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The effect of agricultural policy change on income risk in Swiss agriculture

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Abstract

The study examines the effect of agricultural policy reforms on income variability of Swiss farmers. The observed heterogeneity in income risks across farms and time is explained with farm and regional characteristics. FADN data are used to construct coefficients of variation of total household income and gross revenues at farm-level over the period 1992-2009. Applying linear mixed effect models the effects of off-farm income, direct payments, farm size, specialisation and liquidity on gross revenue and household income variability in three different production regions are measured. The switch from market-based support to direct payments decreased the variability of farm revenues and household income. Off-farm income has a positive and farm size a negative effect on revenue risk. The opposite is true for household income risk. Specialisation increases revenue and household income risk. Direct payments serve as insurance for farmers and make them more willing to take risk from agricultural production.

Keywords: income risk, agricultural policy, direct payments

JEL classification: Q12, Q14, Q18

1. INTRODUCTION

Risks play a substantial role in the decision making process of farmers. More specifically, farmers are, like any risk-averse agent, interested in reducing fluctuations in their household income (Mishra and El-Osta, 2001). Farm income fluctuation is mainly caused by price and yield volatility and influences the ability of farm families to expand their operations and repay debt (Barry et al., 1988). Hence, in order to preserve the existence of an enterprise as the base for income generation, risk has to be managed effectively (Hardaker et al., 1997). Besides its relevance at the farm level, income risks are also of high policy relevance. While many countries frame parts of their agricultural policy objectives in terms of distribution or equity of agricultural incomes (OECD, 1998), also the stabilization of farm revenues is a central goal of agricultural policies in Europe (Tyner et al., 2005). Even though agricultural policy measures are mainly framed as supporting producer incomes and internalizing externalities, these supports may have also additional risk-decreasing (insurance) benefits for farmers (Thompson et al., 2004). For instance, administered prices, flexible levies and export subsidies aim to maintain farmer's income at high level but also reduce domestic price volatility through isolating producers from the world market (OECD, 2009). Developed countries, particularly in Europe, have switched in recent decades from market-based support to decoupled and green support systems, where direct transfers to farmers have become the most important policy instrument. The expected impact of this development on farm income variability is unclear: On the one hand, farmers are more exposed to competitive market forces and price volatility is expected to increase (Thompson and Gohout, 2000, Cafiero et al., 2007, Meuwissen et al., 1999, Meuwissen et al., 2003). For instance, Sckokai and Moro (2005) find an increase in price volatility through the CAP reform. At the same time, decoupled direct payments provide stable income support and thus should reduce the relative variability of farm incomes (OECD, 2009, Cafiero et al., 2007). With the introduction of direct payments, cross compliance obligations as well as other incentive schemes that reduce the negative environmental effects of agricultural production have been introduced. This often leads to changes in production intensities. The effect of intensity changes on field- and farm-level production risk is ambiguous: Less intensive production techniques may be either more risky in terms of yield variability (e.g. organic crop production, Gardebroek et al., 2010) but can also lead to more shock-resilient systems with less volatile yields (e.g. extensive grassland systems, e.g. Schläpfer et al., 2002). In summary, there are diverse paths how agricultural policy affects farmers' income risks. Even though the potential directions of several individual effects of agricultural policy measures on farmers' income risks are known, no clear-cut overall assessment of how the change from market-based programmes to direct payments affects income variability is possible from a theoretical viewpoint. Based on this background, the goal of this paper is to investigate the influence of the past paradigm changes in agricultural policy on the income risk faced by Swiss farmers. In addition, this paper aims to explain the observed heterogeneity in income risks across farms and time with farm and regional characteristics. To fully address income risks in Swiss agriculture at large, we use a set of all available farms in our analysis instead of focusing on a specific agricultural production sector (e.g. crop production). By revealing factors that affect income variability, this empirical assessment is necessary to advice farmers, policy makers and other stakeholders how income risks can be reduced. To investigate the influence of policy changes on income risks, we examine the changes in income variability during the period 1992 – 2009 using long-term farm level panel observations from Swiss agriculture. Switzerland is used as case study because its drastic policy changes are an illustrative example for the policy changes from market support to supporting schemes based on direct payments and cross compliance, which are an outlook for the developments in other countries. In our analysis, income variability (i.e. income risk) is based on two concepts: First, we analyse the variability of agricultural gross farm revenues which, for instance, is relevant for (farm revenue) insurances (see e.g. Hennessy et al., 1997). Currently, no such insurance is available for Swiss farmers (cp. Finger and Calanca, 2011), but it may become an option in the future. Thus, the here presented analysis aims to quantify potentials and pitfalls for such insurance solution. Second, we also investigate the variability of total household income because farmers adjust their whole business including off-farm employment to manage income risks. These two measures for income risk are additionally used to assess the effect of farm structures and financial characteristics on income variability. More specifically, regression analyses are used to explain the effect of direct payments, off-farm income, specialisation, farm size and liquidity on income variability. In addition, we add a spatial dimension to our analysis by conducting separate analyses for valley, hilly and mountain regions. This is motivated by the fact that agricultural policies aim to maintain adequate standards of living for farmers and aim to restrict income disparities (Keeney, 2000). Along these lines, Swiss agricultural policy aims to reduce income disparities between regions with different factor endowments, with a particular focus to support farmers in hilly and mountainous regions (El Benni et al., 2011). To this end, farmers in these regions receive relatively more direct payments than farmers in the high productive valley regions. Thus, the developments as well as the determinants of farmers' income risks are expected to differ across regions, which are investigated in regional specific analyses in this paper. The remainder of this paper is structured as follows. In section 2 the main changes in Swiss agricultural policy are summarized, the data and methods used are described in section 3 and in section 4 the results are presented and discussed. Finally, concluding remarks are presented in section 5.

