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A 'beyond WTO' scenario for Swiss agriculture: Consequences for income generation and the provision of public goods

Robert Huber and Christian Häberli

Abstract

The future agricultural policy framework seems clear. Even though the present trends do not point in this direction there is a strong probability that in the long run Swiss agriculture will have to forfeit border protection, while domestic support will be restricted to fully Green Box-compatible direct payments. We use a normative mathematical programming model to illustrate possible effects for agricultural production and the corresponding agricultural income in the medium term (2012–2018) under such a 'beyond WTO' scenario. We discuss the results with respect to the provision of the public goods stated in Art.104 of the Swiss constitution. The potential effects for agricultural production in Switzerland are considerable. The agricultural sector in the lowlands would be especially affected, with dairy farming remaining the most viable sector. In order to survive commercially, a further drastic reduction in production costs would be unavoidable, and efforts to realise prime premiums would have to be intensified.

Key words: WTO, sector modelling, Swiss agricultural policy

JEL Classification: Q11, Q17, Q18

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1. Introduction

Further multilateral disciplines, and in particular a conclusion of the Doha Round negotiations in the World Trade Organization (WTO), are likely to influence Swiss agriculture substantially. The same goes for a free trade agreement in agriculture and food with the European Communities. Neither of them will abolish all tariffs and other border measures, nor will they prevent all types of subsidies. Nevertheless, both would represent a big step in that direction. The question addressed in this paper is how, in terms of incomes and the provision of public goods, Swiss agriculture would fare under a radical liberalisation scenario.

We have designed such a scenario with the following characteristics: no tariffs, no import quotas, and all domestic support measures limited to those without (or with only minimal) impact on production and trade, as per the definition in the WTO Green Box. There is no evidence on the effect of such a counterfactual scenario for Swiss agriculture (Aerni 2009). We therefore use a normative mathematical programming model to illustrate possible effects for agricultural production and the corresponding agricultural income for the short and middle term (2012–2018). Furthermore, we discuss the results with respect to the provision of public goods under the assumption of strictly Green Box-compatible direct payments.

Our scenario is obviously a far cry from where we are today. Present prospects appear dim for both the WTO Doha Round and for a Swiss–EU agricultural free trade agreement (FHAL). Nevertheless, the direction seems clear and there are two reasons for doing such an analysis: From an economic perspective, a further liberalisation is the most rational alternative for Swiss agriculture (Dietler et al. 2010). Moreover, the identification of economic driving forces in the agricultural sector under such a scenario lays the basis for political and entrepreneurial action.

2. Statement of problem and research questions

Agricultural trade liberalisation is seen by some as a threat especially to the multifunctionality of agriculture and to its ability to continue to provide environmental and social benefits (Dibden et al. 2009, Potter and Tilzey 2007). A radical WTO scenario is also seen as a threat to the survival of (less competitive) agricultural producers (Burell 2001). In Switzerland, some argue that without border protection and by focusing on Green Box-compatible payments, agricultural production would vanish and farmers would become mere 'landscape gardeners' (Binswanger 2009).

However, there is no evidence on the effect of such a scenario. Moreover, in view of the complex and multifaceted consequences along the value chain, a sound analysis of all the consequences for the agricultural sector is extremely demanding. What can be assessed, however, is the effect on agricultural production in a normative economic framework. Which agricultural activities would maximise the income for price taking farmers? The results provide the baseline for further – more holistic – impact analyses of such a scenario.

Our normative mathematical programming model illustrates possible effects for agricultural production and the corresponding agricultural income. We also show the results with respect to the provision of public goods under the assumption of Green Box-compatible direct payments. Thereby we address the following research questions:

- What results from the implementation of our scenario for agricultural production in the short and middle term?
- What effects can be expected on agricultural incomes?
- What effects could be expected for the provision of multifunctional public goods and services (secure food supply, conservation of natural resources, taking care of the landscape and encouraging decentralised settlement)?

Besides the question of the impact of trade liberalisation on importing countries like Switzerland, there is also the wider issue, not addressed

here, of how agricultural and trade policies prevent access to their markets of more competitive foreign suppliers. This clearly has an impact on many poor countries for which agriculture is a powerful tool for rural development, and for trade-induced food security (Häberli 2001, 2008, 2010a, 2010b).

This article is structured as follows. In the next two sections we present a review of normative programming models analysing the impact of liberalisation scenarios on the agricultural sector and describe the development of agricultural policy in Switzerland. We then present a fully Green Box-compatible direct payment system for Switzerland. Our methodological approach is presented in Section 5. Section 6 provides a description of the scenarios. Results and discussion are provided in Sections 7 and 8, respectively. Section 9 concludes.

3. Literature review

Mack et al. (2006) calculated the impact of an EU scenario for Swiss agriculture for the year 2011 employing the agricultural sector model SILAS-dyn (Mack and Flury 2006). They show a large income reduction in the lowlands of up to 72% compared to the base year in 2001. In contrast, the reduction in the mountain region is much lower in their scenarios (up to 39%). They suggest that organic farming would represent an important strategy for the farmers in the Swiss lowlands. This is confirmed by the investigation of Sanders (2009). In this analysis the potential impact of a free trade agreement on the financial performance of organic farming and its relative profitability compared with non-organic agriculture is evaluated by employing the agricultural sector model FARMIS (Sanders et al. 2008). The results indicate that, on average, organic farms are less severely affected by liberalisation policies than non-organic farms.

A further application of the sector model SILAS-dyn can be found in the analysis of Mack (2008). She evaluated the effects of a FHAL on the sectoral income of Swiss agriculture. The implementation of the corresponding scenario leads to an increase of milk production and a reduction of plant production until 2015. The net self sufficiency of Swiss agriculture would decrease by 4%. Again, the reduction in the sectoral in-

come in the lowlands and the hill region are expected to be much higher (42–44%) than in the mountain region (26%).

With respect to environmental impacts, Zimmermann (2008) shows that a liberalisation of Swiss agriculture would result in a significant decline in fertiliser and pesticide use. At the same time, ecological compensation surfaces would increase. However, the import of feed concentrates would also increase significantly.

Peter et al. (2009) show the effect of a FHAL scenario on plant production in Switzerland. In accordance with the results of Mack and Zimmermann, this study shows a large reduction in plant production, an increase in forage based milk production and an increase in the import of feed concentrate.

