Economics Bulletin

Volume 31, Issue 3

Spatial Analysis of Income Inequality in Agriculture

Robert Finger
Agri-food & Agri-environmental Economics Group, ETH Zürich, Switzerland

Nadja El Benni
Agri-food & Agri-environmental Economics Group, ETH Zürich, Switzerland

Abstract

We investigate the spatial dimension of farm household income inequality as well as the importance of spatial considerations for its development over time using data for the period 1990-2009 on Swiss agriculture. To this end, Gini coefficients are estimated and non-parametric bootstrap is used to construct confidence intervals. We find significant differences between Gini coefficients across space, even though most cantons are characterized by homogeneous farm household income inequality. No significant change of Gini coefficients over time is found at the national level. In contrast, the analyses at the cantonal level show a heterogeneous development of income inequality. We find both increases and decreases in cantonal Gini coefficients.

This work was supported by the Swiss Federal Office of Agriculture. We would like to thank the Agroscope Reckenholz-Tänikon Research Station for providing the FADN data and a referee as well as the editor for helpful comments on an earlier version of the manuscript.
Citation: Robert Finger and Nadja El Benni, (2011) "Spatial Analysis of Income Inequality in Agriculture", *Economics Bulletin*, Vol. 31 no.3 pp. 2138-2150.
Submitted: Jun 22 2011.   **Published:** July 20, 2011.

Spatial Analysis of Income Inequality in Agriculture

1. Introduction

Farmers' income levels as well as the distribution of income among farmers are of particular importance in agricultural and rural policy making. In general, governmental intervention in agriculture has a wide range of economic, social and environmental objectives. Among these, many countries have typically framed income objectives of agricultural policies in terms of distribution or equity (OECD, 1998, Moreddu, 2011). A particular goal of agricultural policies is the support of low income groups or disadvantaged areas to reduce inequality and ensure sufficient incomes for all farmers. Thus, distributional goals of agricultural policy are maintaining an adequate standard of living for farmers and minimizing income disparities (Keeney, 2000).

The analysis of income inequalities in agriculture usually takes place at country levels (see e.g. Keeney, 2000, for overviews). However, also the income inequality within and across regions, i.e. the spatial distribution of income inequality, is relevant for policy makers and other stakeholders (Finnie, 2001, Lynch, 2003, Mishra *et al.*, 2009). In agriculture, this spatial distribution of income inequality has received little attention so far. In this research note, we investigate if this spatial dimension is important for farm household income inequality as well as its development over time. The focus on sub-national levels is motivated by the fact that the structure of agriculture and its production varies not only from country to country but also from region to region because of differences in type of land, the climate and the markets for agricultural products (Olesen, 2010).

As an exemplary case study, we analyze the spatial dimension of income inequality across farmers in Switzerland for the period 1990-2009. To this end, the analysis is conducted at the cantonal level, i.e. for the member states of the federal state of Switzerland. The first goal of this note is to investigate if there are spatial differences in agricultural income inequality in Switzerland. Secondly, this note investigates if policy reforms influenced agricultural income inequality and if this influence is spatially homogeneous. The choice of Switzerland as case study is motivated by the fact that it provides a good example of within country heterogeneity with respect to production conditions and agricultural specialization that is also observed in other countries (see Olesen, 2010, for examples in Europe).

