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# Modelling Agricultural Trade and Policy Impacts in Less Developed Countries

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# MODELLING AGRICULTURAL TRADE AND POLICY IMPACTS IN LESS DEVELOPED COUNTRIES[1]

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## Introduction

The role of agricultural policies in addressing the development needs of poorer countries is high on the political agenda, for both structural reasons and as a result of recent market developments. In the first place, there is a growing consensus that agriculture has been neglected in national development strategies, and that there is a need for greater investment in the sector, both to achieve immediate poverty reduction and to stimulate broader pro-poor economic development. This is a core message of the World Bank's latest *World Development Report* (World Bank, 2008). In the case of Africa, members of the African Union committed in 2003 to allocate at least 10% of their national budgets to agriculture and rural development, while more recently the G8 pledged to provide EUR 1 billion of support for investment in African agriculture. As agricultural development receives greater priority, there is a need to clarify the supporting role that agricultural policies should play.

More recently, higher international food prices have added to the need for clarity over the appropriate role for agricultural policies in low-income countries. Higher import prices have potentially disastrous consequences for poor consumers and for farmers with a net deficit in food production. Yet policy debate has traditionally focused on how to address the challenges imposed by *low* prices, and whether or not poor farmers need protection and support. As the constituency of concern has changed, the impossibility of using price policies to address pervasive poverty among both producers and consumers has been exposed. The latest effort to achieve a WTO agreement foundered on the issue of what agricultural policies are suitable for developing countries, with some poorer countries, notably India, arguing that they need the maximum amount of "policy space" to raise import tariffs on agricultural products and protect farmers' livelihoods. Ironically, higher prices mean that the currently available policy space is neither needed nor being used.

This paper presents preliminary work looking into the question of what policy instruments are appropriate in developing countries. It focuses on one particular aspect of that issue: the development of a methodological framework for examining the distributional effects of alternative agricultural policies, including price supports and associated border measures, input subsidies of various kinds (*e.g.* for credit and fertiliser), and direct payments. The aim is to develop a methodological framework that can be used to assess how policy interventions, and shocks such as high prices, will affect incomes throughout society. The starting point of this analysis is the recognition that the impact of a policy on a given household will depend on how that household earns and spends its money. By distinguishing structurally distinct types of household, and seeing how those household types are reflected in the composition of economic activity in

1. This paper was originally prepared for the 2008 OECD Global Forum on Agriculture, held on 20-21 November 2008 in Paris. The authors are grateful for comments received at that meeting and for earlier comments from OECD colleagues.

different countries, it is possible to examine how the distributional impacts of a given policy will differ from one country to the next. The proposed framework also accounts for the impacts of policy changes once household level responses, and their consequent market impacts, are taken into account.

Assessing the economic welfare and distributional impacts of alternative policies is a necessary first step towards a broader evaluation of the arguments for and against the use of different agricultural policy instruments in developing countries. Such an evaluation needs to consider the role of agriculture-specific policies in overcoming market failures, and how such policies complement – or fail to complement – public investments. It also needs to take account of a wider range of factors including the technical feasibility of implementing alternative policies, the availability or otherwise of budgetary resources for taxpayer as opposed to consumer financed policies; administration costs; and the possibility of "government failure," rent seeking and political capture. The broader dynamic role that agricultural policies may play in promoting economic development also needs to be considered.

In 2009-10, OECD will be undertaking a broader analysis that will attempt to assess the full range of costs and benefits to poorer countries from using different agricultural policy instruments. The balance, and the optimal policy set, will in many cases depend on the structure of the economy. This paper represents a first attempt to consider how the welfare and distributional impacts of policies may vary from one country to the next, which is one component of the envisaged project. The broader questions governing the appropriate choice of policy instrument (such as growth linkages) will require the use of other tools and analytical approaches. The ultimate aim is to draw differentiated policy conclusions.

The structure of the paper is as follows. Section 2 provides some background on existing OECD work, which has considered the welfare and distributional effects of agricultural policies in OECD countries and given some illustrative consideration to how those impacts are likely to differ in developing countries. Section 3 considers alternative modelling structures that can be used to quantify these effects in poorer developing countries. Section 4 provides an example of a stylised model that can be used to capture a number of important structural features of developing country agriculture, while Section 5 makes some concluding suggestions for next steps.

