A Forest Sector Model for the Region Baden-Wuerttemberg in Germany - BW-GLOBAL-FOR

Juliana Walkiewicz[1], Wolfgang Britz[2], Matthias Dees[1]

[1] Chair of Remote Sensing and Landscape Information Systems, University Freiburg

[2] Chair of Economic and Agricultural Policy,
Institute for Food and Resource Economics, University Bonn

Corresponding authors: juliana.walkiewicz@felis.de, wolfgang.britz@ilr.uni-bonn.de

Abstract

The BW-GLOBAL-FOR model is a recursive-dynamic, spatial global multi-commodity model for wood and wood based products, with a focus on Germany. It is designed to analyze impacts of market and policy changes with regard to forest management and wood based products on the forest and related industries in the German state of Baden-Wuerttemberg. The project is a joined initiative of the Chair of Remote Sensing and Landscape Information Systems FeLis, Uni Freiburg and the Chair of Economic and Agricultural Policy, Uni Bonn. Preliminary runs underline that the system is able to depict regional developments in Germany in a global context and allows analyzing impacts in markets on prices, supply, demand and bi-lateral trade flows.

Keywords: forest sector model, recursive-dynamic, Baden-Wuerttemberg (Germany)

Introduction

The resource timber pervades our daily life and was a main contributor to our societal and economic development – in early times at the fireplace, where the family assembles by the end of the day or powering the steam locomotive, which nowadays is a symbol for the industrial revolution. Besides the manifold possibilities of using wood in its different components – i.e. for construction, paper- and pulp production, energy use or chemical use, forest provide further important ecosystem services as recreational area, living space or natural conservation area, , As wood is a highly coveted resource, it is necessary to spot on the different competitive forces and how their decisions influence one another, which demands for a deep understanding of the interdependencies between sectors.

The “Clusterinitiative Forst & Holz Baden-Wuerttemberg” is a network of Universities, research institutions, producers, suppliers and service providers whose common denominator is the wood sector. The aim is to strengthen the industrial forestry and wood sector in their region through cooperation, research and development. As the sector employs around 200 000 people, mainly in a small to medium-sized business structure in rural areas, and has a turnover of 30 bn Euro per year, its contribution to the economic well-being of the whole region is considerable. The inclusion of expertise and knowledge from partners with different scopes ensures a holistic view of that branch.

One project is the establishment of a forest market model with a spatial focus on the German state Baden-Wuerttemberg. The goal is to analyze economic and trade activities in the forestry sector with respect to changes in policies or exogenous impacts as changed marked behavior of other sectors or shocks. Market interdependencies between the forest and the wood processing sector are modelled using historical economic data to provide a realistic picture of the current situation. In a second step, through economic simulation, scenarios are modelled which project possible future developments when certain economic or political influences or measures such as incentives, tax changes, etc. effect the forest sector, while keeping other factors constant. Therefore it should be kept in mind that the scenario-based forecasts shouldn’t be regarded as predictions of the definite future but as possible answers to “what-if” considerations.

In this paper the basic structure of the model is presented and the operational plausibility is proved through calibration against a projection up to the year of 2030. Next, a first scenario is run by introducing a large shock which results coincided with intuitive expectations. With this model, that is currently still in an early development stage and that will be incrementally developed further, we aim at setting up in the end a highly useful tool for all interest groups who want to analyze forestry related impacts of different scenarios for the region of Baden-Wuerttemberg.

The paper is structured as followed: In the first chapter a short summary and historical overview of the main existing forest market models is given. Thereafter, in chapter 2, the main attributes of the BW-GLOBAL-FOR-model are presented, followed by a preliminary run via introducing an external shock to the forest sector in the region Baden-Wuerttemberg. The paper concludes with a summary and discussion.

Existing models for wood markets

The BW-GLOBAL-FOR model belongs to the group of dynamic recursive partial equilibrium models for the forest sector. Those are characterized by splitting up the long run market development into an interrelated sequence of short run problems with duration of one period. The results of the optimized behavior from one period enter the subsequent period as updated information and data.

The most well-known and widely applied forest market-models are successors of the IIASA-GTM (International Institute for Applied Systems Analysis – Global Trade Model) which analyzed globally international trade in wood products (Buongiorno, J & Gilles JK, 1983) and the PAPYRUS-model, which was developed to generate long-term projections of the North American pulp and paper industry (Buongiorno, J & Gilles JK, 1987). Both models were developed in the 1980's and afterwards constantly updated.

