians, experts and consumers in all kind of media. Diametrically opposite statements disturbed consumers and created a fear of milk consumption. Later results of milk sample analysis during 2013 (Kos *et al.*, 2014; Skrbic *et al.*, 2014) implied that the fear was justified, since all age categories, especially children, were exposed to high risk related to the presence of aflatoxin M1 in milk. In June 2013 Serbia got its first rule book about the organisation of a rapid alert system for food and feed. In the same month, after long lasting public pressure, the Minister of Agriculture resigned. This was expected, since it happened in some other countries during food scare crises (Motarjemi and Lelieveld, 2014). The new Minister announced the return to the previous standards regarding the maximum level of aflatoxin in milk, the same level used in the EU, for April 2014. The new regulations for the allowable level of aflatoxin in feed were published in March 2014 with the intention to enable milk production with lesser aflatoxin contaminant. But, since most of the 156,000 farms (RZS, 2013) produce feed on their farm, it was impossible to control and apply the new regulation. A third Minister of Agriculture, after a new government takeover in April 2014, had to deal with same crisis. On July 1, 2014 the standard of allowed contamination of milk with aflatoxin returned to the EU standard. This new standard was untenable because contaminated maize from the 2012 crop season was still in use. On July 17, standards changed from 0.05 to 0.25 μg/kg and the Ministry defended this decision with a still higher level of aflatoxin. Finally, the milk crisis from aflatoxin ended in January 2015, when the Ministry of Agriculture tightened the maximum standard for allowed level of aflatoxin in milk from 0.25 to 0.05 μg/kg, which is the EU standard. Several mistakes occurred in the management of this crisis. Some include: parallel existence of several contradictory sources of communication, the low speed of information, a slow recall of contaminated products, and a lack of transparency and trustworthy scientific facts.

The milk supply chain was strongly shaken by the aflatoxin crisis. Scared and confused consumers reacted by decreasing consumption of milk and milk products. The same reaction has been seen in many other food scandal situations (Banati, 2011.) Milk is one of most important food groups in the Serbian diet. Average consumption slowly declined, reaching 207.2 kg ME per capita in 2013. Liquid milk has biggest share of total milk consumption in Serbia. Data for 2013 reveals that consumption of pasteurized and sterilized milk in Serbia decreased by 11.4% compared to 2012, but in Belgrade it fell by 26.6% (RZS, 2014b). Also, exports of milk products to countries with higher food standards dropped suddenly. Decreased demand, both domestic and international, led to accumulation of stocks at dairy processing facilities. It increased nervousness about the financial prospects of the dairy companies. When storage facilities became full, processors started to organise sales with retailers. During a few weeks each month dairy product prices were cut by 15 to 20% from regular prices. Such sales continued almost throughout the period of crisis.

It should be noted that cooperatives, which are the leading organizational form for dairy farmers in New Zealand, Germany, USA, and most other countries, don't exist in the Serbian dairy sector. Nevertheless the Serbian dairy sector has good vertical coordination between farmers and processing companies, especially the bigger ones. During the previous decade dairy processors initiated cooperation with farmers by investing and working together to improve the quantity and quality of farm-milk production. When the milk crisis became obvious, processors worked with farmers, informing them how to decrease the level of aflatoxin in milk. At the beginning, they even helped farmers by offering a supply of mycotoxin absorbers as feed additives.

Figure 1 illustrates the development of yearly milk net export quantities, calculated in ME, monthly farm gate milk prices for Serbia and an International Farm Comparison Network – Dairy Research Centre (IFCN) world milk price indicator in the period January 2007 to December 2014. World milk price is recalculated from USD to the national currencies for Serbia, Germany and New Zealand. Different milk products in international trade for Serbia are converted into ME by counting only the fat and protein content. The shaded field in the graph for Serbia covers the period of the aflatoxin crisis. The price data for Germany, USA and New Zealand, as big net exporters, serve for comparison for markets without a crisis in the observed period. It should be mentioned that all four markets have different dairy policies, which vary from a subsidised dairy sector in EU countries to unsubsidised in New Zealand (Hemme, 2014).

Farm gate milk prices in Serbia followed world milk prices up, with significant time lags observed in 2007 and 2010. The difference between the world milk price and the Serbian farm price narrows until February 2013. This was the result of opening the Serbian market thru implementation of two trade agreements with central European countries (CEFTA) from 2007 and with the European Union, gradually from 2009 to 2014. When the aflatoxin crisis started it 'froze' Serbian milk prices at almost the same level. Meanwhile, the world milk price rose significantly from March 2013 to May 2014, exceeding 45 USD per 100 kg energy-corrected milk (ECM). Prices calculated in EUR (Figure 2) show even a slightly negative trend for milk prices in Serbia during the crisis. Therefore, it can be assumed that dairy farms in Serbia suffered a significant market loss during the crisis. In contrast, milk prices in Germany and New Zealand follow the world milk price, with fewer time lags and with smaller price differences. The exception is the USA during 2014. An increase in domestic milk consumption together with an increase of dairy exports and a strengthening of the USD over EUR kept USA national milk prices significantly above world milk prices.