Overall, the results of these studies show very similar tendencies for agricultural production under different liberalisation scenarios. The sectoral income is reduced significantly. Thereby, the lowlands are much more affected than mountainous regions. Moreover, grassland based milk production is preferred to plant production.

These results provide helpful insights into the relative profitability of different agricultural production activities and the impact on the sectoral income of the corresponding scenarios. However, none of these calculations accounts for a change in the price system and the direct payments system simultaneously. With respect to a potential agreement in the Doha round, this is an important aspect since these negotiations will not only affect tariffs but also domestic support. Thus, our approach is in line with the existing research but adds an important further step to this kind of analysis. In addition, our price assumptions refer also to the world and not only to the EU market.

4. Policy background

4.1 Swiss agricultural policy and the WTO

In the 1990s Swiss agricultural policy underwent a major change (Joerin et al. 2006, BLW 2004). In line with the WTO Agreement on Agriculture

(AoA), Switzerland changed the legal base for its agricultural policy. Back in 1996 the Swiss electorate had, in a public vote, already approved a new constitutional mandate for agricultural policy and legislation. This article, Article 104, assigns multifunctional tasks to agriculture, which include contributing to a secure food supply, conserving natural resources, taking care of the landscape and encouraging decentralised settlement. More importantly, the policy instruments for reaching these objectives were completely reformulated. Price and sales guarantees were abolished, and price support has been gradually reduced. In contrast, direct payments remunerating farmers for specific services in the public and common interest were increased.

This change in the agricultural policy framework was introduced step by step. Lower price support was compensated by different direct payments. While overall support in Switzerland remained high, among the highest of all Organisation for Co-operation and Development (OECD) countries (OECD 2009), the effectiveness of the actual direct payment system was called into question even by the Federal Parliament (WAK 2006). In 2009, the Federal Office for Agriculture proposed a newly designed direct payment system (Vogel et al. 2008, BLW 2009, Lanz et al. 2010). In our opinion this concept actually includes payments for specific products which cannot be classified under the present Green Box definition.

The Doha Round negotiations at the WTO are in a stalemate (mid-2010). The December 2008 agricultural 'modalities' foresee a 70% reduction of the highest tariffs and price support measures as well as the elimination of all export subsidies by 2013 (WTO 2008). Given the high level of support in Switzerland, the implementation of such a scenario, even with some softeners such as the so-called 'sensitive products' would affect the agricultural sector and income generation considerably (BLW 2008).

4.2 Green Box

As already indicated, our model only foresees fully Green Box-compatible support instruments, even though a certain amount of product support (the so-called 'Amber Box') will still be allowed after the implementation of the Doha Round results. It is therefore useful to briefly recall the concept and definition of the Green Box.

The Agreement on Agriculture basically consists of three main pillars: market access, domestic support, and export competition. Different types of domestic support disciplines are defined in 'boxes' of different colours: the specific measures in the so-called Green Box are not subject to any reduction commitments and can even be increased without limitation. They include general government services, direct producer payments, decoupled income support, disaster relief, producer and resource retirement programmes, investment aids, environmental and regional assistance programmes. Specific conditions apply to each of these categories. Most importantly, all of them must meet the chapeau condition enumerated in paragraph 1 and have 'no, or at most minimal, trade-distorting effects or effects on production.' Furthermore, they must not 'have the effect of providing price support to producers' (lit.b). The adverb 'minimal' clearly leaves some room for interpretation; it has never been quantified in a dispute settlement process.

It has been argued that many support measures notified under the Green Box have more than a 'minimal' trade impact (Anderson 2006). Some authors are calling for more flexibility, which would allow developing countries to ensure their needs for food security, livelihood security and rural development (Meléndez-Ortiz et al. 2009). While this debate has yet to produce results in respect of the existing rules and disciplines, we would argue that non-product-specific measures involving an extensification of production, and measures partly compensating a production cost increase would pass even a stringent Green Box-compatibility test. In particular, we retain the following criteria for our selection in Section 6 of the support measures presently used by Switzerland:

- A 'more than minimal' impact on production would result from measures which are product-specific, such as subsidies on oilseed.

- This also applies to generally applicable animal-based subsidies (payments for all grazing animals) and, of course, to the allocation for transforming milk into cheese and for not using silo fodder for such cheese.

- However, measures implying an extensification of production would probably still be 'green' (e.g. allocations for sloping terrain in upland and mountain areas, and summer pasture contributions).

- We would also argue that ethological contributions to animal-friendly production methods involve a reduction in outputs and/or an increase in production costs; we would therefore qualify them as 'green' measures.

- Finally, we still accept contributions for maintaining 'open arable land', although we have some doubts as to their specific production impact. Under certain, relatively stringent conditions, such contributions might nevertheless qualify as tools for landscape management, or environmental protection and biodiversity promotion.

We are fully cognisant that each of the above measures would need to be assessed in detail before reaching a conclusion on its legal status under the Green Box, and that even then opinions may diverge on their 'more than minimal' production impact. As will be shown below, the type and extent of possible 'green' support measures nevertheless remains considerable.

5. Methodology

Since there is no evidence with respect to our research questions we use the normative mathematical programming model S_INTAGRAL which maximises the sectoral income of Swiss agriculture.

S_INTAGRAL has been used in various analyses of the agricultural sector for the Swiss federal administration (Huber et al. 2010 and Peter et al. 2006, 2008b, 2009). Thus, its acceptance in the relevant policy administration is high. Moreover, the model depicts the agricultural production cycle and the existing structures in Switzerland in a detailed manner. Ex-post analyses show that the model is able to reproduce the development of the past in a powerful way (Hartmann et al. 2009).

The model can be characterised as a recursive-dynamic agricultural supply model, maximising sectoral farm income (labour and land rents). This occurs subject to a specific factor endowment and under consideration of different system-specific limitations such as cropping constraints (Peter 2008a). In addition, opportunity costs represent minimal factor compensation for land and labour. If the farmer earns less than the level of opportunity costs, the corresponding economic activity does

not enter the optimal solution. As a result, the income per hour and the rental value of land have a lower limit and thus represent an exit threshold. The level of opportunity costs is given by the observed average income per hour and the observed land rental values in Swiss agriculture.

S_INTAGRAL consists of a 'livestock farming' and a 'plant cultivation' module. The 'livestock-farming module' is integrated with the 'plant-cultivation module' through balances between grassland- and cropland-based forage production and its use, as well as with livestock manure production and application to soil. Additionally, system-specific dynamics, such as the development of farm size or livestock populations, are embedded into the model in a recursive-dynamic manner (Day and Cigno, 1978). This agricultural supply module was finalised by embedding an environment module, which contained the scientific calculation methods for agricultural emissions of nitrogen and greenhouse gases (IPCC, 1997; Minonzio et al., 1998; Schmid et al., 2000).

