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Explicit cost accounting for adaptation, mitigation and ecosystem service provision in agriculture

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Abstract: Farmers, policy makers and scientists are well aware of this problem: obtaining sound cost information for climate change adaptation and mitigation measures in agriculture or ecosystem service provision by agriculture is burdensome. In most cases, data sets are developed for a specific region with a given set of management variants for a baseline period. Adapting such information to another region or adjusting costs to expected future price scenarios requires additional efforts and frequently done an ad-hoc and case by case. A new tool is presented that can be used to identify and analyze the entangled effects of future climate and market situations on farm profitability and the cost of the provision of ecosystem services. The tool can be used as a stand-alone model to inform stakeholders in agriculture, among them farmers, on past and possible future profitability of production alternatives. Results can be identified for farms with specific characteristics, such as technology options and environmental constraints. Using data for Austria, INCAAM (the Index-based Cost of Adaptation in Agriculture Model) is specific to Central European production conditions in its current version. It is designed to be extended or adapted easily to other production conditions and thus to be used for other regions. Because many import farm commodities and their production technology have already been specified in detail, new products can be added to the model with little efforts. INCAAM can be directly integrated into other models or modeling frameworks via flexible interfaces. This is possible since INCAAM is programmed in GAMS, a software package frequently used in integrated assessment models. The features of the software and underlying database will be demonstrated for a range of wheat production systems in Austria.

Keywords*: integrated modelling, ecosystem services, adaptation and mitigation, climate change, cost accounting, agriculture, INCAAM*

1 INTRODUCTION

A better understanding of many processes in agriculture like interactions with the natural environment has led to the development of integrated assessment models. Analysts make efforts to evaluate how policies affect decision making on farms and how the evolving actions shape environmental outcomes.

A given measure might be very effective in order to reduce the emission of greenhouse gases but farmers may not adopt it because costs are too high. A typical example of such a case is public support which is granted to farmers who invest in tanks that use hoses instead of deflector plates to spread slurry on the field. The environmental consequences of these two technologies are significantly different but the cost differences are significant, as well. In order to understand the decision making process of farmers it is necessary to identify all aspects of such a technological change which - from an environmental point - is an improvement. Not only the investment costs are of interest but also the operating costs, the length of life of the equipment and the depreciation and potential savings because less nutrients are lost. In order to adequately model the decision on farms it is important to know the costs of relevant practices and their alternatives in great detail.

Production costs are an essential element in most economic models of agriculture. Some models estimate them assuming specific technologies and/or functional forms using observed data. Others, such as linear programming (LP) or positive mathematical programming (PMP) models, use average production costs which are often based on gross margin (GM) calculations developed for extension services. This is also true for the Positive Agricultural and Forestry Sector Model of Austria (PASMA), a spatially-explicit economic land use model which identifies the GM-maximising activity mix in a given region (see e.g. Schmid and Sinabell, 2006). Such models require comprehensive and detailed cost data which are usually available for the past but rarely for scenarios that make projections into the future.

To overcome this gap, a new data set called ‘Index-based Costs of Agricultural Production’ (INCAP) has been developed. INCAP accounts not only for a wide variety of activities relevant in the Austrian agriculture (e.g. production of quality wheat) combined with specific attributes (e.g. certain management variants), but it is also established as a time series (Heinschink, Sinabell, Tribl, forthcoming). INCAP is basically a data base which captures the technology of most agricultural production activities in Central Europe at a reference period around 2010. Based on this data base INCAAM (the Index-based Cost of Adaptation in Agriculture Model) was developed in order to make such data available for integrated modelling analyses which require data to be available in a defined format and allow for flexibility over several domains like time, space, products, and farming practices.

In this paper, INCAAM and its structure are introduced (chapter 2.1), followed by a brief discussion of existing sources on cost-related data of the Austrian agricultural sector (chapter 2.2). The example of potatoes is used to demonstrate some important features (chapter 3). The paper concludes with a summary, discussion and an outlook (chapter 4).

2 APPROACH AND MATERIALS

Agro-economic models require technical (e.g. input quantities, yields, technology used) and economic information (e.g. input and output prices, agricultural payments). The respective data and literature are made available by numerous organisations, including public agencies, research institutes, interest groups and non-profit organisations. When developing a new data set, it is often more practical and cost-efficient to adapt existing data to the research task than to start from scratch.