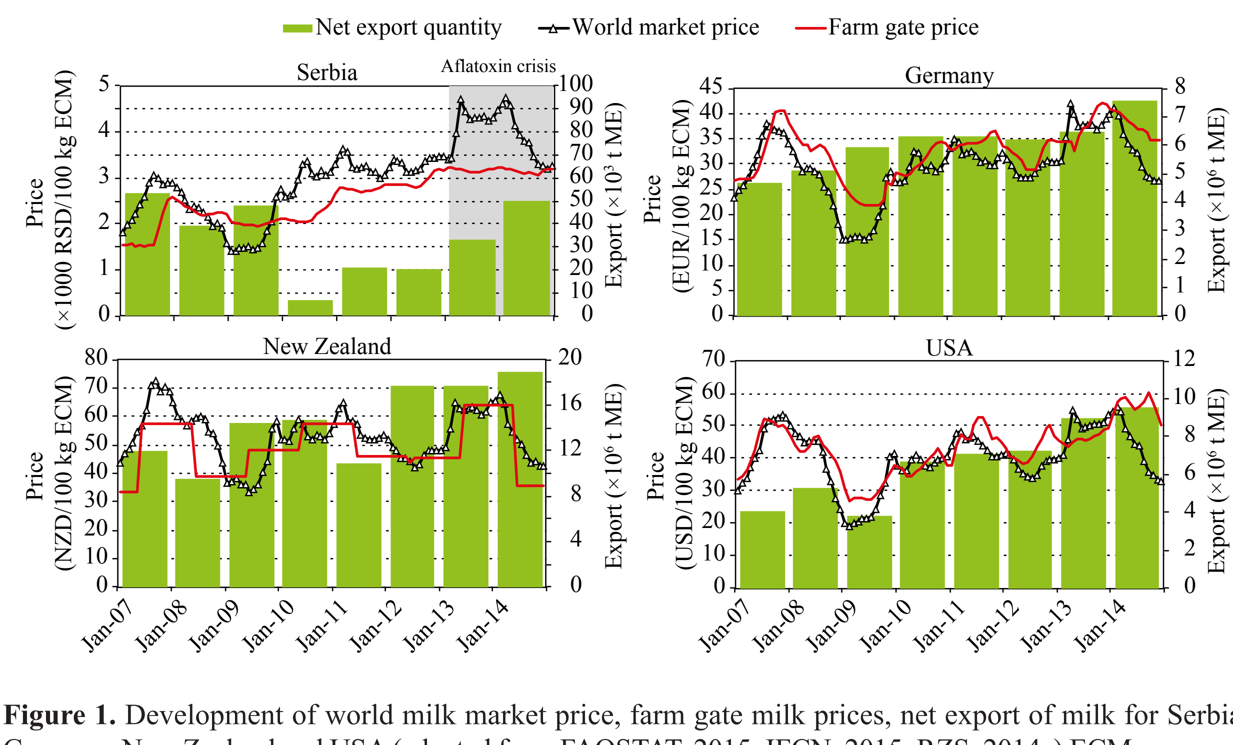

Figure 1. Development of world milk market price, farm gate milk prices, net export of milk for Serbia, Germany, New Zealand and USA (adapted from FAOSTAT, 2015; IFCN, 2015; RZS, 2014a) ECM = energy-corrected milk; ME = milk equivalent.