The Swiss agricultural surface comprises one million hectares of which 40% are suitable for crop production. The model distinguishes three major production zones: plains, hills, and mountain areas. This allows the calibration of the model with respect to the regional factor endowment and also allows one to consider differences in input-output coefficients (e.g. vegetation period, harvest level, mechanisation types, labour costs). S_INTAGRAL integrates all important activities in livestock farming and plant cultivation with regard to revenue, land use, and livestock population. These activities with regard to animals include cattle, swine and poultry farming and with regard to plant cultivation include permanent grassland, arable land and cash or forage crop cultivation. Table 1 provides an overview of the farm products, activities and their specifications in the model.

Table 1: Farm activities and specifications in S_INTAGRAL

Module	Products	Model activities	Specifications
Plant	Root crops	Sugar beet, potatoes	Zone (plain, hills, mountains)
	Cereals	Wheat	
	Feed grain	Barley, maize	Intensity levels (intensive, mid-intensive, extensive)
	Oil seeds	Rape	
	Roughage	Grassland (permanent, rotational)	
Livestock	Milk	Dairy and rearing cattle	Zone; housing system and size; efficiency; feeding system; free range management
	Beef and veal	Sucklers, bulls, calves	
	Pork and chicken	Pigs, broilers	
	Eggs	Pullets, laying hens	

A more detailed insight into the S_INTAGRAL model and its mathematical formulation is provided by Hartmann et al. (2009) and Peter (2008a).

The combination of the agricultural production cycle with an environmental module allows the calculation of a multitude of indicators. Despite various shortcomings in the application of indicators, they are helpful in the assessment of multifunctional agriculture. In combination with a comprehensive mathematical programming model, indicators enable a comparison between alternative policy scenarios and can enhance policy dialogue (Lehtonen et al. 2005, p. 66). Table 2 provides the indicators chosen for the analysis of our scenario and the corresponding meaning with respect to multifunctional agriculture. They are listed with respect to economic and social as well as environmental functions of agriculture. Beyond the indicators related to the agricultural income, these indicators can be related to public goods mentioned in Article 104 of the Federal Constitution (last column of Table 2): secure food supply (A), conserving natural resources (B), taking care of the landscape (C) and encouraging decentralised settlement (D). The level of production can be associated with secure food supply. The level of employment in agriculture relates to structural change and can be used as an indicator for social sustainability and the contribution to decentralised settlement. Conserving natural resources and taking care of the landscape can be assessed by the ecological indicators.

We are aware that there is a difference between an economically sound definition of public goods and the goals formulated in Article 104. However, in order to contribute to the discussion on effects of freer trade on multifunctional agriculture from a policy perspective, we also have to address the goals formulated in the actual policy. In particular, the use of the agricultural production level can be seen as a poor indicator for food security, regardless of whether or not it is corrected for imports (Anderson 2000). However, the political debate with respect to food security is focused on the production level of Swiss agriculture.

Furthermore, we are aware that S_INTAGRAL has some well-known limitations. Firstly, the one-dimensional objective function (income maximisation) does not represent diverging preferences, values and risk behaviour. Secondly, there is a lack of feedback effects which would be expected from input and output markets. In particular, investment decisions which take into account long-term developments can not be represented in our model. Thirdly, the model is linear. Linearity is mathematically convenient, but in reality it may lead to erroneous conclusions if threshold effects occur. Moreover, the regional farm approach implemented in S_INTEGRAL tends to overestimate factor mobility and cannot fully represent the heterogeneity of Swiss agriculture with respect to farm types and surface area. As a consequence, the results of our calculations have to be discussed with respect to these caveats (Section 8).

Table 2: Indicators in S_INTAGRAL for the analysis of multifunctional agriculture

Function	Indicator	Unit	Indicator reflecting	Related public good
Economic and social	Sectoral income per zone	CHF	Level of economic activities per region	–
	Number of farmers (working equivalent)	Nr.	Level of employment in agriculture	D
	Income per full-time farmer	CHF	Economic and social welfare of farmers	–
	Level of production per activity	t	Self-sufficiency in agriculture	A
	Gross profit per input	Ratio	Agricultural productivity (land, labour)	–
	Direct payment budget	CHF	Extent of agricultural support	–
Ecological	Total area of agricultural land	ha	Landscape maintenance	C
	Open arable land	ha	Soil erosion potential	A, C
	Share extensively used grassland	ha	Biodiversity conservation (quantity)	B, C
	GHG emissions	kt	Contribution to GHG emission reduction	B
	N emissions	kt	N leaching potential	B

Abbreviations:

CHF: Swiss Francs; kt: 1000 tons; ha: hectares, GHG: greenhouse gas, N: nitrogen

Public goods: secure food supply (A), conserving natural resources (B), taking care of the landscape (C) and encouraging decentralised settlement (D)

We would like to stress that the results of such normative and linear models do not predict a certain future. However, the model infallibly computes the logical consequences of our assumptions (Sterman, 1991). Thus, they can provide the basis for policy responses and entrepreneurial action.

6. Scenarios

We use the normative programming model to calculate two different scenarios. These scenarios differ with respect to prices and costs.

- Prices: Switzerland represents a small-country case. Thus, we assume prices to be exogenous. The projections of agricultural output prices varies in our scenarios with respect to source, commodities and the underlying assumptions of the different reports (Peter et al. 2010, FAPRI 2009, OECD 2009). We consider two price developments representing an upper and a lower bound of the expected prices. The upper bound is given by the expected prices of a FHAL with the European Union (Peter et al. 2010). The lower bound is given by world market price in the reports of FAPRI and OECD/Food and Agriculture Organization of the United Nations (FAO). A selection of price assumptions is given in Table 4.

- Costs: Production costs in Swiss agriculture are high compared to neighbouring countries. More open markets will certainly allow for lower production costs. However, the amount of this reduction potential is unknown and depends on the type of cost. We assume two different levels for production costs (Table 5). 'High' costs imply that market imperfections limit the possibility for reducing costs. The 'low' level refers to a situation in which variable production costs approach the level of neighbouring countries (e.g. Schmid 2005).