**Background on previous OECD work**

OECD has undertaken a range of quantitative studies that examine the effectiveness of alternative agricultural policies in attaining their objectives. Although the majority of these analyses have focused on reaching policy recommendations for OECD countries, a number of the findings are not dependent on a country's level of development and are relevant for both developed and developing countries, while some of the methods can be harnessed to look at developing country issues.

An objective of agricultural policies in many OECD countries is to protect the incomes of farm households. In order to shed light on the effectiveness of alternative policy instruments in achieving this objective, the OECD has used its Policy Evaluation Model (PEM) to examine the "transfer efficiency" of farm support policies in OECD countries, *i.e.* the effectiveness of alternative forms of support in raising the incomes of farm households relative to the cost to consumers and taxpayers. A general finding of this analysis is that when markets function smoothly, policies that interfere with the functioning of those markets, such as price supports and input subsidies, perform poorly in terms of raising the incomes of farm households (OECD, 2001; OECD, 2003a). A further finding of OECD work is that such measures also often have perverse distributional effects, paying more to larger and richer farmers than to smaller and poorer ones, and taking money away from consumers and taxpayers to boost the incomes of households whose incomes are already above average (OECD, 2003a).

A collection of case studies was used to examine the effects of agricultural and trade reforms in several countries at different stages of development, tracking down the effects of reforms from the global to the domestic market and then the household level (OECD, 2006a). In the context of developing countries, this collection of studies had two main findings. The first was that market interventions often produce ambiguous effects on the distribution of income, and in poor countries it typically is impossible to use a price intervention to make some poor households better off without making other poor households worse off. This trade-off is evident from the recent increase in world food prices, which hurts the urban poor and net food buyers in rural areas, but may benefit some poor farmers who receive increased returns or have an increased incentive to engage with markets. A second finding was of a more conceptual nature: that it is not possible to model all the effects of potential interest, and that in modelling potentially important effects there is a danger of abstracting away from others. Accordingly, the synthesis of these case studies emphasised that the interactions that are of greatest importance will vary from one country to another and that a flexible modelling approach is more appropriate than a one-size-fits-all structure.

This paper seeks to build on the insights that have come from the PEM model and the modelling approaches that were employed in those country case studies. The aim is to propose a general framework for examining the welfare and distributional effects of alternative agricultural policies. The main premise is that while the PEM provides a useful starting point for considering the impacts of reform in developing countries, the results for OECD countries do not carry over automatically because (a) structural data, such as factor ownership shares, and parameters, such as supply elasticities, may be fundamentally different; and (b) some of the underlying assumptions relating to the smooth functioning of markets may not hold. Instead, it is argued that what is needed is an approach that takes the household as the basic unit of analysis and accommodates the fact that households may not be seamlessly engaged with perfectly functioning markets for outputs and factor inputs. A modelling structure is proposed that builds on the strengths of the PEM in capturing product and factor market interactions, as well as the advantages of household models in depicting household level impacts and responses.

**Modelling the welfare impacts of alternative policy instruments**

The welfare effects of agricultural policy shocks are complex, involving numerous and interrelated behavioural adjustments within the economy. No single model can capture all of these effects, but some models are better at describing specific effects than others. Recognising this, researchers have to select what to focus on, for example, the aggregate impact of trade reforms on prices and output, the distributional impact between urban and rural households, or the effects on specific rural household groups or on poverty. Trade-offs are inevitable. For example, if the farm and household level impacts are well described, this may be at the expense of ignoring important economy-wide effects. Conversely, a good accounting for inter-sectoral linkages may mean missing out on some of the specifics of household behaviour (*e.g.*, supply response by small commercial and semi-subsistence households). The limit of modelling complexity is micro economy-wide modelling, in which individual households or groups of similar households are embedded within a general equilibrium model of the entire rural (Taylor, Dyer and Yúnez-Naude, 2005) or national economy. Even here, some sacrifices typically need to be made because of data limitations or to avoid excessive modelling complexity. For example, to date no micro economy-wide model has been estimated that is dynamic or that explicitly incorporates risk and uncertainty.