2. BACKGROUND ON SWISS AGRICULTURE AND POLICY SHIFTS OVER TIME

Swiss farmers experienced a strong shift in agricultural support within the last two decades, the first being in 1992 and the second in 1999. In the pre-reform period, market supports (such as price support and export subsidies) led to high and stable prices for producers. Framed by the Uruguay round, direct payments were introduced in 1992 with the aim to decouple income support from production. At the same time, output price support was reduced and border protection schemes were modified. Note that especially farmers in hill and mountain regions were already supported before the agricultural reforms (however, to a lower extend) using farm household payments and animal head based payments to compensate for adverse production conditions. With the first reform in 1992, area and animal unit based payments were made available to all farmers without regional restrictions. Income related goals of agricultural policy could therefore also be achieved through decoupled direct payments (FOAG, 2007).

Furthermore, an integrated production (IP) program was made available for voluntary participation to support environmental-friendly production systems. In 1999, a referendum that initiated the greening and decoupling of agricultural policy led to steps by which price and sales guarantees were abolished and farmers had to comply with ecological standards to be eligible for direct payments. Furthermore, the first bilateral agreement with the European Union came into force in 2002 which brought about tariff reductions and the removal of technical barriers to trade (Jörin et al., 2006). Farm-level supports were divided into general and ecological direct payments. Integrated production became an obligation to receive general direct payments (i.e. the direct payments system was based on a cross-compliance approach). Within the general direct payments, farmers of the hill and mountain regions are specifically supported with area-based and animal unit based payments. Furthermore, farmers can voluntarily apply to several ecological (and animal welfare) direct payments without any regional restrictions[1]. Since 1999, only minor changes were made to the direct payment system but market deregulation was followed in subsequent years and most of the financial means from market support were converted into direct payments. Note that the presented policy reform steps represent the dates where the main reform steps were initiated. However, the implementation and configuration of specific measures was rather a continuous process than an abrupt change. Thus, even though we described policy reforms using step changes, we consider continuous policy influence over time in our analysis. In 2009, Swiss farmers are supported with direct payments by an amount of 2.7 billion Swiss Francs (FOAG, 2010) and 60.5% of all (general and ecologic) direct payments were given to farmers in the hill and mountain regions. General direct payments make up 79%, 82% and 87% of all direct payments received by farmers located in the valley, hill and mountain region, respectively (FOAG, 2010). Accordingly, ecological direct are most important in the valley regions and least important in the mountain regions. While direct payment support strongly increased over time the producer price index decreased considerably between 1990 and 2009.

3. DATA AND METHOD

3.1. Data source and sampling procedure

To analyse the effect of agricultural policy changes on the income variability of Swiss farmers, we use farm-level data from the Swiss farm accountancy data network (FADN) over the period 1992 to 2009[2]. This period comprises the time from the first agricultural policy reform (1992) where direct payments were introduced over the second reform step in 1999, where a cross-compliance scheme was introduced. The Farm accountancy data are an unbalanced panel data set. Over the time period 1992 to 2009 a number of 9593 farm operations were surveyed, but only 249 (2.6%) farms have entries for all of the 18 years, 2664 (28%) farms have at least 10 years of entries and 5369 (56%) farms have entries of at least 5 years between 1992 and 2009. This limits the applicability of time series analyses, especially if results should show general patterns (i.e. over all farms) of income variability development in Swiss agriculture at large. To overcome the problem of missing data but still be able to measure possible income variability shifts over time we followed the approach used by Beach et al. (2008) and Barry et al. (2001). To this end, we split the whole time interval (1992-2009) into 14 overlapping time periods each comprising 5 consecutive years of entries for the different income measures per farm. For instance, the first time period comprises income data of all farms having entries for each year in the period 1992 – 1996. Consequently, the second time period comprises income data of all farms having entries for each year from 1993 to 1997. On average, this procedure results in a number of 1661 farms per each 5-year

1. For more details on the agricultural policy shifts and specific programs see El Benni and Lehmann (2010) and Mann (2003).
2. The sampling procedure and dataset is described in detail by Dux and Schmid (2010) and Meier (2000).

time period (of in total 14 periods) for which the mean and variability of agricultural gross revenues and total household income at farm- level (i.e. for each farm) is estimated. Though the resulting dataset is still an unbalanced panel, it enables the assessment of changes in income levels and income variability over time. Our analysis focuses on agricultural gross revenues and total household income. While the assessment of risk of agricultural gross revenues is important for e.g. possible revenue insurance solutions, farmers might be more concerned with household income risk. This is especially true for those farmers earning much of their income from off-farm sources. Agricultural gross revenues are defined as price times yields from total crop and livestock production and are expected to be highly affected by changing agricultural policies. Furthermore, farm operations facing high income risk from agricultural production might also face higher household income risk. Total household income is defined as the sum of farm and off-farm income where farm income is defined as gross revenue minus total production and labour costs and interest on debt and land. To account for value changes over time, both income variables are deflated by the consumer price index corrected for the index of rents[3] (FSO, 2011). For each farm operation the mean, standard deviation and coefficient of variation for the different income sources is calculated for the fourteen 5-year time periods. In order to enable a comparison of income risks across farms and over time, the coefficient of variation (i.e. the ratio of standard deviation and mean) is used. In summary, our procedure leads to a panel data set that consists of totally 23261 observations over 14 time periods.
In order to test for differences in parameter estimates for income variability across regions (valley, hill and mountain region) as well as across income measures (household income vs. agricultural gross revenue), Wilcoxon- and Kruskal-Wallis tests (i.e. a non-parametric analysis of variance) are used based on farm-level coefficients of variation.

