Distributional Impacts of Agricultural Policy in West Germany – from the Sectoral Level to the Single Farm

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Abstract*. There is a growing public and political interest in effects of agricultural policy on income distribution in the agricultural sector. However, tools for an ex-ante analysis of impacts of sectoral or macroeconomic policies on the individual farm income level can hardly be found for the agricultural sector. Most of the literature regarding redistributive effects of agricultural policy is ex-post and static in nature. Against this background, the main objective of this paper is to develop a tool that is able to consistently assess impacts of sectoral policy on individual farm incomes, thereby building up on existing approaches of model coupling and taking behavioural effects into account. For illustrative purposes redistributive effects of different liberalization scenarios of European agricultural policy on the West German agricultural sector are analysed. The analysis of inequality effects based on individual data is compared to an analysis based on more aggregate farm groups. It is revealed that the amount of inequality may be seriously underestimated when only taking grouped data into account. Redistributive effects of liberalization scenarios differ slighty in absolute terms and more in relative terms.*

Keywords: farm model, market model, micro accounting, income distribution

1. Introduction

Recent reforms of the Common Agricultural Policy (CAP) of the European Union (EU) were characterized by constantly replacing classical market price support measures by budgetary payments. Moreddu (2011) argues that due to this shift, agricultural support becomes more visible and consequently, the distribution of support among farmers has gained more public attention. Fittingly, the European Commission (2012, p.8) states in its annual "Report on the distribution of direct aid to farmers" that "…direct payments have lost their compensatory character over time and have increasingly become a support ensuring a certain farm income stability …". Increasing public interest in the distribution of agricultural support and the question 'who gets what' is reflected by media coverage (e.g. tagesschau.de, 2009) and in the specialized press (e.g. Agra-Europe, 2013, p.3). Thus, equity issues in the agricultural sector also increasingly become an area of political concern, even on a national or sub-national basis. The European Commission (2012, p.8) e.g. claims that "…the proposals for the CAP after 2013 … aim to reduce the discrepancies between the levels of payments obtained after full implementation of the current legislation, between farmers, regions and Member States …". Besides growing public and political interest, there are also good reasons to analyse the effects of agricultural policy on income distribution in the agricultural sector from an economic point of view. For instance, Mishra et al. (2009) refer to links between farm income inequality and technology adaption, productivity, sector growth, and further social issues as family health.

In other scientific areas, e.g. poverty analysis or tax reform analysis, it is quite common to conduct ex-ante assessments of macroeconomic shocks on individual income distributions on a national level. To this end, methods were developed to commonly assess impacts of macroeconomic shocks on an aggregate and individual level by combining outputs of macro models with individual data, mostly large population or household surveys. In most of the cases macro models are of the CGE type. To review all approaches is beyond the scope of this work. A compilation of the most important approaches can be found e.g. in Bourguignon et al. (2008).

Similar tools for the measurement of impacts of sectoral or macroeconomic policies on the individual farm income level can hardly be found for the agricultural sector. In principle, the LEI model funnel presented by van Tongeren (2000) and Woltjers et al. (2011) would enable the analysis of macroeconomic impacts on individual farm incomes via the Financial-Economic Simulation model (FES), which is an FADN-based, non-behavioural accounting model on the single farm level. However, the analysis of redistributive effects among individual farms on a supra-regional level has not been conducted so far, to the best knowledge of the authors. Further tools worth mentioning are e.g. the CAPRI model (Britz and Witzke, 2012) which depicts farms at regional and farm type level, and a model presented in Valdivia et al. (2012). The latter combines bio-physical process models and economic decision models representing a statistically representative sample of farms. It facilitates the measurement of impacts on the single farm level taking market price effects into account endogenously, however, on a regional scale.

Most of the literature regarding redistributive effects of agricultural policy is ex-post and static in nature. Several studies focus on the distribution of direct payments (e.g. Keeney, 2000; El Benni and Finger, 2012). Fewer studies also take effects of market price support into account and aim to assess redistributive effects of the whole system of agricultural support (e.g. Allanson, 2006; 2008; Moreddu 2011). Severini and Tantari (2013) evaluate the impacts of a recent reform proposal of EU direct payments in an ex-ante way, however without taking any behavioural effects into account.

However, ex-ante policy impact analysis in the agricultural sector has a long tradition. The combination of models to mutually assess effects at different levels of aggregation, taking behavioural effects into account, is very common (see among many others van Tongeren, 2000; Jansson et al., 2009).

Simulation models account for behavioural effects. But the measurement of inequality is highly sensitive to the aggregation of individual data and the traditional approach of applying few representative groups within a simulation model turned out to be inadequate due to unobservable changes in inner-group inequality (Bourguignon et al., 2005; Savard, 2005). The impact of the information loss due to aggregation becomes most obvious in the extreme case when there is only one aggregate group used for simulation. Without any information on the distribution of income an inequality measurement is impossible. Consider a population being divided into k mutually exclusive groups and I^{total} representing an additively decomposable[1] income inequality index of the form: $I^{total} = I^{within} + I^{between}$ with I^{within} representing a (weighted) sum of income inequality inside the k groups and $I^{between}$ the inequality between subpopulation means (Deutsch and Silber, 1999). In the extreme case of just one representative group all the desired information would be hidden in I^{within} whereas only $I^{between}$ would be measurable, but without any meaning in this case. Obviously, inequality inside of aggregated groups is not observable and thus, the loss on information generates a downward bias in the measurement of overall inequality by only incorporating grouped income data.

The share of inequality that is accounted for by the between-groups component is expected to increase with the number of subgroups of a population, other factors being equal (Shorrocks and Wan, 2005). Still, as Elbers et al. (2005) empirically find, even a relatively high number of subgroups may coincide with a high within-group inequality component.