Given that no model can capture all the effects of potential interest, the challenge is to propose a flexible structure that can capture the interactions between households and product and factor markets, and that can accommodate selected market failures and transactions costs that may be important in altering the behavioural responses of particular household groups and, as a result, the aggregate impacts of policy changes. In light of these challenges, the goal of this research is to propose a structure that explicitly models the interactions between households and product and factor markets, and that can accommodate selected market failures and transactions costs that may be important in altering the behavioural responses

of particular household groups and, as a result, the aggregate impacts of policy changes. The approach we propose makes an effort to capture key interactions within the rural economy, but leaves aside full economy-wide impacts for the time being.

### *The Policy Evaluation Model (PEM)*

The starting point for such a model development is the PEM, a partial equilibrium model of the agricultural sector developed at the Organisation for Economic Co-operation and Development (OECD, 2001), which has been used to model transfer efficiency and welfare impacts in a number of OECD countries, as well as other issues, such as production responses to policy changes and the impact of risk on farmers' decisions.[2] The PEM is a market model, where output and factor markets are linked, and distributional effects are determined by the impacts that policies have on factor incomes and by households' command over those incomes. Some salient features of the model are noted in Box 1. For a full exposition, the reader is referred to OECD (2001) and OECD (2003b).

**Box 1. Characteristics of the PEM**

In the PEM, supplies of agricultural commodities are represented by aggregate production functions, in which factors (land, labour, capital) and other intermediate inputs combine to produce output. Supply can be seen as originating from a single producer for each agricultural commodity, or equivalently, many identical ones. Similarly, the demand for agricultural goods is aggregate, represented by a single demand function for each good (either a single consumer or many identical ones). In equilibrium, supply must equal demand to clear all markets. If prices are determined in world markets, net exports fill the gap. Otherwise, domestic prices adjust to ensure that the supply-demand equilibrium is achieved. Similar equilibrium conditions apply to the supply and demand of factors, whose equilibrium prices are determined within the economy.

Agricultural producers are price takers who, given their technologies, select the levels of output and derived input demands that maximise profits. This implies producing where the marginal cost just equals the market price of output, and the marginal value product of each input equals the per unit price. Demand is the sum of all consumer demands and intermediate input demands for agricultural output inside (and outside) the economy. In the PEM, it is represented as a single demand equation for each commodity. If, at a given price, the supply of an agricultural commodity exceeds the demand, either the price will fall (provoking an adjustment in farmers' production decisions) or the surplus will be exported onto the world market, at the given world price. The converse applies for the case where the demand exceeds the supply.

In this adjustment process, all related markets are affected. For example, a decrease in agricultural price will trigger a reduction not only in output but also in the demand for labour, land, and other inputs. Each of these input markets, in turn, will adjust, and their equilibrium quantities and prices will change. In this way, changes in agricultural prices create repercussions in other parts of the agricultural economy. The PEM was designed to pick up the aggregate effects within the agricultural sector. A Computable General Equilibrium (CGE) model would take this one step further, by effectively nesting the PEM within a model of the rest of the national economy, capturing rural-urban linkages and other economy-wide effects.

In order for the market for a good to be well defined and depicted by a single aggregate supply and demand function, the good as well as those producing and consuming it must be relatively homogeneous. The PEM assumes that each agricultural good is homogeneous, as are all inputs with the exception of land. Land is assumed to be heterogeneous but can be transferred (imperfectly) from one use to another. In practice, the farmer (or many identical farmers) in the model can allocate and reallocate land across different uses, including wheat, coarse grains, oilseeds, rice, other arable uses, milk pasture, beef pasture and other agricultural uses.

The possibilities for transforming land from one use to another are represented by elasticities of transformation. The possibilities are bracketed by two extremes. It is possible that a given hectare of land (say, in rice) cannot be converted to a different use (say, oilseeds). In this case, the elasticity of transforming land from rice to oilseeds is zero. At the other extreme, it is conceivable that a farmer could easily shift a given hectare of land from corn to sorghum — that is, that land is readily transferable between these commodities. In this case, the elasticity of transformation would

2. The PEM builds upon a tradition of partial equilibrium models of the farm sector, including Gardner (1987), Atwood and Helmers (1998), Gunter, *et al.*, (1996), and Hertel (1989).

be large. There is a wide range of possible elasticities in between these two extremes.