3.2. Factors affecting income instability of farm households

Based on a literature review (Agrosynergie, 2011, Barnett and Coble, 2009, Barry et al., 2001, Blank and Erickson, 2007, 2009, Cafiero et al., 2007, Finger, 2008, 2010, Gardebroek et al., 2010, Mishra and El-Osta, 2001, OECD, 2003, Serra et al., 2005, Vrolijk, 2006) we expect farm size, specialisation, the farms' dependence on direct payments and off-farm income, liquidity and finally the farms' location (i.e. region) to affect the variability of gross farm revenue and household income. To account for the high correlation between the different explanatory variables we had to define proxies for some of them. For all independent variables, the averages of 5-year time periods for each farm are employed for further analyses. Thus, the explanatory variables are also arranged as a panel data set as described above.
Specialisation. Selecting a mixture of activities that have net returns with low or negative correlations reduces the risk of farm revenues (Berg and Kramer, 2008, Hardaker et al., 1997, Robison and Barry, 1987). In contrast, specialisation often creates economic efficiencies (e.g. due to economies of scales) that may increase net returns, but it also typically exposes the farm household to more risk (Barnett and Coble, 2009). Hence, we expect an increase in income risk with an increase in specialisation. The degree of specialisation is measured by the Herfindahl index with total agricultural gross revenues being the sum of revenues from plant (including arable and permanent crops and other revenues from plant production) and livestock production (including revenues from milk and cattle production and revenues from pig and poultry and other revenues from livestock production). The index ranges between 0 and 1, and indicates a high degree of specialisation close to 1. Note that, for example, a farm specialised on arable crops or milk production would be characterizsed by high shares of revenues from arable crops or milk, respectively, leading to a Herfindahl index close to 1.

$$HI = \frac{arable\ crops^2 + permanent\ crops^2 + rest\ plant^2 + milk^2 + cattle^2 + nonruminants^2 + rest\ animals^2}{total\ agricultural\ gross\ revenues^2}$$

3. Rents make up almost 20% of the consumer price index. As Swiss agriculture is family farm based, rents are not considered in the index used to deflate farm income.

Off-farm income. Off-farm income can be used by farmers to replace farm income losses (e.g. due to decreasing market prices) or to hedge against the variability in farm income (OECD, 2003, Blank and Erickson, 2007). Hence, the variability of total household income can be reduced by diversifying into off-farm employment. In portfolio theory, the farmers objective is assumed to be the maximization of utility U which is derived by the maximization of the certainty equivalent of the expected value of net profits E(Ri) (Blank and Erickson, 2007):

$$E(U_i) = E(R_i) - \left(\frac{\gamma}{2}\right)(\sigma_i^2)$$

with γ being a risk-aversion parameter (which is positive for a risk averse decision maker), and σ_i^2 being the variance of expected returns (i.e. household income). The variance of expected returns is given by the following expression:

$$\sigma_i^2 = x_m^2\sigma_m^2 + x_f^2\sigma_f^2 + 2x_m x_f \sigma_{mf}$$

with x_m being the share of agricultural income on total household income and $x_f = 1 - x_m$ being the share of off-farm income on total household income. The variance of agricultural and off-farm income is denoted by σ_m^2 and σ_f^2 respectively and σ_{mf} is the covariance between both income sources. A negative covariance between off-farm income and farm income implies that diversification into off-farm employment reduces household income risk (i.e. variance) whereas a positive covariance denotes a positive contribution to household income risk. If off-farm income is a risk-free asset, the variance of the expected returns is solely driven by the variance of agricultural income (i.e. $\sigma_i^2 = x_m^2\sigma_m^2$). If off-farm income is risk-free or helps to reduce household income variability, the farmer may respond to off-farm income level increases (e.g. due to an increase in employment opportunities) by allocating more labour to off-farm income activities and by the same time producing more-risky crops with lower labour input (Blank and Erickson, 2007). Based on this background, we expect high off-farm income to increase the risk in agricultural gross revenues and decrease the risk in household income. We use the share of off-farm income on total household income to depict the farmers' dependence on farm income. Hence, assuming that off-farm income is a risk-free income source, a high share of off-farm on total household income reduces income risk. Furthermore, the less dependent a farmer is on agricultural production, the more likely he produces more risky-crops which increase the variance of gross farm revenues.

