Agricultural Policy Impact Analysis with Multi-Market Models: A Primer

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ESA Working Paper No. 07-26

June 2007

Agricultural Development Economics Division

The Food and Agriculture Organization
of the United Nations

www.fao.org/es/esa

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Abstract

Many governments intervene directly in agricultural product, in particular food, markets. A quantitative assessment of the impact of the policy changes on the desired objectives is important as it helps inform and shape the policy debate on the reform alternatives and increases transparency of government policy. This paper reviews the literature on multi-market models which offer more accurate *ex ante* impact analysis than single-market models by including potentially important indirect effects. While fairly complex and requiring large amounts of data multi-market models are however much simpler than computable general equilibrium models. They are typically applied at the sector level and have proven quite popular in particular in agricultural policy reform impact analysis. While more recent work has emphasized the poverty reduction and income distribution objective the models can generate a range of information relevant to policy makers.

Key Words: Multi-market models, agricultural policy impact analysis***.***

JEL: Q11, Q18.

1. INTRODUCTION[1]

A primary goal of policy makers is to evaluate how stakeholders are affected by policy reforms, and for this reason it is important to provide an *ex ante* analysis to measure the impact of these policies among a different groups Many governments intervene directly in agricultural product markets, in particular food, through taxation and subsidization. Key objectives are to redistribute income, generate public revenues, correct market failures and provide incentives to producers (Braverman, Ahn and Hammer (1983)). A quantitative assessment of the policy changes impact on the desired objectives is important as it helps inform and shape the policy debate on the reform alternatives. Greater transparency is also important for the sake of public accountability (Braverman and Hammer (1986)).

Currently, policy makers shifted their focus on poverty and hunger reduction. These issues are still predominantly rural based: the rural poor make up about 70 percent of the world's total poor population. Nevertheless, urbanisation processes have recently increased the number of urban poor and food insecure. Increasingly, therefore, the role of agricultural based growth is recognized and emphasized in promoting rural development, slowing down the pace of urbanization and contributing to an equitable and sustainable overall development. A focus on the welfare of the rural population and its interdependencies with the welfare of urban areas, as well as the interlinkages between agricultural and off-farm activities is essential to foster greater understanding of the links between agricultural policies rural development and poverty and food insecurity.

This paper offers a review of multi-market model, that has been used to analyze *ex ante* the impact of agricultural policy reforms. Discussion of other types of measures and models is limited to a brief comparison with a more detailed discussion of the various tools to analyse policy change available in World Bank (2003).

The most commonly used tool to quantitatively assess agricultural pricing policies are the domestic resource cost (DRC) and the effective protection rate (EPR). Both are modified ratios of domestic prices to international prices, the latter assumed as efficiency benchmarks for the domestic economy. These measures are often calculated at different levels of the value chain of specific commodities and reported as summary indicators of the so called "Policy Analysis Matrix" (PAM) (Monke and Pearson, 1989). These instruments can only partially address the issues of interest outlined above. In particular income distribution, public revenue and the impact of taxes or subsidies on production and consumption are not evaluated.

Another popular method is that of single-market calculations of consumers' and producers' surplus. This type of analysis ignores the interaction among markets, i.e. substitution effects in consumption and production, and provides only limited information with regard to income distribution. The rural labor market is not included and hence the potentially important direct and indirect effects on wages are ignored. Ignoring the direct and indirect effects on wages, prices and incomes means that the estimates of welfare changes will be biased in unknown directions (Arulpragasam and Conway (2003)).

The most sophisticated solution to incorporating direct and indirect effects in several markets has been to prepare computable general equilibrium models (CGE). These model goods and factors markets in all sectors and allow for wages, prices and incomes to be

[1] This paper was prepared as part of the "Linking Agriculture Policies to Poverty and Food Security" module of the FAO's *Roles of Agriculture Project* [www.fao.org/es/esa/roa], funded by the Japanese Government. Content and errors are exclusively the responsibility of the authors and do not necessarily reflect the position of the Food and Agriculture Organization of the United Nations or of the Indonesian Center for Agricultural Socio Economic and Policy Studies. We are grateful for comments by Keith Wiebe that helped improve the paper.

determined endogenously. The main drawback of these types of models is their large data requirements and their high degree of complexity. For a more detailed exposition on the DRC, EPR and CGE models we refer the interested reader to Sadoulet and de Janvry (1995).