Nowadays, within the group of successors, the most common models are EFI-GTM (Kallio,M. et al. 2004) and GFPM (Tomberlin,D. & Buongiorno,J. 1998). EFI-GTM was developed by the European Forest Institute (EFI). Its objective is to analyze supply, demand and trade of the forest industry products in response to market changes. Even though the model covers the whole world, its major focus is on Europe and the smallest unit of consideration is on country level.

From the methodological perspective, the GFPM (Global forest products model) doesn't differ much from the EFI-GTM, but considers trade activities globally. Therefore it disaggregates the world into 180 regions instead of 61, getting more detailed insights in trade between regions beyond Europe.

From the necessity of not only analysing and project market behaviour between countries and their possible mutual impact but also being able to understand internal forces within a defined region of a country, several forest market models have been developed which consider the peculiarities of a certain country or small regions. Those are between others the Norwegian Trade model (NTM, Trømborg, E. & Sjølie, H.K., 2011), the Finnish forest sector model (SF-GTM, Ronnila, M., 1995) and the French Forest Sector model (FFSM, Caurla, S. et al, 2010). The BW-GLOBAL-FOR model follows a similar approach with regard to spatial dis-aggregation as it takes advantage of the detailed data which is available for the county Baden-Wuerttemberg and therefore is able to provide additional and significant information.

Main model attributes

BW_GLOBAL_FOR belongs to the class of multi-commodity models. It is recursive-dynamic with a yearly resolution, i.e. current year results depend on results of past years. Dynamics in the model relate to price expectations of the agents managing the forests, on the dynamic dependencies between standing forest volume, net growth and harvested quantities and finally on the impact of accumulated net growth from the past on current year's harvest decisions.

The model and its data base distinguish currently coniferous and broadleaved forests, and four wood products (sawlogs from coniferous and broadleaved forest, pulp wood, other). The demand for these products is dis-aggregated by the sawmill and pulp and paper industry, the energy supplying sector as chipping companies using wood residues and other users of forest products. Supply is differentiated by forest ownership and grouped by the size of the lot. Therefore we distinguish between public and

private forest owners. The latter in turn consists of two groups: small private owners with land up to 100ha and other private owners with land bigger than 100 ha. The model is regionalized at federal state level for Germany, at national level for neighbouring countries and at continental level for the rest of the World; the final version shall regionalize Baden-Wuerttemberg to NUTS II regions (Regierungsbezirke).

The model is spatial, i.e. it depicts bi-lateral trade flows between the regions. These flows can be simulated based on two distinct concepts. Using the assumption of globally homogenous products, the Spatial Equilibrium (SPE) concept can be applied which results in the spatial arbitrage condition, i.e. price differences between regions cannot exceed transport costs. The advantage of that approach is that so-far non-existing trade relations between regions can emerge in counterfactual runs. As it just accounts for net-trade, it can however not depict counter-trade, and thus generally fails to reproduce a realistic pattern of observed trade. We therefore alternatively model bi-lateral gross-trade based on an Armington approach, loosening the assumption of spatial arbitrage of trading homogenous goods. This approach seems especially suitable for the forest sectors as several studies showed that the Law of one price does rarely hold on European wood markets (see Hänninen,R. 1999; Toppinen,A. et al. 2010). In addition to that, since aggregated data on international trade is not always perfectly comparable across countries – as basic definitions, i.e. for stemwood or crownwood differ – commodities are indeed different and imperfect substitutes. To increase the flexibility further, the Armington approach for international trade flows can be combined with a SPE approach inside Germany.

Forest managers are assumed to have a desired long-time harvest rate of their standing forests which will be realized if their long-term price expectations match actual prices in the market. If current year prices exceed their price expectation, the harvested share and thus output in the current year will increase and vice versa. That relation is modelled based on a sigmoid function. The price-driven harvested share of the previous period determines the standing forest available for harvest in the current year, forming bounds that compress or stretch the s-shaped function. In other words, the desired harvest rate increases if less than the desired quantities were harvested in past years, i.e. if a kind of reserve is accumulated. The net growth rate of the forest is a also function of prices, to reflect that management activities such as clearing, liming, pest and disease control which impact the increment are to some degree price sensitive. The share of the tree parts (logs, pulp wood, other) in the harvested quantity can to some degree be adjusted, based on a Constant-elasticity of transformation function with low transformation elasticities. For Non-European regions, where data on standing forests, net growth and felling are missing, a double-log function depending on producer prices drives the harvested quantities.

The individual demander reacts to current year's demander price based on a double log function. The different demanders are linked to one key product and consume the other products only in small shares. These shares in their consumption are driven by a CES demand function which depends on the relative demand prices of the products. If the Armington specification is used, the demand price of each product is a composite price from domestic sales and imports, with the SPE formulation it is equal to the supply price.