Direct payments. With the reduction in market support, agricultural policy reforms in 1992 introduced decoupled direct payments to compensate farmers for forgone market income. Following the discussion on portfolio effects with regard to off-farm income, we expect direct payments to decrease household income risk as they provide stable (i.e. risk-free) income support and were found to contribute to more stable farm revenues (including income from marketable goods and direct payments) across most EU15 regions (Agrosynergie, 2011). Thus, gross farm revenues (including market income and direct payments) might not be reduced in average, but the presence of fixed payment likely reduce its variance (Cafiero et al., 2007) and therefore also the variance of household income. However, governmental supports, either through output tied support or decoupled direct payments have not only direct but also indirect effects on the income risk farmers face. This is due to their link to production intensities. For instance, an output price supplement of e.g. 20% would not affect the variability of farm revenues. However, this supplement gives incentives to farmers to produce more intensively, e.g. by increasing nitrogen use, which may increase production risk (e.g. Isik, 2002). Hence, the change from market support to direct payments may decrease farm revenue risk if price reduction lead to less intensive production. Furthermore, less intensive production techniques can also lead to more shock-resilient systems with less volatile yields (e.g. Schläpfer et al., 2002). However, dependent on which inputs are reduced, a decrease in production intensities may also lead to an increase in production risk. For instance, Serra et al. (2005) found that the reduction in price supports in favor of area payments may reduce the application of crop protection inputs and therefore increase production risk. Also Gardebroek et al. (2010) found an increase in production risk due to a reduction in production intensities. Hence, the effect of changes from market support to direct payments on income risk via the production intensity link is ambiguous. Since the early 1990s, Swiss agricultural policy has introduced various incentive schemes to reduce production intensities and thus detrimental environmental impacts of agriculture. Note that also the decreasing price levels that accompanied the increasing relevance of direct payments in Switzerland are expected to decrease incentives for intensive production. In addition, Swiss farmers have to follow ecological production standards (cross compliance obligations) to become eligible for direct payments since 1999 which, among others, include restrictions on fertilizer and pesticide use (e.g. El Benni and Lehmann, 2010). These policy measures have resulted in a sharp decrease of production intensities in Swiss agriculture, especially in crop production (e.g. Finger, 2008, 2010). Therefore, the switch in agricultural policy is expected to additionally affect income variability via the production intensity link. As direct payments are strongly correlated with farm size, we used the share of direct payments on total gross revenues (including revenues from agricultural production, direct payments, earnings through e.g. agrotourism activities, direct sells, or machinery rent, etc.) as proxy for direct payments in monetary values. Following the discussion on portfolio effects, we assume a high share of direct payments on total gross revenues to reduce household income risk as these payments are a risk free income source. Furthermore, we expect an increase in gross farm revenue risk with an increase in direct payments which is caused by policy induced behavioural changes (e.g. changes in production intensities).

Farm size. Farm size is a commonly considered variable to explain income risk farmers face (e.g. Barry et al., 2001, Mishra and El-Osta, 2001, Vrolijk, 2006). A typical assumption is that an increase in farm size results in economies of scale and improve production efficiencies as well as that larger farms are better able to smooth extreme events. In addition, larger farms often have some on-farm natural hedge, even for a specific crop, because crop yields in several fields of the farm are not perfectly correlated with each other (Marra and Schurle, 1994). This effect implies that production risks observed at the farm level are often smaller for larger farms, which has been also indicated for Switzerland (Finger, 2011). Based on this background, our hypothesis is that farm size is negatively correlated with income risk (Barry et al., 2001). Thereby we expect that economies of scale improve the return-risk tradeoff facing operators of increasingly larger farms (Blank and Erickson, 2007) which was empirically shown by Yee et al. (2004). We use the total assets of the farm and farm size in hectare agricultural land as suitable proxies for size.

Liquidity. Liquidity refers to the farm`s capacity to generate sufficient cash to meet financial commitments when they occur (Barry et al., 1988). Hence, sudden income drops due to price or yield decreases can be better managed the higher the liquidity of the farm operation is. Hence, assuming liquidity to be an exogenous factor that determines the level of income risk, higher liquidity would allow a producer to take on more risks and should therefore be positively correlated to the coefficient of variation. We used the ratio of fixed to total assets as a proxy for liquidity and refer to this as financial immobility. Hence, an increase of financial immobility should be negatively correlated to income risk (i.e. the coefficient of variation).

Geographical location. Due to different production conditions in the valley, hill and mountain regions we expect differences in the income risks these farmers face. The definition of regions is based on climatic and topographic conditions (cp. LZV 2008) with mountain regions facing the most unfavourable production conditions, followed by the hill and then the valley region. Furthermore, as laid down in section 2, the amount and types of subsidies (i.e. direct payments) paid differ between the three production regions. Due to these differences we expect that the effect of the explanatory variables on income risk differ between the valley, hill and mountain regions.

3.3. Empirical approach to measure the effect of farm characteristics on income risk

To reveal factors that determine income risks, panel regression analyses are used. Thus, the heterogeneity of income variability observed over time (for a specific farm) as well as over space (across farms) is explained with specific farm characteristics. The panel of income variability estimates derived from the above described procedure causes two major problems for regression analysis. First, different farms face different levels of income variability. Model diagnostic showed, that individual farm-specific effects have to be considered and that these farm-specific effects are correlated with the explanatory variables. To account for differences across farms that cannot be explained with the here used explanatory variables, individual farm specific effects are taken into account using a mixed effect regression approach. This approach allows for a subject specific random intercept while at the same time constant coefficients over all individuals are assumed (i.e. the slope is the same across farms). Secondly, income variability estimates are correlated with each other over time (i.e. from one period to another), causing problems of autocorrelation. Highly significant deviation from the null hypothesis of no serial correlation was also shown by different serial correlation tests, which has to be taken into account in the regression analyses. Therefore, we estimated a linear mixed-effect model of the following form:

$$Y_{it} = \beta x_{it} + u_i + e_{it}$$

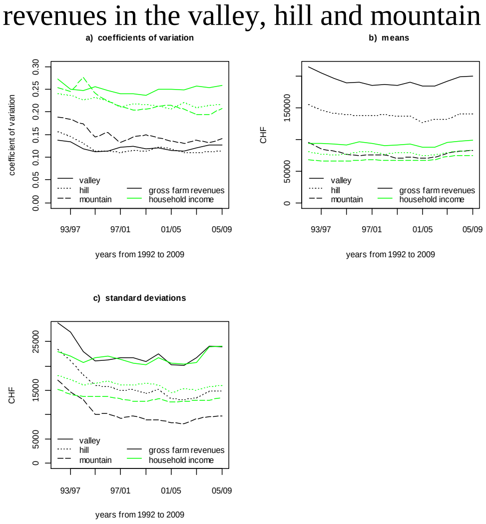
The independent variable Y is the coefficient of variation of gross farm revenues and household income respectively for each farm operation i at time t, β are the parameters of the explanatory variables x, u_i is the farm specific error term and e_{it} the idiosyncratic error term. Farm specific error terms are, however, correlated with each other. To account for this autocorrelation, we fit a continuous first-order autoregressive process in the errors using the corCAR1 function of the nlme package in R (Pinheiro and Bates, 2000). The regression model presented above is estimated with both, the coefficient of variation of gross farm revenues and the coefficient of variation of total household income. For each of these models, we first estimate a regression with all observations, and regions being represented as dummy variables. Second, we estimate the regression for each region separately to identify differences in the explanatory variables across space.