2. MULTI-MARKET MODELS

2.1 Introduction

Multi-market models, also sometimes referred to as "limited general equilibrium" (for example in Quizón and Binswanger (1986)) or "multi-market partial equilibrium" models (as in Arulpragasam and Conway (2003)), fall short of the complexity of CGEs. They focus only on one sector, as opposed to 8-12 for a typical CGE, and do not include a number of balances, such as the balance on savings and investment, supply and demand of foreign exchange, etc., included in GE analysis (Sadoulet and de Janvry (1995)).

However, multi-market models do include direct and indirect effects in a small number of markets. In that sense they are an improvement over single market partial equilibrium analysis. They typically consist of a producer and consumer core and allow for the analysis of the impact of price and non-price policies on production, factor use, prices (for non-tradables), incomes, consumption, government revenues and expenditures and balance of trade (Sadoulet and de Janvry (1995)). The analysis focuses on those markets which are assumed to be strongly interlinked, either on the demand or the supply side. Prices in those markets included in the analysis are endogenous. The bias in estimating welfare changes as a result of policy reforms is diminished, but remains. It follows that multi-market models will generate reliable results when the reforms being analysed affect commodities or factors for which the set of close substitutes and complements are well defined (Arulpragasam and Conway (2003)). They are particularly useful when the issue under analysis is of sectoral importance, not economy wide, and when there is the need to disaggregate to a certain level. Unlike CGEs they are useful for more detailed predictions of specific policies as greater detail of the markets, institutions and policies can be included (Sadoulet and de Janvry (1995)).

Multi-market models have proven particularly popular for work on agriculture sector analysis. In the 1980s the World Bank developed multi-market models for Senegal, South Korea and Cyprus to analyse how the impact of changes in price policies would affect production, demand, income, trade and government revenues (Lundberg and Rich (2002)). Braverman, Ahn and Hammer (1983, 1986) extended the single market surplus method to include income distribution and some general equilibrium considerations. Their analyses cover the agricultural sector and includes an exogenous urban sector.[2] This is important as urban consumption may have an important impact on government revenue/deficits. Moreover staple food price changes are important for the urban poor. They note the trade-off between complete information on the consequences of policy and the need for simplicity in operational work.

Braverman, Ahn and Hammer (1983) use a multi-market model to evaluate quantitatively the impact of alternative pricing policies aimed at reducing the deficits in the Grain Management Fund and the Fertilizer Fund in Korea. In particular they measure the impact of the various alternatives on: i) Production and consumption of rice and barley, ii) real income distribution, including the income distribution in both rural and urban sectors, iii) import levels of rice, iv) self-sufficiency in rice and v) the public budget.

On the supply side Braverman and Hammer (1986) assume a Cobb-Douglas technology. Land and labor are fixed to the region but can be shifted between crops within the

[2] For completeness we mention that Lau et al (1981) is an earlier example of an application of the farm household model in a policy simulation study. They did not include the urban sector.

region. Their allocation is determined by equating their value marginal products between uses. Incomes are determined by profits and non-agricultural receipts are held exogenous. The analysis of demand is based on the Almost Ideal Demand System (AIDS).

Quizón and Binswanger (1986) use a multi-market model to analyse the impact of agricultural policies as well as technical and economic changes on growth and equity in India. Their model covered four outputs and three inputs, including labor. Households are divided by income into four urban and four rural groups. They note that the distributional outcomes from general equilibrium models depend crucially on labor market assumptions.[3] Accurate modelling of wage formation is therefore central to obtaining meaningful results.

More recently multi-market models have been used for agricultural sector Poverty and Social Impact Analysis (PSIA).[4] Murembya (1998) uses a multi-market model along the lines of Braverman and Hammer (1986) to study the impact of loosening agricultural price controls on agricultural production in the smallholder sector, the government budget deficit and on household welfare in Malawi. Dorosh and Bernier (1994) construct a multi-market model in the tradition of Braverman and Hammer (1986) that includes yellow and white maize, rice, wheat and bread, export crops and vegetables, meat and non-agriculture. For vegetables and meat trade is thin and is fixed exogenously in the model. Three household groups are included: urban poor, urban non-poor and rural. Demand side parameters are estimated using an AIDS model while supply side elasticities are based mainly on data from other countries. Dorosh et al (1995) addresses the question of whether open market sales of yellow maize food aid is an effective means of poverty alleviation in Maputo and whether such a policy has any negative effects on the rural poor. Dorosh and Haggblade (1997) assess the impact of food aid monetization in Bangladesh using a seasonal multi-market model that includes 13 commodities and six household groups.

