Early warning systems for commodity markets

Deliverable No. 8.4

SUSFANS DELIVERABLES

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An agricultural commodity price and price volatility forecasting modelling system has been developed and applied for four agricultural commodities to perform forecasts on a horizon spanning from three months to one year. The forecasting system can be used as an early warning system based on seasonal and decadal simulated weather and climate forecasts in combination with financial and macro-economic projections.

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DELIVERABLE SHORT SUMMARY FOR USE IN MEDIA

The state of food security and the stability of the food system can by summarized and measured by food price pressure as well as food price volatility. In this way changes in food prices and their volatility can be used as early warning indicators. The purpose of this report is to illustrate the capacity of an econometric system to provide such services. The price and price volatility forecasting model constitutes SUSFANS's operational early warning system for agricultural commodity markets, and contributes to the wider SUSFANS toolbox. The AgriPrice4Cast model is providing seasonal prices based on short-term yield forecasts for agricultural crops. The seasonal price forecasts allow for the planning of emergency measures in cases of harvest outages, financial market or macro-economic shocks in the world and/or designing storage and other stabilization measures.

The purpose of deliverable D8.4 is to showcase an early warning system (EWS) for the most relevant agricultural commodities. The design of the EWS in the SUSFANS project is complementary to the ones already existing. In particular, we would like to mention the initiatives of the G20 Action Plan on Food Price Volatility and Agriculture in dedicated forums: Agricultural Market Information System (AMIS) and the Rapid Response Forum, GEO Global Agricultural Monitoring Initiative (GEOGLAM) for market and production international monitoring, and risk management tools, such as the Platform for Agricultural Risk Management (PARM), and the initiatives including the Global Agriculture and Food Security Programme (GAFSP). The SUSFANS forecasting system is complementary to the afore mentioned EWS, which are mostly concentrated around production and yield forecasting, as it includes a large set of financial and macro-economic forecasting variables.

In deliverable 8.3 we presented a comprehensive modelling framework aimed at obtaining short-term forecasts. After first testing with our case study commodity coffee we expanded the analysis to more mainstream commodities, which are also more relevant for the EU food market. Short-term forecasts were performed one to twelve months ahead of commodity prices and predictions were generated in addition to Arabica coffee for the following three commodities: wheat, soybeans and corn. These commodities were selected for the reasons that wheat is the "bread" crop of Europe occupying almost half of total cropland in use producing 160 million tons, which corresponds to 50 percent of total coarse grain output. Soy was used as an iconic import crop for Europe with half of total oilseed meal consumption made up of soymeal imports. Corn is another iconic European crop covering 20 percent of total coarse grain output. In our analysis in D8.4 we entertain a large number of univariate and multivariate time series models, including specifications that exploit information about market fundamentals, macroeconomic and financial developments and climatic variables. A comprehensive set of forecast averaging tools was implemented to explicitly address model uncertainty. Our results indicated that variables measuring market fundamentals and macroeconomic developments (and to a lesser extent, financial developments) contain systematic predictive information for out-of-sample forecasting of commodity prices. The market fundamentals in terms of physical production played an increasingly important role compared to the original case study of Arabica coffee.

Within the SUSFANS framework the AgriPrice4Cast model can serve multiple purposes. One of the original ideas was to develop a price and price volatility estimator to inform long-run food security models and provide early warning. This is motivated by the fact that it is less the slowly moving price trends which create episodes of food insecurity, but it is more related to extreme events including episodes of price volatility and price uncertainty both as an endogenous factor due to the shock as wells as the main external shock on the respective food system. Together with the market pressure index from either the GLOBIOM or also MAGNET model, episodes and subsequent states of food insecurity in vulnerable geographies can, thus, be better characterized. Also for long-run assessment of the stability of FNS a price volatility reaction function can serve valuable insights provided that the overall market pressure conditions are replicable in such a longer-run future. It is also recommended that the current statistical methods determining the number of hungry and food insecure should be enriched by indicators of price volatility. Targeted research in this direction should be conducted with partners such as the FAO or IFAD to generate evidence from household or individual level analysis of the impact of volatility and subsequent up-scaling methodologies. Following this line of research the collection of high frequency price data from a multitude of market locations would be a prerequisite to roll out such a new market and food security system. The usefulness of crowd-sourcing tools to collect highly geographically and temporally resolved input data for the EWS cannot be over-emphasized. Finally, the EWS function of the AgriPrice4Cast tool could also be used by the humanitarian community to optimize their operations.

TEASER FOR SOCIAL MEDIA

Early warning systems are essential for the stability of the food system. Food price pressure and a volatile market environment can destabilize the food system. Early waring can be used by farmers for more robust production planning as well as by all up-stream actors of the food system including humanitarian organizations.

Production forecasts are not enough to forecast food prices and their volatility as financial and macro-economic variables dominate price formation.

The added value of the novel SUSFANS forecasting system for short-term food prices is that it combines physical production forecasting from the JRC MARS system with a large set of financial and macro-economic forecasting variables.

ABSTRACT

The state of food security and the stability of the food system can by summarized and measured by food price pressure as well as food price volatility. In this way changes in food prices and their volatility can be used as early warning indicators. The purpose of this report is to illustrate the capacity of an econometric system to provide such services. An agricultural commodity price and price volatility forecasting modelling system has been developed and applied for four agricultural commodities (wheat, soybean, corn and coffee) to perform forecasts on a horizon spanning from three months to one year. The report recommends to complement existing crop forecasting systems, based on seasonal and decadal simulated weather and climate forecasts, with financial and macro-economic projections. The recommendation is driven by satisfactory tests of the forecasting skill of such combined systems for the four commodities. Various potential users of such early warning systems are identified.

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1 Early warning system

The SUSFANS conceptual framework paper on the EU food system (Zurek et al. D1.1) sets the stage for a holistic assessment for a sustainable European FNS. Stability and resilience of the FNS was identified as an important criterium for the system's performance. In section 3.1.4.1.2 the conceptual framework paper talks about the impacts of sectoral policies on global food and nutrition security Although sectoral policies in the EU, like the CAP, food safety policy and trade policy are not directly targeted at global food and nutrition security, they might have an impact on it. At the same time larger global food shocks, such as a multiple breadbasket failure event, might create ripple effects for the EU FNS with consequences on food security and safety. The paper explicitly talks about the relationship of some of the EU's sectoral policies and global food and nutrition security: (1) CAP (Common Agricultural Policy) (2) EU food safety policy (3) EU trade policy (4) Indirect global effects of EU sectoral policies.

Combined with stochastic abiotic and biotic events the FNS system can be subject to extreme shocks which, if unprepared, carry the potential to bring the system close to a tipping point. The current butter market crisis gives a very tiny vision of even a physical supply interruption. However the main aim of the price volatility modeling presented here is to provide input into a framework for the dimension of economic access to food under varying market conditions. We focus on the creation of a price volatility model which could serve the function of an Early Warning System (EWS) addressing the sustainability dimensions of the FNS system defined in Rutten et al. 2017.