Against this background, the main objective of this paper is to develop a tool that is able to consistently assess impacts of sectoral policy on individual farm incomes, thereby building up on existing approaches of model coupling and taking behavioural effects into account. Finally, distributional changes of different liberalization scenarios of European agricultural policy on the West German agricultural sector are analysed.

The structure of the paper is as follows: in Section 2 we present the modelling system with which individual income changes are calculated; in Section 3 the methodology of measuring distributional effects is described; in Section 4 scenarios are introduced; in Section 5 results are presented; and in Section 6 a summary and conclusions are provided.

[1] The term 'additively decomposable' refers to the property of an inequality index, to be subgroup decomposable into exactly two terms: the between-groups inequality component which is gained by replacing all individual incomes by subgroup means and the within-group component, which is a weighted average of inequality within subgroups. The Gini coefficient e.g. is not additively decomposable in this sense (Deutsch and Silber, 1999).

2. Modelling chain

2.1. Description of the overall model chain

Measuring redistributive effects of agricultural policy reforms requires a simultaneous analysis of impacts at different levels of aggregation. Effects at the sectoral level need to be taken into account and at the same time information on individual production and income changes at the micro level is necessary to catch the full impact on income distribution.

In this study, a modelling system consisting of three different single models depicting three different levels of aggregation is developed to consistently measure changes in individual incomes among West German farms resulting from agricultural policy reforms. A schematic overview of the model chain is presented in Figure 1.

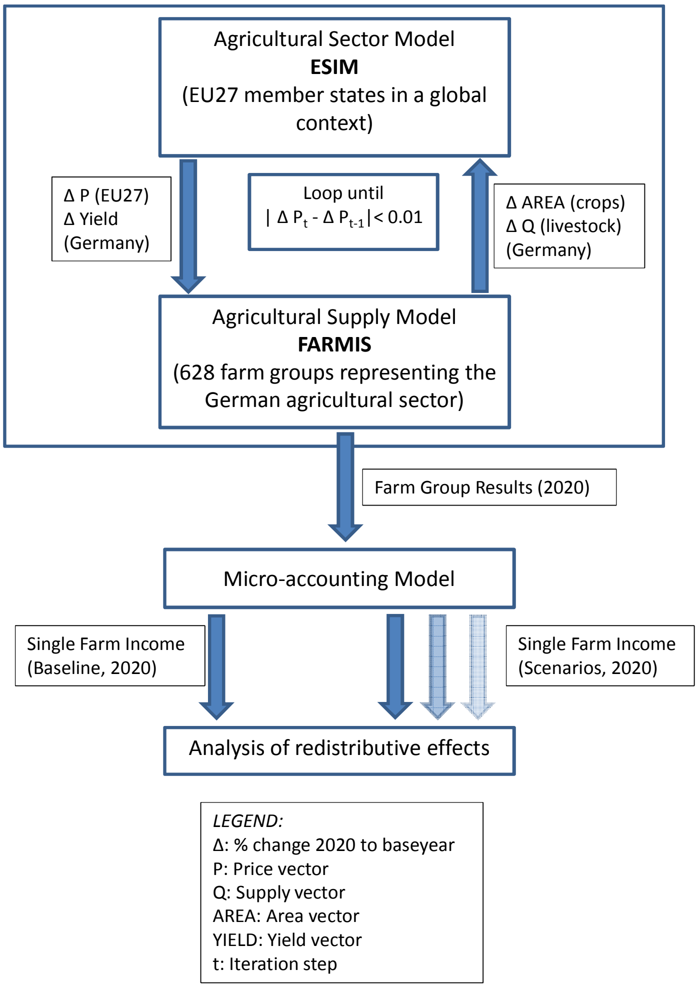


Figure 1: Methodological framework for an ex-ante measurement of redistributive effects of agricultural policies on farm incomes

Source: Own composition on the basis of Mussard and Savard (2010).

The model with the highest level of aggregation is an agricultural sector model depicting European agricultural markets in detail and the agricultural sector of rest of the world in a more aggregate manner. It is a partial model in the sense that it explicitly models the agricultural sector and takes all other sectors as exogenously given. Thus, most of the core macroeconomic variables such as inflation rates and GDP growth rates are exogenous to the model. At the meso-level, a model which depicts the supply side of the German agricultural sector in great detail is applied to measure impacts of agricultural policy changes on 628 heterogeneous farm groups. Both simulation models are two already pre-existing large scale models, the European Simulation Model (ESIM; Grethe, 2012) at the sectoral and the Farm Modelling Information System (FARMIS; Osterburg et al., 2001; Bertelsmeier, 2005; Offermann et al., 2005) at the farm group level. They both have been combined in previous studies to measure the impact of agricultural policy on income distribution, however, on the basis of farm groups rather than individual farm incomes (Deppermann et al., 2011). The models are coupled in an iterative way until they converge on exchanged variables in the analysis of a joint scenario (Deppermann et al., 2010).

After convergence between ESIM and FARMIS is achieved, farm group results are passed in a top-down manner to the newly developed micro model to assess individual farm incomes for the year 2020, the final year of the simulation period. The micro model is an accounting model in the sense of Bourguignon et al. (2008), i.e. without own behavioural component. It further disaggregates the results of the farm groups commonly calculated by ESIM and FARMIS. The micro model serves as an add-on to the FARMIS model, since it relies on its structure. It is based on the German farm accountancy data network (FADN).

With this modelling system, different ex-ante evaluations of policy scenarios are conducted. Based on simulation results for the year 2020 income distribution indices are calculated. Results for the year 2020 are utilized in an ex-post manner for the calculation of different inequality indices to evaluate the state of income inequality in the agricultural sector and the degree of progressivity of different reform packages. To this end, inequality indices of different policy scenarios are compared to a reference scenario.