The elasticity of transformation of land from one activity to another is extremely important for policy analysis, because it is a key to farmers' ability to adjust to price shocks. The developers of the PEM made an effort to obtain the most realistic estimates available of aggregate elasticities of transformation for land, drawing from studies by experts in each of the six OECD countries for which the PEM was developed (Canada, the European Union, Japan, Mexico, Switzerland and the United States). Factor shares required to calibrate the constant elasticity of transformation (CET) functions used in the model were also obtained from expert studies, along with price elasticities of factor supplies and commodity demands.

This way of modelling land allocations is a major strength of the PEM. It avoids making the unrealistic assumption that land is perfectly transferable across activities or that land is fixed within activities. Its reliability obviously depends on the extent to which the elasticities used in the model approximate the true substitutability of land across production activities.

In contrast to land, capital (cows and other farm-owned) is assumed to be perfectly substitutable across crop activities but not substitutable between beef and dairy production and other activities. Purchased factors, including labour, are generally assumed to be perfectly substitutable across activities. The exceptions are concentrate feed, which is used only in livestock activities, and chemicals and irrigation, which are not used for livestock.

The PEM has been used to examine the market effects of crop support measures in six OECD countries, and trace out the distribution of welfare effects among farm owners, consumers, taxpayers and input suppliers. A key finding of this analysis is that measures which distort farmers' production decisions are ineffective at delivering additional income to the farm household, as a significant share of the gross transfer leaks to input suppliers or leads to deadweight efficiency losses.[3] Thus, a dollar of market price support raises the incomes of farm households – *i.e.* the owners of farm assets – by less than half a dollar (the total of 0.47 includes increased returns to land and to other farm owned factors), while input subsidies increase farm households' incomes by just one third of a dollar (Table 1). By contrast, payments which distort markets less, such as area payments and, even more so, payments based on historical entitlements, are considerably more effective at raising farm based incomes. That said, no form of payment linked to farming in any way provides the gain in net income that would result from a fully decoupled income payment.

**Table 1. Distribution of economic effects of support measures**

| | *Gain or loss per dollar of taxpayer and consumer costs for:* | | | | | |
|---|---|---|---|---|---|---|
| ***Caused by a simulated 5% increase in:*** | **Taxpayers** | **Consumers** | **Farm households** | | **Input suppliers** | **Deadweight loss** |
| | | | *land* | *other farm owned* | | |
| **Market price support:** | | | | | | |
| Main crop | -0.42 | -0.58 | 0.28 | 0.19 | 0.19 | -0.34 |
| All crops | -0.28 | -0.72 | 0.34 | 0.16 | 0.23 | -0.27 |
| ***Payments based on:*** | | | | | | |
| Variable input use | -1.17 | 0.17 | 0.24 | 0.09 | 0.31 | -0.36 |
| Output of main crop | -1.22 | 0.22 | 0.40 | 0.17 | 0.18 | -0.26 |
| Output of all crops | -1.12 | 0.12 | 0.45 | 0.15 | 0.18 | -0.21 |
| Plantings of main crops | -1.04 | 0.04 | 0.84 | 0.03 | 0.02 | -0.11 |
| Plantings of all crops | -1.02 | 0.02 | 0.86 | 0.02 | 0.02 | -0.09 |
| Historical entitlements | -1.01 | 0.01 | 0.95 | 0.01 | 0.01 | -0.03 |

*Source:* OECD (2001).

3. The deadweight losses reported here are the consequence of domestic resource allocation effects and, in the case of exporting countries, include transfers to overseas consumers via lower world prices.

An important point to note about these results is that the returns to specific farm households depend on whether they own the land they operate, or whether they rent it. If farmers rent land, then the increased returns to land are passed on to non-operator landlords. In many OECD countries, a significant share of land is rented, meaning that a further share of the benefits of support leak to non-operator landlords (Table 2). On average across the OECD area, this means that, in the case of market price support and input subsidies, no more than a quarter of a dollar of consumer and taxpayer support accrues as additional income to the farm household, a finding confirmed in another OECD study (OECD, 2003a).