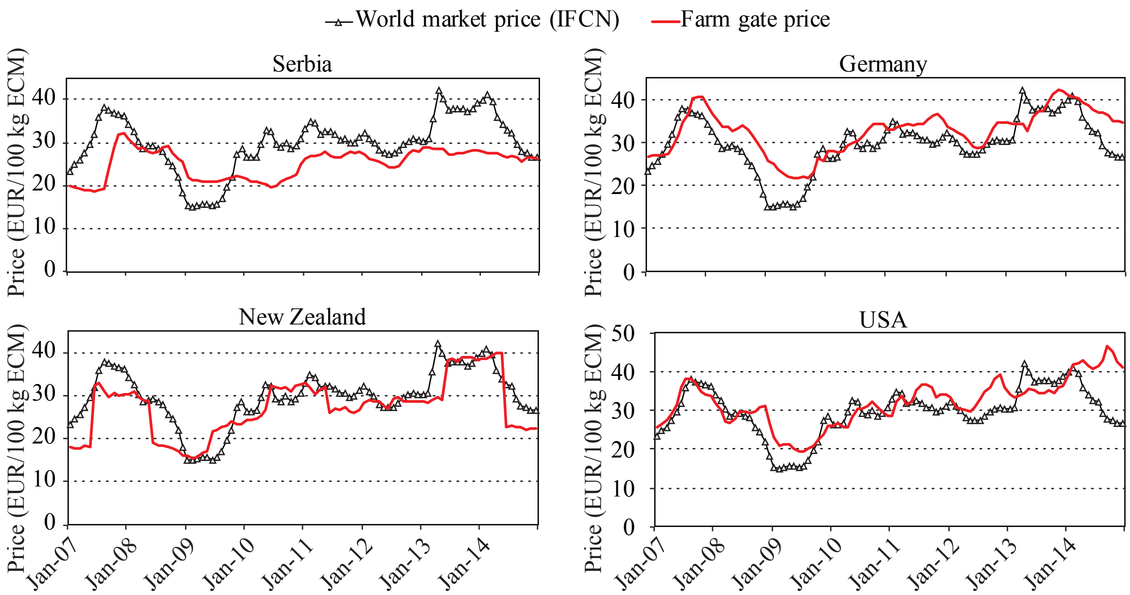

Figure. 2 Milk price pairs analysed for price transmission (adapted from IFCN, 2015; OANDA, 2015; RZS, 2014a). ECM = energy-corrected milk.

Net exports of milk from Serbia in 2013 increased mainly because of a strong decline in imports, compared to exports. Higher milk prices in the region, and the world market depressed imports. During the crisis Serbia lost its position in its main export market Montenegro. Exports of liquid milk products, where perception of consumers about health issues effects was stronger, were halved. At same time, the crisis had little impact on cheese and other non-liquid milk products exports. On other side, Serbian milk products become price competitive in markets with higher aflatoxin standards up to 0.5 µg/kg. Exports increased mostly to the Russian market, reaching 20 million EUR. The EU sanctions to Russia in 2014 increased Russian demand for milk products from Serbia, pushing export to 31 million EUR. In same period, net exports for the main exporting countries of New Zealand, USA and Germany showed a stable increase.

4. Methodological approach and data

The analysis is modelled using a non-linear price transmission approach to capture the effect on the price relationships. This paper uses a MS-VECM in order to analyse price transmission. Related to the Markov switching vector autoregression framework, a MS-VECM is a special type of the more general regime-switching model, which can be employed in the analysis of price transmission when a few price regimes govern the market conditions and changes in the market regimes are unknown or driven by many shifts in food market policy (Hamilton, 1989). Nevertheless, market participants can alter their behaviour according to their expectations before the new price regime is introduced or overthrown. Therefore, a MS-VECM permits the recognition of different price transmission regimes, even if the state variable cannot, or can only partly be observed.

The state variable indicates the predominant price transmission regime at a given point in time. Since the mentioned variable is unobserved, a stochastic process in case of the state variable is assumed. In other words, the change in regime should be considered as a random and unpredictable event. However, these price regime shifts must be involved in the investigation of the stochastic properties of the market volatility. Thus, the MS-VECM assumes that the state variable is generated from a Markov process, which is regulated by a constant transition probability matrix, where the state of the market tomorrow is driven only by the state of the market today. This model was introduced by Krolzig (1997) in order to analyse business cycles.

Recently, Brummer *et al.* (2009), followed by Gotz *et al.* (2013), introduced this model for the analysis of price transmission.

The unrestricted Markov switching vector error correction model is employed as a framework for the horizontal price transmission analysis and estimation of co-integrated relationships with the first-differenced variables and the error correction term, similar to Gotz *et al.* (2013):

$$\Delta p_t = \nu (s_t) + \alpha (s_t) (\beta(s_t)' p_{t-1}) + \sum_{i=1}^{p-1} A_i (s_t) \Delta p_{t-i} + \varepsilon_t \tag{1}$$

where p_t indicates a vector (M × 1) of milk prices, $\nu(s_t)$ is a vector of intercept terms or an observable regime indicator variable, $\alpha(s_t)$ is the vector of the speed of adjustment coefficients, $\beta(s_t)$ represents the long-run co-integrating vector with one period lags and A_i are matrices (M × r) of the short-run parameters of the system that capture the autoregressive part of the price movements (M is the number of variables, r is the number of parameters). Finally, ε_t denotes the error term, which we assume has a zero mean and constant variance, $\varepsilon_t \sim$ i.i.d.$(0,\sum (s_t))$. However, the variance can vary between regimes. The core segment of this model specification is the state variable $s_t = 1, ..., M$. This is an unobserved variable, representing which of the M possible regimes governs the model at time t. All terms in equation 1 indicate the dependence of these parameters on the state variable. The probability of being in state s in period t might depend on the full time series of variables, but the simplifying Markov assumption can be written as:

$$P(s_t \mid s_{t-i}, \Delta p_{t-1}, \beta' p_{t-1}) = P (s_t \mid s_{t-i}, \Pi), \tag{2}$$

where the square matrix Π includes the transition probabilities π_{ij} for switching from the regime in row i to the regime in column j, conditioned only on the regime in the previous period. The MS-VECM acts as an error correction mechanism in each disequilibrium regime because the regimes are generated by a stationary Markov chain (Phoong *et al.,* 2014).