The price and price volatility forecasting model constitutes SUSFANSs operational early warning system for agricultural commodity markets in the wider SUSFANS's tool box. The AgriPrice4Cast model providing seasonal prices based on short -term yield forecasts. The seasonal price forecasts for the EU allow for the planning of emergency measures in cases of harvest outages, financial market or macro-economic shocks in the the world and/or designing storage and other stabilization measures (Rutten et al. 2017).

The purpose of deliverable D8.4 is to develop an early warning system (EWS) for the most relevant agricultural commodities. The design of the EWS in the SUSFANS project should be complementary to the ones already existing. In particular, we would like to mention the initiatives of the G20 Action Plan on Food Price Volatility and Agriculture in dedicated forums: Agricultural Market Information System (AMIS) and the Rapid Response Forum, GEO Global Agricultural Monitoring Initiative (GEOGLAM) for market and production international monitoring, and risk management tools, such as the Platform for Agricultural Risk Management (PARM), and the initiatives including the Global Agriculture and Food Security Programme (GAFSP).

GEOGLAM provides a framework which strengthens the international communitys capacity to produce and disseminate timely and highly accurate forecasts of agricultural production at national, regional and global scales through the use of Earth Observations (EO) including satellite and ground-based observations. GEOGLAM developed the Crop Monitor reports which provide global crop condition assessments in support of the AMISpact the market situation and outlook. The AMIS Information Group meets twice per year to review the progress of AMIS and to discuss technical issues including the collection of the latest supply and demand data, preparation of forecasts, establishment of indicators and capacity development initiatives. market monitoring activities. In 2016, GEOGLAM developed the Early Warning Crop Monitor. The Early Warning Crop Monitor brings together international, regional, and national organizations monitoring crop conditions within countries at risk of food insecurity.

The Global Food Market Information Group consists of technical representatives from countries participating in AMIS. It is responsible for providing regular reliable, accurate, timely and comparable data regarding the supply and demand position and its probable short term development, as well as regarding prices, of the AMIS crops. Furthermore, it organises the timely collection of national policy developments that could impact the market situation and outlook. The AMIS Information Group meets twice per year to review the progress of AMIS and to discuss technical issues including the collection of the latest supply and demand data, preparation of forecasts, establishment of indicators and capacity development initiatives.

There are also private sector initiatives to provide production and market information to its clients in the food sector. For example the Thomson-Reuters Eikon platform is a set of software products provided for financial professionals to monitor and analyse financial information including for agricultural commodities. It provides access to real time market data, news, fundamental data, analytics, trading and messaging tools. The Eikon platform also provides information on yield and production forecasts based on their proprietary remote sensing based estimates.

There is a series of deliverables on short-term price and price volatility forecasting in SUSFANS. In the first deliverable D8.1 we investigated "Fundamentals, Speculation or Macroeconomic Conditions? On the Determinants of Commodity Price Dynamics, with an Application to Arabica Coffee" (Crespo Cuarisma, Hslouskova and Obersteiner, 2016). In D8.1 we analysed the role played by market fundamentals, speculation and macroeconomic conditions as empirical determinants of commodity price changes. We selected arabica coffee as the first agricultural commodity with the aim to take the most sensitive crop to temperature changes as a first case study in the hope to "benefit" from large production variations explaining commodity price volatility. By combining model averaging techniques we explain historical patterns with an in-depth analysis of out-of-sample predictability of commodity prices using fundamentals as well as macroeconomic and nancial variables. Our results indicate that variables related to global macroeconomic and nancial developments contain valuable information to explain the historical pattern of coffee price developments, as well as to improve out-of-sample predictions of coffee prices. What turned out to be rather surprising was that production variability did not play any significant role in price volatility. What we found was that storage was large enough to completely buffer variation in production volumes, and that commodities are only traded on a financial optimization calculus. This means that financial market variables and macro-economic variables are responsible for most of the variation in prices for this particular commodity.

In deliverable 8.3 we presented a comprehensive modelling framework aimed at obtaining short-term forecasts (Crespo Cuarisma, Hslouskova and Obersteiner, 2017). After first testing with our case study commodity coffee we expanded the analysis to more mainstream commodities, which are also more relevant for the EU food market. Short-term forecasts were performed one to twelve months ahead of commodity prices and predictions were generated in addition to Arabica coffee for the following three commodi-ties: wheat, soybeans and corn. These commodities were selected for the reasons that wheat is the "bread" crop of Europe occupying almost half of total cropland in use producing 160 million tons, which corresponds to 50 percent of total coarse grain output. Soy was used as an iconic import crop for Europe with half of total oilseed meal consumption made up of soymeal imports. Corn is another iconic European crop covering 20 percent of total coarse grain out-put. In our analysis in D8.3 we entertain a large number of univariate and multivariate time series models, including specifications that exploit information about market fundamentals, macroeconomic and financial developments and climatic variables. A comprehensive set of forecast averaging tools was implemented to explicitly address model uncertainty. Our results indicated that variables measuring market fundamentals and macroeconomic developments (and to a lesser extent, financial developments) contain systematic predictive information for out-of-sample forecasting of commodity prices. The market fundamentals in terms of physi-cal production played an increasingly important role compared to the original case study of Arabica coffee (D8.1/D8.2).

The SUSFANS niche Based on extensive desk research screening agricultural market information systems and EWS we found that there is no real time algorithmic forecasting and EWS for agricultural commodities. All agricultural risk and market forecasting systems are in the end expert driven. An algorithmic system is neither available for OECD countries nor for food security risk management in developed countries. Our research also found that there is probably no such system developed or used in the private sector. This is exactly where the SUSFANS project tries to innovate by developing an algorithmic price forecasting system.

Forecasting skill of the JRC MARS wheat forecasts Developing a blueprint of an algorithmic and thus fully automized and unsupervised EWS is a joint deliverable between IIASA and the JRC. The JRC is already contributing to the GEOGLAM through its MARS-Crop Yield Forecasting System by JRC/MARS/AGRI4CAST. For this deliverable JRC has contributed and analysis of the forecasting skill of its MARS crop yield forecasting system for wheat in the EU. The European Union (EU) produces about one-fifth of the worlds wheat (Triticum spp.).The JRC assessed the quality and intraseasonal development of wheat yield forecasts performed by the JRC MARS unit of the European Commission (EC) since 1993. A total of 2450 intraseasonal forecasts were evaluated for 362 wheat forecast years for 25 EU Member States (MS). Yields were forecast accurately by July in median yielding years with errors below 2%, but were overestimated by 10% in low yielding years and underestimated by 8% in high yielding years. Forecast accuracy of high yielding years improved gradually during the season, and yield reductions due to drought were anticipated with lead times of 2 months, but June and end-of-campaign production forecasts consistently underestimated losses caused by large-scale weather events that affected several countries simultaneously.

