A Note on Price Risks in Swiss Crop Production – Empirical Results and Comparisons with other Countries

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Abstract
The liberalization of Swiss agricultural markets will not only decrease crop price levels but is also expected to increase the volatility of prices. Even though these potential increases in price volatilities for Swiss producers are acknowledged as an important fact, no empirical estimates are available yet. To fill this gap, we estimate absolute and relative crop price volatilities of wheat, barley, maize, triticale, potato, rapeseed, and sugar beet applying autoregressive models using annual price data for the period 1991–2009. The results for Switzerland are compared with estimates for the USA, Germany, France, and the Netherlands. Relative price volatilities, expressed by the coefficient of variation, are found to be lower in Switzerland by a factor of 2–3 compared to the other considered countries. For some crops such as potatoes the differences are even higher. An increase in price volatilities of this magnitude due to market liberalization may become a threat to Swiss farmers. Thus, anticipatory actions of policy makers and producers with regard to the development of price risk management strategies might worth to be considered.

Keywords: *crop price volatility, time series analysis, agricultural markets, Switzerland*

JEL classification: *Q1, E3*

1. Introduction

The liberalization of agricultural markets and its impact on farm income and farming structure are highly discussed topics in Swiss agriculture (see e.g. Baldwin and Hufbauer, 2006, BLW, 2009a, Bösch et al., 2011, Jörin et al., 2006)[1]. In particular for the crop producing sector, price reductions are expected due to market liberalization and its effects on Swiss agriculture has been addressed in several recent studies (e.g. Bergmann et al., 2009, BLW, 2008, Huber and Lehmann, 2009, Peter et al., 2009). In addition, further integration into the European market not only affect mean prices but is also expected to increase price volatility (BLW, 2009b).
However, the potential effects of market liberalization on crop price variability are still debated in the literature (e.g. Poulton et al., 2006) and the change from protected to more open markets must not necessarily increase price risk which is illustrated by the following two extreme cases:

A) First, we assume a small country without commodity trade which solely depends on domestic crop production. If crop yields in a specific year are exceptionally low, there will be a shortage of supply. Assuming inelastic demands for agricultural products this will lead to an increase in domestic price levels. In contrast, crop prices will decrease sharply if yields are high because no export of crops is possible (note that this is an extreme example for illustration purposes). The described situation implies that volatilities in domestic production levels are transmitted to crop prices to a very large extent. In contrast, if trade would be allowed, goods are imported if domestic prices are higher, and exported if they are at lower than the international level. Even though transaction and transportation costs will affect this transmission process, the possibility to import and export agricultural products would set limits to domestic price fluctuations (Poulton et al., 2006, Rapsomanikis and Sarris, 2008, Winters et al., 2004). The described example, however, usually reflects the situation in developing countries were resources allowing for high trade integration (e.g. financial resources, infrastructure) are very limited (cp. Poulton et al., 2006, Winters et al., 2004).

1 Note that on March 07, 2012, the parliament decided to stop the negotiations on free trade agreements for agricultural markets with the European Union (http://www.parlament.ch).

B) In contrast to the situation described in example A, a small country like Switzerland is already involved in agricultural trade, especially with European countries. However, trade is highly regulated by tariffs, quotas, subsidies and other trade regulations that are used flexibly to adjust (the price of) imports if domestic supply is low, and to prevent imports competing domestic producers if the supply is sufficient. This means, domestic prices are usually on higher than international levels. Furthermore, the flexible adjustments of imports imply that price volatilities, for instance from European markets, are transmitted only to a limited extent to the Swiss market. Because imports are mainly used to meet excess demand unmet by domestic production, price fluctuations from international markets are not fully reflected in domestic producer prices. However, if market liberalization (by agreeing on certain rules on trade distortions) unables policy makers to flexibly adjust trade flows, price swings from international markets will be transmitted to domestic producers. The here described situation is obviously not unique to Switzerland because also other developed countries (e.g. the European Union) protect domestic producers from international markets, however, to a smaller extent. Along these lines, empirical and theoretical findings for other developed countries support the expectation that market liberalization (i.e. the reduction of border protection measures) increases price volatility (e.g., Yang et al., 2001, Berg, 2002, Mahul, 2003).

Even though potential changes in price variability are acknowledged as an important issue for Swiss agricultural policy (BLW, 2009b), they have never been studied empirically so far. To fill this gap, this paper gives a first brief empirical indication for differences in absolute and relative crop price variability between Switzerland and other countries. This comparison may contribute to a more specific knowledge on the kind and magnitude of price risk changes for Swiss crop producers. Note that we are aware that the extent of increased volatility due to market liberalization is difficult to predict. Our analysis thus not aims to make predictions, but rather to present comparisons across countries that give first indications on potential effects. Furthermore, we aim to present more insights in the topic of price volatility and price risk management that might be useful for stakeholders in Swiss crop production.

To this end, we estimate the absolute and relative variability of prices for Swiss crops and compare them with results obtained for France and Germany, two of the most important crop producers in the European Union and important trade partners of Switzerland. Given that Swiss crop production is marginal in the context of Europe at large, the market conditions in these countries should reflect likely market conditions in Switzerland under market liberalization. Furthermore, we include the United States of America as a proxy for the world market and the Netherlands that represents a small crop producing country in the European Union. We investigate the seven most important crops for Switzerland, namely wheat, barley, maize, triticale, potato, rapeseed and sugar beet. The remainder of this paper is organized as follows: The data and estimation methods and results are presented in section 2 and 3, respectively. Section 4 provides a brief overview on price risk management instruments for farmers and section 5 summarizes the results and concludes the paper.