All models are coded in the GAMS (The General Algebraic Modeling System) programming language, which facilitates an automatized coupling of the modelling system. Furthermore, the calculation of inequality indices also was translated into GAMS code. The ESIM-FARMIS linking is managed by a steering file, which was developed to run the system without manually exchanging results between the single elements.

2.2. From the sectoral to the meso-level: an iterative approach

The modelling system covering the sectoral and the meso-level is described in more detail in Deppermann et al. (2010). The linkage of the two models allows us to quantify adjustment processes both at the sectoral level and at the farm group level for the German agricultural sector. Below, the two models and their interface are briefly presented.

ESIM (Grethe, 2012) is a comparative-static, net-trade, partial equilibrium model of the European agricultural sector. It depicts the EU-27 at the member state level with a strong focus on the CAP. In addition, ESIM also models the rest of the world, though in greatly varying degrees of disaggregation. Altogether ESIM contains 31 regions and 47 products as well as a high degree of detail for EU policy including specific and ad valorem tariffs, tariff rate quotas, intervention and threshold prices, export subsidies, coupled and decoupled direct payments, production quotas, and set-aside regulations.

All behavioural functions (except for sugar supply) in ESIM are isoelastic. Supply at the farm level is defined for 15 crops, 6 animal products, pasture, and voluntary set-aside. Human demand is defined for processed products and each of the farm products except for rapeseed, fodder, pasture, set-aside, and raw milk. Some of these products enter only the processing industry (e.g. rapeseed) and others are used only in feed consumption (e.g. fodder or grass from permanent pasture). Processing demand is defined for raw milk (which is divided into its components, i.e., fat and protein), oilseeds, and inputs for biofuel production. ESIM has a very detailed depiction of the complex system of substitution of land among different products and the relationship between ruminant production and agricultural area. The price formation mechanism in ESIM assumes an EU point market for all products except for non-tradables, for which the price results from a domestic supply and demand market clearing equilibrium at the EU member state level (raw milk, potatoes, fodder, silage maize, and grass).

FARMIS is a comparative-static process-analytical programming model for farm groups (Osterburg et al., 2001; Bertelsmeier, 2005; Offermann et al., 2005). Production is differentiated for 27 crop and 15 livestock activities. The matrix restrictions cover the areas of feeding (energy and nutrient requirements, calibrated feed rations), intermediate use of young livestock, fertilizer use (organic and mineral), labour (seasonally differentiated), crop rotations and political instruments (e.g., set-aside and quotas). The model specification is based on information from the German farm accountancy data network, supplemented by data from farm management manuals. Data from three consecutive accounting years is averaged to reduce the influence of yearly variations common in agriculture (e.g., due to weather conditions) on model specification and income levels. Key characteristics of FARMIS are: 1) the use of aggregation factors that allow for representation of the sectors' production and income indicators; 2) input-output coefficients which are consistent with information from farm accounts; and 3) the use of a positive mathematical programming procedure to calibrate the model to the observed base year levels. Prices are generally exogenous and are provided by market models. An exception to this applies to specific agricultural production factors, such as the milk quota, land, and young livestock, where (simplified) markets are modelled endogenously, allowing the derivation of respective equilibrium prices under different policy scenarios. FARMIS uses farm groups rather than single farms not only to ensure the confidentiality of individual farm data, but also to increase manageability and the robustness of the model system when dealing with data errors that may exist in individual cases. Homogenous farm groups are generated by the aggregation of single farm data. For this study, farms were stratified by region, type, and size, resulting in 628 farm groups which represent the German agricultural sector, of which 467 are located in West Germany.

ESIM and FARMIS were linked through the exchange of solution variables (vectors of price and yield changes from ESIM to FARMIS and vectors of quantity changes from FARMIS to ESIM) until both models converged on these variables in the analysis of joint scenarios. Convergence is defined to be reached when the difference in price and area (supply for livestock) changes less than 1% between two iteration steps. Before this final and rather mechanical procedure was pursued, considerable preparatory work was undertaken. Policy parameters and assumptions as well as a wide range of further parameters exogenous to both models were harmonized, including inflation rates, technical progress and changes of factor costs. Consistent product interfaces were defined and for a first stand-alone baseline scenario, vectors of price and yield changes were created by ESIM and implemented (as exogenous variables) into FARMIS. Afterwards, a detailed comparison and analysis of the reaction of both models to the same vector of price changes concerning the area allocation for crops as well as the supply of livestock products were conducted. If necessary and possible, the models were adjusted to achieve a high degree of analogous model behaviour. Finally, the iteration process was carried out. As a final result, the German supply component in ESIM was replaced by FARMIS.

The above described modelling system is calibrated to a base period (average of the years 2006-2008). The baseline (the reference scenario) and reform scenarios are conducted for the year 2020. Scenarios are evaluated in comparison to the baseline scenario and thus provide a comparative-static analysis of exogenous policy changes.

2.3. From the meso to the micro-level: a top-down approach with micro accounting

After ESIM and FARMIS converged in the first step of the modelling chain, detailed results regarding production patterns, factor demand and income sources for 628 farm groups are obtained representing the whole German agricultural sector. This information is necessary to further be disaggregated for an analysis of inequality effects. For this reason a microsimulation model is developed and integrated into the modelling system (Figure 1). In the following sections at first the choice of the methodology, the income variable under consideration, and the choice of the study area are explained before the model is introduced in detail.