EFI-GTM, the well-known forestry model, uses linearized demand and supply functions - where, as it seems, no cross-price effects are reflected - and fixed input shares. It uses a SPE formulation for international trade, as the model description suggest in combination with lower and upper bounds to prevent a jumpy solution behaviour. Here, BW-GLOBAL-FOR offers alternative approaches with different functional forms depicted cross-price effects and the Armington assumptions and can thus be seen as a complement to existing forest and wood sector models. Structural properties are clearly influenced by Computable Equilibrium Modelling.

The model is sourced with data from the UNECE/FAO Forest and Timber statistics for Europe, global FAO Forest statistics and from the German Federal Forest Inventory (Bundeswaldinventur). In order to allow comparison of projected and simulated results with the past developments, the expost-data covers the years 1990-2010. After using interpolation and trends to fill gaps in the data, Bayesian based estimators (cf. Britz and Witzke 2005, Heckelei 2008) remove inconsistencies between the different data sets to generate a data set that is consistent across products, space and time, against which the economic model is calibrated. That includes a simple trend based global projection. The parameterization of the model is at current state based on assumptions, using ranges of key parameters such as price elasticities as found in other studies (Michinaka et al, 2011; Turner, J.A. & Buongiorno, J., 2011; Simangunsong, B.C.H. &Buongiorno, J., 2001; Hartebrodt, C. et al., 2006) for

wood and forest products. The Armington elasticities are in the range of those estimated by Hertel et al. 2007. The content of the different data bases is not yet fully exploited; equally, we have not yet compared our trend based projections to other work but activities are planned in the near future. A full model documentation provide Britz et al. 2014.

The model and related data transformation are encoded in GAMS. The simulation model uses a strict equation template to clearly separate structural properties of the model from data and parameters. It is defined as a Mixed-Complementarity Problem and solved with PATH4.7 (Ferris and Todd 2014). Its Graphical User Interface (GUI) and result exploitation are based on GGIG (Britz 2014a).

Results from a preliminary counterfactual run

In order to prove that the prototype version of BW-GLOBAL-FOR is operational, we calibrate the model against a mechanistically produced projection until 2030, the so-called ex-ante baseline. That projection is trend driven, but made internally consistent. For the application described below, we use the Armington assumption to drive bi-lateral trade flows, in combination with the SPE approach for trade between the German federal states.

In order to test the model reactions with regard to plausibility along with the stability of the modelling framework, we introduce a rather large shock in the region we are focusing on: we let the standing forest in Baden-Württemberg increase in each year by 5%. The cumulative effect seen in the final simulation year 2030 of that change basically more than doubles output at the end of the simulation horizon compared to the ex-ante baseline, even once price feedback is factored in, and is outside the range of simulations normally carried out with that type of model. But such drastic experiments are useful to highlight the mechanisms which drive the model's reactions, linked to its structure and parameterization.

A first interesting finding is the impact of that regional supply shock on the prices, see figure 1, at global (in red), German (in blue) and regional level (Baden-Württemberg, in green).