2. Data and Methodology

2.1 Data

We use annual (nominal) producer price data[2] of wheat, barley, maize, triticale, potato, rapeseed, and sugar beet in US Dollar per ton[3] for the period 1991–2009. The data is taken from the database of the FAO (2011), which has been chosen to ensure consistent definitions of price levels for all countries and crops. Furthermore, we decided to use US Dollar as currency to enable comparisons between countries. However, we are aware that the price variabilities estimated in US Dollar can comprise exchange rate fluctuations that are not faced by

2 «The producer's price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any VAT, or similar deductible tax, invoiced to the purchaser. It excludes any transport charges invoiced separately by the producer. Time series refer to the national average prices of individual commodities comprising all grades, kinds and varieties, received by farmers when they participate in their capacity as sellers of their own products at the farm gate or first-point-of-sale.» (FAO, 2011).

3 The conversion to US Dollar is defined as follows: «Prices in US Dollars are equal to producer prices in local currency times the exchange rate of the selected year. The main exchange rates source used is the IMF. Where official and commercial exchange rates differ significantly, the commercial exchange rate may be applied.» (FAO, 2011).

all producers, i.e. are an artifact of the calculation. Thus, we repeat all presented calculations also in local currencies.

Though monthly prices of the considered crops would be available for Switzerland, they usually do not differ within a year, but only discrete jumps from one (constant) level to another occur (SBV, 2010). To provide a recent (but representative) example, the price index for cereals was constant from December 2010 till July 2011, but increased by 3% in August 2011 where it remained so far (January 2012) (SBV, 2010). This type of variation is in contrast to monthly price variations observed in many other countries, and simply boils down to price differences across years, not months. Annual prices are thus the only data to work with yet. Restricting on annual price data, however, decreases the sample size considerably and thus limits our statistical analysis.

2.2 Methodology

Following the economic literature, we define risk as the economically relevant consequences of changes in the market or institutional environment, and we refer to the variability of prices as example for risk faced by a farmer (Moschini and Hennessy, 2001, Musshoff and Hirschauer, 2011). The terms price variability and price volatility are used interchangeably in the following. Absolute (e.g. the standard deviation) and relative (e.g. the coefficient of variation) measures can be used to measure price volatility. While the former measure allows for the interpretation of price volatility in its original values, the latter enables the comparison of price risk based on different price levels, e.g. between different countries. We will use both, the standard deviation and the coefficient of variation, to assess price risk in Swiss crop production and for comparisons of price volatility between different countries.

To accurately measure price volatility, deterministic price developments, i.e. trends in the mean, must be removed from the time series. At first, if price developments are deterministic, farmers are assumed to associate (parts of) these long-term developments in their decisions. Second, ignoring trends in the data would cause an overestimation of the standard deviation and coefficients of variation and thus risk. As shown in Figure 1, crop prices for European countries tend to decrease in the here considered time period 1991-2009 and an estimation of price variability using the raw price data would be misleading. However, the actual prices may differ from their long-term trend due to many reasons, e.g.

due to exceptionally high or low production levels. This (non-deterministic) deviation from expected price levels is considered in our analysis as risk faced by the farmer (see e.g. Finger, 2010, for references).

To account for the time trends in the data, first differences are used. To control for alternative approaches to remove this deterministic development, we additionally based our analysis on parametrically (linear, quadratic, and cubic) detrended time series which has, however, not affected the qualitative interpretation of the results. Moreover, the dependency structure (autocorrelation) between the observations must be considered to not over- or underestimate price volatility.

In order to analyze the auto-correlated time series of crop prices adequately, a Box-Jenkins approach for time series analysis is employed (Box and Jenkins, 1970). Due to the small number of observations (i.e. the lack of sufficient degrees of freedom), the power of the unit root test is clearly limited (Sarris, 2000). Thus, we focus on graphical inspection of the time series in our analysis (see Johnston and DiNardo, 1997, for details).

Following Sarris (2000), we use an ARMA (autoregressive moving average) model to account for the dependency structure in the time series[4]. The ARMA model is defined as follows:.

$$P_t = \varepsilon_t + c + \sum_{i=1}^{p} \varphi_i P_{t-i} + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i}$$

Where P_t is the crop price at time t, and being the error term that is assumed to be identically and independently distributed (i.i.d.) and follows a normal distribution.

4 To additionally account for the heteroscedasticity in the employed time series model, GARCH (generalized autoregressive conditional heteroscedasticity) models could be employed. However, the low number of observations in our analysis restricts its application. For future research that can rely on larger datasets, these types of time series models can be an important tool to test if liberalization steps induce increasing volatility over time.

$$\sum_{i=1}^{p} \varphi_i P_{t-i}$$

represents the autoregressive (AR) part and

$$\sum_{i}^{q} \theta_i \varepsilon_{t-i}$$

represents the moving average (MA) part of the model with order p and q (i.e. how many lags are taken into consideration for the AR and MA part of the model), respectively (see e.g. Johnston and DiNardo, 1997, Box and Jenkins, 1970, for details). Assuming that cereal prices follow an ARMA process around a nonzero mean, c represents the model intercept.