Minot and Goletti (1998) use a spatial multi-market analysis which focuses on market liberalization of the rice sector in Vietnam. Their model is innovative in the sense that it allows for differences in impact across regions (see also Minot and Goletti (2000)). Building on their work (and also using the Viet Nam Agricultural Spatial-Equilibrium Model) Goletti and Rich (1998a) study alternative policy options for agricultural diversification in Viet Nam and Goletti and Rich (1998b) use the Madagascar multi-market spatial-equilibrium model to analyse agricultural policy options for poverty reduction.

Srinivasan and Jha (2001) analyze the effect of liberalizing foodgrain trade on domestic price stability using a multi-market model. In their model the direction of trade is determined endogenously.

Lundberg and Rich (2002) built a multi-market model to look at agricultural reforms in Madagascar. This was meant to be a generic model that could be adapted to policy analysis in a number of African countries. On the product side this model includes fine and coarse grains, roots and tubers, cash crops, livestock, other food products and non-agricultural production. On the input side fertilizer, feed and land were included. Labor was not included as the authors surmised that this input was more appropriately studied through the use of a CGE model. Stifel and Randrianarisoa (2004) built on Lundberg and Rich (2002) to analyze the impact of agricultural reforms, such as tariff changes, but also going beyond price changes by looking at infrastructure improvements and yield increases, in Madagascar.

Using Stifel and Randrianarisoa (2004) as a starting point, multi-market models were developed for Egypt, Indonesia and Paraguay as part of the "Linking Agriculture Policies to Poverty and Food Security," module of FAO's Roles of Agriculture Project [www.fao.org/es/esa/roa]. Siam and Croppenstedt (2007) adapt Stifel and Randrianarisoa

[3] Quoting Taylor (1979).

[4] For detailed information on PSIA see the so dedicated World Bank website [www.worldbank.org/psia]. For a detailed overview of analyses on agricultural market reforms on poverty and welfare see Lundberg (2005).

(2004) to assess the impact of wheat market liberalization in Egypt. The model does not include seasonality nor an aggregate for all other food as well as non-food commodities. Labor and water are included in the model through fixed coefficients and their respective levels are derived from the level of land allocated to a particular crop. Sayaka et al., (2007a, 2007b) adapt Siam and Croppenstedt (2007) to model the impact of rice tariff policy as well as maize, cassava and soybean yield increases in Indonesia.[5]

The main features of selected multi-market exercises for agricultural policy impact are reported in table 1 (see end of document).

2.2 Implementation

Arulpragasam and Conway (2003) outline four steps involved in preparing a multi-market model:

1) Starting from the policy reform to be analyzed, the relevant markets to include in the analysis is determined. This is based on data examination and consultation with experts. The researcher also needs to consider at which geographic level, i.e. national, regional, sub-regional, the analysis is feasible and desirable. Finally what the appropriate level of disaggregation with regard to household types [for example poor, rich or landless, landowning] has to be decided. Also type and amount of data available will help determine the amount of detail that could feasibly be included in the multi-market model. The availability and accessibility of data are essential and this hurdle should be tackled first. Additional details, in the form of markets, household groups, time and/or regional disaggregation will add realism but will also add to the complexity of calibration, simulation and model validation.[6]

Analysis using the multi-market model can help quantify the gains from liberalization policies, as well as highlight potential problem areas, especially as new market patterns emerge and new markets evolve. The nature of multi-market models implies a very focused – on a particular market – research question. Reforms with important second round effects are best addressed with more comprehensive, economy wide, models. Arguably in countries with a very large agricultural sector the model may yield results that are then of wider significance and more easily identified as such. At any rate the inclusion of a labor module would be a pre-requisite to be able to derive results that address more general issues related to rural development.

2) The core of the demand side of the multi-market model is a matrix of own- and cross-price elasticities for a number of food and/or non-food commodity groups, and a vector of income elasticities of demand for the same commodity groups. These parameters measure how consumers change their consumption when there is a change in the price of any commodity, a change in income (or total consumption expenditure), or both. The most popular functional form to estimate price and income elasticities is the Deaton and Muellbauer's (1980) AIDS model. Sadoulet and de Janvry (1995) assert that "while consistent econometric estimation of the full producer core and of a complete demand system is desirable, it is evident that this is a large task, highly demanding in data and typically requiring two to three years of econometric analysis." Braverman, Ahn and Hammer (1983)

[5] Work on the Paraguay multi-market model is ongoing. The model is also based on Siam and Croppenstedt (2007). The studies for Egypt and Indonesia area available at: http://www.fao.org/es/esa/en/pubs_wp.htm.