In our calculations, we combine the upper (lower) bound of output prices with low (high) production costs. This results in the best and worst cases of the returns from selling agricultural products as shown in Table 3.

Table 3: Scenarios

	Scenario: 'high returns'	**Scenario: 'low returns'**
Prices	Upper bound	Lower bound
Costs	Low	High

In order to illustrate these assumptions in more detail, Table 4 summarises some further details of the underlying assumptions. A selection of

the different upper (lower) bound prices and low (high) cost assumptions is given for the years 2010 to 2018. For 2011, prices and costs are held constant at 2010 levels. From 2012 to 2015, these parameters decrease stepwise to the world market price level in the corresponding variation of the scenario. These levels of prices and costs are held constant over the last period from 2015 to 2018.

The price decrease varies between 58% for wheat, pig meat and cattle meat, and 21% for milk production. This variation reflects the different levels of existing support in Switzerland. The reduction in production costs varies between 50% for the costs of feed concentrate to 5% for the purchase of seeds. Moreover, some of the costs also increase in the corresponding period. Fuel price (last column), for instance, increases by 60% in accordance with the OECD/FAO scenario (OECD 2009, p. 16). Technological progress is represented by productivity gains in machinery and animal housing systems. Whereas the development of the housing systems is part of the optimisation procedure, the productivity gain of machinery is given exogenously (second-last column in Table 4). The development in the higher cost scenario is based on the assumptions that existing machinery would be used to its potential working load (which today is not the case in Switzerland). This will lead to a fixed cost reduction of 20% (ART 2009). In the lower cost scenario, our assumption is that more productive machinery will reduce fixed cost to a level of 60%. Gains in labour productivity correlate with the development of housing systems and machinery.

Moreover, we implement a direct payment system which we consider to be more Green Box-compatible than the present system. Tables 6 and 7 provide an overview of a general and ecological direct payments system implemented in the normative programming model compared to the existing system. Direct payments per unit, the corresponding overall spending of the Federal Government and the percentage of each direct payment category of total spending from the model are presented for the years 2009 and 2018. General direct payments comprise 86% of total direct payments in the year 2009 (Table 6). Ecological direct payments amount to 14% of total payments (Table 7). These levels are held constant in our calculations. However, the payments per animal are decreased from 35% in the existing system to 7% for particularly animal-friendly conditions in the Green Box-compatible system.

The conditions for the allocation of direct payments are not altered in our scenarios. Thus, farmers have to provide proof of ecological performance (e.g., balanced use of fertiliser, appropriate proportion of ecological compensation areas, and crop rotation suitable for soil protection measures) and comply with further conditions such as a minimal amount of work, age limit and a possession of basic agricultural qualifications (BLW 2004, p. 18).

It should be noted that the present WTO disciplines would allow increases without limits for each of the direct payments remaining in our scenarios. Because of the various internal policy constraints implied we have however refrained from pursuing these possibilities in this study.

Table 4: Price and cost parameters for the different scenarios

		2010	2011	2012	2013	2014	2015	2016	2017	2018	Source
Prices	**CHF**										
Wheat	upper	56.00	56.00	48.51	41.02	33.53	26.04	26.04	26.04	26.04	Peter et al. (2010) OECD/FAO (2009) FAPRI (2009)
	lower	21.75	22.67	23.66	24.00	23.85	23.91	24.07	24.10	24.15	
Oilseed	upper	68.70	68.70	64.87	61.04	57.22	53.39	53.39	53.39	53.39	
	lower	50.57	51.24	51.23	52.07	52.25	52.42	52.70	52.36	52.25	
Sugar	upper	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	
	lower	3.36	3.44	3.49	3.41	3.31	3.34	3.33	3.34	3.38	
Barley	upper	34.87	34.87	31.67	28.46	25.26	22.05	22.05	22.05	22.05	
	lower	18.06	18.69	19.27	19.71	20.20	20.44	20.63	20.78	21.00	
Pig meat	upper	4.26	4.33	4.33	3.81	3.29	2.77	2.26	2.26	2.26	
	lower	1.56	1.63	1.77	1.73	1.71	1.66	1.70	1.74	1.80	
Cattle meat	upper	8.45	8.36	8.36	7.47	6.59	5.70	4.81	4.81	4.81	
	lower	3.29	3.29	3.50	3.55	3.66	3.64	3.61	3.57	3.57	
Chicken	upper	2.63	2.70	2.70	2.35	2.00	1.65	1.30	1.30	1.30	
	lower	0.99	1.01	1.01	1.03	1.06	1.09	1.11	1.13	1.15	
Milk	upper	0.64	0.64	0.64	0.61	0.57	0.54	0.50	0.50	0.50	
	lower	0.35	0.39	0.40	0.40	0.41	0.42	0.42	0.43	0.44	

Table 5: Cost parameters for the different scenarios

		2010	2011	2012	2013	2014	2015	2016	2017	2018	Source
Costs (as a % of 2009 costs)											
Seed	Low	1.00	1.00	0.98	0.95	0.93	0.90	0.90	0.90	0.9	
	High	1.00	1.00	0.99	0.98	0.96	0.95	0.95	0.95	0.95	
Pesticides	Low	1.00	1.00	0.93	0.85	0.78	0.70	0.70	0.70	0.7	
	High	1.00	1.00	0.96	0.93	0.89	0.85	0.85	0.85	0.85	
Feed concentrate (average)	Low	1.00	1.00	0.88	0.75	0.63	0.50	0.50	0.50	0.5	
	High	1.00	1.00	0.91	0.83	0.74	0.65	0.65	0.65	0.65	
Machinery (variable costs)	Low	1.00	1.00	1.02	1.04	1.06	1.08	1.08	1.08	1.08	Peter et al. 2010 (high) Own (low)
	High	1.00	1.00	1.04	1.09	1.13	1.17	1.17	1.17	1.17	
Machinery (av. fixed costs)	Low	1.00	1.00	1.03	1.05	1.08	1.10	1.10	1.10	1.1	
	High	1.00	1.00	1.05	1.10	1.14	1.19	1.19	1.19	1.19	
Buildings (av. fixed costs)	Low	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.02	1.02	
	High	1.00	1.00	1.01	1.02	1.03	1.04	1.04	1.04	1.04	
Productivity gains (machinery)	Low	1.00	1.00	0.90	0.80	0.70	0.60	0.60	0.60	0.6	
	High	1.00	1.00	0.95	0.90	0.85	0.80	0.80	0.80	0.8	
Fuel price	Low	1.00	1.00	1.08	1.15	1.23	1.30	1.30	1.30	1.3	
	High	1.00	1.00	1.15	1.31	1.46	1.61	1.61	1.61	1.61	