FARMIS applies farm groups instead of individual farms due to better manageability and an increased robustness of the model. Especially potential data errors in individual cases could result in higher solution instability. Furthermore, the application of individual data would lead to high variations among the calculated input-output coefficients between farms (Osterburg et al. 2001). Thus, the aggregation bias which occurs from aggregation over individuals is accepted in favour of stability and manageability of the model. This certainly is a justifiable choice, especially when taking into account that over- and under predictions of individual production patterns tend to equal each other out in the aggregate level. Furthermore, the time needed to set up the model with an updated database (which would likely be longer with the implementation of individual farms) has to be taken into account. However, for the measurement of inequality, which so far has not been a traditional field of analysis for the FARMIS model, this choice is rather unfortunate because a certain part of inequality will be hidden inside the groups and thus, will not be observable.

For this study it was decided that the two large scale models at the top of the modelling chain shall be kept exercisable as stand-alone models. This has the advantage that updated versions of the single models can easily be implemented in the modelling chain. This rather practical choice relates to the "institutional challenge" of "sustainable maintenance of linked model systems", which is a matter of "sufficient financial and/or human resources" (Offermann, 2008, p.361). Hence, to make use of synergy effects in model development it was decided to run the FARMIS model based on farm groups and develop an add-on model that allows a further disaggregation of the grouped results instead of directly running FARMIS with individual farms. The microsimulation model itself can easily be switched to an updated model database.

The indicator applied for the measurement of income inequality among farms in the German agricultural sector is family farm income (FFI). FFI provides information on the return to land, labour, and capital resources owned by the farm family, as well as the remuneration of entrepreneurial risk. Henceforth, the terms income and FFI will be used synonymously. Due to the dominance of corporate farms in East Germany all successional analyses related to the measurement of inequality in this study are restricted to 467 West German farm groups representing 8034 individual farms, because no comparability between different farm structures could be ensured when using FFI as an indicator.

For the base period both individual and grouped data can be observed and thus, the information on inequality which is lost due to data grouping and working with average values instead of micro data can be calculated. For the current base data of the modelling system, a comparison of the relative Gini coefficient reveals some differences in inequality for the base period: the relative Gini coefficient of single farm income data is 0.55 and the relative Gini coefficient of farm group income data is 0.40.

The objective of the microsimulation model is the disaggregation of farm group results of the last year of the simulation period. Individual FFI data are generated by tracing back farm group results to the individual farms which were used for the generation of farm groups in the base year. The basic idea of the model is to calculate base year values of the shares each single production activity contributes to individual farm gross margin and resource requirements, and then adapt these proportionally according to the changes of respective farm group activity levels, gross margins and factor prices between the base year and 2020.

Figure 2 sketches the mode of operation of the microsimulation model. The *first step* (steps are indicated by Roman numerals in dashed circles) refers to the generation of farm groups based on individual FADN data in the base period for utilization in the FARMIS model. For the study at hand the micromodel takes 467 farm groups into account, which are generated by aggregation of 8034 West German farms that are included in the FADN data for the base year. Grouping implies the calculation of average production quantities, factor costs, gross margins and income values as well as the generation of aggregation factors to represent the respective proportion of the basic population for each farm group. These values are subsequently applied in the FARMIS model to run simulations.

Gross margins for single production activities refer to market revenues less attributable production costs for a specific activity and are not directly apparent in FADN data[2]. However, since this information is crucial for running simulations with FARMIS, several assumptions and additional calculations are made to generate activity specific gross margins, when defining the farm group programming models (for details see Offermann at al., 2005 and Osterburg et al., 2001).

In *step two*, base year income of individual farms is broken down into several components which reflect the shares that single production activities contribute to the individual farm income. For that purpose activity levels from FADN data are combined with respective average gross margins which were calculated for FARMIS groups in step one. Furthermore, individual costs for hired labour, capital, and rented land, are as well separately calculated by utilizing average group prices and individual input quantities.

Since not all commodities, income sources and costs indicated in the German FADN are also allocated to activities and included in FARMIS (e.g., forestry and agri-tourism are not explicitly covered in the model), a part of the original FFI is not changed by the model and is assumed to be fixed. In step two the 'variable part' of the income (the part depicted in the FARMIS model, i.e. the core agricultural production activities) is calculated for all individual farms by summing up all income components of the single production activities and all (negative) factor costs.

Step three indicates a simulation run of the ESIM-FARMIS modelling chain. In this process, farm group results for the year 2020 are generated. The generated changes of activity levels between the base year

[2] For example, variable input costs are not directly attributed to production activities in the German FADN.

and the year 2020 are applied to individual base year levels in *step four*. That is, all individual farms covered by a specific farm group have the same percentage changes in production for all commodities. The same approach is used for capital costs. The quantity of rented land is calculated according to new farm specific crop activity levels less the farm owned share of land. Labour requirements are calculated regarding new production quantities, and hired labour costs are derived taking into account individual farm resources of family workers. Adjusted activity levels and resource requirements then are multiplied by respective gross margins and factor prices calculated by the modelling system for the year 2020. Adding up the single gross margins and cost components generates the variable part of each individual farm income for 2020.

In *step five*, the difference of the variable part of the income in the base year and the variable part of the income in 2020 (which can be positive or negative) is added to the original base year FADN values of farm income. That way, also the fixed part of the income is considered.

In a last step the generated individual data are aggregated and compared to original group results. In most cases group results are perfectly met. In case of small divergences, individual incomes are scaled to meet group results exactly.

