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Effects of Aggregation and Model Structure on Model Linkages

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1. Problem Statement

Agricultural policy, affecting the food and agricultural sector from the global market down to the farm level, has become increasingly complex over the last century. As a result quantitative food and agricultural policy analysis turned to be an extensive research area which mostly requires practice of comprehensive analytical tools, i.e., a modeling framework that represents the food and agricultural sector at the global, national and farm level.

There is an extensive literature discussing the utilization of model linkages and the interaction between linked models. However, in this study we only concentrate on a selection of characteristics of model linkages. In particular, our focus is on aggregation problems which arise due to the transfer of results between two adjacent models that are differently aggregated at sectoral or regional level. Nevertheless, analysis showed that sector disaggregation leads to more divergence results rather than the regional disaggregation. Furthermore, in order to reveal interaction with other model characteristics, we are taking the difference in a partial (PE) and general equilibrium (GE) model structure into account by pair wise combining the four characteristics (i.e., disaggregation, aggregation, PE and GE).

We also review the literature to allow for comparison between our current findings and those coming from the literature. This overview summarizes the results by focusing on a selective number of variables, namely the effects on trade, price and output as well as welfare.

2. Modeling Framework and Methodology

The analysis in this paper is based on the GTAP modeling framework. We start our analysis by employing version 7 of the GTAP data base (NARAYANAN and WALMSLEY, 2008) to create data bases with different levels of aggregation. The first data base is highly disaggregated at the sectoral level and includes all 20 available food and agriculture sectors. On the contrary, the second data base is highly aggregated in the food and agricultural sector and includes only 4 sectors, namely grains, crops, meat and livestock products as well as processed food. Both data bases carry identical 8 regions. In order to expose the regional disaggregation differences, the databases with 8 regions are disaggregated to 11 regions. The second set of characteristics (PE and GE) is achieved by HERTEL (1992). PE models are therefore obtained from the GE-GTAP model by exogenizing prices and outputs of nonfood tradable commodities, income as well as the non-land primary factor rental rates of the mobile endowment commodities.

3. Experiment Results

Our results of an EU agricultural trade liberalization show comparable outcomes of experiments analyzing the impact of removed export subsidies and import tariffs of the EU-27's food and agriculture sector. Within these experiments, we used a pair wise combination of different levels of aggregation (DIS and AGG) and model structure (GE and PE).

In terms of regional disaggregation, we experience very low differences in all simulations. Hence, the following analyses are focused on the sector disaggregation. For trade balance effects, we see that the results of GE-AGG are much more pronounced than the ones which are based on GE-DIS at the sectoral level. Particularly the crops sector shows results deviating by almost 100% followed by the processed food sector. The same differences can also be seen between the PE-AGG and the PE-DIS version of the GTAP framework. Furthermore, the comparison of the GE and PE results shows that the discrepancy based on the model structure is very low compared to the effect due to the aggregation.

The relatively lower differences due to model structure can be explained by the initiating shock which is only given to the EU's food and agricultural sector. Thus, exogenous variables in the PE model are only marginally affected. A higher shock to the agricultural sector or shocking the non-agricultural sector would therefore lead to a more pronounced difference between the PE and GE models. On the other hand, the differences due to sector aggregation are based on the false competition effect (NARAYANAN *et al.*, 2009). High aggregation causes an artificial competition which leads to a higher own-price elasticity of source-wise imports with respect to their corresponding prices in the GE-AGG and PE-AGG versions. Accordingly; we observe a much higher trade effect in the GE-AGG which is initiated by the value shares of source specific imports in aggregated imports across sources. As an example, it is particularly striking that Sub Saharan Africa's change in the trade balance differs by more than 100% between GE-AGG and GE-DIS.

With regard to prices, we conclude that aggregation differences at the sector level are higher than model structure differences. While changes in prices are higher in GE than the ones in PE; controversially the changes in quantities are lower in GE than PE changes. Thus, this conclusion is applicable for disaggregation at both levels.

In accordance with the literature overview, we also conclude that GE models as well as disaggregated models give higher welfare changes both at sectoral and regional level. Since GE models capture the whole economy and aggregated models underestimate the heights of tariffs, PE-AGG delivers the lowest welfare levels whereas GE-DIS gives highest welfare gains. However, it can clearly be seen that the total welfare change is dominated by the allocative efficiency effect.

Our simulation results lead to the conclusion that sector disaggregation is the origin of the differences in results rather than regional disaggregation. The experimental set up (e.g., same model and data) also enables us to clearly derive the conclusion that the bias in results due to aggregation is much higher than the one due to model specification. Furthermore, most of the differences in the results can be traced back to false competition (trade effects) and averaging of tariffs (welfare effects) which are both effects resulting from the sector aggregation. If our GE-DIS version of the GTAP framework is used as a reference point, then the GE-AGG version overstates the EU''s trade balance effect of processed food by 32%, whereas it is only 5% in the case of PE-DIS. Accordingly, it would be appropriate to develop a measure for false competition and evaluate it regularly in simulations since it has significant effect on results.

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