At the model identification stage, we use the autocorrelation functions and partial autocorrelation functions to specify the ARMA model. The autocorrelation function (acf) at lag s is defined as the ratio of covariance and variance of the observations in period t and t-s: $\rho_s = \mathrm{cov}(P_t, P_{t-s}) / \mathrm{var}(P)$ The partial autocorrelation function (pacf) at lag s is the autocorrelation between P_t and P_{t-s}, where the influence of all in-between lags (i.e. lag 1 through lag s-1) has been removed. The patterns of the autocorrelation function and the partial autocorrelation function are used to identify if the model is of autoregressive, moving average or mixed form and to identify the order of the model (see e.g. Johnston and DiNardo, 1997, for details). If an ARMA model is selected, it is compared with other possible model specifications (i.e. order of p and q) using the Akaike Information Criterion. Finally, model diagnostics are performed on the selected model. In order to check for the normality of model residuals, quantile-quantile plots and histograms are used. The Ljung-Box test and plots of autocorrelation functions and partial autocorrelation functions are used to analyze if the model residuals still contain serial correlation patterns.

The acf and pacf plots[5] (i.e. the correlograms) of the cereal prices suggest an autoregressive models of order 1, AR(1), for all time series. As first differences were used, the final model can thus also be denoted as ARIMA (1,1,0) model

5 The acf plots show autocorrelations that «dye out», which is a typical pattern for AR processes, and the pacf plots indicate a model order equal to 1 (Johnston and DiNardo, 1997).

which is also supported by the residual diagnostics . For all crops and countries the null hypothesis that the residuals from the ARIMA models are independently distributed could not be rejected by Ljung-Box tests.
In AR(1) models, the residual variance estimate is corrected for the dependency structure at lag 1 as follows: $\sigma_P^2 = \sigma_\varepsilon^2 / (1-\varphi_1^2)$, where σ_P^2 is the variance of differenced prices, σ_ε^2 the variance of the error terms and φ_1^2 is the squared first coefficient of the AR model. Thus, the higher the dependency (correlation) between subsequent price observations (i.e. φ_1), the higher is the difference between the residual variance and the variance estimated in the AR model. Based on this empirical relationship, we will calculate and present standard deviations of crop prices, as an absolute measure of price risk.
To furthermore account for trade-offs between price variability and expected price levels as well as to enable a 'risk comparison' across crops and countries, we will additionally employ the coefficient of variation as a relative measure of price risk. In order to calculate coefficients of variation, the standard deviation derived from the ARIMA model is divided by the median crop price for the period 2002–2009[6]. This period is chosen to estimate currently relevant median prices because crop prices have decreased significantly during the 1990s but remained relatively stable in the chosen period (compare Figure 1). All presented analyses are conducted with R (R Development Core Team, 2010).