The development process was structured as such: (a) definition of scope and structure of the data set; (b) exploration of existing data sets for relevance for and compatibility with INCAP; (c) selection of existing data sets and fitting them into INCAP’s structure; (d) identification of alternative sources in case of missing data; (e) replacement of explicit data by functions whenever possible to allow swift updates. In order to improve its reliability, INCAP is (f) subject to a series of checks and sensitivity analyses, (g) validated against other sources and scrutinised by experts and – if necessary – (h) revised to improve data quality and thus the quality of model results based on these data.

After completing these tasks, a flexible adapter was developed to extract relevant data from INCAP to an existing agricultural sector model (PASMA) in a standardized manner. This adapter is called INCAAM. It is implemented in the widely used software GAMS and designed to generate idiosyncratic data sets for a range of models and other applications in a flexible and efficient way.

2.1 The structure of INCAP and INCAAM

Production activities in INCAP comprise three dimensions: (a) attributes, such as management variants, that aim at differentiating costs by activity, (b) cost items and (c) time. Regions are not an INCAP dimension. For spatially-explicit analyses, site- and region-specific characteristics (i.e. INCAP attributes) need to be assigned separately.

Due to differing attributes and cost items, INCAP is divided into plant (INCAP.p) and livestock (INCAP.l) production activities. INCAP.p contains all relevant crops (arable crops, feed, permanent crops), forage (silage, hay, grazing), fruit and vegetables. The activities represented in INCAP.l include meat, milk, eggs, wool and breeding animals.

INCAP attributes and management variants

To reflect heterogeneity in production conditions and in the cost struc-ture, the numeric level of certain cost items is differentiated by attribu-tes that belong to certain attribute groups. For instance, the attribute group ‘farming system’ consists of the attributes ‘conventional’ and ‘organic’. Some attribute groups are applicable to both INCAP.p and INCAP.l (e.g. farming system), whereas others are specific to plant activities (e.g. tillage system).

In INCAP.p, the attribute groups (and attributes) represented include field size (number of hectares, continuously adjustable), farming system (conventional; organic), tillage system (standard; conservation), labour type (own labour only; own and hired labour), climate (dry; humid) and plant protection intensity (high; medium; low). The result-ing degree of differentiation is noteworthy: For instance, combining 30 plant production activities with the attributes mentioned (two different field sizes, two farming systems, two tillage systems, two labour types, two climate types, three plant protection intensities) gives 2,880 unique combinations in a single period. At present, some activity-attribute-combinations are technically or economically not meaningful (e.g. the activity ‘hybrid maize’ combined with the attribute ‘organic farming’ or the combination ‘spelt, conventional farming’) and are meanwhile removed from INCAP. Activities are moreover linked to certain land types (arable land; permanent cropland; permanent grassland). For example, the activity ‘quality wheat’ is assigned to the land type ‘arable land’, as it can only be produced on arable land.

In spatially-explicit analyses (e.g. carried out in PASMA), activities are constrained to geographic areas with suitable production conditions (specified at e.g. NUTS 3 level or even at a 1x1 km2 grid). Production options may change over time or depending on a given scenario, and INCAP can be used for such scenario analyses. For instance, grape cultivation is limited to the eastern part of Austria in the baseline scenario. In a climate change scenario, the spatial constraint may be relaxed to allow grape cultivation in other parts of the country as well.

INCAP Cost items

Similar to the attribute groups, the cost items considered for plant and animal activities differ from one another. INCAP.p accounts for vari-able costs of seeds/propagating material, fertiliser, plant protection, machinery, insurance against natural hazards and other (e.g. cleaning, drying, storage). In INCAP.l, specific cost items include stock replace-ment, feed and veterinary services.

Time domain in INCAP

The baseline data set is established for the reference period, i.e. the an-nual average 2011-2013. To generate data for specific years, price indices are applied to each cost item in the reference period. Currently, the indices stretch from the past (year 2005, e.g. agricultural price index) to the future (year 2050, e.g. OECD-FAO agricultural price index).

INCAAM

INCAAM is an adapter between the variants of INCAP databases (implemented in Excel) and agricultural sector models or farm models or other applications (so far not yet developed). It is implemented in the widely used software GAMS and currently designed to generate idiosyncratic data sets for two models (an agricultural sector model and a farm model). In future, INCAAM will be used for other applications to feed them with detailed data on production costs in agriculture in a flexible and efficient way.