The estimation of a MS-VECM is based on maximizing the likelihood function with the expectation-maximization algorithm (Krolzig, 1997). The parameters characterizing the unobserved state variables and transition probabilities are first estimated, based on estimated starting values for the parameters. In the second step, the starting values are updated from the parameters estimated in the first step within an alternative procedure. The procedure continues until estimated parameters of two consecutive estimations do not differ significantly.

Data sets representing 96 monthly observations for the world market milk price and national farm-gate milk prices from January 2007 to December 2014 for Serbia, Germany, New Zealand and USA were used (Figure 2). The source of farm gate milk prices are national Statistics offices and the IFCN Database. Data for the world milk price are calculated by IFCN[1]. The combined IFCN world milk price indicator represents the milk price a processor could theoretically pay to its farmers, if it was selling its products on the world spot market and producing at standardised costs. It is based on weighted average of three IFCN world milk indicators: skim milk powder & butter, cheese & whey, and whole milk powder according to shares of the related commodities traded on the world market (IFCN, 2015). National and world milk prices are converted in ECM with 4% fat and 3.3% protein.

5. Empirical results

At the beginning of the model estimation, the augmented Dickey-Fuller (ADF) stationarity test and the Johansen co-integration test are conducted. The ADF test with constant and linear trend, presented in Table 1, indicates that all five original data series are I(1) or non-stationary processes. At the same time, first leg differences are stationary.

[1] IFCN performs analysis of dairy farm economics since 2000, reaching 98% of the total world milk production in 2014 (http://tinyurl.com/z4e6p4x).

Table 1. Augmented Dickey-Fuller (ADF) stationarity test.

Series	ADF test	Statistical significance
p_t^{rs}	-2.14147	0.2292
Δp_t^{rs}	-4.74039	0.0012
p_t^{ger}	-2.39969	0.1446
Δp_t^{ger}	-5.22095	0.0002
p_t^{nz}	-2.45369	0.1302
Δp_t^{nz}	-9.68220	0
p_t^{usa}	-1.39165	0.5832
Δp_t^{usa}	-6.36572	0
p_t^{wr}	-2.00052	0.2862
Δp_t^{wr}	-6.12006	0

The results from Table 1 give the opportunity to show that individual I(1) time series could form a stationary linear combination. The Johansen co-integration test in Table 2 reveals five co-integration equations at the 1% level of significance. In other words, the test confirms the hypothesis of existing statistically significant long-run connections among observed time series.

In the next phase it is necessary to confirm the differences in the log-likelihood function values between a suggested Markov switching model and the linear VECM. The results of the LR linearity test explain the advantage of the non-linear Markov switching model over the linear vector error correction model for all four models at the 5% significance level. The Markov switching vector error correction model is estimated with varying number of regimes and lags, where the optimal model specification is chosen using the Akaike and Schwarz information criteria.

The model specification consists of two different states of market integration for all four markets. The first state explains the 'standard' regime with a modest level of price volatility. The second state is presented as the 'extreme' regime with a high level of price volatility. Table 3 demonstrates the filtered regime transition probabilities that vary between 0 and 1. Therefore, Table 3 indicates the probability that one market regime switches to another.

Milk price regime classification in Figure 3, shows probabilities of extreme regime for analysed markets, acquired by the model. Analysis revealed that domestic milk market in Serbia had two switches to the extreme price regime before the Aflatoxin crises. It should be noticed that gap between lower Serbian and higher world milk prices was narrowing from 2010 to January 2013. During whole period of crises, milk prices remained in the standard regime. This finding is opposite to results for some other agricultural products, for example wheat, in a period of crisis caused by rigid agricultural policy measures (Djuric *et al.,* 2012; Gotz *et al.,* 2013). Domestic grain markets temporally disconnected from international markets, increasing price volatility. Characteristics of dairy production could be a reason why the dairy market in Serbia continues with the standard regime during crisis. Dairy production is unique because of very long biological lags.

Table 2. Johansen co-integration test.

No. of CE(s)	Eigenvalue	Trace statistic	Critical value	Prob.
None	0.45779	162.8347	69.8188	0
At most 1	0.40479	106.5205	47.8561	0
At most 2	0.25521	58.78667	29.7970	0
At most 3	0.19996	31.67776	15.4947	0.0001
At most 4	0.11416	11.15295	3.84146	0.0008

Table 3. Transition probabilities.