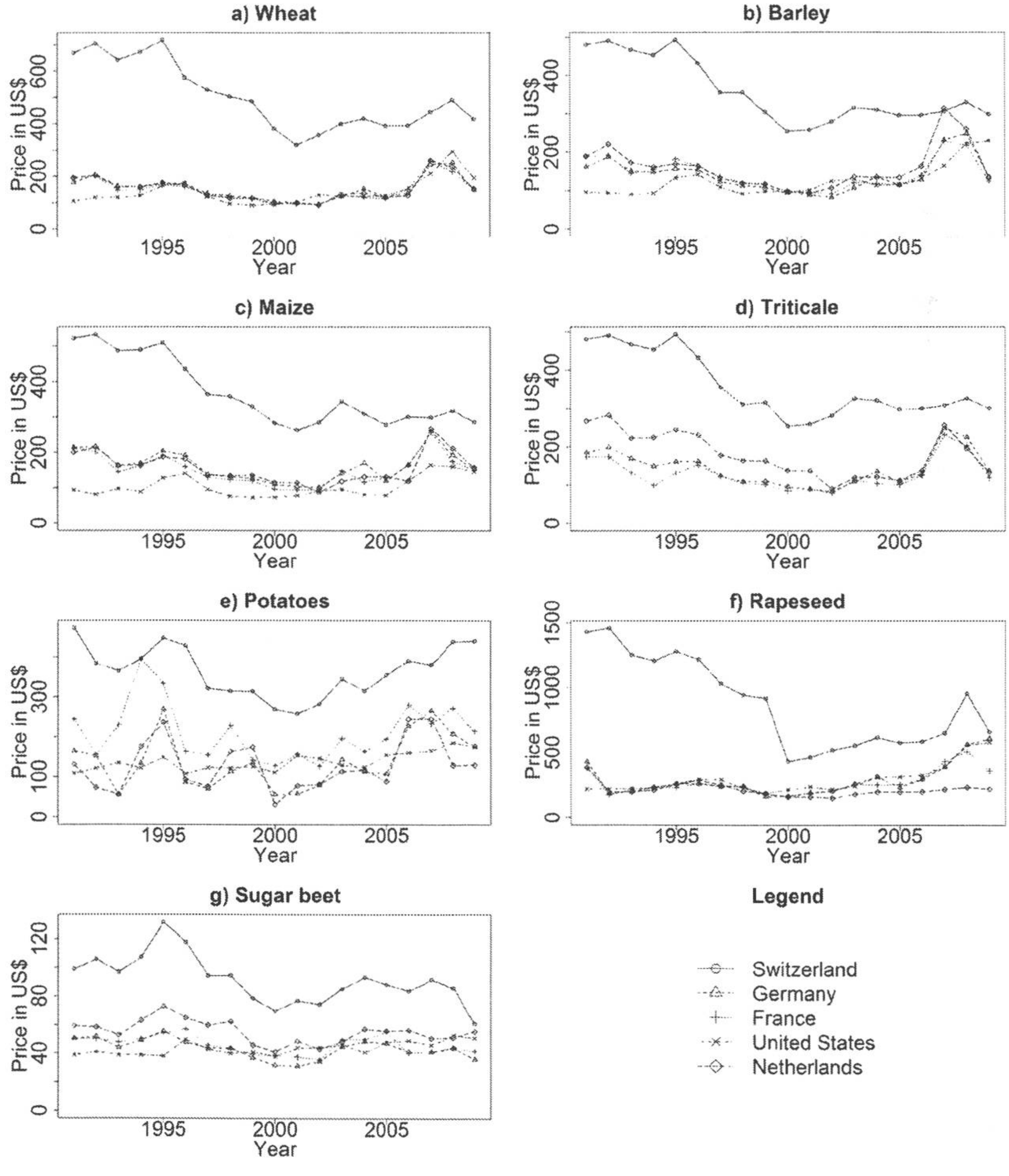
3. Results

Figure 1 shows the prices for wheat, barley, maize, triticale, potato, rapeseed and sugar beet in Switzerland, Germany, France, the Netherlands and the USA for the period 1991 to 2009. Crop prices are markedly higher in Switzerland than in all other countries. However, a decline in prices can be observed for all of the considered crops (except for potatoes) since the early 1990s. Figure 1 shows furthermore that price peaks (e.g. for the years 2007/2008 for most countries and crops) are usually not fully transferred to the Swiss market. Thus,

6 Note that the standard deviation of prices is, however, based on the full period 1991–2009.

Swiss crop prices tend to be less volatile in terms of relative price variability because neither positive nor negative short-term deviations from trends are fully transmitted to the Swiss market.

Figure 1. Prices for Wheat, Barley, Maize, Triticale, Potatoes, Rapeseed and Sugar beet 1991–2009.



Source: FAO (2011).

Table 1 shows the median and mean prices in US Dollar for the period 2002–2009. Compared to other countries, price markups for Swiss crops range from about +60% (comparing sugar beet prices in the USA and Switzerland) to more than 200% (e.g. comparing wheat prices in the Netherlands and Switzerland). This result can be explained by the strong border protection schemes applied in Switzerland, compared to more (but not fully) liberalized markets, for instance, of the European Union. With further market liberalization and integration, Swiss producer prices are likely to converge to the European level[7].

Table 1. Median (Mean) price for the period 2002-2009 in US $.

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	Switzerland	Germany	France	Netherlands	USA
Wheat	409.40	143.45	140.95	135.60	144.00
	(414.58)	(160.11)	(155.28)	(157.90)	(170.75)
Barley	303.00	130.70	122.25	135.70	130.50
	(304.08)	(147.48)	(144.38)	(173.28)	(154.13)
Maize	300.15	159.35	150.20	130.65	107.50
	(303.14)	(162.95)	(154.29)	(152.90)	(117.13)
Triticale	304.75	132.40	115.75	126.90	n.a.
	(307.89)	(147.26)	(134.38)	(145.63)	
Potato	367.55	161.15	206.30	123.55	158.00
	(368.56)	(165.79)	(210.69)	(144.11)	(155.75)
Canola	600.90	303.60	275.40	200.10	321.50
	(639.85)	(359.25)	(321.075)	(200.78)	(367.50)
Sugar Beet	85.65	42.65 (42.28)	43.00	47.00	53.45
	(83.025)		(44.90)	(47.25)	(52.40)

Table 2 shows the estimated standard deviations as well as the calculated coefficients of variation that are derived from the fitted ARIMA(1,1,0) models. We find contradictive results comparing absolute and relative price variability,

7 Of course, the Swiss origin of products may be attributed with some additional willingness to pay from processors and customers, which may induce higher price levels even under market integration (e.g. Bösch, 2012).

i.e. comparing standard deviations and coefficients of variation, respectively. For instance, the standard deviation of wheat prices is by far highest in Switzerland. The conclusion on price variability changes, however, if the absolute deviation of prices is set in relation to the much higher wheat price levels (Table 1). In fact, the coefficient of variation of wheat prices is smallest in Switzerland. Due to high price levels in Switzerland, also the absolute dispersion of crop prices is much higher than in other countries. Thus, to compare price risk between different countries the relative variability of crop prices is the more meaningful expression and we will thus always refer to the coefficient of variation if comparing price volatility[8]. Even though farmer's incomes are affected by absolute price variability, relative price variability remains to be the more meaningful measure to indicate actual income risk arising from price volatility. If high absolute price variability is accompanied with high income levels (e.g. due to high price levels), the relative variability of income levels remains small[9]. Note that also other sources of risk, e.g. from volatile production and cost levels, but also direct payments and off-farm employment affect income variability[10]. Putting the role of price risks in a larger framework considering also determinants of income risk is beyond the scope of this analysis but is presented for Swiss case studies elsewhere (e.g. El Benni and Finger, 2012, Lehmann and Finger, 2012, Finger, 2012a,b).
We find that potato prices are the most volatile in the EU Member states, with coefficients of variation ranging from 0.38 (France) to 0.63 (the Netherlands) (Table 2). High volatility of potato prices for EU Member countries were also found by Artavia et al. (2010), Meuwissen et al. (1999) and EC (2001), who acknowledge that potato is one of the agricultural products with the highest price volatility. This is particularly due to the perishable nature of potatoes that makes it less storable than, for instance, cereals. The price variability of potatoes in the US is smaller than in the EU countries (CV=0.11). Pavlista and Feuz

8 Note that the small sample size limits the application of formal test procedures. Future research relying on larger datasets should however test for differences in coefficients of variation.

9 Note that this trade-off motivates also the analysis of risks in a mean-variance framework (e.g. Musshoff and Hirschauer, 2011).

10 For instance, direct payments decrease the influence of price variability on income risks. Thus, the higher the share of non-volatile direct payments for farmers' income, the lower will be the impact of price volatility for the riskiness of farm business (see e.g. Finger and Lehmann, 2012, for further discussions).