Assessing the usefulness of the SUSFANS price and price volatility models within an EWS model constellation Complementary to the JRC yield and production forecasting tool IIASA has built meta-price and price volatility models under Workpackage 8 of the SUSFANS project. These two tools can be considered as the core set of basic tools to make up the Early Waring System (EWS) for short term market price pressure and volatility with direct relevance for Europe. By extending this work to connect to GEOGLAM capabilities or even AMIS it is straight forward to build an operational forecasting system for agricultural commodity prices on a horizon spanning from three months to one year. The EWS needs to be tested for production fluctuations on seasonal and decadal historically observed weather events and those expected for climate change related events. Given the somewhat surprising results from task 8.1 to 8.2 illustrating the great importance of macro-economic and financial variables is appears of little value to start implementing an operational price and price volatility forecasting system in the absence of reliable forecasts of the macro-economic and financial variables. Also in view of developing a non-stationary model for market stabilization policy design in T8.4 we decided to report for D8.3 on a sensitivity analysis with respect to the fluctuating production data. The disturbance exercise performed here mimics more the impact of production short-falls and excess due to deteriorating forecasting skill rather than the impact of the actual production level. This "artificial"' disturbance exercise provides us with insights of a "controlled" statistical experiment, which at this stage gives us better insights on how a value of information of a production forecasting system could be assessed.

The market pressure index can be determined by a conditional forecasting exercise using an array of forecasts informing the regressor variables of the models of choice. Such variables are production forecasts, macro and financial market variables. These forecasts could stem from models of the SUSFANS tool suit or from other sources. Production forecasts for particular production regions are provided by the EU MARS system, the USDA, or even commercial providers such as Thomsen Reuthers. Likewise a production system pressure index could be used to inform the production value of the estimated price forecasting model. Furthermore, exchange rate, stock market forecasts or other economic variables entering the respective price forecasting models could be used. The EWS would have to be adapted to the needs of the user. A Europe based humanitarian organization anticipating high prices or price uncertainty coinciding with a high probability of a major conflict arising in say 6 month ahead would trigger an early order of food supplied potentially needed to save lives in the arising conflict. Alternatively, a pig farmer sourcing soy indexed to the Brazilian market might want to engage in a soy option trading arrangement to contain input price risk based on certain market pressure index forecasting signal. A country like Algeria might be interested to buy a food price index insurance contract to avoid temporary current account imbalances and renewed food riots based on a European wheat price pressure index. While Algeria would be only interested in hedging against very extreme price situations the humanitarian organization and the farmer might be incentivized at much lower price process signals from the market pressure index. Thus, depending on the user of the price forecasting products developed in SUSFANS different trigger indicators and values for action can be formulated. The forecasting model together with the trigger indicator and the trigger or threshold value then define an EWS tailored to the needs of the respective user.

2 Sensitivity analysis with respect to the production data

In the following we study how forecasts and thus the forecast performance measures for grain commodities such as wheat, soybeans and corn have changed when the production data on these commodities were slightly perturbed. We perform model re-estimations with the simulated and perturbed production data instead of the actually realized observations of the production data. Two interpretations of the re-estimation experiment are possible. The perturbation stands for the fluctuation of the shift in the actual shift in the production or a shift in the production from the forecasted quantity due to and unexpected production event. The the simulation the perturbation of the production data was performed in the following way

$$y_{mt}^{loc,sim} = y_{mt}^{loc} + \hat{\sigma}_m^{loc}\epsilon_t \tag{1}$$

where y_{mt}^{loc} is the production of commodity m (m = wheat, soybeans or corn) at time t and location loc where loc = world, US and EU for wheat, loc = world, US and Brazil for soybeans and loc = world, US and China for corn. The error term ϵ_t in (1) in this experiment is assumed to follow a standard normal distribution, $\epsilon_t \sim N(0, 1)$, and $\hat{\sigma}_{m,loc}$ is an estimated standard deviation of the error terms corresponding to the production variable if this production variable is a part of the best model. Best models are reported in Table 6 for wheat, Table 9 for soybeans and Table 12 for corn (see D8.3 document). We have conducted 100 simulations ($sim = 1, \ldots, 100$) for each best model where the corresponding production variable occurred. In more detail

$$y_{mt}^{loc} = \psi_0 + \sum_{l=1}^{p} \psi_l' x_{t-l} + \vartheta_{mt}^{loc} \tag{2}$$

where $\vartheta_{mt}^{loc} \sim N(0, \sigma_m^{loc})$, ψ_l is the vector of coefficients ($l = 1, \ldots, p$) and x_t is the vector consisting from the variables of the best models (such as the commodity price or fundamental, macroeconomic, financial or climatic variables). Results, namely the forecast performance measures such as mean absolute error (MAE), mean square error (MSE), directional accuracy (DA), directional value (DV), return from a simple trading strategy and its Sharpe ratio, are presented in Table 1 for wheat, Table 2 for soybeans and Table 3 for corn for both the actual production data and the simulated production data. The presented performance measures based on the simulated production data are averages of 100 performance measures that were calculated with respect to the simulated production data. Note that if the best model contains more than one production variable (related to different locations) then the simulation exercise is repeated for each production variable separately while keeping the actual values of remaining production variables.

Key Results A number of key results can be observed from the simulation experiment using simulated production shocks:

In all instances the performance based on the perturbed/simulated production data is worse than the performance based on the actual production data. This might suggest that production shocks are actually correctly priced in.Relative performance seems to scale with the size of production which is natural as the shock was also implemented accordingly. However, this scaling is not fully consistent. The inconsistency might give an

	MAE	MSE	DA	DV	return	Sharpe ratio
Forec. horizon: 1-month						
Actual	7.331	128.674		84.351	37.015	0.514
Simulated						
y_w^{world}		131.503		77.801	28.977	0.397
y_w^{US}	7.536	134.233				
y_w^{EU}	7.529	131.851				
Forec. horizon: 3-months						
Actual	17.930	702.687	74.306	83.032	28.086	0.574
Simulated						
y_w^{world}		720.376	71.181	79.610	24.405	0.488
y_w^{EU}	18.048					
Forec. horizon: 6-months						
Actual	22.839				26.808	0.799
Simulated						
y_w^{world}					25.382	0.739
y_w^{US}	23.836					
Forec. horizon: 9-months						
Actual		2090.370	81.944	88.849	23.242	0.744
Simulated						
y_w^{US}		2108.067				
y_w^{EU}		2160.638	80.243	83.405	20.846	0.644
Forec. horizon: 12-months						
Actual	35.394	2491.006				
Simulated						
y_w^{US}	41.757	3146.583				

Table 1: Actual and simulated values of performance measures based on the best models for wheat.

indication on the value of information of forecasting systems in a particular region.The performance measured by the different indicators also do not provide a consitent evaluation of the performance of the models with respect to the shocks implemented. This suggest that depending on the shock a user needs to decide which indicator is more appropriate.

3 Market pressure index

For the purpose of developing a trigger value for a potential price EWS we calculate a market pressure index. This index can be use to define threshold values to establish for example a traffic light system of market pressure alerts on a continuous basis with respect to the different forecasting horizons. These threshold values are yet to be defined. Ideally, an expert panel of specific user groups should define such threshold values for their individual use cases.