2.2 Data sources and data validation

A series of sources was reviewed with respect to their suitability for INCAP in terms of cost items, their differentiation by attributes and time reference. It must be emphasised that this section does not discuss their strengths or weaknesses per se, but rather identifies aspects which lead to a decision for or against their inclusion in INCAP.

GM calculations are available for Austria as ‘Standard GM’ (BMLFUW, 2008), ‘Internet GM’ (AWI, 2015a), ‘Time Series GM’ (AWI, 2015b) and ‘GM based on Economic Accounts of Agriculture (EAA)’ (Sinabell et al., 2011; Strauss et al., 2012). Further ones are developed in working groups (‘Betriebszweigauswertung’ BZA by BMLFUW, 2015) and by consultants in educational or extension services (e.g. rural education institute LFI, unpublished; Austrian Chamber of Agriculture LKÖ, unpublished). GM calculations for foreign countries are provided in the Bavarian version of ‘Internet GM’ (LFL Bayern, 2015) or by international organisations (e.g. ‘Dairy Report’ by IFCN, 2015). Bookkeeping data are provided by the ‘Farm Accountancy Data Network’ (FADN) for Austria (e.g. LBG Austria, 2014; AWI, 2015c), all other EU countries (EC, 2015) and Switzerland (see e.g Hoop and Schmid, 2015).

INCAP data are effectively expert estimates and not real costs observed on farms. On reason is that production details are evaluated that are (not yet) adopted on existing farms. In order to avoid biased results, efforts were made to compare costs observed on farms with those in the data base. For this purpose data collected from farmers who participate in extension groups on specialised products like wheat growing were used to compare with the data generated from desk research. The results show that the median of observed production costs on farms is strikingly similar to the expert judgments but that variability of costs on farms is very high (Heinschink et al., forthcoming).

3. THE EXAMPLE OF POTATOES

INCAP includes several dozen of combinations of production costs for potatoes. There are three variants for three different markets. Starch potatoes are produced for the starch industry, "industry poatoes" are produces for producers of snack like fried potatoes, potatoes chips and the like, and "ware" potatoes are sold to supermarkets and other channels for the use of consumers and restaurants.
Gross margins for these products in the reference period are presented in Figure1. It shows not only the three variants for the different markets but also the variations of production. Gross margins of organic production and standard conventional production are explicitly calculated and a differentiation is made whether labour is hired or provided by the family farm (Figure 1). Depending on the region the expenses for crop protection are different, so a high and low variant are shown.

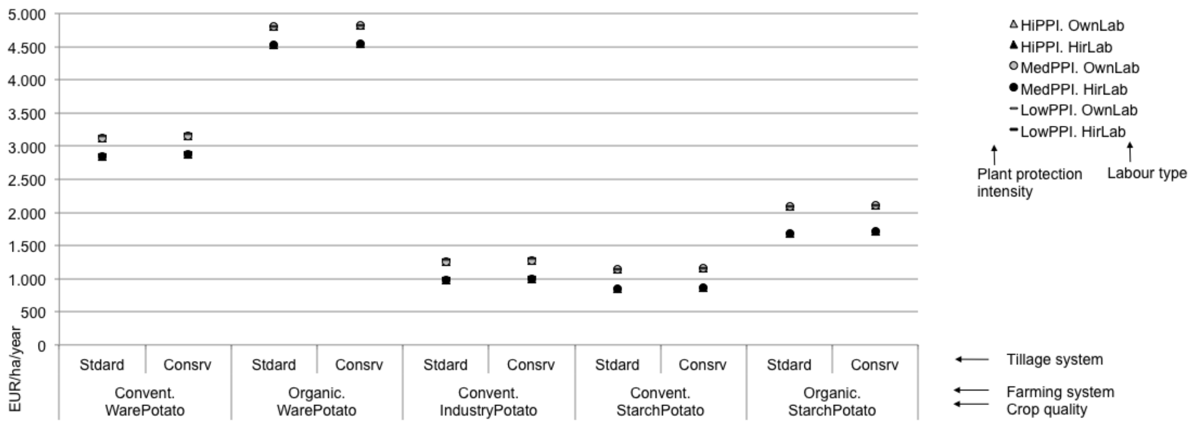

Figure 1: Gross margins of combinations of variants of potatoes in the baseline period (avg 2011-2013), €/ha.