(2005) explain this situation with the effects of market diversification (in particular the strengthening of frozen and fry market) that started in the early 1990s. As expected, the high level of applied border measures such as a quota system and tariffs lead to low price volatility (CV=0.12) for potatoes in Switzerland.
For sugar beets, coefficients of variation are low for all countries, ranging from 0.09 (USA) to 0.15 (Switzerland). No significant differences are found between the here analyzed countries. This can be explained by the fact that sugar is still a highly protected market, with especially strong protection for domestic production. For instance, the EU quota system ensures little price volatility (Musshoff and Hirschauer, 2009). In contrast, the remaining share of sugar freely traded on the world market may be subject to extreme fluctuations (Nganje and Stoltman, 2000).
For EU countries as well as for Switzerland we find coefficients of variation for rapeseed prices in the range of 0.24 to 0.28, which are much higher than those for the USA (CV=0.15). One possible reason for high volatilities might be the production of biofuels from rapeseed, which is especially relevant in European countries (while ethanol production is more relevant in the USA). Hence, the rapeseed price is also influenced by (volatile) energy prices and changes in governmental programs (subsidies, mandatory blending) over the time period considered.
The coefficients of variation of wheat, barley, triticale and maize prices are lowest in Switzerland. For instance, the coefficients of variation range from 0.10 (barley) to 0.14 (wheat) in Switzerland and from 0.26 (maize) to 0.31 (barley) in Germany. On average, the coefficients of variation of cereal prices tend to be 2- (wheat, maize) to 3-fold (barley, triticale) smaller in Switzerland compared to the other analyzed countries.
We also repeated all calculations using (nominal) prices expressed in local currencies to remove the influence of exchange rates on our results. The qualitative results remain as before: relative price variability is by far the smallest in Switzerland. However, differences between Switzerland and the European countries are more distinct: while coefficients of variation for Switzerland become (slightly) smaller, higher relative price variabilities are observed for the European countries. Thus, we have to acknowledge that the here presented comparison of coefficients of variation represents a conservative outlook for likely price variabilities in the future.

Table 2. Coefficients of Variation (and Standard Deviations) of crop prices derived from the fitted ARIMA (1,1,0) models

Table 2. Coefficients of Variation (and Standard Deviations) of crop prices derived from the fitted ARIMA (1,1,0) models

	Switzerland	Germany	France	Netherlands	USA
Wheat	0.14 (57.54)	0.28 (40.53)	0.26 (37.16)	0.31 (41.76)	0.27 (38.75)
Barley	0.11 (33.22)	0.31 (40.51)	0.29 (35.72)	0.38 (51.91)	0.15 (19.82)
Maize	0.12 (36.26)	0.26 (40.76)	0.26 (39.40)	0.33 (43.40)	0.20 (21.67)
Triticale	0.11 (33.81)	0.30 (39.97)	0.33 (38.60)	0.34 (43.37)	n.a.
Potato	0.12 (45.35)	0.46 (74.35)	0.38 (77.37)	0.63 (78.32)	0.11 (17.84)
Canola	0.28 (170.14)	0.27 (81.40)	0.27 (74.21)	0.24 (48.47)	0.15 (46.92)
Sugar Beet	0.15 (12.69)	0.12 (5.30)	0.14 (6.00)	0.13 (6.92)	0.09 (4.19)

Numbers in parentheses denote standard deviations.

In summary, we find no distinct differences for (relative) price volatilities of sugar beets and canola between Switzerland and other countries. However, compared to Switzerland, much higher price variabilities (factor 2–3) were found for cereals in Germany, France, the Netherlands and the USA. Extreme differences in price variabilities have been indicated for potatoes, where relative price variabilities in EU countries tend to be higher by factor 3–5. These results show that Swiss crop producer could face a dramatic increase in price risks if Swiss agricultural markets are further integrated and are opened towards the European Union and/or the world market. However, our results also indicate that differences in price variability are heterogeneous across crops.

4. Managing Price Risks

Swiss farmers currently operate in a climatic and market environment that causes only low inter-annual variabilities of incomes (e.g. El Benni and Finger, 2012). Low price volatility is an important determinant for these low income variabilities. Due to the low income risks currently faced in Swiss agriculture, explicit (market based) risk management measures are – except for the hail insurance – not widespread used or are even not available. However, if price risks increase due to market liberalization in the magnitude indicated by the here presented results, income volatility is likely to increase significantly. Thus, increasing price volatility due to market liberalization may be a substantial threat to Swiss farmers. In order to cope with these risks, all involved stakeholders (e.g. policy makers, farmers union, producer associations) should have strategies at hand to deal with these risks. Because some of these strategies may require several years to be installed effectively, anticipatory actions should be taken as soon as possible to be able to sustain potential increases in price risks in the future. In this process, Switzerland can benefit from various experiences made in other countries in this field. In the following, we identify and discuss very briefly some of the main options that could be relevant. We do not consider governmental intervention to reduce price variability, because this has been proven to be market distorting and welfare reducing (Schneider, 2011). Furthermore, we think that ex-ante strategies provide a more sustainable path to future price risk management, and governmental ex-post strategies are thus not considered. Therefore, we focus on ex-ante on-farm and market solutions that can reduce the impact of price volatility on farmers` income. To analyze the effectiveness of these strategies in Swiss agriculture, further research is needed considering the following options:

- *Diversification*. The idea of diversification is to reduce the risk of the overall return by selecting a mixture of activities that have net returns with low or negative (e.g. price) correlations (Berg and Kramer, 2008, Hardaker et al., 1997). However, diversification might not be the best solution for every farmer. For instance, the change from specialization to diversification can increase marginal costs (i.e. reduce economies of scale) and can therefore lower the average income of farmers. Furthermore, for farms with a broadly diversified production program additional diversification has less value than for a highly specialized farm (Berg and Kramer, 2008).