	MAE	MSE	DA	DV	return	Sharpe ratio
Forec. horizon: 1-month						
Actual	17.095	633.045				
Simulated						
y_s^{BR}	17.350	640.527				
Forec. horizon: 3-months						
Actual	37.902	2740.142				
Simulated						
y_s^{world}	38.208	2777.909				
Forec. horizon: 6-months						
Actual			67.361			
Simulated						
y_s^{world}			64.229			

Table 2: Actual and simulated values of performance measures based on the best models for soybeans.

	MAE	MSE	DA	DV	return	Sharpe ratio
Forec. horizon: 1-month						
Actual	9.505	180.601		73.650	28.938	0.334
Simulated						
y_c^{world}	9.710	190.294		69.959	23.389	0.271
y_c^{US}	9.553	182.251				
y_c^{CH}	9.580	182.702		70.434	24.008	0.278
Forec. horizon: 3-months						
Actual	18.149	613.232	71.528	80.985		
Simulated						
y_c^{world}	18.280	671.802				
y_c^{CH}	18.526	662.946	70.653	79.935		
Forec. horizon: 6-months						
Actual		1241.291			23.513	0.578
Simulated						
y_c^{CH}		1275.882			20.655	0.501
Forec. horizon: 9-months						
Actual	28.901	1696.506				
Simulated						
y_c^{US}		1822.524				
y_c^{CH}	29.058	1769.972				
Forec. horizon: 12-months						
Actual	30.973	1774.714	88.194	92.452	21.657	0.844
Simulated						
y_c^{US}	34.692	2329.445	79.771	85.390	17.624	0.642
y_c^{CH}	33.615	2149.343	81.410	87.399	18.280	0.670

Table 3: Actual and simulated values of performance measures based on the best models for corn.

A humanitarian organization would define early warnings at a different threshold than a producer organization.

Market pressure index, I_m, for each commodity m under consideration (wheat, soybeans, corn, coffee) was calculated as follows

$$I_{m,t} = 100 \ln \left(\frac{\hat{P}_{m,t+h|t}}{P_{m,t}} \right) \tag{3}$$

where $P_{m,t}$ is the price of commodity m at time t and $\hat{P}_{m,t+h|t}$ is the price forecast of commodity m at time t for time $t+h$. The price forecasts were generated by the best models with respect to the directional value performance measure (DV).
For a given agricultural commodity, this variable provides the percent difference between the predicted price and actual price where the predicted prices is based on market fundamentals, macroeconomic and financial developments, as well as the dynamics of climatic variables. The forecasting model used to obtain the predictions is chosen after an exhaustive scrutiny of the predictive ability of a large number of state-of-the-art multivariate time series specifications and combinations thereof. The index indicates whether the prevalent climatic and economic conditions are expected to lead to an increase or a decrease of the price of a particular agricultural commodity at a given horizon (from one to twelve months ahead) and by how much the price is expected to change.

Figures 1, 3, 5 and 7 present the dynamics of the market pressure index for wheat, soybeans, corn and Arabica coffee based on the forecast horizons 3, 6, 9 and 12 months. On the other hand, figures 2, 4, 6 and 8 present both market pressures index together with the realized change of the actual price for the forecast horizons 1, 3, 6, 9 and 12 months. The quantity (in %) presented in the titles of the latter set of pictures gives the percentage on how many times the direction of the market pressure index and the realized change in actual price values coincide for the last 12 years. It can be viewed as the directional accuracy measure (hit rate) over the period of last 12 years (back from January 2016). Note that the highest hit rates for all forecast horizons were achieved for wheat: 72% for one month horizon, 74% for 3-months horizon, 81% for 6- and 9-months horizons and 83% for 12-months horizons. Note in addition that for all grain commodities the directional accuracy increases with increasing forecast horizons.

4 Conclusion and suggested ways forward

In this deliverable we have evaluated two principle components of a comprehensive early warning system involving price and price volatility forecasts potentially linked to a physical production forecasting system such as the JRC MARS system. The JRC MARS system's forecasting skill was evaluated under conditions of "regular" and extreme production con-

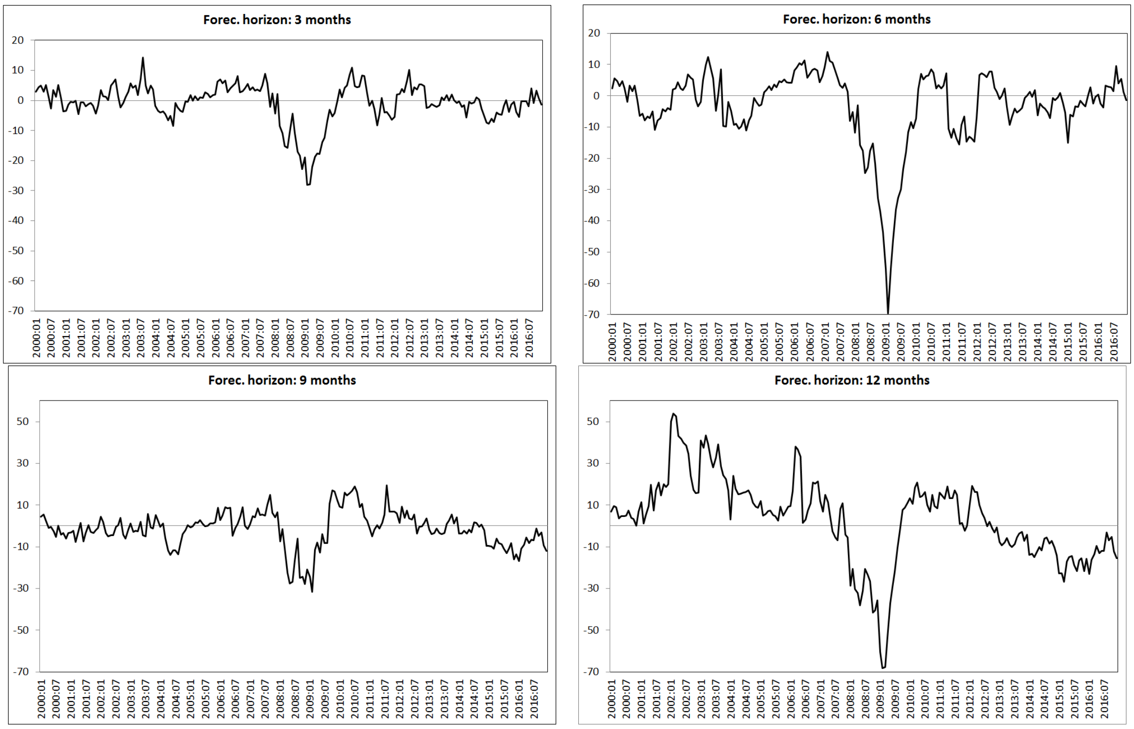

Figure 1: Market pressure index for wheat.

ditions. We observed that the forecasting skill deteriorated up to 10% forecasting error in extreme years. This indicates that in extreme years drivers of forecasting skill deterioration of the crop production system might be compounded with economic driver variables. However, under regular conditions we can conclude from our production shock experiments that the deterioration in price forecasting skill seems to be correlated with the size of the production shock depending on the overall contribution of information about the production fundamentals.