2. Background

Due to large spatial variations in topographic and climatic conditions, Swiss agriculture is very heterogeneous with farms being located at altitudes between 200 and 2000 m a.s.l. Swiss agriculture is particularly dependent on milk and meat products that represent about 50% of the production value in 2009. However, also crop production and special crops such as vine, fruits and vegetables play an important role in Swiss agriculture (BLW, 2010). The specialization of agricultural production as well as the structure of farms depends on regional topographic and climate conditions as well as tradition (Gerwig, 2008). Switzerland is divided in three major landscape zones. The most important region for crop production is the Swiss Plateau. This region is characterized by flat and hilly terrain and is located between the two other landscape zones, the mountains of the Jura and the Alps. The altitude at the Swiss Plateau ranges between 400 and 700 m a.s.l. and annual precipitation ranges between 1000 and 1500 mm[1]. Most of the surface of Switzerland is covered by the Alpine regions that are particularly used for animal production based on forage and roughage production. The pre-alpine and alpine regions are characterized by cold and wet climate with annual precipitation levels of about 2000 mm. Within the Alps, inner-alpine valleys (e.g. the Rhone valley in the Valais) are characterized by distinct agricultural production conditions usually with low levels of rainfall (500-700 mm). Due to this spatial heterogeneity in production conditions and agricultural specialization, we expect that agricultural incomes and in particular income inequality differ across Switzerland. Thus, our first hypothesis is that income inequality in Swiss agriculture differs spatially.

Furthermore, we expect that income inequality changed over time. Switzerland has one of the most protected and supported agricultural production in the world (OECD, 2007). However, Swiss agricultural policy made major shifts throughout the last decades. In the beginning of the early 1990s, mainly price support was used to increase farmers' incomes. Throughout the 1990s,

[1] Information on climatic conditions is taken from the Swiss Federal Office of Meteorology and Climatology (www.meteoswiss.ch).

price support was reduced and direct payments were introduced as additional sources for income support. Since 1999, general (e.g. area based) direct payments that require the fulfillment of obligatory ecological cross compliance schemes were introduced. In summary, the support mechanisms used in Swiss agricultural policy switched in the last decades from one extreme to another, i.e. from massive price support to direct payment based support that requires keeping with very strict ecological standards. This also means that the primary focus of agricultural support changed from income support to preservation of ecological benefits and reduction of environmental damages from agricultural production. Overviews and further descriptions of agricultural policy reform steps in the last decades in Switzerland are provided in El Benni and Lehmann (2010), El Benni *et al.* (2011) and Mann (2003). Due to the heterogeneous structure of agricultural production, we expect that the influence of these policy changes has not been spatially homogeneous. Consequently, we also expect spatial heterogeneous influences of agricultural policy reforms on farm household income inequality. Thus, our second hypothesis is that income inequality in Swiss agriculture changed, spatially heterogeneously, in the considered 1990-2009 period.

3. Methodology

Income inequality is estimated using the Gini coefficient. This coefficient ranges between 0 (total income equality, all farmers have the same income) and 1 (maximal inequality, one farmer receives the entire income). The Gini coefficient is related to the Lorenz curve, which plots the proportion of total income (i.e. of all farm households) that is earned by a specific (cumulative) proportion of the farm population. An example of a Lorenz curve is presented in Figure 1, which shows the distribution of farm incomes in the cantons of Zurich and Valais in 1999. The Gini coefficient is defined as the ratio of the area between the Lorenz curve and the line of perfect equality (45° line) divided by the area under this line of perfect equality. Based on the example shown in Figure 1, the Gini coefficient can be calculated as G=A/(A+B). Mathematically, the Gini coefficient is defined as $G = 1 - \frac{1}{\mu}\int_0^{y*}(1 - F(y))^2 dy$, where F(y) is the cumulative probability distribution of income and μ is its mean and $y*$ is its upper limit (Dorfmann, 1979). We use the function *Gini* from the package *ineq* of the language and environment for statistical computing R (R Development Core Team, 2010) to calculate Gini coefficients.

In order to reveal the statistical accuracy of the point estimates for the Gini coefficient, non-parametric bootstrap is used (see DiCiccio and Efron, 1996, for details). To this end, the Gini coefficient is estimated for 1000 data replicates that are generated by sampling with replacement from each of the initial datasets. Thus, the estimation procedure[2] is replicated for the 1000 newly generated datasets. This leads to 1000 estimates for Gini coefficients, which are used to construct 95% confidence intervals. Gini coefficients and confidence intervals are estimated for each canton as well as for Switzerland at large.