- *Storage and inter-temporal smoothing.* On-farm storage can reduce the exposure to low crop prices as selling of the harvest can be postponed to later periods (e.g. Bokusheva et al., 2012). For instance, farmers can sell their crops in postharvest periods where price premiums might be present. Moreover, on-farm storage may allow farmers to blend their production to reduce downgrading losses (Strahan and Page, 2003). Furthermore, on-farm storage capacities can reduce the impact of volatile fodder costs and enable inter-temporal smoothing (e.g. Briner and Finger, 2012). Of course, costs are crucial to benefit from on-farm storage.
- *Forward marketing contracts.* Forward marketing contracts (more precisely flat-price contracts) establish the price and the delivery of a commodity of a given quality within a specified time period between producers and purchasers (e.g. processors) and can thus be used to eliminate price risk (Schneider, 2011, Bielza et al., 2007, Harwood, 1999). However, in return to risk elimination, farmers must relinquish on possible higher than contracted prices at the time of harvest.
- *Future contracts.* A future contract is an (priced) agreement to trade a certain volume of a commodity at a specified future time. The actual delivery and payment of the commodity are not required until the future contract matures. In contrast to (flat-price) marketing contracts, price risk cannot be eliminated and basis risk remains reflecting differences in prices across space, time, or quality (Harwood, 1999). Future markets are less developed in Europe compared for instance with the U.S. but the number of markets offering futures contracts on agricultural commodities has increased (Bielza et al., 2007, Powers, 1994, Hueth and Hennessy, 2002, Elam, 1992, Harwood, 1999). Due to further abandonment of price supports, the interest on future markets may increase in Europe (Meuwissen et al., 2011).
- *Options.* A commodity option gives the holder the right to take a futures position at a specified price before a specified date (Harwood, 1999). By paying a premium the producer receives the option to sell specific quantities for a predetermined price to protect against unexpected low prices while at the same time must not forego gains from favorable prices at the cash market. Compared to futures and forward contracts, this reduces problems of

potential mismatches between the determined and produced quantities, and does not oblige the producer for physical transactions (Schneider, 2011). In general, futures and options may be instruments for intra-industrial (e.g. bilateral) agreements. However, the involvement of a large number of actors in risk transferring actions may be required for these instruments.

- *Revenue insurances*. In the (simplest) case of revenue insurance a target revenue is established for a single commodity for which indemnities are paid if actual revenues fall below the target (an insurance which comprises the whole farm income is known as whole-farm income insurance). Hence, revenue insurances pay out for farmers regardless of whether prices or yields led to revenues shortfalls. For an overview and examples of different revenue insurance solutions see e.g. Turvey (1992), Turvey, (2011), and Bielza et al. (2008). In general, the establishment of such insurance schemes is difficult due to adverse selection and moral hazard problems that could require subsidization of insurance schemes (Cafiero et al., 2007). Furthermore, revenue insurance products were found to complement other risk management strategies such as options and futures (Coble et al., 2000, Mahul and Wright, 2003). Nevertheless, the interest of policy makers in this type of insurance increased recently (see e.g. EC, 2011).

In summary, there are potential instruments available, and experiences have been made with these instruments in other countries. Producers, policy maker and other stakeholder could construct (price) risk management instruments based on these backgrounds. More comprehensive discussions and overviews of different instruments are provided, for instance, by Harwood (1999), Musshoff and Hirschauer (2011), Schneider (2011), Moschini and Hennessy (2001), Tomek and Peterson (2001), Bielza et al. (2008), and OECD (2011). Of course, to evaluate the viability of price risk management instruments for Swiss farmers, also the effect of e.g. direct payments or off-farm income must be taken into account.

5. Summary and conclusion

Crop prices and absolute price volatilities (i.e. standard deviations) are – by far – highest in Switzerland, compared to the USA and the European Member States Germany, France and the Netherlands. In contrast, relative crop price volatilities expressed as coefficients of variation are lowest for Switzerland. This is a result of border protection measures for agricultural products (e.g. tariffs and quotas). However, with an agricultural free trade agreement between Switzerland and the European Union, crop price volatility is expected to increase for Swiss producers. Our analysis suggests that this increase might be substantial if price variability would approach current levels in other European countries. For potatoes, for example, a look across the border indicates potential increases in relative price variability of factor 3–5. Potential increases in relative price variability are found to be in the range of factor 2–3 for wheat, barley, triticale and maize. Thus, price variability can constitute a very significant source of income risks for farmers in the future. Even if the extent of increased price volatility on income risk is difficult to predict, it might be worth for policy makers and producers to develop risk management strategies to cope with higher price variability in crop production. Other countries have experiences with various on-farm and market instruments to cope with these risks. Building on this background and assessing the effect of other policy measures on income risk (i.e. direct payments) can ensure that producers, policy makers and other stakeholders create adequate and sustainable risk management instruments for Swiss crop production. Taking into account that the implementation and application of these instruments may require some years (e.g. for implementation in education, development of market infrastructure), anticipatory actions of policy makers and producers with regard to the development of price risk management strategies should be considered.

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References

Antón, J. and Kimura, S., 2009. Farm Level Analysis of Risk, and Risk Management Strategies and Policies: Evidence from German Crop Farms, Paper presented at the International Association of Agricultural Economists Conferences, Beijing, China, August 16–22.