	From regime	To regime	
		standard	**extreme**
Serbia	standard	0.86911	0.13088
	extreme	0.01029	0.98970
Germany	standard	0.94808	0.05191
	extreme	0.03622	0.96377
New Zealand	standard	0.97344	0.02655
	extreme	0.10283	0.89716
USA	standard	0.55116	0.44883
	extreme	0.54945	0.45055

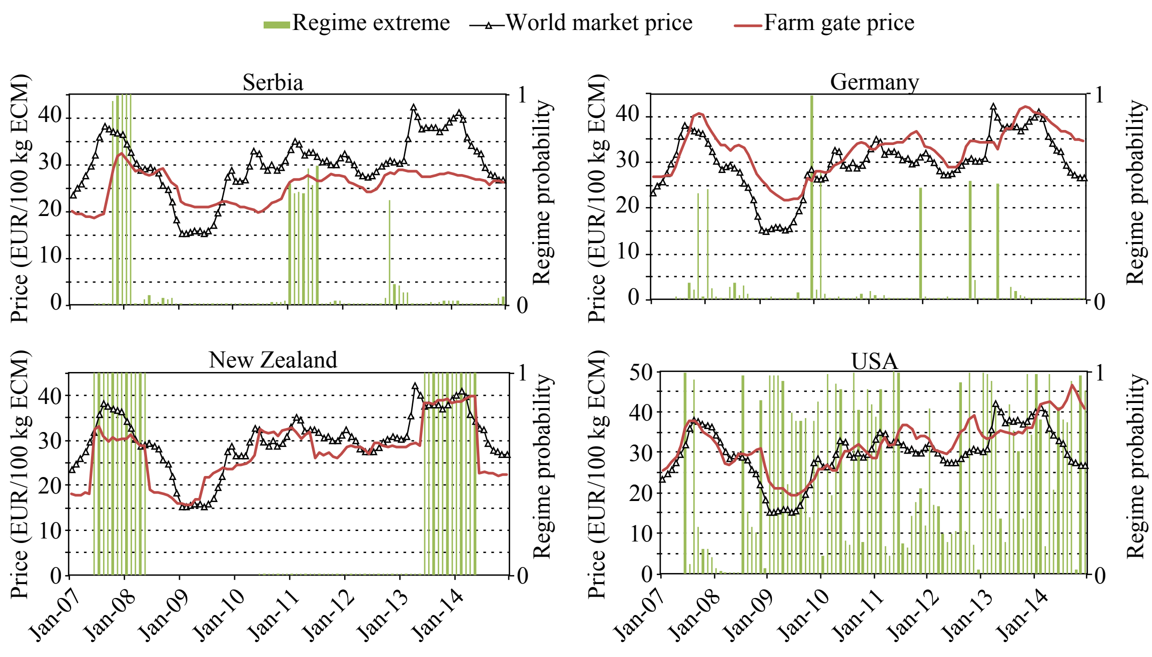

Figure 3. Milk price regime classification (adapted from: IFCN, 2015; OANDA, 2015; RZS, 2014a). ECM = energy-corrected milk.

Such lags cause production cycles from 10 to 15 years (Anderson *et al.,* 2009; Ferris, 1997). In other words, once the number of cows decreased strongly, it takes many years to increase to the previous level. The milk industry in Serbia, faced with shrinking demand for dairy products during crisis, reacts in a responsible way to protect its own long-term interest, securing its input market. Dairy companies in vast number didn't cut procurement of raw milk from farmers, although it was expected taking in account their short-run interest. Aware of the negative consequences for its future production, the supply of raw milk remained stable. The price of this decision for dairy companies was greatly increased stocks of dairy products, lower margins and lost profit. It inferred that the burden of crises was shared among dairy companies and farms. Additionally, feed prices faced a strong negative trend, enabling farmers to cut the cost of milk production. At the end of the Aflatoxin crises in Serbia, world milk prices fell and equalised with milk prices in Serbia.

Compared to the other three markets, Serbian milk price transmission regimes are most similar to the German market. The model demonstrates that the German market was dominantly in a standard regime with several low probabilities for switches to extreme regimes. In the period from 2013 to the end of 2014 the German dairy market was in its standard regime and prices followed the trend of world market prices. The stable domestic market was identified for New Zealand, with only two year-long periods of extreme price regimes. During period from June 2013 to June 2014 the milk market in New Zealand was in an extreme regime with volatile prices. Since milk prices in its national currency at same period were fixed, the source of price volatility in the model comes from variability of exchange rates between the NZD and the EUR. As a biggest single world milk exporter, New Zealand has significant influence on world market prices. USA has high number of switches between regimes. It demonstrates high sensitivity and fast reactions of domestic dairy market players to world market price signals. After a relatively stable period from March 2011 to the end of 2012, the milk price became more volatile again. USA milk exports increased and reinforced the USD value over the EUR, which pushed milk prices to a high value, where they remained even through 2014.