**Table 2. Share of farmed land owned by the farmer**

| | 1990 | 1993 | 1995 | 1997 | 2000 |
|---|---|---|---|---|---|
| | | | *percentage* | | |
| Belgium | 33.0 | 32.8 | 32.3 | 31.9 | |
| Denmark | 80.9 | 78.9 | 77.5 | 75.1 | 74.8 |
| Germany | 43.3 | 39.9 | 38.1 | 37.0 | |
| Greece | 76.4 | 75.2 | 73.7 | 73.8 | |
| Spain | 72.3 | 72.7 | 72.3 | 72.3 | |
| France | 43.3 | 39.3 | 36.8 | 34.9 | |
| Ireland | 87.6 | 88.1 | 87.6 | 86.7 | |
| Italy | 80.9 | 77.8 | 78.1 | 78.1 | |
| Luxembourg | 50.4 | 47.6 | 47.1 | 46.5 | 46.1 |
| The Netherlands | 66.9 | 64.6 | 69.7 | 71.7 | |
| Austria | | | 78.0 | 77.2 | |
| Portugal | 69.0 | 69.6 | 69.6 | 69.6 | |
| Finland | | | 77.9 | 80.2 | |
| Sweden | | | 54.8 | 54.4 | |
| United Kingdom | 61.6 | 61.9 | 63.7 | 65.2 | |
| EU15 | | | 59.4 | 59.0 | |
| United States | 58.0 | | | 61.4 | |
| Canada | | | | | 82.1 |

*Notes:*

**EU**: total agricultural area (AA) is split between three categories: AA owner farmed + AA tenant farmed + AA share farmed or in other modes of tenure. **USA**: Total land operated defined as owned land plus land rented or leased from others (including AUM land) less land rented out. **Canada:** Area owned in percentage of total area of farms

*Source:*

**EU** (region and countries): EUROSTAT, Structure of agricultural holdings. **USA:** Farm Costs and Returns Survey. (USDA) in Farm Operating and Financial Characteristics, 1990 and 1997 Census of Agriculture, USDA. **Canada:** Statistics Canada, Statistical profile highlights, 1998.

*Source:* OECD (2003a).

From the standpoint of this paper, the critical question to be asked is: To what extent do these results, and their attendant policy implications, carry over to developing countries? There are three reasons why they might not and why the PEM might need to be adapted: (i) because the underlying data differ (in particular, the ownership of factors); (ii) because the parameters of the model differ; and (iii) because the assumptions of the model are not reasonable. We explore these issues in turn.

*Structural differences*

The first point to note is that, with the standard PEM, the impacts of a given policy on farm household incomes are derived from the supply side, *i.e.* by allocating to households the returns to the factors that they supply to the production of food and other commodities. In developing countries, however, farm

households are often both producers and consumers of food. Table 3 reports the percentage of total agricultural production sold for each household landholding quintile in the 15 countries covered by the FAO's RIGA dataset, which was constructed from a pool of several dozen LSMS and other multi-purpose household surveys in a joint project between the World Bank and FAO. The averages for all agricultural households ranged from 30% of production marketed (Nigeria) to 61% (Vietnam). Low marketed-surplus shares are not surprising for small farms. What is perhaps more striking is that, even for the largest landholding quintile in each country, the shares ranged from 30% to 71%. In most developed OECD countries, the share of production consumed on the farm is negligible and thus can be ignored, as in the PEM.

When the household is a producer and consumer of food, the transfer efficiency of farm support will depend on what happens on both the supply side and the demand side. In many developing countries, an important share of farm households are net buyers of food, so raising farm prices would actually have a negative transfer efficiency for this group (although some households that lose from higher prices in the short term may ultimately gain if those higher prices provide enough incentive for them to become net sellers). The dual role of farmers as producers and consumers has implications for welfare analysis using the PEM, as supply and demand effects would need to be allocated across households. It also has deeper implications for the appropriate modelling structure – a point taken up below.