In order to test if there are significant differences across cantons, the Gini coefficient estimates from the bootstrap analysis are used. In a first step, 50 Gini coefficients are randomly selected from the 1000[3] available bootstrap samples for each canton and year. Subsequently, Kruskal-Wallis tests (non-parametric analyses of variance) are employed on these samples to test if the canton has a significant influence on the size of Gini coefficient. These subsets of 50 Gini coefficient estimates per canton and year are also used to estimate if there is a significant trend on the cantonal level in Gini coefficients by regressing all observations (linearly) against a time variable (i.e. the years 1990-2009). The same procedure is applied to Gini coefficients estimated at the country level.

4. Data

In our analysis, we use farm level household income data of the Swiss National Farm accounting Network (FADN) that covers the period 1990 to 2009 (Dux and Schmid, 2010). The number of observations within the FADN data ranges between the minimum value of 2326 in 2002 and the maximum value of 4638 in 1993. We estimate Gini coefficients at the cantonal as well as at the national level. Because the number of observations in specific cantons and years can be small, we limit our analysis to cantons with at least 50 observations per year. This requirement is fulfilled for the entire period 1990-2009 in the cantons of Zurich, Bern, Luzern, Fribourg, St. Gallen, Aargau and Thurgau. For the cantons of Uri, Schwyz, Solothurn, Appenzell-Ausserrhoden, Graubünden, Vaudt, Valais and Jura this is the case only for selected years.

[2] This also includes trimming and weighting for each dataset (cp. data section).
[3] We used different numbers of randomly selected subsamples ranging from 5 to 1000 observations. The choice of the subsample size did not affect the here presented results.

Figure 1. Lorenz curve of farm household income in the cantons of Zurich and Valais 1999.