In this deliverable we have evaluated the components of a potential fully automatized and unsupervised price and price volatility EWS, which would be straight forward to implement together with the JRC MARS system or more on a global scale together with AMIS information feeds. It is recommended that such EWS should, however, only put into operation together with respectively high performing forecasting systems of the necessary macro-economic and finanical variables driving the agricultural commodity price and price volatility models estimated by SUSFANS forecasting models. Further research needs to be conducted to build and select appropriate macro-economic and financial market forecasting models to drive food price models. These issues need to be discussed with the relevant Commission services and shall be conducted within the scope of the SUSFANS project.

Within the SUSFANS framework the price4casting model can serve multiple purposes. One of the original ideas was to develop a price and price volatility estimator to inform long-

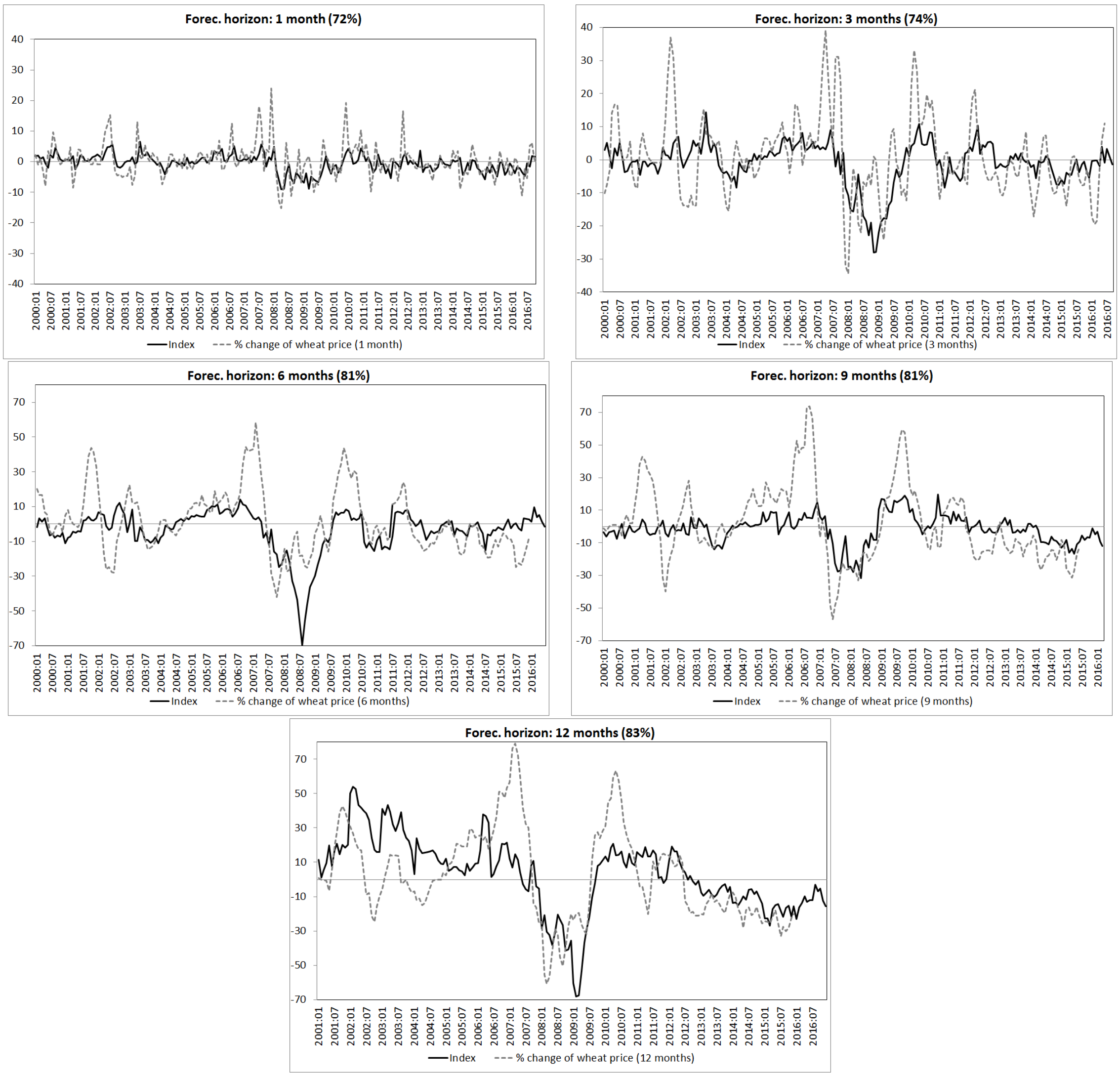

Figure 2: Market pressure index and the percentage change of the wheat spot price.

run food security models. This is motivated by the fact that it is less the slowly moving price trends which create episodes of food insecurity, but it is more related to extreme events including episodes of price volatility and price uncertainty both as an endogenous factor due to the shock as wells as the main external shock on the respective food system. Together with the market pressure index from either the GLOBIOM or also MAGNET model episodes and subsequent states of food insecurity in vulnerable geographies can, thus, be better characterized. Also for long-run assessment of the stability of FNS a price volatility reaction function can serve valuable insights provided that the overall market pressure conditions are replicable in such a longer-run future. It is also recommended that the current statistical methods determining the number of hungry and food insecure should be enriched by indicators of

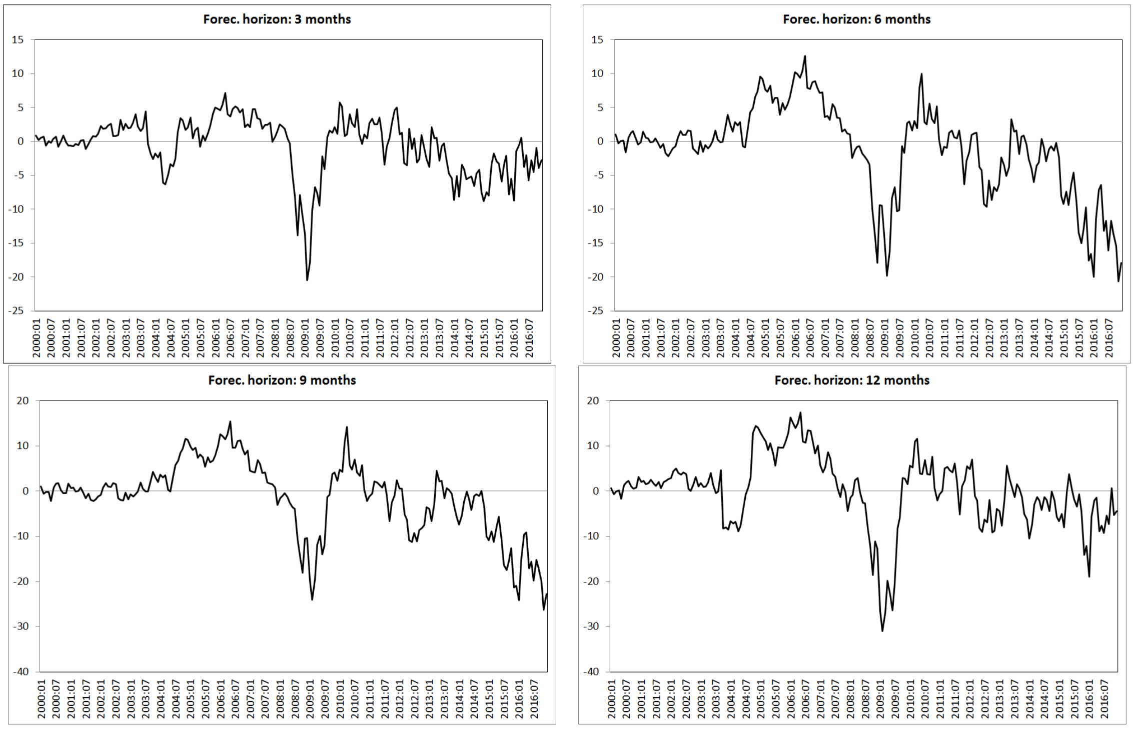

Figure 3: Market pressure index for soybeans.