4. RESULTS AND DISCUSSION

4.1. Income risk and shifts over time

Figure 1 shows the shift of the coefficients of variation, mean and standard deviations of gross farm revenue and household income in the valley, hill and mountain region over time. Note that the presented lines represent averages of – on average – 1661 farms for each period. Figure 1a shows that household income is much more variable than gross farm revenues, which is supported by the Wilcoxon test for Switzerland at large as well as at the regional level. The coefficient of variation for gross farm revenues decreases at the national as well as regional level between 1992 and 2009. This decreasing instability is less the result of decreasing mean revenues but of decreasing absolute deviations (see Figure 1b and c). This is especially true for the mountain region, where mean revenues only slightly decreased compared to the valley region. Also household income instability decreased over time, at least for the hill and mountain region. In contrast, the income variability of farmers located in the valley regions remained rather stable (see Figure 1a). To test if this observed decrease in income risks is significant, we employ two different strategies: First, we compare income risks at the first (1992/1996), intermediate (1998/2002) and the last (2005/2009) of the 14 considered periods using Mann-Whitney tests. While the change from the first to the intermediate time period captures the effect of the first agricultural policy reform in 1992, the change from the intermediate to the last time period intends to capture the effect of the second agricultural policy reform in 1999. The analysis shows that the decrease of the coefficients of variation for gross farm revenue and household income between the first and the intermediate time period is significant (at least at the 5% level) for each of the regions. From the intermediate (1998/2002) to the last time period (2005/2009), significant decreases in gross farm revenue and household income risk were only found for the hill regions. Second, we use simple panel regression for each region to estimate the time trend in both of the coefficients of variation. It shows that for both gross farm revenue and total household income the decrease of the coefficients of variation is significant in all but the valley region, where a negative but insignificant effect of time on household income instability was observed. Figure 1a shows furthermore a regional gradient in the instability of gross farm revenues, which is highest in the mountain region. To test for significant differences of gross farm revenue instability between the regions Wilcoxon tests were applied to the first time period (1992/1996) and to the last time period (2005/2009) considered. It shows that the coefficients of variation of gross farm revenue differ significantly between the regions for both, the first as well as the last period. However, the figure also shows that the regions converged with respect to gross farm revenue instability. In contrast, the regions diverged with respect to household income instability. For the first time period (1992/1996), no significant differences in household income instability between the regions were found. However, for the last time period (2005/2009) household income instability is significantly higher in the valley than in the hill and mountain regions. Also the mean income and standard deviations of farm gross revenues and household income show significant differences between regions with the highest values observed in the valley, followed by the hill and then the mountain areas. In summary, agricultural policy reforms rather decreased than increased the variability of farm revenues and household incomes in Switzerland. Furthermore, the impact of the policy reforms on income variability was much higher in the mountain then in the valley regions, i.e. the stabilization effect was stronger. This is true for gross farm revenues as well as household income. This observation of decreasing income risks is the starting point for the subsequent analyses. More specifically, we use panel regression analyses to explain the observed changes in income risks using the explanatory variables presented in section 3.2.

Figure 1: Coefficient of variation, means and standard deviation of household income and gross farm revenues in the valley, hill and mountain region over time



Source: Own estimates

Similar to income risks, also the explanatory variables changed over time. Agricultural policy shifts are one of the major determinants for these changes. Thus, linking the observed changes in income risks with observed changes in explanatory variables enables to implicitly capture the policy effects. To test whether the explanatory variables significantly changed over time, we estimated the time trend for each variable and region by panel regression following the procedure described in section 3.3. Due to space limitations, the results are not shown graphically but are described within the text. It shows that the share of off-farm income on total household income is highest in the mountain region, followed by the hill and then the valley region. Comparing the average of the years 1992 to 1996 and the average of the years 2005 to 2009 with each other (i.e. the first and the last time slot used in the regression analyses) an increase from 14% to 21% in the valley, from 22% to 25% in the hill and from 30% to 32% in the mountain regions can be observed. Hence, the regions converged with respect to the share of off-farm on total household income. A spatial gradient is also found for the share of direct payments on total gross revenues, which is highest in the mountain region and lowest in the valley region. Between 1992/1996 and 2005/09 periods, significant increases from 10% to 19% in the valley, from 16% to 26% in the hill and from 30% to 40% in the mountain regions can be observed. The Herfindahl index shows that mountain farmers are more specialised than farmers located in the valley region which is caused by the natural conditions, that often only allows for milk and cattle production. However, the regression results show that farmers in the valley and hill regions became significantly more specialised over time but specialisation decreased in the mountain region. Financial immobility, as the ratio of fixed to total assets (as proxy for liquidity) is about 80% for each of the regions considered. While a small but significant increase in financial immobility can be observed for the valley and hill region, no significant changes over time can be observed for the mountain region. In general, farm size increased significantly over time within each region considered. Farm size measured in hectare agricultural land increased from about 19 to 22 hectare in the valley regions and from 18 to 20 hectare in the hill and mountain regions but no significant differences can be observed between the regions. In contrast, farm size measured in total assets shows significant spatial differences with valley farmers having the highest and mountain farmers having the lowest assets. For all regions, an increase in assets of between 29% (mountain) and 33% (valley) can be observed over the time period 1992-2009.