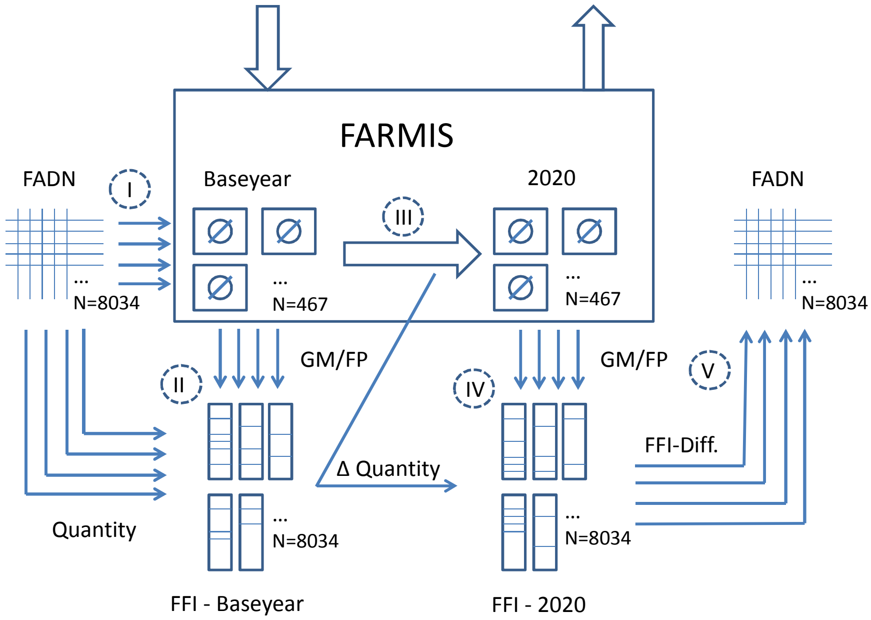


Figure 2: Microsimulation model in connection with FARMIS

Source: own compilation.

The micromodel in principle is of the micro accounting type in the sense of Bourguignon et al. (2008) since the model is static which means there is no behaviour depicted in the model itself. Adaptions of production patterns are taken into consideration, however, only as exogenous information. The fact that all farmers in one group react in the same proportional way when adapting their production patterns to new price incentives, is certainly a strong assumption. Still, heterogeneity among production patterns of farms in the same group is taken into consideration because different commodities might face different price changes. Furthermore, taking into account that an average group represents 17.2 FADN farms and that stratification was undertaken according to type, region, and size, an assumed similar behaviour of individual farms belonging to the same group seems reliable. It can be argued that behavioural adaption processes are to a great extend already covered by the FARMIS model.

However, one caveat which appears in almost all analyses of distributional effects on the national or comparable level remains. The overall farm population of West Germany consist of more than 160,000 farms. This in turn means that 8,034 FADN farms still account for only a fraction of all farms and have to be weighted by an aggregation factor to represent their respective proportion of the overall population.

Thus, an implicit assumption is that one single farm depicted in the modelling system (or in the FADN data) on average represents more than 20 farms of the overall population. This assumption is common to virtually all analyses of distributional effects since only observed units can be modelled and complete population surveys on the national level practically do not exist.

Summing up, the model is applied to account for heterogeneity of farms inside a group to overcome the problem of measuring inside-group inequality. Results are disaggregated in a static, top-down manner, after the ESIM-FARMIS model chain is solved. In principle, the approach is comparable to other standard micro accounting approaches utilizing representative groups. However, this analysis refers to 467 representative farm groups from a behavioural model, which in comparison is an outstanding high number. As Lofgren et al. (2003, p.334) argue, the distinction between the microsimulation approach of modelling a single unit and the representative agent approach of applying only grouped data is not always sharp. This especially becomes evident, when it is taken into account that single units from large data surveys are assumed to be representative for a share of the overall population.

3. Measurement of distributional effects[3]

Kakwani (1986) develops the following measure of redistribution that is based on a comparison of relative Gini coefficients[4] and decomposes the total effect into a vertical and a re-ranking component, which Allanson (2006) applies to agricultural policy:

$$\mathrm{R} = \mathrm{G_x} - \mathrm{G_y} = (\mathrm{G_x} - \mathrm{C_y}) + (\mathrm{C_y} - \mathrm{G_y}) = \mathrm{V} + \mathrm{H} \tag{1}$$

where R represents the overall effect of redistribution as the difference of the Gini index in the base situation (G_x) and the Gini index in the new situation (G_y), C_y is the concentration index of income in the new situation, and V and H are indices of vertical redistribution and re-ranking, respectively. Generally, the concept of vertical equity represents the idea that a monetary burden on individuals should increase with their capacity to bear that burden. A positive (negative) sign for V indicates that in case of income losses, in our case due to a reduction of government support, the burden is progressively (regressively) allocated among the total farm population. Nevertheless, V does not measure the "pure" degree of deviation from a proportional burden share because it also depends on the average rate of burden. This becomes obvious with a further decomposition of V:

$$\mathrm{V} = \mathrm{G_x} - \mathrm{C_y} = \frac{\mathrm{P} \cdot \mathrm{s}}{(1-\mathrm{s})} \tag{2}$$

where s represents the share of average burden in average base income of the whole farm population and P represents the Kakwani (1977) measure of progressivity which equals C_B - G_x, with C_B being the concentration index of burden. P measures the extent to which the burden is distributed more unequally or equally than income in the base situation (Aronson et al., 1994). However, the degree of deviation from a proportional share of burden does not entirely explain the new state of distribution (Atkinson, 1980; Plotnick, 1981). The index of vertical redistribution equals the overall effect of redistribution only if no re-ranking of farms occurs. In our analysis this would be the case if farms were arranged in ascending order of income in the baseline situation and still hold the same rank after liberalizing the agricultural sector. Otherwise the index of vertical equity overestimates the redistribution effect by not including rank reversal effects. To account for re-ranking, the index H (which is also known as the Atkinson-Plotnik-index of re-ranking) is applied in equation (1). It can be interpreted as an indicator of arbitrariness or discrimination of the examined income redistribution system. Atkinson (1980) refers to the effect as "mobility" induced by an income policy, which might be of interest in its own right. If re-ranking occurs, it always has a negative impact on the overall redistribution index (Lambert, 2001).