[6] Siam and Croppenstedt (2007) calibrate their baseline data using interlinked excel sheets that may be useful to others, even if considerable adaptation will inevitably be required, in simplifying this kind of exercise. The excel file for this Egypt multi-market baseline is available from André Croppenstedt.

use two approaches to generate the demand systems: a) one using econometric estimates from survey data, and; b) one using only aggregate consumption values to calibrate the AIDS system. Typically multi-market models are written in log-linear form due to a lack of empirical knowledge of the full functional forms. This means that the model is useful only for local simulations around the initial equilibrium point (see Sadoulet and de Janvry (1995) for a detailed discussion of this important point). Income group specific CPIs are calculated which allow one to generate real income effects.

3) With regard to the supply side parameters fairly detailed data at the producer level is required to estimate a system of output supply and input demand functions which are derived from a profit function [typically Cobb-Douglas or translog]. For example Braverman and Hammer (1986) assume that production technology can be characterized by a translog restricted profit function with land assumed a fixed factor of production. Fertilizer, labor and other inputs are the variable inputs. The profit function yields the supply of output, demand for factors and the net return to the farm from land ownership. While land is considered fixed its allocation to the crops is determined by equating its marginal revenue product in each use. Fertilizer supply is assumed exogenous. They allow for four versions of the model, each with different assumptions concerning the labor market. These are: a) the rural wage rate is fixed, b) the rural wage is endogenous, but the rural population and labor supply is fixed, c) the rural wage and labor supply are endogenous but the rural population is fixed; d) all three variables are endogenous.

The more rigorous approach as followed for example by Quizón and Binswanger (1986) is to estimate all producer, consumer and factor market relationships to get elasticities. As an alternative to this rigorous approach one may pick "plausible" estimates (or best guesses) from other studies, as practiced by Braverman and Hammer (1986). This is obviously faster and more pragmatic but also arguably less precise. Sadoulet and de Janvry (1995) argue that the two approaches are mutually reinforcing. They find that the researcher could usefully begin with the more pragmatic approach and "once the model has thus been used for policy simulations, the analyst has a better feel for which are key parameters in the determination of the results and should be estimated econometrically (Sadoulet and de Janvry (1995, p. 323))."

The pragmatic approach has merit also because: a) local experts typically have well-founded prior beliefs about the likely range and sign of supply and demand elasticities – and estimates which are quite different may therefore be hard to sell; b) even with carefully derived estimates a model may generate unconvincing or counter-intuitive or just plain off the char results which then leads back to the pragmatic approach. Other issues/problems with regard to elasticity estimates are: a) solid econometric studies already exist but provide a relatively wide range of results, and; b) the results may, for example, be particularly sensitive to model closure conditions or the input demand elasticities.

4) Market closure conditions are imposed for each good. For non-tradable commodities the equilibrium condition is the equality between supply and demand. For tradables prices are given by the border price and net exports equilibrate supply and demand at the exogenous domestic price. The resulting model needs to be consistent with observed macroeconomic data, for a particular period of time. The data should also be representative and we note that Braverman and Hammer (1986) used a three year average to smooth out crop production fluctuations as rainfall in Senegal fluctuates strongly.

Whether commodities are modelled as tradable or non-tradable is also important. Changes in the productivity of tradable good will only affect external transactions. Increased productivity of a non-tradable commodity will tend to drive its price down, other things being

equal, as increased productivity also affects incomes, as well as the prices of other commodities that are substitutes/complements in production or consumption.

4) .Simulations of the impact of several alternative policies and events on food prices, real household incomes, income distribution, crop productions, and a number of other important economic variables can then be obtained by introducing the policy changes. Results may be sensitive to data quality and availability. It is important to understand how sensitive the full model simulations are to these types of error. Some idea as to the likely magnitude of these errors is needed. Sensitivity analysis is also appropriate with regard to the assumptions made concerning the institutions governing markets and market clearing. It is also normal to re-run the policy experiments with a variety of values for the assumed supply and demand parameters. Model validation is obviously key but also very difficult in practice. Finally, a further step that could greatly widen the information generated would be to combine the new prices and quantities with household survey data to estimate the impact on welfare of households at the household survey level and to possibly link the results to a wider range of household and community variables.