4.2. Regression results on the effects of farm characteristics on income risk

Table 1 shows the results of the four separate linear mixed effect models explaining the instability of gross farm revenues (i.e. the coefficient of variation) by different farm characteristics and by region. In addition, a model including the interaction effect of each of the explanatory variables with the dummy variable region was estimated. Its results will be mentioned in the text but are not depicted in the tables due to space limitations. All ratios used as explanatory variables as well as the coefficients of variation are expressed as percentage terms. Thus, the effects of the estimated parameters can be interpreted as follows: a 1% increase in the explanatory variables changes the coefficient of variation (expressed in percentage, i.e. between 0% and 100%) by the size of the estimated parameter. We choose to present the results of the models with total assets in 1000 CHF as a proxy for farm size and will discuss the results for the variable farm size in hectare within the text. Note that in general, the direction of the effects and the levels of significance for all other explanatory variables are the same in both of the models considered. Confirming the descriptive analysis presented above, region dummies in the first model of Table 1 show that gross farm revenues are significantly more variable in the mountain than in the valley region, which is the reference category in this panel regression. Comparing the estimated effects of the explanatory variables at the national level with those derived in separated regressions at a disaggregated level (models 2-4) reveals the heterogeneity of these effects. Model 1 suggests that off-farm income do not influence the instability of agricultural gross revenues. However, regarding the regional specific models it shows that this is not true at a disaggregated level. Within the valley region (model 2), instability of agricultural gross revenues significantly increases with an increasing share of off-farm income on total household income. This is in line with the hypothesis that part-time farming is positively correlated to more risky production, e.g. because of shifts in labour allocation and changes in enterprise portfolios. In particular, lowland farms may feel free to enter risky activities on their farmland as soon as they feel protected by a seemingly secure off-farm employment. However, the opposite result was found in the hill regions (model 3), where an increasing share of off-farm income reduces the variability of gross farm revenues. Interregional differences of family labour allocation structures may be one reason different characters of off-farm employment opportunities between the regions another. To test if specific effects are significantly different in the 3 regions, we used regressions with all interaction terms. This analysis (not shown) indicates that the effect of off-farm income is significantly less pronounced in the hill and mountain region compared to the valley region. The impact of direct payments on income variability differs with region. For mountain farmers (model 4) a high share of direct payments on total gross revenues increases agricultural revenue variability, but decreases variability in the valley and hill region (model 2 and 3). These different effects might be explained by the link of governmental support to production intensities which differs between the regions already before the agricultural reforms (i.e. farmers located in the mountain regions produce less intensive than farmers located in the hill and valley regions). The degree of specialisation has a positive and significant effect on the variability of gross farm revenues for all regions. Hence, the more specialised a farm is, the more unstable farm revenues become which is in line with our hypothesis. The effect of specialisation is significantly lower in the hill than in the valley region. As expected, an increase in the degree of financial immobility (i.e. the proxy for liquidity) increases instability of farm revenues in for all regions but the effect is not significant. In line with our hypothesis, a clear result is found for farm size which has a significant negative effect on gross farm revenue instability in the hill and mountain region. In addition, we estimated the same models as depicted in Table 1 with farm land in hectare agricultural land instead of assets (as proxy for farm size). Farm size in hectare agricultural land has a significant negative effect on gross farm revenues variability in all of the models considered and the effect is also significant for the valley region (not shown). In general, the results show that all of the explanatory variables but financial immobility (as proxy for liquidity) explain some of the variation in gross farm revenue variability. However, while farm size has a negative effect and specialisation a positive effect on gross farm revenue risk over all geographical regions considered the effect of direct payments and off-farm income differs with region.

Table 1. Panel regression results for the effect of farm structure on gross farm revenue risk

	All regions	valley	hill	mountain
intercept	2.15705***	2.17397***	2.42099***	2.06711***
	2.07384|2.24026	*2.05755|2.29040*	*2.25353|2.58845*	*1.86967|2.26455*
off-farm income	0.00006	0.00063***	-0.00042*	0.00001
	-0.00018|0.00030	*0.00020|0.00105*	*-0.00088|0.00004*	*-0.00038|0.00040*
direct payments	-0.00208***	-0.00745***	-0.00702***	0.00373***
	-0.00346|-0.00069	*-0.00997|-0.00493*	*-0.00978|-0.00426*	*0.00155|0.00591*
specialisation	0.00560***	0.00673***	0.00320***	0.00533***
	0.00479|0.00642	*0.00558|0.00787*	*0.00475|0.00363*	*0.00363|0.00703*
financial immobility	0.00056	0.00014	0.00100	0.00166
	-0.00040|0.00152	*-0.00117|0.00144*	*0.00285|-0.00047*	*-0.00047|0.00378*
farm size in assets	-0.00007***	-0.00003	-0.00017***	-0.00015***
	-0.00011|-0.00004	*-0.00007|0.00002*	*-0.00024|-0.00009*	*-0.00025|-0.00005*
hill	-0.00255			
	-0.03336|0.02826			
mountain	0.15439***			
	0.11086|0.19793			
CAR1	0.78	0.77	0.77	0.79
logLik	-11088.39	-4973.98	-3210.14	-2933.44
AIC	22198.78	9965.96	6438.28	5884.88
No of obs (farmers)	23261	10314	6843	6104
	(4513)	(2105)	(1340)	(1148)