price volatility. Targeted research in this direction should be conducted with partners such as the FAO or IFAD to generate evidence from household or individual level analysis of the impact of volatility and subsequent up-scaling methodologies. Following this line of research the collection of high frequency price data from a multitude of market locations would be a prerequisite to roll out such a new market and food security system. The usefulness of crowd-sourcing tools seem to be self-evident.

The price4casting models presented here can also be used by the partial equilibrium models of SUSFANS to better inform investment decisions on the farm level. Uncertainty and stochasticity in future returns from agricultural produce will induce mainly waiting behavior and lead on an aggregate scale to more inertia of technological adoption and diffusion. Furthermore, the higher the price uncertainty the lower the propensity of farm enterprise to invest in capital cost items. Such micro-calculations could help inform parameters in the partial and even general equilibrium models of SUSFANS on the likelihood of system shifts was wells as exogenous assumptions of productivity or efficiency increases. In order to derive numerical values for more aggregate models it would be necessary to develop and deploy stochastic optimization models for farm or even field level decision making under price uncertainty. The respective theories and tools can be found in the classical investment theory such as real options and portfolio approaches.

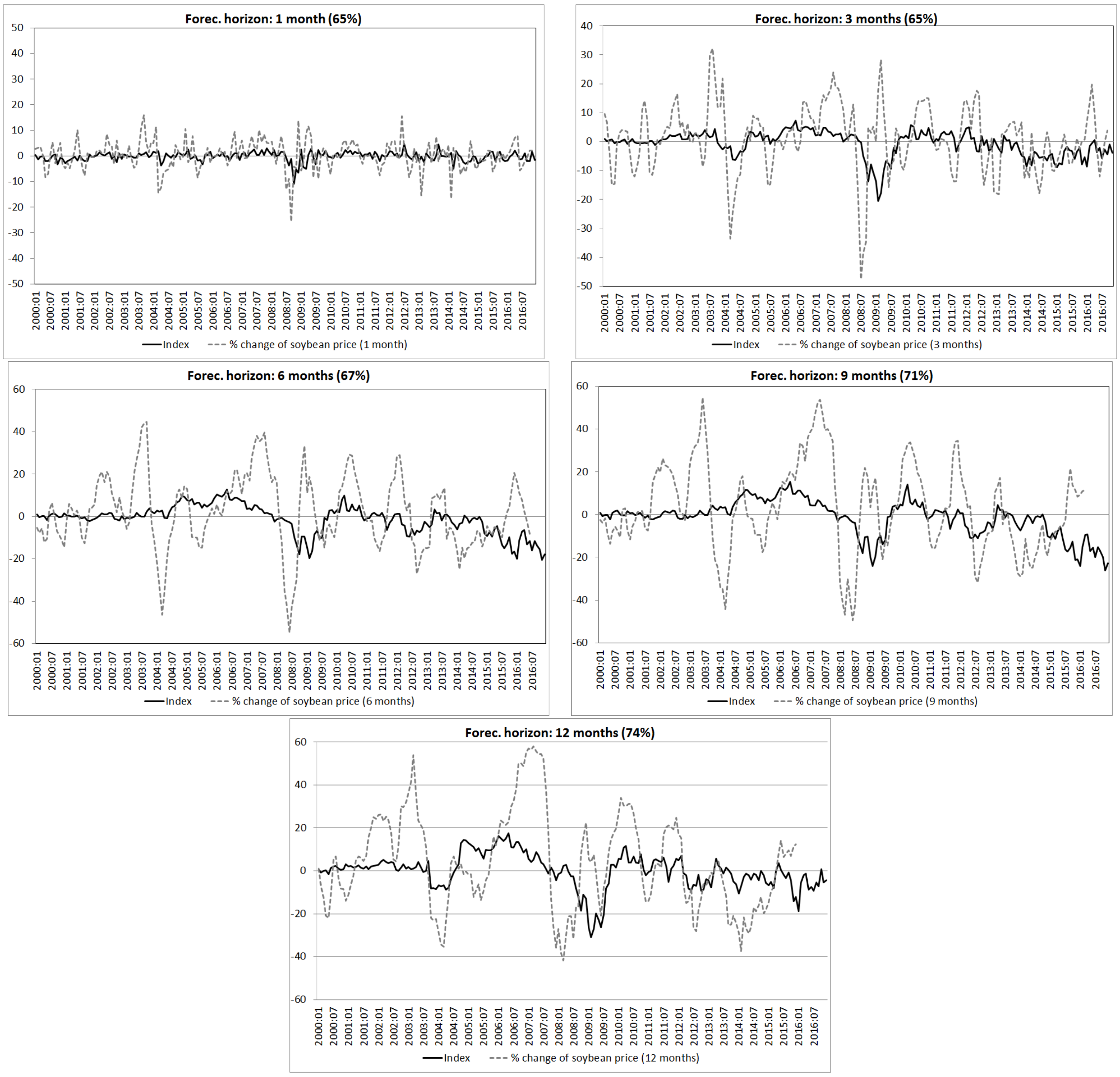

Figure 4: Market pressure index and the percentage change of the soybeans spot price.

The EWS function of the price4casting tool was also designed for serving the humanitarian community and there would be merit develop such a system in follow-up project to SUSFANS. Not only that the price4casting models could help optimize the financial risk management of humanitarian organizations but the methodology could also help to improve the predictive power for event forecasts if appropriate regressor variables could be sourced. It has to be noted that proper risk management for humanitarian organizations using the price4casting tool would be of enormous value as the hazards of high prices for emergency food supply purchases and the likelihood of outbreaks of conflicts are highly correlated. There are of course exceptions such as the hazards of earthquake events are uncorrelated to food prices. Furthermore, humanitarian organizations could use such risk quantification tools to develop