The results presented in Table 4 show that there are no significant changes between the regimes for Serbia, Germany, and New Zealand. Hence, those markets retain a relatively high level of persistence for the standard regimes. The standard regime of 83 observations is detected for the Serbian market, which takes place throughout the entire observed sample period. A similar situation is noticed for Germany and New Zealand, where the standard regime remains dominant in 88 and 71 observations, respectively. The US market depicts many regime switches and the standard regime is identified in only 50 sample observations.

The principal analysis of the Markov switching model parameters contains results of market integration, equilibrium, stability and duration of market effects. According to Götz *et al.* (2013), the level of integration of the domestic markets to the world market is described by the parameters of the long-run equilibrium, the contemporaneous price transmission, and the speed of adjustment. The level of statistical significance of these parameters is estimated by the delta method (Greene, 2003). The long-run equilibrium intercept β_0,

Table 4. Main model estimates of the MS(V)ECM.[1,2]

	Serbia		**Germany**		**New Zealand**		**USA**	
	standard	**extreme**	**standard**	**extreme**	**standard**	**extreme**	**standard**	**extreme**
MS-VECM specification	MS(2)VECM(1)[3]		MS(2)ECM(2)		MS(2)ECM(2)		MS(2)ECM(2)	
LR linearity test	7.857		8.631		13.581		7.46	
Probability	0.02		0.013		0.001		0.024	
N	83	12	88	7	71	24	50	45
Integration								
Long run equilibrium intercept	-0.024 (0.834)	3.858 (0)	-0.169 (0)	2.969 (0)	-0.216 (0)	11.759 (0)	0.596 (0.008)	-0.529 (0.036)
Long run slope	1.945 (0.062)	2.304 (0.384)	0.663 (0.086)	0.289 (0.026)	0.495 (0.095)	1.078 (0.074)	1.531 (0.036)	2.284 (0.097)
Contemporaneous price transmission	2.339 (0.310)	4.715 (0)	3.281 (0)	8.382 (0.265)	3.789 (0)	22.711 (0.002)	0.657 (0.419)	19.489 (0.970)
Speed of adjustment	-0.405 (0)		-0.262 (0.001)		0.894 (0)		0.158 (0.064)	
Equilibrium								
Average ECT	-0.011	-0.094	-0.013	-0.085	-0.021	0.015	-0.094	-0.087
Stability								
Standard errors	0.008	0.163	0.005	0.173	0.001	0.061	0.329	0.5
Duration	115.787	23.613	61.292	1.193	37.745	12.008	2.142	3.552

[1] Numbers in parenthesis represent statistical significance level.

[2] MS-VECM = Markov switching vector error correction model; ECT = error correction term.

[3] (1) and (2) refer to the used models.

presented in Table 4, is around 0 in all four markets for the standard regimes and is significantly different than 0 in cases of extreme regimes. Regarding long-run price transmission, the parameter results show the relative differences of long-run slope coefficients between standard and extreme regimes in all cases. New Zealand, USA and Serbia have an increasing trend of elasticity in the extreme regimes, when compared to the standard regimes. For New Zealand and USA, the long-run price elasticities increase in extreme regimes compared with standard for 118 and 49%, respectively. Those markets react faster to extreme milk price changes on the world market. The long-run price elasticity in Germany decreases for 56% in the case of the extreme regime, which can be explained by the fact that milk prices on the national market are mostly above world milk price levels and they are more stable. In Serbia, the long-run price elasticity strengthens by 18% in the extreme regime, which means that the Serbian market 'modestly' reacts to world milk price changes, compared to the other three markets.

This study also identified highly significant contemporaneous price transmission parameters in the Markov switching models for Serbia, Germany and New Zealand. Those contemporaneous price transmissions are higher in the extreme regimes than in the standard regimes. The speed of adjustment of deviations from the long-run equilibrium is statistically significant in each regime switching model, showing that the examined markets are integrated with each other and to the world dairy market, while New Zealand has the strongest integration. The larger the domestic price changes, the higher the speed of adjustment (Götz *et al.,* 2013).

The equilibrium between the national market and the world market is illustrated by the level of the error correction term (ECT). In other words, it presents the size of deviation from the long-run equilibrium between the national and the world market. This term is calculated as follows:

$$ECT_t = \ln p_{t\text{-}1}^{national} - \beta_0 - \beta_1 \ln p_{t\text{-}1}^{world} \tag{3}$$

The calculated error correction term signifies that when the size of the absolute value is larger, greater disconnection between actual prices and the equilibrium level emerges. An average ECT>0 depicts that the national price is higher than its equilibrium level; while average ECT<0 indicates that the national price is lower than its equilibrium level. Thus, when the average ECT<0 producers suffer losses due to the unfavourable price development and compared to the equilibrium state, especially in case of extreme regimes in Serbia, USA and Germany.