The described approach was so far based on the relative Gini coefficient. One property of relative measures of inequality is that proportional changes in all incomes do not change inequality. However, it

[3] This methodology was also applied in Deppermann et al. (2011) and the first two paragraphs are to a large extent identical with the formulation used there.

[4] The relative Gini index (G) can (in discrete form) be specified as: $G = \left(\frac{1}{2n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|y_i - y_j\right|\right)/\mu$ where y_i is the income of individual i (i = 1, 2, 3,…, n) and μ represents the average income. For example, see Pyatt (1976).

depends on subjective evaluation what kind of changes keep inequality unaffected (Chakravarty, 1990). According to different normative views on inequality equivalence, different concepts of inequality measures exist. In addition to the relative measure the absolute Gini index is applied in this work to broaden the view on inequality effects. The two concepts are closely related since the absolute Gini index is obtained by multiplying the relative one by the mean income of the sample, yet they react differently to income changes. Absolute measures of inequality are invariant to equal absolute changes in all incomes.

Generally, the described method of decomposing the overall redistribution effect can be applied to the absolute Gini index as well (Allanson, 2008):

$$AR = AG_x - AG_y = \mu_x G_x - \mu_y G_y = (\mu_x G_x - \mu_y C_y) + (\mu_y C_y - \mu_y G_y) = AV + AH \qquad (3)$$

where A indicates the absolute versions of the respective measures and μ_x and μ_y represent the average income of the base and new situation, respectively. In the absolute version, the (relative) concentration index of burden (C_B) indicates whether a burden is progressively or regressively distributed. It shows how the shares of the total burden are distributed, keeping the ranks in sequence of the base situation. Thus, a negative (positive) C_B indicates that small initial incomes have to bear a greater (smaller) part of the burden than higher incomes. Comparing C_B with the relative index of progressivity (P) makes it clear that in absolute terms, a burden might be indicated as progressive (positive C_B) while in relative terms it is denoted as regressive in the case that $C_B < G_x$, since $P = C_B – G_x$. These potential discrepancies might also be found with regard to the overall effect of distribution.

To evaluate a liberalization of agricultural policy as positive in terms of redistributive effects, it is obvious that the new situation should be more equal than the previous situation. Based on the above discussion, the argumentation is that the overall redistributive effect of any reform package must be at least positive in absolute terms and preferably be positive in relative terms as well.

To be consistent with the scenario definitions, baseline results with the assumed status quo of agricultural policy are the base from which redistributive effects are measured. Following Lerman and Yitzhaki (1995), this implies that (marginal) income changes are weighted by baseline-rankings.

4. Scenarios

With the above described modelling system, scenarios are conducted for the year 2020 with the model base period being an average of the years 2006-2008. Three different liberalization scenarios are compared with a reference scenario (the baseline) regarding their income distribution. In the baseline, the 2003 Reform and the Health Check of the CAP are fully implemented except for the abolishment of milk quotas. Milk quotas are assumed to increase until 2015 according to the Agenda 2000 decision, including the additional 2% quota increase in 2008 and the fat adjustment in 2009/10. It is assumed that a (first generation) biofuel share of 8% in total EU transport fuel consumption will be reached by 2020. Furthermore, the sugar market reform decided upon in 2005 is implemented and set-aside obligations are removed in 2008. The baseline adopts constant levels of tariffs, export subsidies, tariff rate quotas (except for sugar), and the current system of intervention prices. For the international environment, ESIM is calibrated to FAPRI world market price projections (FAPRI, 2011) and no changes in external trade policies of the EU are assumed until 2020.

To account for the effects of liberalizing agricultural policy on income in the agricultural sector, the baseline results in 2020 are compared with results of other scenarios in 2020. The single scenario results reflect impacts of different, exogenously defined policy changes to the baseline scenario. The strongest liberalization scenario assumes a full market liberalization of EU agricultural policies (i.e., the abolishment of all intervention prices, tariffs, quotas, subsidies, and direct payments). Therefore, in 2020 the EU price level equals the world market price for tradable products. In another scenario isolated effects of a separate abolishment of direct payments (DP) are analysed (henceforth, No_DP scenario) and in another scenario all price policies are abolished (henceforth, No_Pricepol scenario), but direct payments are still paid to farmers to single out the effects of different policy instruments.

The creation of a baseline requires several assumptions regarding the development of agricultural markets until 2020. Since it is well-known that overall distributional effects may be influenced by the distribution of a variable in the base situation (Lerman and Yitzhaki, 1995), it should be kept in mind that although the baseline depicts a likely development of markets, some insecurity remains in any ex-ante analysis.

5. Results

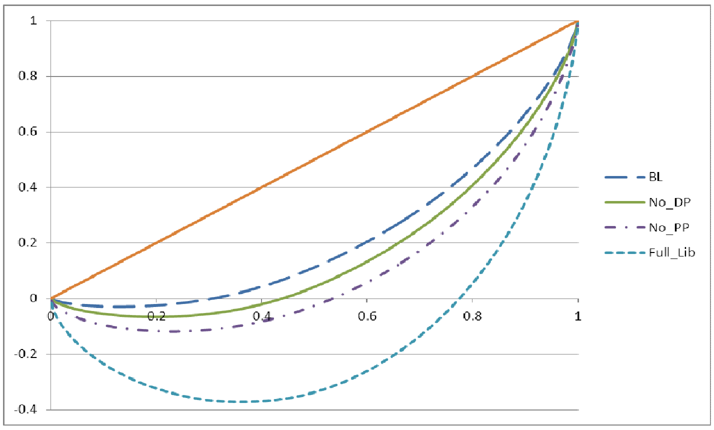
In this chapter distributional effects of different scenarios are presented. Thereby, results are based on 8034 individual farm data on the one hand and on 467 FARMIS groups on the other hand to evaluate the aggregation error which appears when distributional impacts are accounted for by the application of grouped data.