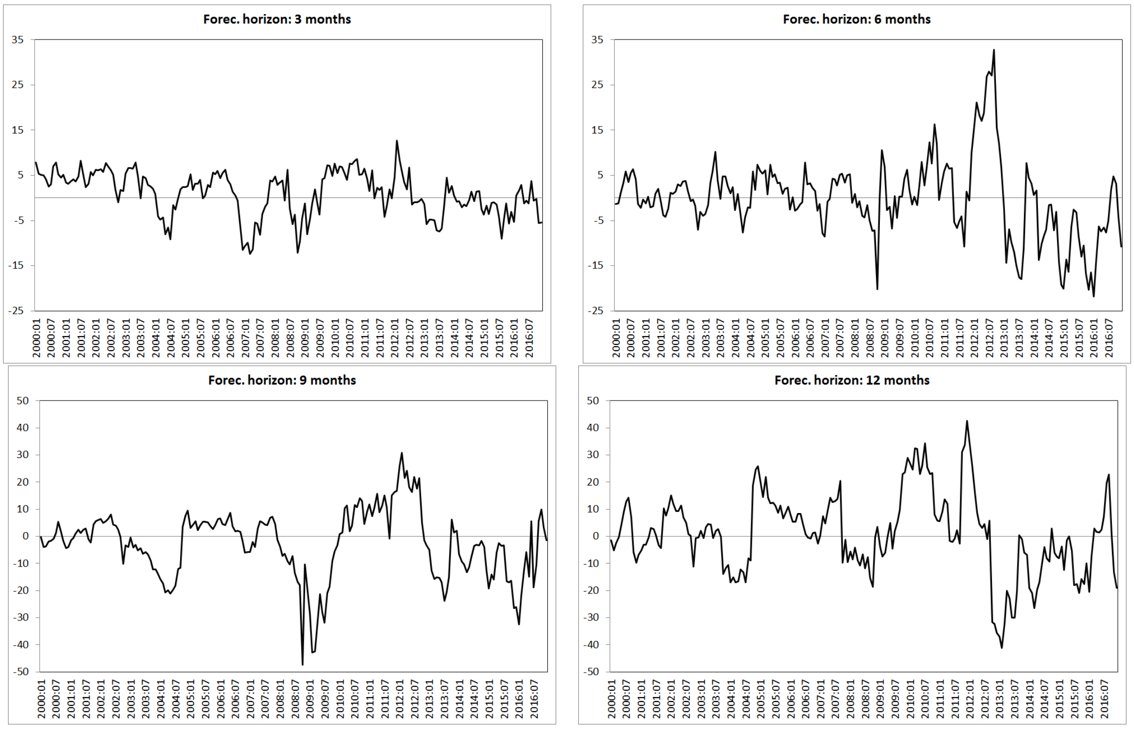

Figure 5: Market pressure index for corn.

physical or financial insurance arrangements.

Food and food price volatility will certainly also impacts consumption patterns, not only in situations of humanitarian emergency. In SUSFANS it was not investigated how the price4casting model could be used to improve the understanding of consumer behavior in the SHARP model. It is well conceivable that price and price volatility induced changes can be expected in terms of consumption behavior in general and for food products in particular. A focused study on the impact of price volatility on dietary shifts of poorer households in the EU would be recommended including epidemical studies.

Food price volatility will definitely also have an impact on the behavior of downstream actors of the EU Food system. The price4casting model would definitely be of great value for larger players in the industrial food chain using financial instruments to more efficiently derisk their financial exposure to commodity price volatility. It has been observed that European actors make increasingly more use of financial instruments such as Asian option constructions to better manage their financial performance. The price4casting model developed in SUSFANS could potentially be of large value to the industry and the performance of the EU food sector overall and even boost its competitiveness. The value of the combination with the long-run tools of SUSFANS for the operations of supply chain actors and their desire to

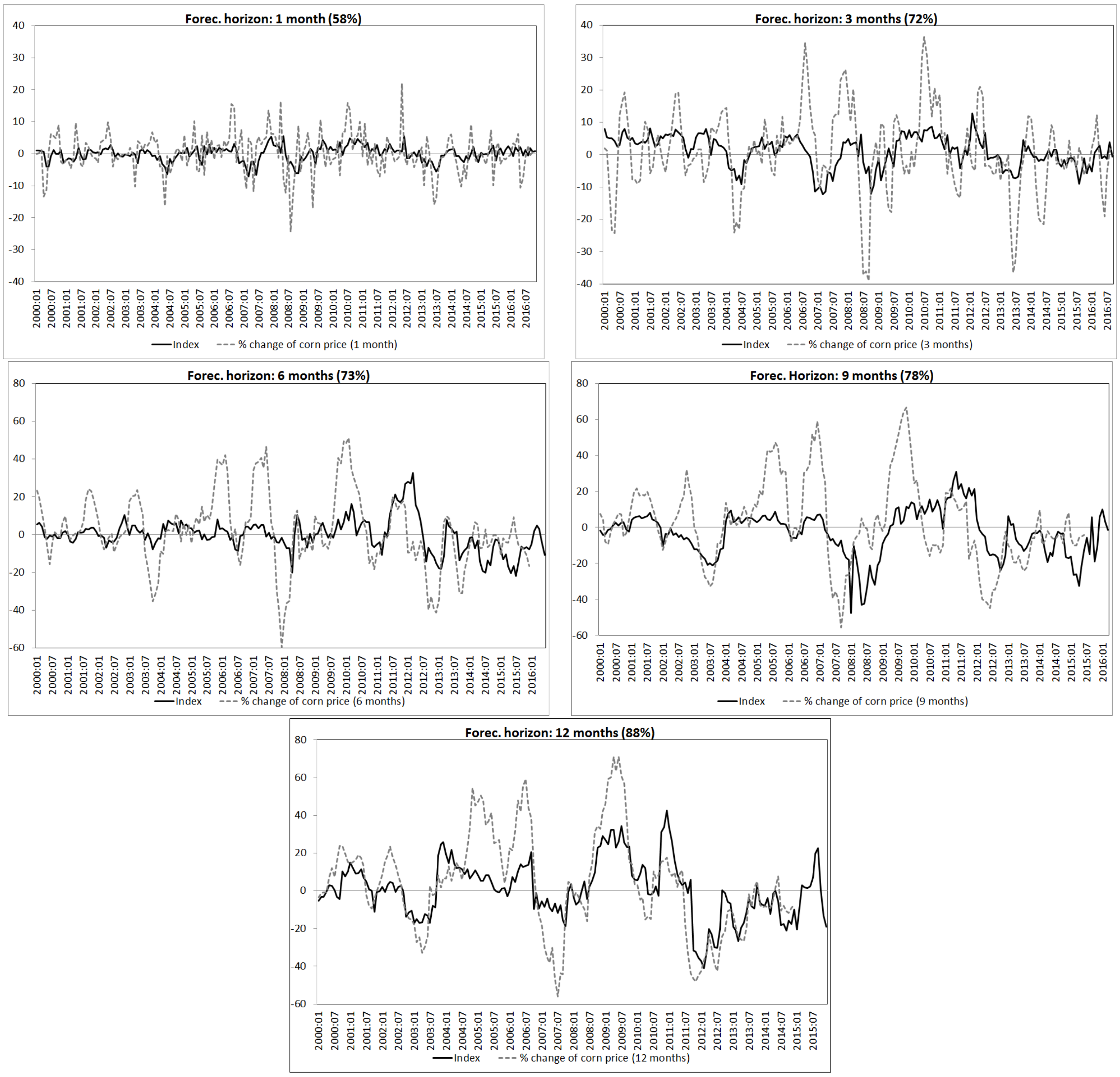

Figure 6: Market pressure index and the percentage change of the corn spot price.

manage also longer range risks for larger capital investments still needs to be demonstrated.