Notes: *, **, *** denote significance at the 10%, 5%, and 1% level respectively. The values in *italic* are the lower and upper bounds of the 95% confidence interval of the estimated parameters.
Source: Own estimates

Table 2 shows the results of the four regression models with household income variability as dependent variable. It shows that an increase in the share of off-farm income on total household income decreases the instability of household income at least for the valley and hill region. This is in line with the stated hypothesis that off-farm income can be used by farmers to reduce income risk and supports the results of other studies (Mishra and Sandretto, 2002, OECD, 2003). The model including the interaction terms between each of the variables and the dummy variable region (not shown) shows that the effect of off-farm income on household income variability is much less pronounced (i.e. significantly smaller) in the hill compared to the valley region. Table 2 shows furthermore that an increasing share of direct payments on total gross revenues significantly decreases the variability of household income for all three regions considered. No significant differences with respect to the effect of direct payments exist between the valley, hill and mountain region. The results show that the more specialised a farm is the more variable household income becomes. Hence, the positive effect of specialisation on gross farm revenue risk (as shown in Table 1) is transferred to the household income level. Financial immobility has a significant and positive effect on the variability of household income. Hence, the lower the liquidity of a farm is, the more variable household income becomes. This is true for each of the regions considered as well as in the pooled model. This is in contrast to the hypothesis, that higher liquidity allows the producer to take on more risks and therefore increases the coefficient of variation. One explanation for the observed positive effect might be that our proxy does not well capture the real liquidity of a farm operation. Immobilization can be furthermore the result of income changes rather than an exogenous factor determining the level of income risk[4]. The results show furthermore that farm size increases the variability of household income for all but the mountain region. Apparently, large farms can afford to enter more risky operations as a possible loss could be buffered. Such risky operations are hardly possible for the grassland-based systems of mountain farms. The results in term of direction and significance of the effects are the same if farm size in hectare is used instead of farm size in assets. In general, the results show that off-farm income, direct payments, financial immobility (i.e. liquidity) and farm size are important factors determining the variability of farm household income. The effects are similar for the different regions.

Table 2. Panel regression results for the effect of farm structure on household income risk

	All regions	valley	hill	mountain
intercept	2.69378***	2.65206***	2.85951***	2.60923***
	2.60442|2.78314	*2.52567|2.77845*	*2.67852|3.04050*	*2.40176|2.81669*
off-farm income	-0.00046***	-0.00115***	-0.00054**	0.00018
	-0.00070|-0.00021	*-0.00159|-0.00071*	*-0.00100|-0.00009*	*-0.00022|0.00058*
direct payments	-0.00633***	-0.00704***	-0.00869***	-0.00467***
	-0.00780|-0.00485	*-0.00974|-0.00434*	*-0.01164|-0.00573*	*-0.00696|-0.00238*
specialisation	0.00316***	0.00395***	0.00147*	0.00312***
	0.00229|0.00404	*0.00270|0.00520*	*-0.00019|0.00314*	*0.00134|0.00490*
financial immobility	0.00274***	0.00292***	0.00178*	0.00396***
	0.00171|0.00377	*0.00150|0.00434*	*-0.00021|0.00376*	*0.00173|0.00618*
farm size in assets	0.00012***	0.00014***	0.00013***	-0.00002
	0.00008|0.00016	*0.00009|0.00019*	*0.00004|0.00021*	*-0.00013|0.00008*
hill	-0.04405***			
	-0.07732|-0.01077			
mountain	0.01420			
	-0.03278|0.06118			
CAR1	0.81	0.82	0.81	0.81
logLik	-10872.31	-4843.11	-3162.59	-2944.87
AIC	21766.62	9704.23	6343.18	5907.74
No of obs (farmers)	23261	10314	6843	6104
	(4513)	(2105)	(1340)	(1148)

Notes: *, **, *** denote significance at the 10%, 5%, and 1% level respectively. The values in *italic* are the lower and upper bounds of the 95% confidence interval of the estimated parameters.
Source: Own estimates

In general, the panel regression results show, that off-farm income has a positive effect on gross farm revenue variability and a negative effect on household income variability. These results support the hypothesis, that off-farm income not only increases the mean household income but also decreases its variance. In addition, the positive effect of off-farm income on gross farm revenue risk supports the hypothesis that the farmers respond to increasing off-farm income is to produce more risky-crops with lower labour input. The regression results show furthermore that (in general) direct payments have a negative effect on household income and gross farm revenue variability. Hence, direct payments can be used by farmers as a risk mitigation strategy to reduce the risk at the household income level. The risk reduction effect at the gross farm revenue level might be explained by changes in production intensities

4. To test for the stability of the parameters, we estimated an additional model without the variable financial immobility. For each model (over all regions as well as for the single regions), the estimated parameters of off-farm income, direct payments, specialization and farm size show the same signs and significances as shown in Table 2.

due to the shift from market support to direct payments which have led to risk reductions in the hill and valley regions and to risk increases in the mountain region.

5. SUMMARY AND CONCLUSION

Analysing income risks in Swiss agriculture in the period 1992-2009 using FADN data at farm level, we find that the switch from market based to direct payment based income support led to significant decreasing volatility of both, gross farm revenues and household income. The decrease in the coefficients of variation of both income sources can mainly be attributed to the first agricultural policy reform in 1992, where direct payments were introduced and market support was reduced for the first time. In contrast, the second agricultural policy reform in 1999, where direct payments were based on a cross-compliance approach (and market support was further reduced), did not lead to significant changes in gross farm revenue or household income risk for Swiss farmers at whole. The regional disaggregated analysis, however, revealed significant reductions in income risk (i.e. at the gross farm revenue and household income level) for the hill regions also after the second reform in 1999. In general, the effect of agricultural policy reforms was highest for the mountain region, where the strongest decrease in income volatility (i.e. the coefficients of variation) can be observed. The strong support particular of farmers producing under adverse production conditions (i.e. in the mountainous regions) decreased not only absolute (i.e. standard deviations) but also relative income instability (i.e. coefficients of variation). In contrast, the reforms had much smaller effects on revenue and income variability in the valley regions, where absolute instability indeed decreased but relative instability remains rather stable.