**Table 3. Farmers' market participation in the 15 RIGA countries***

| Region/country and survey year | % of **each land quintile's total production that is sold** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** | **Total** |
| Africa | | | | | | | |
| Ghana 1998 | 31 | 36 | 36 | 32 | 33 | 39 | 33 |
| Madagascar 1993 | 59 | 56 | 57 | 56 | 55 | 54 | 56 |
| Malawi 2004 | 48 | 43 | 45 | 47 | 49 | 49 | 47 |
| Nigeria 2004 | 35 | 30 | 29 | 28 | 28 | 30 | 30 |
| Asia | | | | | | | |
| Bangladesh 2000 | 62 | 47 | 48 | 47 | 49 | 52 | 54 |
| Indonesia 2000 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Nepal 1996 | 54 | 43 | 44 | 44 | 49 | 51 | 48 |
| Pakistan 2001 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Vietnam 1998 | 60 | 56 | 57 | 59 | 64 | 71 | 61 |
| Eastern Europe | | | | | | | |
| Albania 2005 | 41 | 41 | 42 | 48 | 47 | 53 | 48 |
| Bulgaria 2001 | 61 | 47 | 45 | 47 | 48 | 53 | 50 |
| Latin America | | | | | | | |
| Ecuador 1995 | 56 | 49 | 36 | 40 | 42 | 51 | 46 |
| Guatemala 2000 | 44 | 43 | 39 | 42 | 47 | 50 | 44 |
| Nicaragua 2001 | 49 | 49 | 49 | 46 | 47 | 50 | 49 |
| Panama 2003 | 30 | 24 | 27 | 31 | 38 | 56 | 34 |

*Source:* Zezza *et al.* (2007).

In terms of factor ownership, the structural conditions under which developing country agriculture operates can be fundamentally different from those in high income OECD countries. Analysis of the RIGA datasets shows that the share of land owned by farm households can vary at least as much in poorer countries as in rich ones. Landlessness is most prevalent in Latin America and Africa, varying from 40% to more than 60% of rural households (Table 4). However, these numbers may mask collective forms of land

access. In terms of PEM calculations, this would imply a further dilution of the net income benefits of coupled support, such as price support and input subsidies.

**Table 4. Percentage of rural households owning land, by expenditure quintiles**

| | Percentage of land-owning households Expenditure quintiles | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **All** |
| ***Africa*** | | | | | | |
| Ghana 1998 | 30.9 | 32.4 | 38.5 | 37.8 | 33.6 | 34.6 |
| Madagascar 1993 | 73.7 | 80.9 | 75.2 | 72.9 | 69.8 | 74.5 |
| Malawi 2004 | 94.7 | 94.9 | 93.4 | 91.6 | 82.4 | 91.4 |
| Nigeria 2004 | 78.7 | 73.3 | 68.5 | 62.0 | 55.2 | 67.5 |
| ***Asia*** | | | | | | |
| Bangladesh 2000 | 32.7 | 40.7 | 52.5 | 55.9 | 63.6 | 49.1 |
| Indonesia 2000 | 44.3 | 48.7 | 43.5 | 40.4 | 37.4 | 42.8 |
| Nepal 1996 | 76.0 | 79.8 | 79.9 | 79.1 | 81.2 | 79.2 |
| Pakistan 2001 | 20.2 | 28.0 | 35.1 | 38.0 | 42.4 | 32.7 |
| Vietnam 1998 | 91.8 | 93.3 | 90.7 | 90.8 | 84.5 | 90.2 |
| ***Eastern Europe*** | | | | | | |
| Albania 2005 | 91.5 | 91.9 | 95.8 | 95.0 | 95.4 | 93.9 |
| Bulgaria 2001 | 34.1 | 61.7 | 76.1 | 78.9 | 75.4 | 65.2 |
| ***Latin America*** | | | | | | |
| Ecuador 1995 | 63.5 | 62.5 | 55.2 | 55.2 | 53.3 | 58.0 |
| Guatemala 2000 | 62.7 | 59.9 | 53.4 | 44.8 | 38.0 | 51.8 |
| Nicaragua 2001 | 45.8 | 44.1 | 45.4 | 40.4 | 33.7 | 41.9 |
| Panama 2003 | 68.8 | 54.1 | 49.4 | 45.2 | 36.8 | 50.9 |

*Source:* Zezza *et al.* (2007).

Not owning land may not equate to renting, because there is a variety of ways in which farmers may obtain access to land for production. Households with uncertain land rights may or may not face increased land rents. Similarly, some poor farmers may not have the cash to purchase inputs, meaning that a potential leakage of coupled support is avoided, and the transfer efficiency of support would be higher. As with the farmer's status as buyer and seller, such differences imply that the PEM model may not be most appropriate for analysing impacts in developing countries.