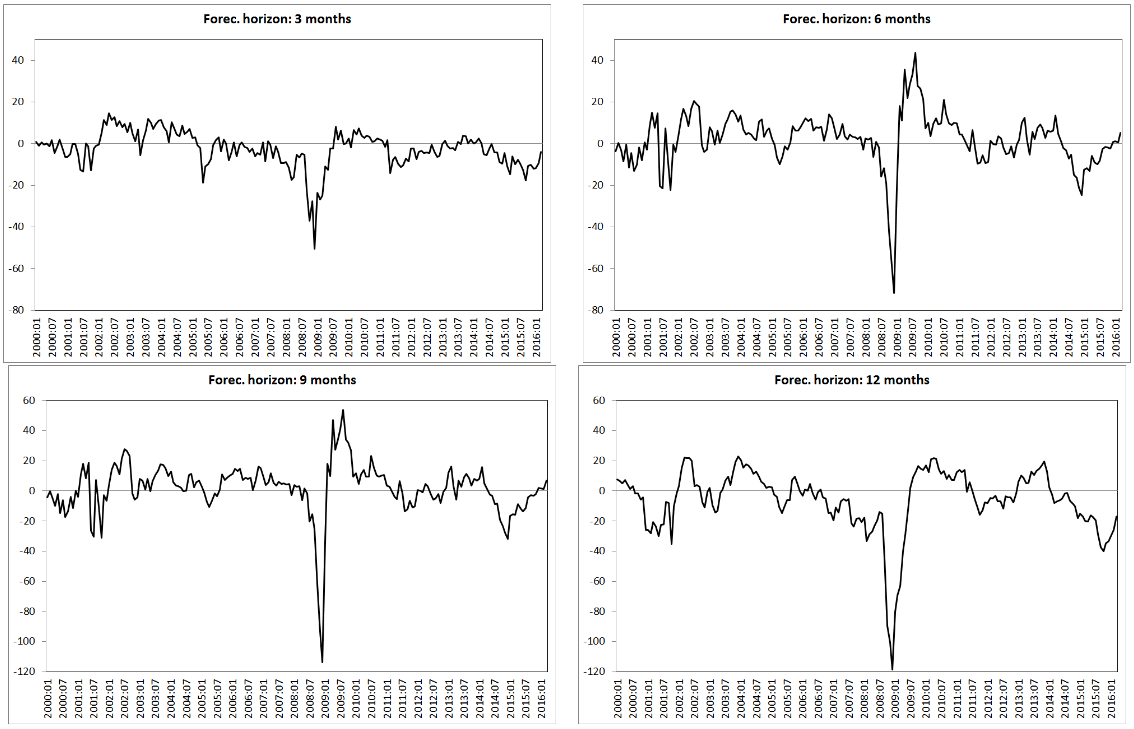

Figure 7: Market pressure index for Arabica coffee.

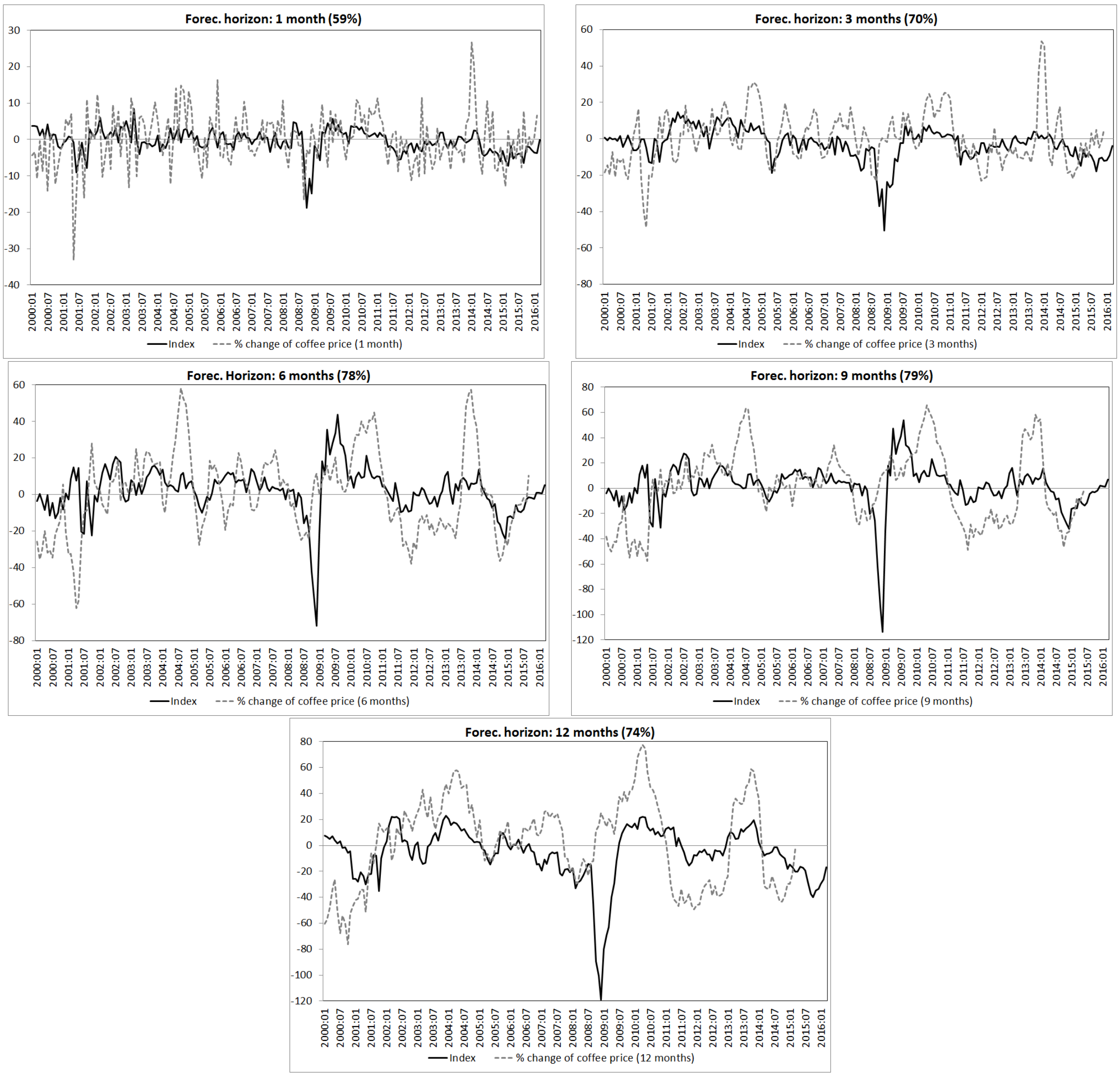

Figure 8: Market pressure index and the percentage change of the Arabica coffee spot price.