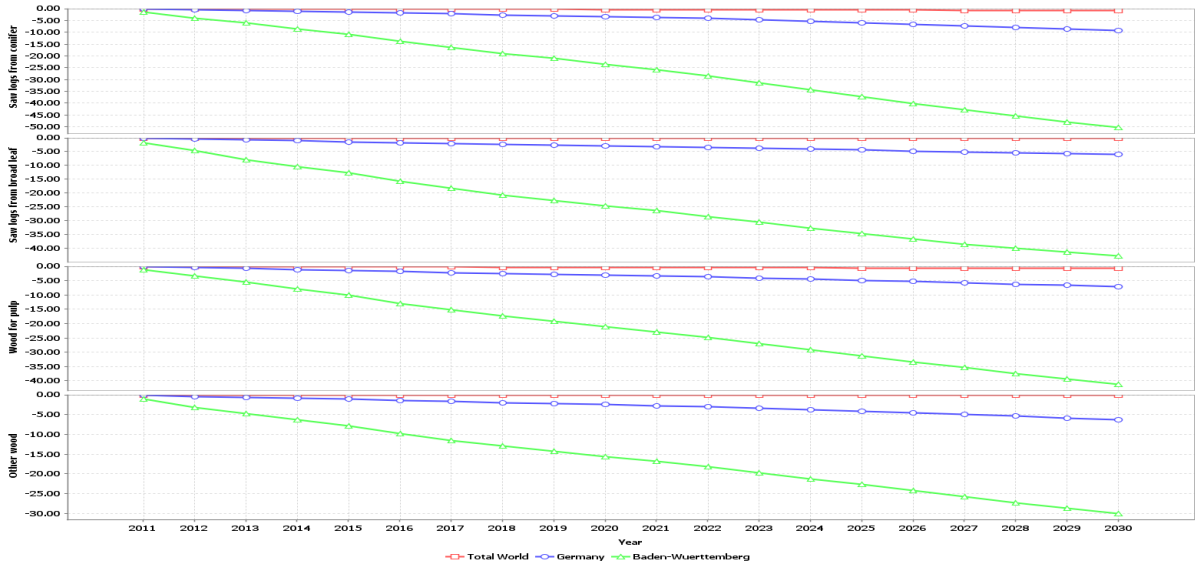

Figure 1: *Relative price changes in response to a harvest share increase of 5% p.a. in Baden-Wuerttemberg on Baden-Wuerttemberg, Germany and global level*

The scenario thus underlines that the Armington based approach to depict trade flows leads to a plausible reaction to regional shocks: the price impact in Baden-Württemberg is considerably larger than in other regions. This result for Baden-Wuerttemberg is in line with the study of Hartebrodt et al. (2006), who concludes that a quantitative expansion of supply leads to a severely reduction in price as demand for wood is econometrically identified as inelastic. The following graphs show that as expected, imports decline, again, the impact is largest in Baden-Württemberg:

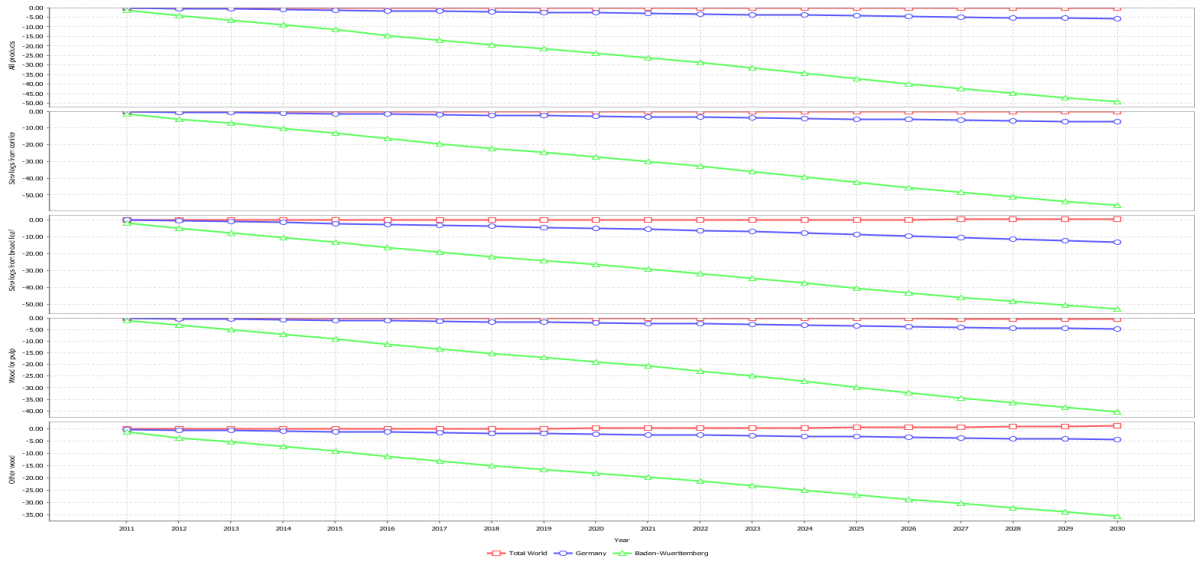

Figure 2: *Relative import changes in response to a harvest share increase of 5% p.a. in Baden-Wuerttemberg on Baden-Wuerttemberg, Germany and global level*

The following figures 3 and 4 graphs show that in parallel, exports and domestic sales increase. Having both imports and exports present in the model is again an outcome of the Armington specification.