Table 6: General direct payments implemented in S_INTAGRAL

		Reference 2009			Scenario 2018[1)]		
		Total expenditure (million CHF)	as a percentage (%)	Payment (CHF per unit)	Total expenditure (million CHF)	as a percentage (%)	Payment (CHF per unit)
General direct payments							
	Area of farmland (lowlands)	1067	47	1040	1538	68	1500
	Area of farmland (hills, mountains)[2)]		–	–	274	12	2000
Payments based on acreage (ha)	Open arable land	177	8	600	104	5	600
	Specific crops (rape, sugar beet, pea)	63	3	1000–1900		–	
	For sloping terrain in uplands and mountains	84	4	100–190	84	4	100–190
Payments per animal (head)	Kept under difficult production conditions	196	9	260–750		–	
	Grazing animals	373	16	430–660		–	
Total general direct payments		1960	86		2000	88	

[1)] For comparison, the total expenditure in the year 2018 in the 'high return' scenario is taken from the result section.

[2)] Include a compensation for production disadvantages (replacing the payments per animal under difficult production conditions).

Table 7: Ecological direct payments implemented in S_INTAGRAL

		Reference 2009			Scenario 2018[1)]		
		Total expenditure (million CHF)	as a percentage (%)	Payment (CHF per unit)	Total expenditure (million CHF)	as a percentage (%)	Payment (CHF per unit)
Ecological direct payments							
Payments based on acreage (ha)	Payments for extensive production of crops	30	1	400	18	1	400
	Payments for ecological compensation areas	39	2	500	90	4	500
Payments per animal (head)	Payments for particularly animal-friendly conditions	239	11	90–280	165	7	90–280
Total		308	14		273	12	

[1)] For comparison, the total expenditure in the year 2018 in the 'high return' scenario is taken from the result section.

[2)] Include a compensation for production disadvantages (replacing the payments per animal under difficult production conditions.

7. Results

Results of the calculations are presented, firstly, with respect to the two scenarios. The two scenarios are then compared.

7.1 Scenario 'high returns'

In 2018 the sectoral income in the Swiss lowlands is reduced by 42% compared to the base level in 2009 (2^{nd}–5^{th} row in Table 10). In the same period, labour demand sinks by 21%. As a consequence, income per farmer (working equivalent) at world market prices and without product subsidies decreases to CHF 52,420, in other words 72% of the 2009 income.

In contrast, the income per full-time farmer equivalent increases to a level of 102% in the hills (CHF 57,420) and even more in the mountains, to 155% (CHF 75,124). This can be inferred from the smaller reduction in the sectoral income of 31% and 21% and the greater decrease in the demand of full-time working equivalents of 32% and 42% in the hill and mountain regions respectively. Thus, the severest impact of the income reduction can be observed in the lowlands.

The overall production for all regions sinks to a level of 85% for milk, 59% for meat and 76% for plant production. The reduction in animal and plant production is illustrated in more detail in Tables 8 and 9, respectively. These tables reveal that regional differences are important with respect to production activities. In the lowlands, the number of milking cows remains constant (Table 8). On the other hand, milk production is reduced in the hill and mountain areas to 82% and 59%, respectively. Suckler cows are not competitive in any region. This can be inferred from the fact that this activity profited the most from the per head payment for grazing animals in the existing direct payment system which is abandoned in our scenario because it is not Green Box-compatible. Pig production diminishes in all regions too. In contrast, under our assumptions, poultry production is competitive in the lowlands and the hill region. The level of plant production is reduced significantly for wheat and fodder crops (Table 9). Other cash crops such as rape seeds, sugar beet and potatoes are also reduced. The reason for this level of rather unprofitable cash crops is the cropping constraint in the model. Pay-

ments for open arable land are an incentive to cultivate crops. In order to get these payments, farmers have to apply a crop rotation condition which precludes them from cultivating only the most profitable crops. Two effects can be observed in the type and level of grassland. First, permanent grassland replaces high-yield rotational grassland and crop activities and increases to a level of 546,000 ha. Moreover, a switch from intensively to mid-intensively used permanent grassland leads to a significant decline in the production of biomass per hectare on all land units. Second, the amount of extensively used grassland more than doubles in the period between 2009 and 2018. Consequently, more than one third of the total agricultural area is cultivated less intensively. Since the whole extensive biomass has to be consumed in our model (fodder balance), low productivity cows (7,000 kg milk per year) with a higher potential consumption of extensive biomass are preferred to high production cows (9,000 kg per year).

The extensification of land-use is also represented by the gross profit per land unit which decreases by 33% (Table 10). In contrast, the overall gross profit per working hour is reduced only slightly to a level of 96%. However, the regional differences mentioned above are not covered by this indicator. In this scenario, general direct payments increase slightly to a level of 104% which corresponds to 2.2 billion Swiss Francs. These payments ensure that the whole agricultural surface is still cultivated even though open arable land will be reduced. The increase in extensively used grassland is highest in the hill region. Still, the amount of these ecological compensation areas also doubles in the lowlands and the mountain region. The level of GHG emissions is also reduced due to the reduced production to a level of 72%. Nitrogen (N) emissions decrease to the same extent. Ammonia, representing N emission from animal activities, is reduced by one third and nitrate emissions from plant production by a quarter. The reason for this reduction can be attributed to the large decline in the consumption of feed concentrate from 1.6 million to 0.8 million tons (last column in Table 10).