A cost break down and the development of costs, revenues and yields over a period of 15 years is shown in Figure 1. The potatoes variant chosen for this example is "conventional ware potatoes", the variant usually supplied to super markets. Figure 2 shows very well the fact that famers observed that the physical yields are not necessarily correlated with the economic benefit of growing potatoes. Revenues are represented by bars in the positive scale and costs and cost items are depicted on the negative scale. The line with the white dots shows the gross margins, the main variable of interest for a decision maker. The average gross margin over this period was approximately 3,000 Euros per hectare. The figure also shows that in years of high physical yields revenues are typically lower.

Producers of potatoes not only face volatility in physical yields but also in revenues and gross margins. The cost of production increased consistently reaching almost 3,000 Euros per hectare by the end of the observation period (see negative scale in Figure 2).

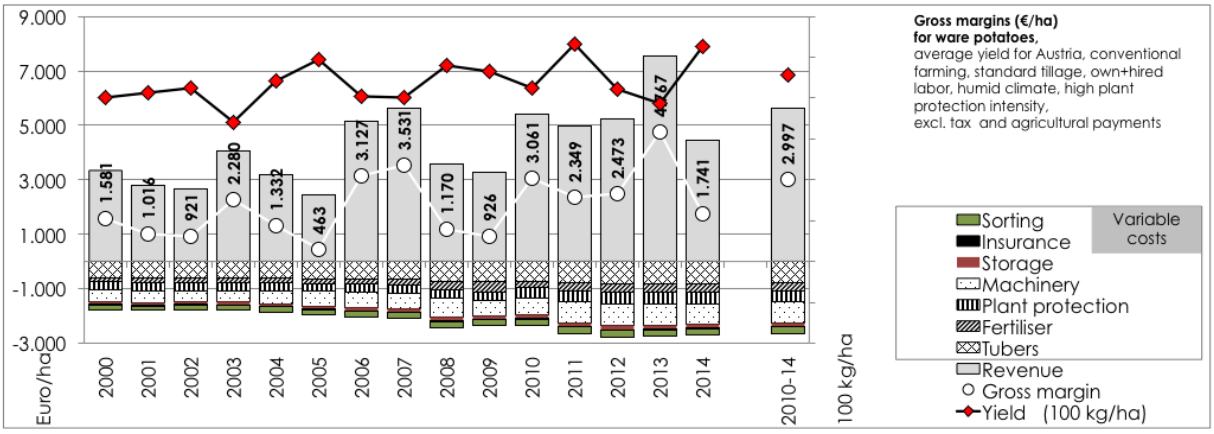

Figure 2: Cost break down of ware potatoes over 15 years

Figure 1 and Figure 2 show the dimensions and the data structure of INCAP in a detailed manner. Potatoes are just one production activity and it was chosen because it makes evident that even a standard product can be produced in many different ways and each variant implies different costs and profits. INCAAM, the adapter to economic model makes use of the richness of the data set and extracts those elements that are used for further modelling.

4. SUMMARY, DISCUSSION AND OUTLOOK

The paper presents INCAP (Index-based Costs of Agricultural Production), a new data set to explore costs of all important agricultural activities in Austria and sketches major elements of INCAMM (the Index-based Cost of Adaptation in Agriculture Model). Based on existing data collections, INCAP extends the scope in several aspects. First, in accounting for a wide range of attributes and management variants, the data allow to represent revenue and cost structures of almost any farm in almost any region in Austria. The data are therefore useful for both farm-specific analyses and aggregate spatially-explicit analyses. Second, the time dimension is accounted for (2005-2050) and thus it is possible to generate consistent data sets for arbitrary base year periods and future years.

A more elaborated data set will be made available to the public as a spreadsheet file. A prototype of the adapter INCAMM will be made available as open source software as well. The primary use of the data and the software and primary purpose is its use in farm and sector models for Austria but it could also be used for many other purposes. As shown in the literature, the cross-sectional and time dimensions of such data sets are very valuable in analysing uncertainty and risk in agricultural production systems. With minimal additional efforts, the data can also be used for farm-specific cost analyses when bookkeeping data are not available. A flexible adapter like INCAAM to extract data and provide them in the needed format is very helpful in this respect.