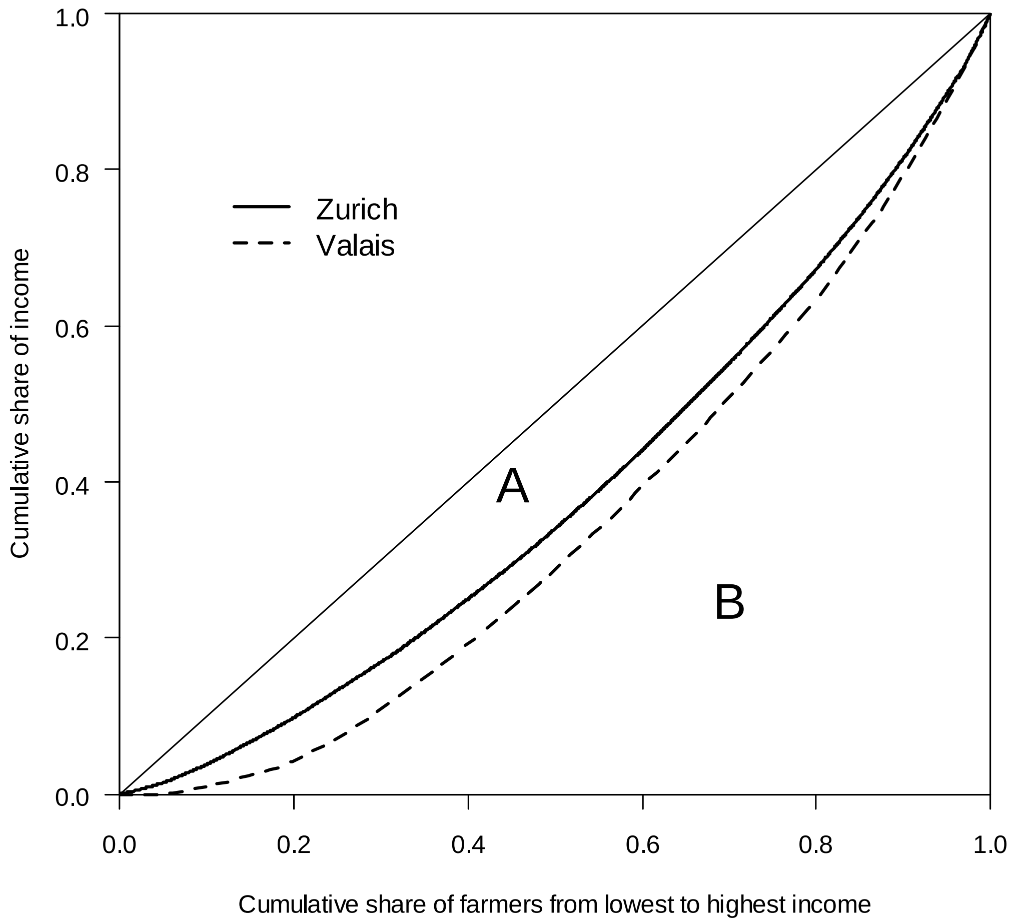


Table 1 summarizes the years used for these cantons. Due to insufficient amounts of available data, the remaining 10 cantons are not considered in our analysis.

Table 1. Swiss cantons and years used for the analysis.

Canton	Abbreviation	Years used in the analysis
Zurich	ZH	1990-2009
Bern	BE	1990-2009
Luzern	LU	1990-2009
Uri	UR	1993-2009
Schwyz	SZ	1992-2009
Obwalden	OW	1993-1998, 2004-2009
Fribourg	FR	1990-2009
Solothurn	SO	1990-2001, 2004-2009
Appenzell-Ausserrhoden	AR	1991-1995, 1997, 1999-2000, 2003-2009
St. Gallen	SG	1990-2009
Graubünden	GR	1990-2000, 2003-2009
Aargau	AG	1990-2009
Thurgau	TH	1990-2009
Vaudt	VD	1990-2000, 2004-2009
Valais	VS	1990-2002
Jura	JU	1990-1999

To draw conclusions from the here used sample data to the entire farm population in Switzerland, we use weights for each farm, i.e. farms in the sample are replicated according to these weights. Weights are based on the farm size, the farm production system, and the region and are provided with the FADN data. To exclude extreme values within each subsample, the 2.5% households at the top and bottom end of the total household income distribution (after weighting) were excluded from the analysis.

5. Results and Discussion

Table 2 shows the Gini coefficients for the 16 analysed cantons for the period 1990-2009 (cp. Table 1). It shows that farm household income inequality is relatively homogeneous across Switzerland: The average Gini coefficient (penultimate column of Table 2) for Swiss cantons (except for the canton of Valais) is in the range of 0.19 and 0.24. The average Gini coefficient for Switzerland at large is within this range (0.22). However, with an average Gini coefficient of 34, the canton of Valais has a much higher[4] farm household income inequality than other cantons. This high value is caused by a large heterogeneity of agricultural production that

[4] The confidence intervals for the Gini coefficients for the Valais are large (cp. Figure 2) and overlap with the confidence intervals for other cantons. Thus, no significant differences are found.

includes crop production, animal production and the largest absolute (and by far largest relative) shares of vine and fruit production areas (SBV, 2010)[5]. The lowest average Gini coefficient is found for Graubünden, a canton within the Alps that has virtually no arable land (4% of the total agricultural surface) and almost all farms depend on animal production. This low heterogeneity across farms in this canton with respect to farm activities and production conditions reduces the observed income inequality. The Kruskal-Wallis tests, which are based on 50 Gini coefficients for each canton and year that are randomly selected from the 1000 bootstrap samples, indicate significant differences in Gini coefficients between cantons for all years. Thus, the income inequality is not homogenous within Swiss agriculture and the spatial dimension of farm household income inequality is relevant.

[5] In 2009, vineyards and fruit production covered 11% and 6%, respectively, of the total agricultural land in Valais (SBV, 2010).

Table 2. Gini coefficients of farm household income in Swiss cantons 1990-2009.