The market stability is shown by the regime-specific standard error of the estimated model. The estimated standard errors for the extreme regime are considerably higher than standard errors for the standard regime for Serbia, Germany and New Zealand. The USA market has substantially higher standard errors in both regimes compared to standard errors of the other three markets in the standard regime. Such market price volatility increases market uncertainty along with a pessimistic aftermath on investment perspectives.

The duration of the domestic market effects could confirm the previous conclusion about market stability. In the case of Serbia, Germany, and New Zealand, the average duration of the standard regime is significantly higher than the average duration of the extreme regime. It means that after the extreme regime is over, the standard regime remains for a long period of time. In other words, the standard regime pushed the market closer to its equilibrium and decreased the level of market instability.

The applied MS-VECM model is used to estimate farm gate milk prices in Serbia, if one assumes a scenario without the milk crisis (Figure 4). A similar approach for the wheat sector in Serbia was used by Djuric *et al.* (2012). The first scenario is a dynamic forecasting from the presented model, which uses only forecasted values of the lagged dependent variables. The second scenario uses static forecasting, taking in account actual values of the lagged dependent variables. The first scenario offers an average forecast estimation according to the domestic market situation and expectations, while the second scenario involves more influence of international dairy price changes. Based on such an estimate, it is possible to give answer to the question how much did dairy farmers lose during the aflatoxin crisis? Both scenarios respond with significantly higher

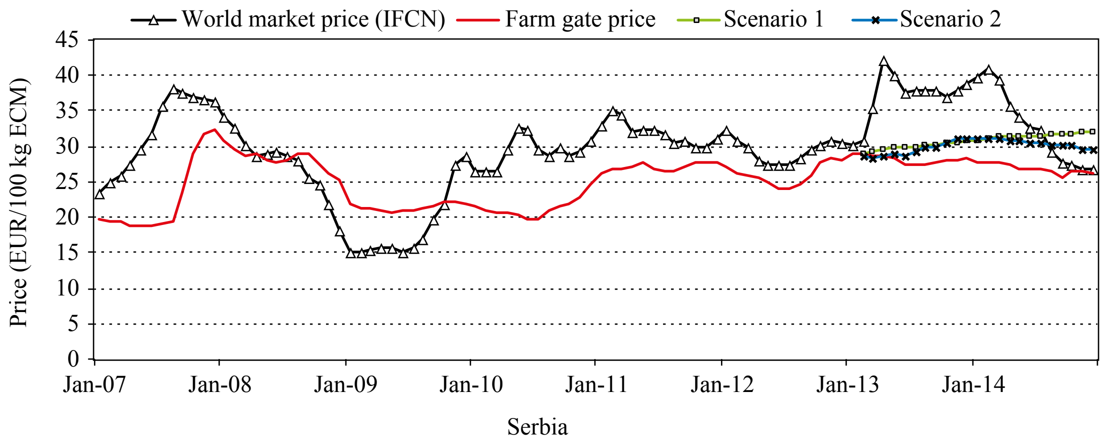

Figure 4. Milk price estimate for Serbia with two scenarios without Aflatoxin M1 crisis (adapted from IFCN, 2015; OANDA, 2015; RZS, 2014a). ECM = energy-corrected milk.

prices than actual during crisis period. Multiplying the average monthly milk production amount, during the 23 month period, by the milk price differences (forecasted minus actual), infers that Serbian dairy farmers suffered a loss of 96.2 million EUR in Scenario 1 and 74.7 million EUR in Scenario 2.

Serbian farmers, who produce and deliver at least 3,000 litres of milk per quartile, were able to receive milk premiums during the crisis. This coupling measure is one of most important single measures for dairy farmers in agricultural policy. Although milk premiums were questioned before the crisis regarding their level and how they are paid, they remained and helped farmers that delivered milk to dairy plants to partially cover their losses. In total, during the crisis farmers received 77.45 million EUR of milk premiums. It can be inferred that the loss incurred during the crisis is significantly covered by this measure. But, the distribution of premiums was highly unequal. Only one smaller group of dairy farms, more precisely, medium sized and large farms, received premiums during 2013 and 2014. Their shares in total number of dairy farms during years of crises were 10.5 and 11.8% respectively. The vast number of small farms with only 3 or 4 cows, depending of production region, didn't receive such support from the government. Those farms produce half of all milk in Serbia. Besides that, small farms receive significantly lower milk prices from dairy companies and have difficulty improving their milk quality. Therefore, the crisis hit the small farms hardest. The loss suffered during the crisis significantly slowed down investment in dairy farming, especially on the numerous small farms. At same time, production costs during the crisis increased for all farms because of the use of mycotoxin absorbers and additional milk testing.