Artavia, M., Deppermann, A., Filler, G., Grethe, H., Häger, A., Kirschke, D. and Odening, M., 2010. Ertrags- und Preisinstabilität auf Agrarmärkten in Deutschland und der EU: Betriebswirtschaftliche und agrarpolitische Implikationen. In: Rentenbank (Hrsg.): Auswirkungen der Finanzkrise und volatiler Märkte auf die Agrarwirtschaft. Schriftenreihe der Rentenbank Band 26, 53–87.

Baldwin, R. and Hufbauer, G., 2006. The Shape of a Free Trade Agreement between Switzerland and the United States. Policy Analyses in International Economics, Peterson Institute, Washington DC.

Berg, E., 2002. Assessing the Farm Level Impacts of Yield and Revnue Insurance: an Expected Value-Variance Approach. Paper presented at the Xth EAAE Congress, 28–31 August, Zaragoza, Spain, 2002.

Berg, E. and Kramer, J., 2008. Policy Options for Risk Management, In: Meuwissen M., Van Asseldonk, M., Huirne, R. (eds), Income stabilization in European Agriculture, Wageningen Academic Publishers, The Netherlands.

Bergmann, H., Benz, L. and Fueglistaller, U., 2009. Auswirkungen einer Agrarmarktliberalisierung auf die Schweizerischen Weichweizen-Mühlenunternehmen. Forschungsbericht Schweizerisches Institut für Klein- und Mittelunternehmen (KMU-HSG), Universität St. Gallen.

Bielza, M., Garrido, A. and Sumpsi, J.M., 2007. Feasibility of a Cash Forward Contract: An Application to the French and Spanish Potato Sectors, Agribusiness 23(2): 245–261.

Bielza, M., Conto, C.G., Dittman, C., Gallego, F.J. and Stroblmair, J., 2008. Agricultural insurance schemes. Report to the European Commission, Brussels.

BLW, 2008. Agrarbericht 2008. Bundesamt für Landwirtschaft (BLW), Bern.

BLW, 2009a. Negotiations on agriculture, food safety, product safety and public health. Bundesamt für Landwirtschaft (BLW), Bern.

BLW, 2009b. Agrarbericht 2009. Bundesamt für Landwirtschaft (BLW), Bern.

Bösch, I., 2012. Preferences for Attributes of Industrial Potatoes: An Empirical Investigation of the Swiss Market. American Journal of Potato Research 89(3), 199–206.

Bösch, I., Weber, M., Aepli, M. and Werner, M., 2011. Auswirkungen einer Marktöffnung auf die Schweizer Nahrungsmittelindustrie. Die Volkswirtschaft 2011(7/8), 55–58.

Bokusheva, R., Finger, R., Fischler, M., Berlin, R., Marín, Y. and Pérez, F., 2012. Factors determining the adoption and impact of a postharvest storage technology. Food Security 4(2), 279–293.

Box, G. and Jenkins, G., 1970. Time series analysis: Forecasting and control. Holden-Day, San Francisco.

Briner, S. and Finger, R., 2012. Bio-economic modeling of decisions under yield and price risk for suckler cow farms. 123rd EAAE Seminar «Price Volatility and Farm Income Stabilisation», Dublin, February 23rd–24th, 2012.

Cafiero, C., Capitanio, F., Cioffi, A. and Coppola, A., 2007. Risk and Crisis Management in the Reformed European Agricultural Policy. Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie 55 (4), 419–441.

Coble, K.H., Heifner, R.G. and Zuniga, M., 2000. Implications of crop yield and revenue insurance for producer hedging, Journal of Agricultural and Resource Economics 25 (2): 432–452

EC, 2001. Risk Management Tools for EU Agriculture. Working Document of the European Commission Agricultural Directorate.

EC, 2011. Proposal for a Regulation of the European Parliament and of the Council on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). European Commission, Brussels, COM(2011), 627/3.

Elam, E., 1992. Cash Forward Contracting versus Hedging of Fed Cattle, and the Impact of Cash Contracting on Cash Prices, Journal of Agricultural and Resource Economics 17(1): 205–217.

FAO, 2011. Food and Agriculture Organization of the United Nations (FAO), Internet database. http://www.fao.org

El Benni, N. and Finger, R., 2012. Where Is the Risk? Price, Yield and Cost Risk in Swiss Crop Production. 28th Triennial Conference of the International Association of Agricultural Economists (IAAE), August 18 to 24, 2012, Foz do Iguaçu, Brazil.

Finger, R., 2010. Revisiting the Evaluation of Robust Regression Techniques for Crop Yield Data Detrending. American Journal of Agricultural Economics 92(1), 205–211.

Finger, R., 2012a. Nitrogen Use and the Effects of Nitrogen Taxation Under Considerations of Production and Price Risk. Agricultural Systems 107, 13–20

Finger, R., 2012b. Modeling the sensitivity of agricultural water use to price variability and climate change – an application to Swiss maize production. Agricultural Water Management 109, 135–143

Finger, R. and Lehmann, N., 2012. The Influence of Direct Payments on Farmers' Hail Insurance Decisions. Agricultural Economics. 43(3), 343–354

Hardaker, J.B., Huirne, R. and Anderson, J.R., 1997. Coping with Risk in Agriculture, First edition, CABI Publishing, Wallingford.

Harwood, J.L., 1999. Managing Risk in Farming: Concepts, Research, and Analysis. Agricultural Economics Report No. 774. Washington, DC: U.S. Dept. of Agriculture, Economic Research Service.