	Year																						
Canton	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**Mean**	**SD**	**Time trend**
ZH	0.22	0.21	0.19	0.18	0.19	0.21	0.17	0.2	0.2	0.24	0.22	0.24	0.26	0.25	0.22	0.23	0.28	0.22	0.25	0.25	0.22	0.029	+0.0036 ***
BE	0.19	0.19	0.19	0.19	0.19	0.21	0.21	0.2	0.19	0.21	0.2	0.21	0.21	0.21	0.2	0.19	0.2	0.2	0.22	0.2	0.20	0.009	+0.0009***
LU	0.21	0.21	0.19	0.19	0.19	0.2	0.24	0.22	0.2	0.21	0.21	0.22	0.22	0.22	0.21	0.22	0.22	0.21	0.23	0.25	0.21	0.016	+0.0016***
UR	---	---	---	0.17	0.19	0.22	0.24	0.2	0.21	0.21	0.19	0.2	0.23	0.19	0.19	0.2	0.19	0.19	0.2	0.22	0.20	0.018	+0.0003*
SZ	---	---	0.21	0.2	0.2	0.2	0.2	0.19	0.2	0.2	0.2	0.22	0.2	0.18	0.17	0.15	0.2	0.19	0.19	0.21	0.20	0.016	-0.0001 (n.s.)
OW	---	---	---	0.19	0.16	0.18	0.27	0.21	0.21	---	---	---	---	---	0.2	0.2	0.19	0.18	0.18	0.23	0.20	0.029	+0.0001(n.s.)
FR	0.22	0.21	0.21	0.24	0.24	0.26	0.28	0.22	0.22	0.23	0.21	0.22	0.23	0.23	0.22	0.21	0.23	0.23	0.25	0.24	0.23	0.018	+0.0002 (n.s.)
SO	0.21	0.21	0.2	0.21	0.19	0.2	0.19	0.19	0.18	0.2	0.17	0.19	---	---	0.21	0.21	0.25	0.24	0.24	0.24	0.21	0.022	+0.0022***
AR		0.2	0.19	0.18	0.16	0.21	---	0.15	---	0.19	0.24	---	---	0.19	0.19	0.17	0.2	0.16	0.2	0.23	0.19	0.025	+0.0006***
SG	0.19	0.19	0.18	0.18	0.18	0.18	0.19	0.17	0.17	0.19	0.18	0.2	0.19	0.19	0.18	0.2	0.2	0.2	0.23	0.24	0.19	0.018	+0.0021***
GR	0.19	0.18	0.21	0.18	0.19	0.19	0.19	0.16	0.16	0.19	0.17	---	---	0.19	0.19	0.18	0.2	0.22	0.23	0.21	0.19	0.019	+0.0013***
AG	0.2	0.23	0.2	0.21	0.2	0.24	0.23	0.2	0.22	0.23	0.21	0.24	0.23	0.25	0.21	0.2	0.23	0.22	0.24	0.23	0.22	0.016	+0.0010***
TH	0.18	0.19	0.19	0.19	0.21	0.22	0.21	0.21	0.19	0.2	0.18	0.21	0.19	0.21	0.19	0.25	0.22	0.19	0.26	0.25	0.21	0.023	+0.0023***
VD	0.28	0.26	0.34	0.28	0.24	0.28	0.26	0.22	0.23	0.23	0.19	---	---	---	0.2	0.28	0.23	0.2	0.2	0.21	0.24	0.040	-0.0047***
VS	0.33	0.31	0.35	0.27	0.32	0.4	0.32	0.31	0.3	0.36	0.35	0.33	0.42	---	---	---	---	---	---	---	0.34	0.041	+0.0048***
JU	0.21	0.24	0.26	0.2	0.25	0.29	0.27	0.18	0.2	0.22	---	---	---	---	---	---	---	---	---	---	0.23	0.036	-0.0018**
CH	0.22	0.22	0.22	0.22	0.23	0.23	0.23	0.22	0.23	0.23	0.22	0.22	0.21	0.22	0.21	0.22	0.22	0.21	0.22	0.22	0.22	0.0054	+0.0001 (n.s.)