Table 8: Animal production activities and percentage change in 2009, 2012 and 2018

Scenario		'high returns'			'low returns'		
	2009	2012	2018	2018 as a percentage of 2009	2012	2018	2018 as a percentage of2009
Animal production							
Milking cows (total number)	598'132	541,826	500,413	84	495,251	426,839	71
Lowland	268,012	268,007	267,165	100	256,910	217,523	81
Hills	166,990	167,224	136,884	82	139,408	122,750	74
Mountains	163,129	106,594	96,364	59	98,933	86,566	53
Suckler cows (total number)	80,727	27,142	20	0	27,389	17,615	22
Lowland	29,779	9,268	7	0	8,924	132	0
Hills	44,241	16,019	12	0	16,610	14,531	33
Mountains	6,707	1,855	1	0	1,855	2,952	44
Fattening pigs (thousands)	2,630	2,656	1,093	42	2,656	0	0
Lowland	1,777	1,822	859	48	1,824	0	0
Hills	787	746	233	30	744	0	0
Mountains	65	87	0	0	87	0	0
Poultry (thousands)	37,229	39,239	46,612	125	39,239	3,239	9
Lowland	20,936	22,424	29,249	140	22,424	0	0
Hills	9,657	11,126	12,883	133	11,126	3,239	34
Mountains	6,634	5,688	4,480	68	5,688	0	0

Table 9: Plant production activities and percentage change in 2009, 2012 and 2018

Scenario		'high returns'			'low returns'		
	2009	2012	2018	2018 as a percentage of 2009	2012	2018	2018 as a percentage of 2009
Plant production (in ha)							
Wheat	65,033	69,775	37,514	58	69,775	69,775	107
Other cash crops (rape, sugar beet)	57,939	36,483	43,417	75	36,651	17,584	30
Fodder crops (maize and barley)	86,385	109,436	58,736	68	99,184	77,528	90
Extensive crops	72,109	66,097	45,213	63	60,948	46,112	64
Grassland (permanent)	314,449	390,943	546,216	174	426,314	605,224	192
Rotational grassland	141,678	148,504	59,320	42	112,861	15,228	11
Extensive grassland	75,337	219,085	178,276	237	246,278	173,825	231

Table 10: Development and percentage change of indicators in 2009, 2012 and 2018

Scenario		'high returns'			'low returns'		
	2009	2012	2018	2018 as a percentage of 2009	2012	2018	2018 as a percentage of 2009
Sectoral income per zone (m CHF)							
Lowland	1'557	1,345	894	57	1,145	548	35
Hills	758	686	525	69	594	459	61
Mountains	654	606	584	89	655	602	92
Labour (working equivalent)							
Lowland	21,472	20,245	17,048	79	19,628	14,230	66
Hills	13,359	12,599	9,103	68	10,826	8,533	64
Mountains	13,490	9,667	7,773	58	9,315	7,075	52
Income per full-time farmer equivalent (CHF)							
Lowland	72,518	66,421	52,420	72	58,328	38,497	53
Hills	56,746	54,435	57,650	102	54,843	53,821	95
Mountains	48,475	62,653	75,124	155	70,322	85,143	176
Level of production per activity							
Milk (Bn. kg)	3.374	3.165	2.873	85	2.960	2.443	72
Meat (1000 t)	479	453	282	59	438	71	15
Plant production (1000 t)	30,544	17,284	23,102	76	16,692	10,106	33

Table 10 continued

Scenario		'high returns'			'low returns'		
	2009	2012	2018	2018 as a percentage of 2009	2012	2018	2018 as a percentage of 2009
Gross profit per input (CHF)							
Land	2,895	2,570	1,952	67	2,334	1,565	54
Labour	21.9	22.1	21.1	96	21.5	19.2	88
Direct payment budget (m CHF)							
General direct payments	1,939	2,063	2,019	104	2,218	2,199	113
Ecological direct payments	324	347	272	84	350	229	71
Area of agricultural land (1000 ha)	1,025	1,025	1,025	100	1,025	1,025	100
Open arable land (ha)	253,035	252,134	168,818	67	236,627	189,566	75
Extensively used grassland (ha)							
Lowland	28,474	76,633	67,856	238	79,868	55,361	194
Hills	17,183	63,833	54,252	316	88,018	60,219	350
Mountains	23,769	78,620	56,168	236	78,392	58,244	245
GHG emissions (1000 t)	4,967	4,351	3,564	72	4,180	3,125	63
N emissions (1000 t)							
Ammonia	38.8	34.7	26.0	67	32.7	20.6	53
Nitrate	39.8	39.0	30.6	77	37.3	31.4	79
Feed concentrate (1000 t)	1,695	1,586	825	49	1,424	341	20

7.2 Scenario 'low returns'

The implementation of this scenario has a profound impact on the sectoral income in the Swiss lowlands. The income from product sales sinks to a level of 35%, mainly as a result of free trade conditions. Workload reduces by 34% which results in an income level per (present) full-time farmer equivalent of 53% compared to the baseline income in 2009. The reduction in the hill region is much smaller. Income per full-time farmer equivalent remains at 95%. In contrast, the income per full-time farmer equivalent increases by 76% in the mountain region. This is the consequence of a particularly large reduction of workload in this region (−48%).

Agricultural production of all commodities reduces significantly. Milk production sinks to a level of 72%. Still greater is the reduction in meat and crop production: 85% and 67%, respectively. This large reduction is confirmed by the development of agricultural activities (Table 10). Whereas milk production is reduced to a level of 71%, meat production disappears to a great extent. Pig and poultry production are no longer profitable in any region. Sensitivity analysis shows that a price premium of approximately 10% and 30%, respectively, would make poultry and pig production profitable. An exception to the decline in meat production is the low-intensity meat of suckler cows in the hill and mountain regions. However, the level of production is low compared to 2009. For crop production, a shift from intensive to mid-intensive cultivation can be observed. Thus, almost 75% of the open arable land is still used but only 33% of the production level is maintained. This effect can also be seen for grassland. There is an increase of permanent and extensively used grassland which translates into an extensification of the agricultural production. Again, the highest extensification can be found in the hill region where the amount of extensive grassland increases more than threefold.

The reduction in gross profit per unit of land is reduced to a level of 54%. With respect to the income per working hour in all three regions, the reduction amounts to 22%. This corresponds to an income of CHF 19 per working hour. The amount of general direct payments is increased by 13%. On the other hand, ecological direct payments are decreased by 29%. This can be explained by the reduction of the pay-

ments for particularly animal-friendly conditions. Since the income-maximising solution results in a marked reduction in the number of animals, the amount of payments per head also decreases. Greenhouse gas emissions decrease by 37% and N emissions are also decreased. However, there is a difference with respect to the ammonia and nitrate. The reduction in the latter is much smaller than that of the former. This can be inferred from the fact that the number of animals is significantly reduced, whereas a level of 75% of land in crop production is maintained. In addition, the consumption of feed concentrate is reduced to a level of 20% compared to 2009. This can be attributed to the large decline in poultry and pig production.