Huber R. and Lehmann B., 2009. WTO agreement on agriculture: potential consequences for agricultural production and land-use patterns in the Swiss lowlands. Danish Journal of Geography 109 (1), 131–145.

Huet, B. and Hennessy, D.A., 2002. Contracts and risk in agriculture: Conceptual and empirical foundations (Staff General Research Papers 5324), Ames, IA: Iowa State University, Department of Economics.

Joerin, R., Campo, I.S., Maier, T. and Flury, C., 2006. Market liberalization and the role of direct payments in Switzerland. Paper presented at the Annual meeting of Japanese Association of Regional Agriculture and Forestry Economics. Osaka, St. Andrew's University.

Johnston, J. and DiNardo, J., 1997. Econometric Methods. McGraw-Hill, New York.

Kobzar, O., van Asseldonk, M.A.P.M. and Huirne, R.B.M., 2004. Farm level yield, price and cost variations, Paper presented at the 86th EAAE Seminar «Farm income stabilization: what role should public policy play?», Anacapri, Italy, October 21–22, 2004.

Lehmann, N. and Finger, R., 2012. Optimizing whole-farm management considering price and climate risks. 123rd EAAE Seminar «Price Volatility and Farm Income Stabilisation», Dublin, February 23rd–24th, 2012.

Mahul O., 2003. Hedging price risk in the presence of crop yield and revenue insurance. European Review of Agricultural Economics 30 (2), 217–239.

Mahul, O. and Wright, B.D., 2003. Designing optimal crop revenue insurance, American Journal of Agricultural Economics 85(3): 580–589.

Mann, S., 2003. Doing it the Swiss Way. EuroChoices 2 (3), 32–35.

Meuwissen, M.P.M., Huirne, B.M. and Hardaker, J.B., 1999. Income Insurance in European agriculture, European Economy No. 2, Luxembourg.

Meuwissen, M.P.M., van Asseldonk, M., Pietola, K., Hardaker, B. and Huirne, R., 2011. Income Insurance as a risk management tool after 2013 CAP reforms? Paper presented at the EAAE 2011 Congress «Change and Uncertainty», Zurich, Switzerland, August 30 – September 2.

Moschini, G. and Hennessy, D.A., 2001. Uncertainty, risk aversion, and risk management for agricultural producers, In: Bruce L. Gardner and Gordon C. Rausser (eds). Handbook of Agricultural Economics 1, 88–153.

Musshoff, O. and Hirschauer, N., 2009. Optimizing Production Decisions Using a Hybrid Simulation-Genetic Algorithm Approach. Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie 57 (1), 35–54.

Musshoff, O. and Hirschauer, N., 2011. Modernes Agrarmanagement. Vahlen, München.

Nganje, W. and Stoltman, G., 2000. Price Variability and Financial Risk for Sugar Beet Growers. Annual Meeting of Western Agricultural Economics Association Vancouver, Canada, June 29 – July 3, 2000.

OECD, 2011. Managing Risk in Agriculture: Policy Assessment and Design. OECD Publishing, Paris.

Pavlista, A.D. and Feuz, D.M., 2005. Potato Prices as Affected by Demand and Yearly Production, American Journal of Potato Research 82, 339–343.

Peter, S., Bösch, I., Mamardashvili, P., Weber, M. and Lehmann, B., 2009. Auswirkungen eines allfälligen Freihandelsabkommens auf die Getreidebranche in der Schweiz. Studie zu Handen der Branchenorganisation swiss granum,Gruppe Agrar-, Lebensmittel und Umweltökonomie, ETH Zürich.

Poulton, C., Kydd, J.,Wiggins, S. and Dorward, A., 2006. State intervention for food price stabilization in Africa: Can it work?, Food Policy 31(4): 342–356

Powers, N.J., 1994. Marketing practices for vegetables (AIB-702). Washington, DC: U.S. Department of Agriculture, Economic Research Service.

R Development Core Team, 2010. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Rapsomanikis, G. and Sarris, A., 2008. Market Integration and Uncertainty: The Impact of Domestic and International Commodity Price Variability on Rural Household Income and Welfare in Ghana and Peru. Journal of Development Studies 44, 1354–1381.

Sarris, A.H., 2000. Has world cereal market instability increased? Food Policy 25, 337–350.

Schneider, L., 2011. Bearing risk is hard to do: crop price risk transfer for poor farmers and low-income countries. Development in Practice 21(4–5), 536–549.

Strahan, R. and Page, J., 2003. Economics of on-farm grain storage and drying, Proceedings of the Australian Postharvest Technical Conference, Canberra, 25–27 June 2003: 15–18.

Tomek, W.G. and Peterson, H.H., 2001. Risk Management in Agricultural Markets: A Review. Journal of Futures Markets 21(10), 953–985.

Turvey, C.G., 1992. An Economic Analysis of Alternative Farm Revenue Insurance Policies. Canadian Journal of Agricultural Economics 40, 403–426.

Turvey, C.G., 2011. Whole Farm Income Insurance, The Journal of Risk and Insurance, In Press, DOI:10.1111/j.1539-6975.2011.01426.x.

SBV, 2010. Landwirtschaftliche Monatszahlen. Swiss Farmers Union (SBV). Brugg, Switzerland.

Winters, L. A., McCulloch, N. and McKay, A., 2004. Trade Liberalization and Poverty: The Empirical Evidence. Journal of Economic Literature, 62(1), 72–115.

Yang, J., Haigh, M.S. and Leatham, J., 2001. Agricultural Liberalization Policy and Commodity Price Volatility: A GARCH Application. Applied Economics Letters 8, 593–598.

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