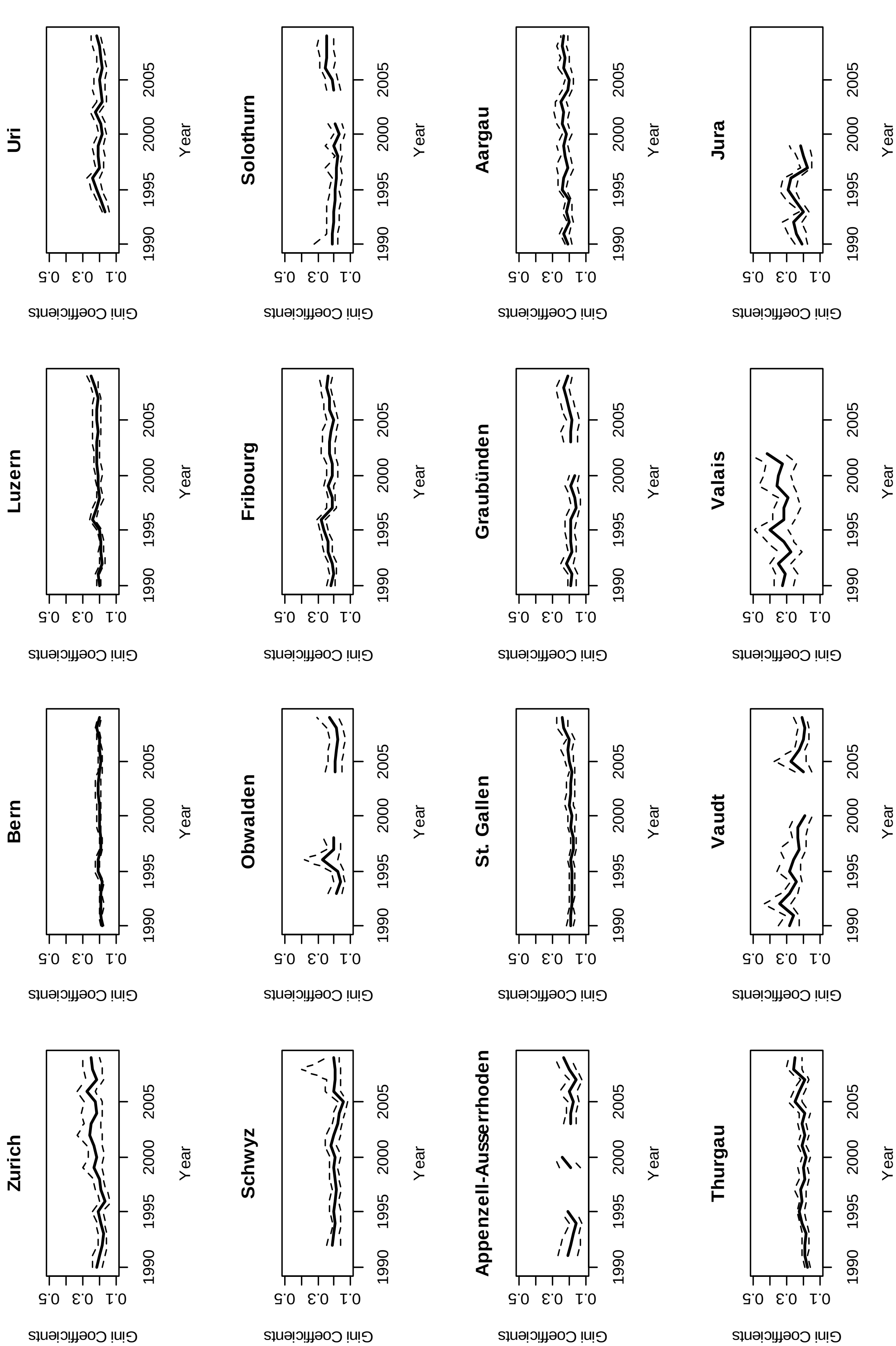
In all years, the Kruskal-Wallis test indicates significant differences of Gini coefficients between cantons. *, **, *** denote significant trends over time at the 10%, 5% and 1% level. n.s. denotes no significant trend.