Liberalizing the agricultural sector has clear negative impacts on average farm income. In the Full_Lib scenario, the scenario with the lowest average income, 31% of all individual farms have negative incomes, whereas in the baseline there are only 10%. Results should be interpreted against the background that with this strong reduction in average income, significant structural change such as an increase in farm size and farmers leaving the sector can be expected which is not depicted in current model specifications.

Even though the relative Gini coefficient is well defined for negative incomes (Amiel et al, 1996; Cowell, 2009), some difficulties may rise in interpretation of its results, e.g. it is argued that inequality may be overestimated in such a case (Chen et al, 1982). Recalling that average distances among individuals appear in the numerator of the relative Gini and mean income in the denominator (footnote 4 on page 8), it becomes clear that the relative Gini, assumed that absolute distances between income units do not change, increases exponentially with decreasing mean income. This is true also when negative incomes are excluded. However, the appearance of negative incomes tends to make this effect more pronounced because the spread between numerator and denominator in this case may increase without having a 'natural bound': absolute average distances can be kept constant and at the same time mean income can become close to zero[5] if some of the incomes are negative. Vice versa, with the allowance for negative incomes absolute average distances can increase without a 'natural bound' while keeping mean income constant. If this happens with an already comparatively low mean income, changes in absolute distances may seem disproportionally strong in relative terms. This is also the reason why the relative Gini is no longer bound to the maximum value of one.

This should be kept in mind when individual and grouped data are compared regarding their inequality effects. In Figure 3 relative Lorenz curves are presented for the baseline and all scenarios to illustrate the impact of negative values and at the same time demonstrate that the Gini based inequality analysis in Table 1 ranks distributions appropriately. For the absolute Gini the appearance of negative incomes is unproblematic.

Figure 3: Relative Lorenz curves for baseline and all scenarios



Source: Own calculations.

In the following, general inequality effects shall be discussed shortly on the basis of individual data since this analysis reveals more information on inequality than the analysis based on FARMIS groups. Additionally, despite varying magnitudes of the single indicators, the direction of inequality effects is not

[5] Of course mean income can become negative as well, which would result in a negative value for the relative Gini. However, we abstract from this possibility here since the discussion of negative Ginis is beyond the scope of this paper and not relevant in the empirical analysis.

substantially different between the approaches. Emerging differences are discussed in more detail subsequently.

In the No_DP scenario income is reduced by 8,953€ on average, which accounts for 19.7% of income in the baseline scenario (Table 1). In absolute terms the DP cut leads to a slightly more equal situation. Little re-ranking effects occur and the overall redistributive effect also is small, which is due to the low value of average support reduction rather than due to a low level of progressivity of the reduction. The C_B measure indicates that support reduction is progressively distributed which means that higher incomes bear a higher burden of a DP cut than smaller incomes do. The results are in accordance with a priori expectations: farms with higher income have a greater acreage and get higher DPs. In relative terms we observe an opposite inequality effect. The DP cut is regressively distributed and leads to a more unequal distribution of income. The negative P value indicates that income losses are more equally distributed than initial income in the baseline scenario. Compared to other scenarios, P is even more negative with an abolishment of DPs representing a higher degree of regressivity of income reduction. Income losses account for a larger share in lower incomes compared to higher incomes.

In the No_Pricepol scenario (Table 1, Section III) support cuts are pronounced in the livestock sector since tariffs and export subsidies are in place for several products in the baseline scenario and milk production is restricted due to the quota scheme. Furthermore, the sugar market is also heavily affected by relatively high border protection and the production quota which is still in place in our baseline scenario.

Compared to the No_DP scenario, much stronger income effects occur when price policies are abolished. Average income is reduced by 48%.[6] The overall absolute effect of redistribution (AR) is positive, which also indicates a positive absolute index of vertical equity since the absolute index of re-ranking always is non-positive. Thus, farms with higher incomes tend to bear a higher absolute burden from liberalization compared to farms with lower incomes.

In relative terms, income inequality increases compared to Baseline values. The redistributive effect is -0.222, which is more than the double of the effect in the No_DP scenario. However, almost half of the overall effect originates from re-ranking effects. The index of progressivity is clearly negative, which indicates that low-income farms bear a larger share of the overall burden than their share of baseline income.

In the Full_Lib scenario (Table 1, part IV) the liberalization policies of the No_DP and No_Pricepol scenarios are combined. Effects of both single scenarios go into the same direction, which is reflected in the results of the Full_Lib scenario. Redistributive effects of the combined scenario are stronger – i.e., they are more equalizing in absolute terms and more unequalizing in relative terms – compared to the single scenarios. Progressivity, however, is intermediate in the Full_Lib scenario. The observed increased overall redistributive effects (more negative in relative and more positive in absolute terms) are caused by a larger scale factor s. However, the more than proportionally strong reaction of R partly goes back to a high share of negative incomes in the income distribution.

From Table 1 it can be observed that the analysis which is based on individual data and the one which is based on FARMIS groups clearly differ in terms of magnitude of the single indicators. However, the direction of inequality effects and the evaluation of policy reforms are similar.