7.3 Scenario comparison

Figure 1 illustrates representative developments in the different scenarios for the sectoral income, the number of milking cows and land-use. The vertical line indicates the level before the first price cut. As imposed in our scenarios, the income level in the 'high return' scenario is higher than the level in the 'low return' scenarios. However, the reduction in income varies significantly between the regions. The sectoral income in the mountain region remains on the same level in the 'high returns' scenario. In contrast, the sectoral income in the lowlands falls to a level of less than 550 million CHF in the 'low returns' scenario. This is one third of the level in 2009. These differences can be explained by the existing structures: agriculture in the mountain regions is already dependent on the direct payment system in order to produce at all. Thus, the fall in returns from agricultural production is less severe since a smaller fraction of the producers' income is affected. In contrast, in the lowlands, the decreased production prices change the income level considerably. This effect is accentuated by the flexibility in the amount of work. On average, more than 5.3% of work equivalents leave the sector in the mountain region compared to approximately 3.7% per year in the lowlands. These two effects, higher impact on income and lower rates of reduction in workload mean that the lowlands are much more vulnerable to price decreases in our scenarios than the other two regions.

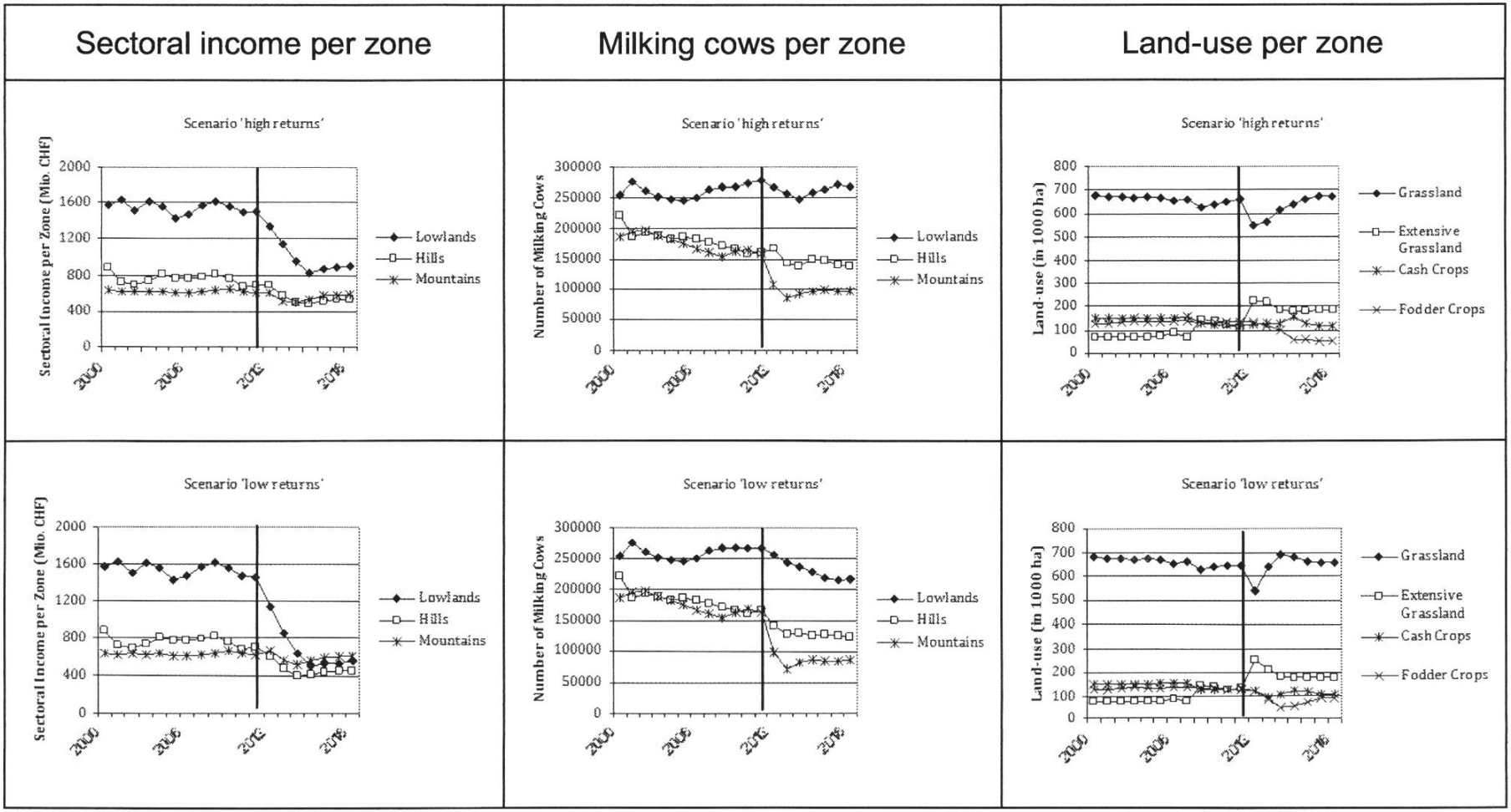

Figure 1: Development of income, number of milking cows and land-use from 2000–2018

Milk production turns out to be the most competitive agricultural activity in our model. Thus, the number of milking cows in the lowlands remains constant under the 'high returns' scenario. In the hill and mountain regions, the implementation of our scenarios leads to a lower number. Still, the reduction is much smaller than for other activities. The same holds for all regions in the 'low returns' scenario. However, some of the milking cows are replaced by suckler cows in the hill and mountain regions.

The development of land-use is comparable in both scenarios. The transition from the existing price to world market prices results in a peak of extensively used grassland. However, after 2014 the amount levels off at 200,000 ha.

In conclusion, our results show the following effects:

- Under our assumptions, the lowland area is the most vulnerable region. Despite structural change, the sectoral income decreases by up to one third of the level in 2009. In addition, the production incentives favour grassland-based milk production. However, the level of production is lower than today. Meat and crop production are reduced to low levels.

- In contrast, the income per farmer increases in the mountain region. This is caused by a higher level of general direct payments compared to those in the lowlands, a higher rate in the structural reform process (working equivalent), and a lower share of returns from market production with respect to total income. Despite a large decrease, grassland-based milk production remains the dominant activity in the mountain region.

8. Discussion

8.1 Results

Our results show very similar tendencies to those found in other studies, with respect to the main conclusions from Section. However, our results also show important differences. In contrast to Mack (2008) and Peter

(2009), the number of milking cows decreases in our calculations. Moreover, extensively used grassland increases much more significantly than in comparable studies. These differences can generally be inferred from the change in the direct payment system. Moreover, our worst case scenario reveals a much more severe impact on the sectoral income than has been suggested by these studies. In addition, some of the intensive production activities decline significantly, which results in a reduction of feed concentrate imports. This has important consequences for the provision of public goods.