Kurashige and Hwan Cho (2001) provide estimates for farm household income inequalities (using Gini coefficients) in 17 OECD countries during the 1990s. Their results show a range of Gini-coefficients from 0.21 (in Norway) to 0.52 (in Italy). Comparing these results with the here presented Gini coefficients shows that income inequality in Swiss agriculture at large is at the lower end of income inequalities observed in other countries. Even the highest Gini-coefficient at the regional scale observed for the canton of Valais is not exceptionally high in an international comparison, but rather reflects average income inequality in other countries. Thus, farm household incomes are (in an international context) very equally distributed across Swiss farmers, even at the cantonal scale. This is caused by the goal of Swiss agricultural policy to reduce (income) disparities between regions with different factor endowments, with a particular focus to support farmers in mountainous regions (El Benni *et al.*, 2011).

The estimated Gini coefficients together with the bootstrapped 95% confidence intervals are presented in Figure 2. It shows that point estimates for specific cantons have to be interpreted carefully, because specific confidence intervals are wide. Either a high number of observations or equal distributions of incomes are necessary to derive reliable point estimates with narrow confidence intervals.

The time trends presented in the last column of Table 2 show that there is no significant change of income inequality in Swiss agriculture at large. Thus, policy changes during the 1990s had no significant influence on the income inequality among farmers at the national level. In contrast, the analyses at the cantonal level show a heterogeneous development of income inequality. We find both increases and decreases in cantonal Gini coefficients. A significant decrease of farm household income inequality during the period 1990-2009 is indicated for the cantons Vaudt and Jura. Increasing Gini coefficients are indicted for the cantons of Zurich, Bern, Luzern, Uri, Solothurn, Appenzell-Ausserrhoden, St. Gallen, Grausbünden, Aargau, Thurgau and Valais.

Figure 2. Gini coefficients for farm household income inequality and 95% confidence intervals or Swiss cantons: 1990-2009.



In summary, an increasing farm household income inequality over time was found for 11 out of the 16 analysed Swiss cantons, a decreasing trend was found for 2 cantons, while no significant trend was indicated for 3 cantons. The increase of income inequality in the majority of cantons due to the switch from market based (i.e. price-) support to direct payment based support for farmers contrasts the experiences from other countries (see Moreddu, 2011, for an overview on selected OECD countries). In the payment based approach, low income farms are expected to (in general) receive over-proportional more support than it is the case for market based support, which is expected to equalize incomes across farms. However, supporting schemes in Switzerland are mainly linked to farm assets (e.g. farm size), which seems to marginalize this effect in some regions (cp. El Benni *et al.*, 2011).

In conclusion, our analysis revealed significant cantonal differences in farm household income inequality in Swiss agriculture. Thus, analyses of agricultural incomes should explicitly consider this spatial dimension. At the national level, we found no significant change in income inequality over time for the period 1990-2009 – even though agricultural income support changed dramatically from price-support to direct payments within this period. In contrast, a much more heterogeneous picture has been found at the cantonal level, i.e. the influence of agricultural policy reforms on farm household income inequality was not spatially homogenous. Thus, conclusions regarding the state and development of income inequality across farmers drawn from national levels may not be representative for smaller aggregation levels. Because other European countries face similar degrees of heterogeneity with respect to production conditions and agricultural specialization (Olesen, 2010), we expect that similar regional specific effects of agricultural policy on farm household income inequality could be observed as they have been indicated in our analysis for Switzerland. While the effect of governmental support on income disparities between farm types has been already investigated for the European Union (OECD, 2003), the link to spatial distributions of income inequalities was not yet made. Therefore, future research has to address this regional dimension of agricultural income distribution also in other countries. A potentially next step of this research is to identify the determinants of different income inequality levels as well as for the different developments of farm household income inequality over time. Moreover, additional policy relevant insights could be gained if proxies for farmers' wealth instead of household incomes are considered to analyse inequalities across farms.