3 CONCLUSION

Like any model, the Multi-market model is intended to capture the most important effects of policy changes and/or external shock(s) on a given economy and households. It represents a simpler alternative to computable general equilibrium models, in constructing the model certain simplifications and categorizations must be made in order to keep the model tractable. More important, these simplifications are necessary to facilitate interpretation of the model structure, and the results generated from application of the model.

Multi-market models offer more accurate *ex ante* impact analysis than single-market models by including potentially important indirect effects. This comes at the price of considerably more complexity and greater data requirement which, however, are much lower than for full computable general equilibrium models. Their utility will depend on the judgement made by the researcher as to what is an acceptable trade-off between complete information on the consequences of policy and the need for simplicity in operational work. They are typically applied at the sector level and have proven quite popular in particular in agricultural policy reform impact analysis. In part this popularity is a reflection of a lack of data or the absence of a CGE. Having said this we don’t feel that a CGE can generate the detail that a multi-market model could be designed to capture and the latter are not simply a nested version of the former. While more recent work has emphasized the poverty reduction and income distribution objective the models can generate a range of information relevant to policy makers.

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Table 1 Selected examples of multi-market models for policy analysis.

Title Author/year	Country	Main features	Focus/ hypotheses to test	Policy impacts
Quizon and Binswanger (1986), "Modelling the impact of agricultural growth and government policy on income distribution in India."	India	Four agricultural outputs with endogenous quantities and prices (rice, wheat, other cereals and other agricultural products), two factors (labour, and animal traction) and one input (fertiliser). Eight representative households. Selected policy variables affect endogenous supply and demand of outputs and inputs.	a) Impacts of green revolution and public investment on welfare of different social groups; b) impacts of technological changes; c) impact of international trade liberalisation.	Technological improvements without export liberalisation favour both rural and urban poor, but negatively affect large farmers. With export liberalisation, urban poor are strongly worse off, due to high price increases.
Bravermann and Hammer (1986), "Multimarket Analysis of Agricultural Pricing Policies in Senegal."	Senegal	Five agricultural outputs with endogenous quantities and prices (peanuts, cotton, rice, millet, maize), two factors (labour, and land) and one input (fertiliser). Four regions. The model is linearised (only percent changes are explicitly modelled). Applicable only for local shifts around the benchmark.	Impacts of reduced public spending by means of cuts to subsidies to peanuts producers	Farmers partially shift productions from peanuts to cotton, whose exports are subsidised. Expected budget improvements occur only partially, due to offsetting increases of subsidies to cotton exports.
Dorosh and Del Ninno, (1995), "Poverty Alleviation in Mozambique: a Multi-Market Analysis of the Role of Food Aid."	Mozambique	Six agricultural commodities and one non agricultural commodity. Three household groups (urban poor, urban rich and rural). Three price/quantity equilibrium mechanisms: a) world-price-based domestic prices for non rationed traded goods - imports adjust to equal domestic demand; b) domestic equilibrium price/quantity for non-traded/exogenous import goods; c) Domestic equilibrium price for yellow maize, imported in fixed quantities and official price; rents (clearing-official price) accrue for importers/dealers. Demand elasticities estimated with AIDS system. Supply elasticities based on other countries. New price vector from the multi-market model is used with the household database for poverty impact analysis	Impact of increased imports and open market sales of yellow maize food aid on poverty and food security of urban and rural households.	Increased imports of yellow maize reduce its domestic price, greatly increasing the real income and calories intake of urban poor. Indicators of urban poverty and food security improve significantly. Increased imports of yellow maize hamper rural incomes only marginally, thanks to low cross price elasticity of demand of yellow maize with local staples (e.g. while maize).
Minot and Goletti, (2000), "Rice Market Liberalization and Poverty in Viet Nam."	Vietnam	Five agricultural outputs with endogenous quantities and prices: Rice, maize, sweet potatoes, cassava. Seven regions are considered to analyse policy impacts according to specific regional specialisation. Supply is modelled with double log functions and demand with a linear approximation of the «Almost Ideal Demand System»	Impacts of rice market liberalisation on small farmers income and food security.	A progressive liberalisation of the rice market should be implemented replacing export quotas with export taxes. Increased budget revenue should enable to support small producers and poor consumers.

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