From a social perspective, the implementation of our scenarios has mixed effects. The reduction in income per full-time farmer equivalent is severe in the Swiss lowlands. In contrast, this indicator is improved in the mountain region. However, this increase comes at the expense of the overall demand for work in the agricultural sector. Thus, the number of farmers would decrease to a low level. As a consequence, the contribution to the constitutional goal of 'encouraging decentralised settlements' would be reduced. To what extent the agricultural sector can actually contribute to this goal is however debatable (OECD 2008, Anderson 2000).

Economic effects have also to be regarded as double-edged: direct payments are the main (and in the 'low returns' scenario the only) source of income. Thus, farmers would be even more dependent on public support in the short and medium term. On the other hand, the reduction in price support leads to an increase in allocation efficiency since there is a shift towards more profitable milk production. Moreover, the food processing industry can profit from lower input costs which would result in higher market shares and lower consumer prices.

However, the level of production is decreased considerably. This also affects the self-sufficiency of agriculture. Since the imports of feed also decrease significantly, the degree of net self sufficiency does not decline to the same extent as overall production. Nevertheless, the question to what degree this reduces the chances of achieving the goal of a secure food supply are questionable irrespective of the chosen indicator. Anderson (2000) argues that food security is a consumer issue and Mann (2008) does not see food security as a joint product of agricultural production. In contrast, Hättenschwiler and Flury (2008) show that under

the assumption of a standardised crisis scenario food security could be affected in the medium and long term.

In addition, results show that a WTO-compatible direct payment system in the same magnitude as today cannot make up for the complete loss in returns from selling agricultural commodities. Clearly, the agricultural sector needs to make further efforts beyond structural change especially in the lowlands. Without an additional increase in labour productivity, and production efficiency resulting in lower production costs, the economic and social goals of a multifunctional agricultural sector will hardly be achievable. On the other hand, further efforts to reach higher output prices by implementing a value-added and/or export strategy are also indispensable.

From a strictly ecological perspective, the effects are positive. The whole agricultural surface is still cultivated in our scenarios. The high general direct payments per area of farmland prevent the abandonment of agricultural land. In addition, an ecologically beneficial extensification can be anticipated. In particular, the extent of extensively used grassland increases considerably, thereby also improving biodiversity. The level of this extensification depends not only on the direct payment system chosen but also on the level of returns from agricultural production, since a lower level of production also reduces GHG and nitrogen emissions.

8.2 Methodology

Our results show which activities would emerge in the short and medium term if farmers were income maximisers and price takers. However, this does not rule out the possibility of farmers behaving in a way which is not addressed by our methodology. Farmers could, for instance, work (more) outside the agricultural sector. In this case they would be less dependent on their agricultural income and could continue agricultural activities with less income than the underlying opportunity costs.

Another possibility would be the implementation of a value-added strategy such as regional products ('Swissness'), geographical indications (AOC) or organic farming (see also: Mack (2006) and Sanders (2009)). Both developments would result in a less severe outflow of work from

the sector, a development also observed in the case of Austria when it entered the EU in 1995 (Hofreither 2006). Moreover, price premiums for domestic products would lessen the extreme effects of our 'low returns' scenario with respect to pig and poultry production.

Another constraint in the interpretation of our results is the high factor mobility of land and labour. If structural change is smaller and more farmers remained in the sector, the positive environmental effects of lower production would decrease; on the other hand, agricultural production would increase.

The degree of structural change also depends on the demand for labour of the whole economic sector. If farmers find no employment outside the agricultural sector, the structural change is slower than under our assumptions. This would lead to a smaller income increase per full-time farmer equivalent.

The lack of representation of investment decisions in our model framework is a further important consideration. Investments are not a constraint in our scenarios. Thus, the model constantly invests under the condition that the investment yields at least the underlying opportunity costs. In reality, however, farmers' investment potential is constrained. They may simply reduce labour and other cost-intensive activities and switch to less labour-intensive activities such as low value-added commodities. In contrast to the previous argument, this would lead to a higher flow of labour out of the agricultural sector.

In addition, high payments based on acreage lead to less mobility of the land due to increased land rents (Happe et al. 2008, Hofer 2002, Baur 1999). In this case, the increase in the farmer's income may be lower since some of these payments spill over to the land owner. This effect, however, is not reflected in our model since general direct payments have no allocative effects in our methodological approach.

Finally, it should be emphasised that our model is based on the present regulatory and financial incentives system. A scenario as dramatic as 'open borders and no price support' would of course call for a total review and reformulation of Switzerland's agricultural policy, including the direct payments system and flanking measures, as well as upstream and downstream sectoral policies.

9. Summary and conclusion

We use a normative mathematical programming model to illustrate possible effects for agricultural production and the corresponding sectoral income in the short and medium term (2012-2018) for a 'beyond WTO' scenario in Switzerland.

Despite structural change (increase in farm size, lower work demand and increase in productivity) the overall sectoral income decreases considerably. Milk production is the most profitable activity, whereas crop and meat production decrease. High acreage-based direct payments hinder the abandonment of agricultural land.

The lowlands are much more affected by our scenario than mountain regions, since the latter already depend much more heavily on the direct payment system in order to produce at all. Thus, the fall in returns from agricultural production is less severe in mountain regions since a smaller fraction of their income is affected.

These findings are in line with other calculations of the consequences for Swiss agricultural production of a liberalisation scenario. Beyond that, our calculations show a clear extensification of the agricultural sector (fewer animals, more extensively used grassland) under a WTO-compatible direct payment system. This can mainly be attributed to the abandonment of animal-based direct payments which do not fit into the Green Box.

With respect to the provision of public goods mentioned in Article 104 of the Swiss constitution, our result shows mixed effects. The effects on the environment (conserving natural resources and biodiversity, and taking care of the landscape) are positive, but the contribution to social goals (encouraging decentralised settlement, secure food supply through domestic production) decreases.

These mixed results do not imply that a further liberalisation of Swiss agriculture is undesirable. Besides the economic rationale for more open markets mentioned in the introduction, our results clearly show that policymakers and farmers should adopt a proactive attitude in order to cope with the consequences of such a foreseeable development. Thus, further reductions in production costs beyond the ones made in our assumptions are an issue of commercial survival, especially in the

Swiss lowlands; this also implies that efforts in order to realise price premiums must be intensified.

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