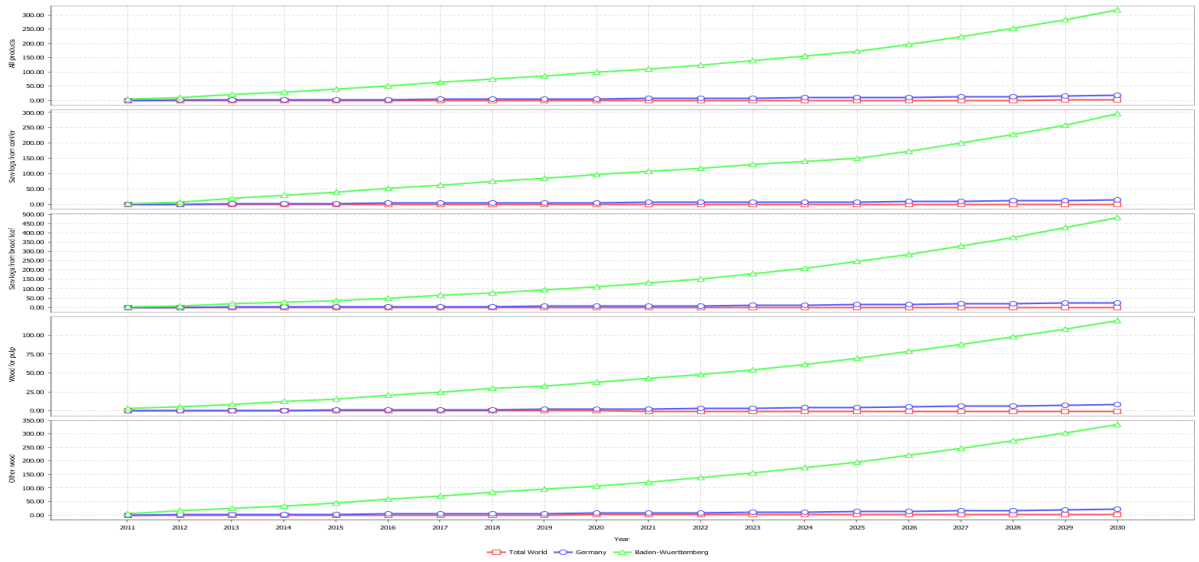

Figure 3: *Relative export changes in response to a harvest share increase of 5% p.a. in Baden-Wuerttemberg on Baden-Wuerttemberg, Germany and global level*

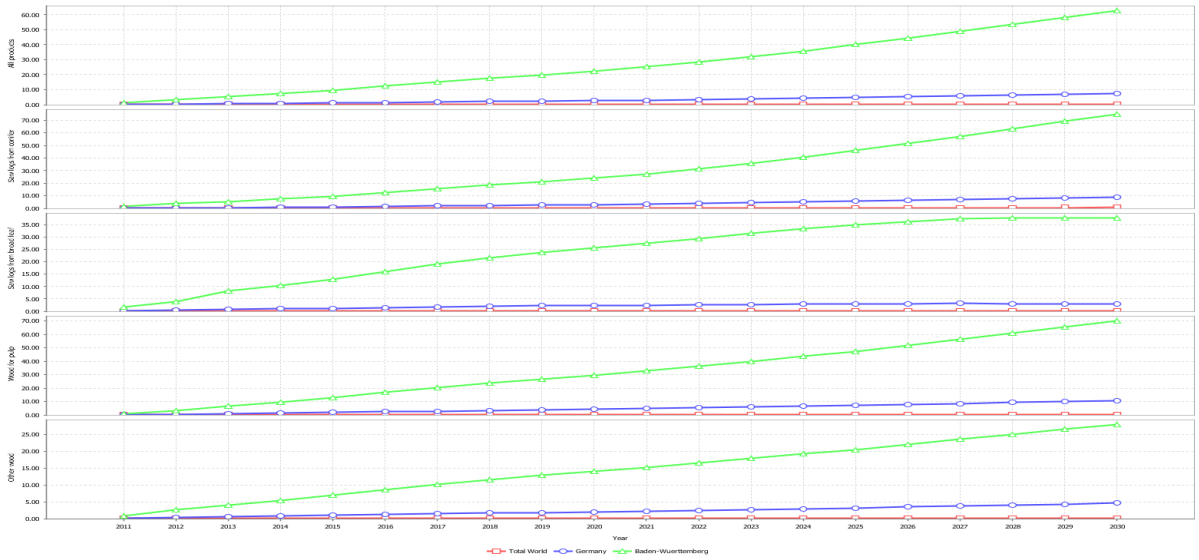

Figure 4: *Relative changes in domestic sales in response to a harvest share increase of 5% p.a. in Baden-Wuerttemberg on Baden-Wuerttemberg, Germany and global level*

Summary and conclusions

BW-GLOBAL-FOR is an innovative recursive-dynamic multi-commodity model for wood and wood based products with features such as CES (Constant elasticity of substitution) and CET (Constant elasticity of transformation) function, modeling international trade based on the Armington assumptions and a sigmoid driven determination of the harvested share. It thus complements other international models simulating wood and wood based product markets which are differently structured. While work to improve its data base and parameterization is ongoing, first simulation runs with the prototype version model prove that it is able to produce plausible simulation responses in response to shocks in wood and wood based product markets.

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