References

BLW (2010) *Agrarbericht*. Federal Office for Agriculture (BLW), Bern, Switzerland.

Di Ciccio, T.J. and Efron, B. (1996) "Bootstrap Confidence Intervals" *Statistical Science* **11**, 189-212.

Dorfman, R. (1979) "A Formula for the Gini Coefficient" *The Review of Economics and Statistics* **61**, 146-149.

Dux, D. and Schmid, D. (2010) *Grundlagenbericht 2009*. Zentrale Auswertung von Buchhaltungsdaten, Forschungsanstalt Agroscope Reckenholz-Tänikon ART, Tänikon, Switzerland.

El Benni, N, and Lehmann, B. (2010) "Swiss agricultural policy reform: landscape changes in consequence of national agricultural policy and international competition pressure" In J. Primdahl, and S. Swaffield, eds. *Globalisation and Agricultural Landscapes - Change Patterns and Policy trends in Developed Countries*. Cambridge University Press, Cambridge, pp. 73-94.

El Benni, N., Mann, S., and Lehmann, B. (2011) *Distributional Effects of Direct Payments in Switzerland*. Paper prepared for the 122nd EAAE seminar "Evidence-Based Agricultural and Rural Policy Making: Methodological and Empirical Challenges of Policy Evaluation". Ancona (Italy), February 17-18, 2011.

Finnie, R. (2001) "Unequal Inequality: The Distribution of Individuals' Earnings by Province" *Canadian Journal of Regional Science/Revue Canadienne Des Sciences Regionales* 24, 265–288.

Gerwig, C. (2008) *Entscheidungen im Strukturanpassungsprozess*. PhD Thesis, ETH Zurich, Switzerland.

Keeney, M. (2000) "The Distribution Impact of Direct Payments on Irish Farm Incomes" *Journal of Agricultural Economics* **51**, 252-263.

Kurashige, Y. and Hwan Cho, B. (2001) *Low Incomes in Agriculture in OECD countries*. Organisation for Economic Co-operation and Development (OECD), Paris.

Lynch, R.G. (2003) "Estimates of income and income inequality in the United States and in each of the fifty States: 1988-1999" *Journal of Regional Science* **43**, 571-587.

Mann, S. (2003) "Doing it the Swiss Way" *EuroChoices* **2**, 32-35.

Mishra, A., El-Osta, H. and Gillespie, J.M. (2009) "Effect of agricultural policy on regional income inequality among farm households" *Journal of Policy Modeling* **31**, 325-340.

Moreddu, C. (2011) *Distribution of Support and Income in Agriculture*. OECD Food, Agriculture and Fisheries Working Papers, No. 46, OECD Publishing.

OECD (1998) *Agriculture in a Changing World: Which Policies for Tomorrow?* Organisation for Economic Co-operation and Development (OECD), Paris, France.

OECD (2003) *Farm Household Income – Issues and Policy Responses*. Organisation for Economic Co-operation and Development (OECD), Paris, France.

OECD (2007) *Agricultural Policies in OECD Countries : Monitoring and Evaluation 2007*. Organisation for Economic Co-operation and Development (OECD), Paris, France.

Olesen, O. (2010) "A regional picture of farming in Europe - what, where and how much?" *Eurostat - Statistics in Focus 44/2010*.

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.

SBV (2010) *Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung*. Schweizer Bauernverband (SBV, Swiss Farmers' Union), Brugg, Switzerland.