Besides these strengths, limitations must also be taken into account. Constant farming technology (expressed as machinery costs per application and hectare) and methods (e.g. number of plant protection applications) were assumed throughout the timeframe in order to achieve consistency. These assumptions may however be adjusted in order to examine the effects of technological change.

In order to improve the validity of the results and therefore the usefulness of INCAMM, it will be necessary to systematically compare data like those presented here with activity-specific costs observed on farms. Once the data and the software will be published, a first step is taken to close this information gap. The work on INCAAM may stimulate the discussion on the value of specific cost information and thus contribute to a better understanding of the specific agricultural situation in Austria.

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REFERENCES

AWI (Federal Institute of Agricultural Economics), 2015a. IDB Deckungsbeiträge und Kalkulationsdaten. URL: http://www.awi.bmlfuw.gv.at/idb.html (01.07.2015).

AWI (Federal Institute of Agricultural Economics), 2015b. Deckungsbeiträge. URL: http://www.awi.bmlfuw.gv.at/index.php?id=tierproduktion (06.09.2015).

AWI (Federal Institute of Agricultural Economics), 2015c. Buchführungsergebnisse (FADN results) – Spreadsheet tables. URL: http://www.agraroekonomik.at/index.php?id=buchfuehrungsergebnisse (17.07.2015).

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management) (2008. Deckungsbeiträge und Daten für die Betriebsplanung 2008, 2nd ed. Vienna, Austria.

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management), 2015. Ergebnisse und Konsequenzen der Betriebszweig-auswertung aus den Arbeitskreisen in Österreich. URL: http://www.arbeits-kreisberatung.at (01.03.2015).

EC (European Commission), 2015. FADN Public Database. URL: http://ec.europa.eu/agriculture/rica/database/database_en.cfm (20.02.2015).

Heinschink, K., F. Sinabell, Ch. Triebl (forthcoming), Crop production costs in Austria: Validation of simulated results using farm observations, ÖGA-Jahrbuch, vol. 26. Vienna, Austria: Austrian Society of Agricultural Economics (ÖGA).

Heinschink, K., F. Lembacher, F. Sinabell, Ch. Triebl (forthcoming), Differentiation of variable costs in the Austrian agricultural production, ÖGA-Jahrbuch, vol. 25. Vienna, Austria: Austrian Society of Agricultural Economics (ÖGA).

Hoop, D. and Schmid, D., 2015. Zentrale Auswertung von Buchhaltungsdaten – Grundlagenbericht 2014. Ettenhausen, Switzerland: Agroscope, Institut für Nachhaltigkeitswissenschaften (INH).

IFCN (International Farm Comparison Network), 2015. IFCN Dairy Report. URL: http://www.ifcndairy.org/en/output/dairyreport/ (01.10.2015).

LBG AUSTRIA, 2014. Betriebswirtschaftliche Auswertung der Aufzeichnungen freiwillig buchführender Betriebe in Österreich 2013. Vienna, Austria.

LFL BAYERN, 2015. Deckungsbeiträge und Kalkulationsdaten. URL: https://www.stmelf.bayern.de/idb/default.html (20.02.2015).

Schmid, E. and Sinabell, F., 2006. The Austrian agricultural sector in 2013 – Management and environmental perspectives. Darnhofer, I., Schmid, E. and Palkovics, M. (Eds.. ÖGA-Jahrbuch, vol. 15, 35-43. Vienna, Austria: Austrian Society of Agricultural Economics (ÖGA).

Sinabell, F., Kniepert, M. and Strauss, F., 2011. Die Quantifizierung von Ertrags- und Einkommensrisiken in der österreichischen Landwirtschaft auf Sektorebene. In: Agrarpolitische und betriebswirtschaftliche Optionen zum Risikomanagement in der österreichischen Landwirtschaft (Policy options and management strategies to cope with risks in Austrian agriculture. 177-214. Vienna, Austria: Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW).

Sinabell, F., Kniepert, M. and Strauss, F., 2012. Quellen der Einkommensvolatilität in der österreichischen Landwirtschaft (Sources of income volatility in the Austrian agriculture). Hambrusch, J., Hoffmann, C., Kantelhardt, J. and Oedl-Wieser, T. (Eds.. ÖGA-Jahrbuch, vol. 21(2), 51-60. Vienna, Austria: Austrian Society of Agricultural Economics (ÖGA).