It is intuitive that indices are larger when calculated on the basis of individual data since within-group inequality is additionally included in the analysis. For baseline results between-groups inequality accounts for 75% of total inequality measured on individual basis[7] while for the Full_Lib scenario only 59% of all inequality are covered by between-groups inequality.

From a decile group analysis (not presented in this paper) it becomes clear that some farms with low or high incomes formerly belonging to middle class income groups move to the fringe of the overall distribution while contrarily high (low) income farms of low (high) income groups surge to the middle of the distribution. Thus, the ranking of incomes in the individual approach is different from ranking individuals due to the average incomes of their groups, which is implicitly the ranking in the grouped data approach. However, average income is only 3% lower in the lowest decile group and 7% higher in the top group when individual rankings are considered.

[6] Income effects of this size should be interpreted in light of the modelling system not allowing for changes in farm numbers.

[7] The ratio is the same for relative and absolute indices.

Table 1: Decomposition of changes in income inequality (individual data vs. grouped data)

		Relative analysis		Absolute analysis	
		Individual data	**Grouped Data**	**Individual data**	**Grouped Data**
I) Baseline Results					
Average income (in €)		45,424			
Gini index of income	(A) G_x	0.560	0.422	25,443	19,164
II) No_DP scenario					
Average income (in €)		36,470			
Average support reduction (in €)		8,953			
Average rate of reduced support (support reduction/base income)	s	0.197			
Gini index	(A) G_y	0.662	0.487	24,155	17,775
Concentration index	(A) C_y	0.649	0.480	23,662	17,496
Total redistributive effect	(A) R	-0.102	-0.065	1,288	1,389
Index of re-ranking	(A) H	-0.014	-0.008	-493	-279
Index of vertical equity	(A) V	-0.089	-0.058	1,781	1,668
Index of progressivity of support reduction	P ; C_B	-0.361	-0.236	0.199	0.186
III) No_Pricepol scenario					
Average income (in €)		23,823			
Average support reduction (in €)		21,601			
Average rate of reduced support (support reduction/base income)	S	0.476			
Gini index	(A) G_y	0.782	0.498	18,632	11,857
Concentration index	(A) C_y	0.683	0.434	16,265	10,349
Total redistributive effect	(A) R	-0.222	-0.076	6,811	7,308
Index of re-ranking	(A) H	-0.099	-0.063	-2,367	-1,508
Index of vertical equity	(A) V	-0.123	-0.013	9,178	8,815
Index of progressivity of support reduction	P ; C_B	-0.135	-0.014	0.425	0.408
IV) Full_Lib scenario					
Average income (in €)		14,046			
Average support reduction (in €)		31,378			
Average rate of reduced support (support reduction/base income)	S	0.691			
Gini index	(A) G_y	1.256	0.739	17,642	10,377
Concentration index	(A) C_y	1.005	0.582	14,111	8,179
Total redistributive effect	(A) R	-0.696	-0.317	7,801	8,787
Index of re-ranking	(A) H	-0.251	-0.156	-3,531	-2,198
Index of vertical equity	(A) V	-0.445	-0.160	11,331	10,985
Index of progressivity of support reduction	P ; C_B	-0.199	-0.072	0.361	0.350

Source: Own calculations.

In each scenario the overall redistributive effect is more negative in case of the relative Gini and less positive in absolute terms when calculated on the basis of individual data. The vertical effect in absolute terms is higher for all scenarios, but then overcompensated by an also higher re-ranking effect. In relative terms both, V and H are more negative in all scenarios.

However, redistributive effects do not differ substantially in the absolute analysis. Especially, the vertical effect and thus the C_B indices are very close between the approaches. For the relative analysis it is then comprehensible that differences are higher between the two approaches since $P = C_B - G_x$, and absolute differences in C_B are small. Combining evidence from the absolute and the relative analysis, it seems that after the disaggregation of groups individual farms change their ranks to a certain extent but on average have similar absolute income changes while in relative terms income changes are more regressive. In other words, small incomes formerly belonging to high-income groups and now being ranked below high incomes formerly belonging to small-income groups lose a similar absolute amount of income in the scenarios, which accounts for higher losses in relative terms because of their lower income.

However, large differences in the relative analysis, especially between the G_y values, should be interpreted with caution due to a higher share of negative incomes in the individual analysis because several individual farms with negative incomes were 'hidden' in groups with positive average income (22% of groups in Full_Lib have negative income and 31% of individuals in the same scenario).

6. Conclusions

In this paper a tool that is able to consistently assess impacts of sectoral policy on individual farm incomes in West Germany, while taking behavioural effects into account, is presented. The tool was illustrated by three different liberalization scenarios of the CAP. Results indicate that inequality increases in all scenarios in relative terms and decreases in absolute terms.

Comparing the inequality analysis based on individual data with an analysis of grouped data reveals that the amount of inequality may be seriously underestimated when only taking grouped data into account. However, redistributive effects from scenario analysis differ slightly in absolute terms and more in relative terms. Yet, the differences in the relative analysis should be interpreted with caution due to the appearance of negative incomes in the sample.

When comparing inequality effects on a subgroup base, e.g. only for specific farm types (not presented in this paper), differences are more pronounced even in absolute terms. Thus, the tool enables a more specific analysis of inequality effects than an analysis of grouped data.

A caveat of our methodology clearly is that the micromodel which disaggregates farm groups is static and relies on the behavioural changes of the groups of the meso-model, which are mapped accordingly. To a certain extent this approach determines individual income changes.

Nevertheless, heterogeneity among production patterns of farms in the same group is taken into consideration because different production patterns and factor endowments of individual farms are accounted for. Furthermore, with an average group representing 17.2 FADN farms and stratification undertaken according to type, region, and size, an assumed similar behaviour of individual farms belonging to the same group seems reliable.

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