To assess the effect of farm structures and financial characteristics on income variability, we estimate panel regression models to explain the effect of direct payments, off-farm income, specialisation, farm size and liquidity on gross farm revenue and household income risk. It shows that off-farm income and direct payments reduce household income risk. Hence, both income sources not only increase mean income levels but also decrease its variance and can thus be used as risk mitigation strategy by farmers. However, in the valley region, an increase in off-farm income also increases the risk in gross farm revenues. This suggests that farmers relying less on their farm income are willing to take more risk from agricultural production. This finding supports the theoretical result of Blank and Erickson (2007) who found that hedging with off-farm income results in a more risky portfolio of enterprises. However, while off-farm income increases the risk in agricultural production, direct payments reduce gross farm revenue risk. Hence, the decrease in production intensities due to the shifts from market support to direct payments had led to risk reductions in agricultural production (at least for the valley and hill region). For all regions considered, specialisation increases the risk of gross farm revenues which is also transferred to the household income level. Hence, a diversification in farm enterprises could be used by farmers as risk mitigation strategy with regard to gross farm revenue risk as well as household income risk. In contrast, farm size decreases the risk of gross revenues but increases the risk of household income. This supports the finding of Finger (2011) and Marra and Schurle (1994) who found that production risks observed at the farm level are often smaller for larger farms due to on-farm natural hedge. A contradictory result to theory was found for the effect of liquidity on the coefficients of variation which was negatively correlated to household income and gross revenue risk (i.e. we use the ratio of fixed to total assets, named financial immobility, as proxy for liquidity). In general, a high liquidity (low immobility) enables the farmers to take on more risk and thus should be positively (negative) correlated to income risk. However, this seems not to be the case for Swiss farmers and should be analysed further.

The analyses revealed some interesting trade-offs farmers face with regard to production strategy choices. For instance, the most promising strategy for valley farmers to reduce the volatility in farm gross revenues would be to increase farm size and enter into full-time farming. However, from a household income perspective, valley farmers should increase off-farm income and reduce farm size. Also for the hill regions, an increase in farm size would decrease gross farm revenue risk but would increase household income risk. These results show the trade-off between different management options available to farmers. While one strategy is suitable to decrease the risk from agricultural production, the other is better suited to decrease overall household income risk. However, these are not the only trade-offs the farmer can face. The increase in off-farm income, and thus the reduction in household income risk, may reduce the need for enterprise diversification or to use other risk-reducing strategies (Mishra et al., 2004). The risk reducing effect of direct payments on both, farm revenues as well as household income variability, may furthermore increase the willingness to take risk from agricultural production. Moreover, direct payments bound to farm area decrease the overall incentive to release land, and farmers are thus not able to increase farm sizes, which would reduce farm revenue risks.

From a revenue insurance perspective, the here presented results imply problems of adverse selection and moral hazard if farmers' off-farm employment and the degree of specialisation is not taken into account. Adverse selection revers to the problem, that a farmer with high off-farm income and a high degree of specialisation may be more likely to use farm revenue insurances than a farmer with lower off-farm income and a diversified farm enterprise portfolio. This is because farmers with high off-farm income and a high degree of specialisation were found to face higher risk from gross farm revenue than farmers with low off-farm income and a low degree of specialisation. Of course, these decisions may also change after the insurance contract is specified, causing problems of moral hazard. In addition, we find that farm size has significant implications for income risks at the farm-level. As an increase in farm size decreases the risk from gross farm revenues, small farms may be more likely to apply for revenue insurances. Thus, potential insurance contracts should specify farmers' off-farm employment, the degree of specialisation and farm size. The results show furthermore, that direct payments have a risk reducing effect on agricultural revenues as well as household income. Hence, they serve as a kind of insurance for farmers and therefore affect optimum planning strategies. Risk-averse farmers who would ordinarily self-insure through diversification without insurance (i.e. direct payments) behave as if they were risk-neutral (Turvey, 1992). For Switzerland, this increasing importance of direct payments has even induced a crowding out effect of other risk management strategies such as the hail insurance (Finger and Lehmann, 2011).

By comparing the farm revenue and household income perspectives, our results imply that governmental intervention is not necessarily needed even if farm revenues would become much more volatile (e.g. due to market liberalisation). Our results show that farmers adjust their off-farm income and farm programs (e.g. by adopting agri-environmental programs to receive additional direct payments) to manage household income risks. Beside traditional risk reducing options like portfolio diversification, Swiss farmers can rely heavily on farm-level governmental support which serves as complementary risk-reduction strategy to diversification (Mishra et al., 2004). Hence, adopting e.g. agri-environmental programs to receive additional direct payments is a further strategy that can be taken to reduce household income risk and ensure the existence of the farm. However, this might only be possible for farmers under more favourable production conditions who can better adapt their farm operation to changing institutional and market conditions. For the meat and milk producing Alpine farms it is hardly possible to increase income from direct payments as this latter option is often already exploited. Thus, these farms may require additional risk management strategies and measures if income risks would increase. Any risk management instruments must therefore take regional specific risk profiles into account.

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