On subsequent link of dairy supply chain, processors coped with crisis on various ways. Some, mostly bigger dairy processors diminishing margins and organise periodical sales with retailers, while others built their own retail network of small dairy shops, focusing more on alternative market channels or niche markets, etc. No doubt, it can be inferred that part of the cost of the crisis were carried by processors, but exact details of this were not gathered in this study.

6. Conclusions

This paper examined a problem with Aflatoxin M1 in the Serbian dairy industry and its impact on the domestic market. The empirical results indicate the occurrence of two different states of milk market integration i.e. price transmission regimes, for: Serbia, Germany, New Zealand and USA. Serbian milk market is integrated in the world milk market, although Serbian farmers do not benefit fully from high milk price changes, but it did not fully suffer from low world milk prices either. Compared with the other three markets in the long-run, the Serbian market reacted only partly to world milk price changes. Serbia has market stability in the standard regime, but in the extreme regime the market is destabilized, much like in Germany, which can be explained by the geographical proximity of these markets.

The model didn't confirm an extreme regime in Serbian dairy sector during the Aflatoxin crisis, as was confirmed in several recent studies for other agricultural products during periods of market disturbances (Gotz *et al.,* 2013; Djuric *et al.,* 2012). Specific characteristic of cow milk production, with its long biological lag, is one reason why milk processing companies didn't react to protect short-term profit. The dairy sector in Serbia is an exceptionally good example of vertical coordination during the last two decades. Big dairy companies first start to work with dairy farmers, followed recently by middle sized and small milk processors. Vertical coordination among farmers and milk processors helped both sides to alleviate challenges brought by crisis.

Simulated scenarios confirm occurrence of loss during the aflatoxin outbreak in the Serbian milk market. The estimated range of the loss was between 74.7 and 96.2 million EUR in the period from January 2013 to December 2014. It infers that the aflatoxin crises temporally reduced the degree of Serbian market integration with world milk markets, causing losses for the national dairy supply chain.

The key lessons learned from the milk aflatoxin crisis can be presented in two segments. The first group covers effects on the food supply chain, and the second to the government response to the food scare crisis.

The burden of the crisis was not distributed proportionally among farmers. Middle and large dairy farms (22%) that produce half of milk on national market, were protected from two sides. Dairy processors typically pay significantly higher milk prices to those farms to secure quantity and quality inputs. Additionally, dairy subsidies, retained during the crisis, in total were almost enough to compensate the dairy farm's losses, but they were allocated only to middle and big size farms. That helped them to overcompensate for its forecasted loss during the crisis. On the other side, the numerous small dairy farms, representing second half of national market, bore the biggest burden of negative crisis effects. Small dairy farms were not able to compensate for their loss with milk premiums, and received significantly lower milk prices. Their investment abilities were significantly reduced. In the period of preparation for EU accession, such investment on small dairy farms is crucial for their future.

Experience from the milk contamination crisis shows once more the importance of vertical cooperation between processing companies and family farms in developing countries, especially those without cooperatives. Dairy processing companies were under pressure and lost profit during crisis. Without market power, transferred to highly concentrated retailers about decade ago, dairy companies were challenged to manage the situation alone and to protect own long-term interest. Beside loss of some traditional export markets, dairy companies were looking for opportunities in the new markets and succeeded to lower the supply pressure on the domestic market.

The aflatoxin milk crisis in Serbia reveals typical mistakes in crisis management. The lack of credible information, daily accusations, and dodging responsibility between government and its opposition, together with silence from the dairy companies and scientists were the causes of expanding negative effects. The food crisis proved to be a very 'seismic active' area for government. The two year crisis was managed by three ministers of Agriculture. 'Easy' policy measures like a tenfold increase in allowed level of aflatoxin in milk proved to be highly negative and further decreased demand. Besides that, the crisis brought unexpected cost for the government, because of the retained milk premiums during the crisis. Negative experience forced government to negotiate with food supply representatives for a Protocol of cooperation in communication during food scare crises, immediately after the crisis.

The contribution of research in this paper to literature on food scare crisis is composed from linking the milk aflatoxin M1 crisis and long-run milk price transmission on the Serbian milk market, and examined approach how to measure the crisis' effect on the most vulnerable link in the milk supply chain, the farmers. Also, the distribution of the crisis burden among farm types was examined. Additionally, adjusting government policy during the crisis as well as adjusting of other links in the milk supply chain were analysed. An open question for future research is how to design procedures for measurement of food scare crisis effects on each food chain link for effective policy measures.

Acknowledgments

This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Projects No. III 46009 and III 46006.

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