*Parameter differences*

A second reason why the PEM results for OECD countries may not carry over is that the elasticity parameters may be substantially different. The PEM results depend on various elasticities of substitution: between land and other farm owned inputs (capital and labour), between land and purchased inputs, between farm owned inputs and purchased inputs (fertiliser and energy) and among purchased inputs. They also depend on the elasticities of factor supplies.

In general, one would expect these elasticities to be lower in less developed economies. But this could either raise or lower transfer efficiency. For example, a low supply response for purchased inputs could mean a greater share of gross transfers accruing as rent to input providers. On the other hand, a relatively inelastic supply of farm-owned factors (land or other) could result in a greater share of the benefits of support reaching the farm household. The only way to know whether the benefits to farm households of a given policy in a particular developing country are higher or lower than the six-country PEM average would be to parameterise the PEM model appropriately.

*Suitability of the PEM model structure*

The final reason why the PEM might not provide robust estimates of the impacts of agricultural policies in developing countries is that the underlying assumptions may not be appropriate. This is because the PEM corresponds to a world in which markets operate smoothly and farmers operate as commercial profit-maximising producers with uniform technologies. In developing countries, most agricultural producers function as households, making simultaneous decisions on production, consumption and labour allocation. They are heterogeneous in terms of their resource endowments, technologies, access to markets, and other key variables likely to shape policy outcomes. When most agricultural producers behave as households rather than commercial businesses, estimates of market supply and demand that assume the traditional dichotomy of firms and consumers may be biased and misleading.

Market access is critical in shaping agricultural households' behaviour. As long as perfect markets for all goods, including labour, exist, the household is indifferent between consuming own-produced and market-purchased goods. By consuming all or part of its own output, which could alternatively be sold at a given market price, the household implicitly purchases goods from itself. By demanding leisure or allocating its time to household production activities, it implicitly buys time, valued at the market wage, from itself. Under these circumstances, the household effectively behaves as a profit maximising firm, and the PEM representation of market interactions might be reasonable as long as all agricultural households' production and consumption are taken into account. In practice, however, production and consumption decisions are inter-related, because market prices do not correspond to the household's opportunity costs, for example, because of the high costs of getting goods to market or the imperfect substitutability of hired labour for family labour on the farm. A range of constraints on agricultural behaviour in developing countries may also need to be considered. These include a lack of access to credit and insurance, and transaction costs associated with selling output and purchasing inputs.

***The farm household model***

What is therefore needed is a modelling framework that can accommodate these specific aspects of developing country agriculture. The standard structure for modelling developing country farming at the micro level is the farm household model. The origins and characteristics of the farm household model are summarised in Box 2.

The recognition of the household's joint role as a producer and consumer of food is not important when modelling the impacts of policies on production, provided that the markets for output and household labour function seamlessly. Under these circumstances, production and consumption decisions are in effect separable. The household takes market prices and chooses the output level (and implied allocations of land and other inputs) that maximise profits and hence income. However, consumption does depend on production. Profits are part of the household's full income, and demand decisions are made to maximise utility subject to this constraint. The same policy may affect a farm household positively as a producer yet negatively as a consumer. This means that even when markets work well, recognising the household's joint role as producer and consumer is important when studying the welfare effects of policy changes.

**Box 2. Agricultural household models**

In its dual role as producer and consumer, the household makes production, labour allocation and consumption decisions that may be interdependent upon one another. In its most general conceivable form, the household's objective is to maximise a discounted future stream of expected utility from a list of consumption goods including home-produced goods, purchased goods, and leisure, subject to what may be a large set of constraints. In practice, research focus, analytical tractability, and available data result in significant simplifications of both the objective function and the constraints. Most agricultural household models are static and assume that prospects are certain or, equivalently, that households are risk neutral.[1] Constraints typically include cash income, family time and endowments of fixed productive assets, and production technologies (all of which may be combined into a single "full-income" constraint if markets function smoothly; see Singh, Squire and Strauss, 1986), and prices of inputs, outputs, and non-produced consumption goods. Price-related constraints either fix prices exogenously (the case of household tradables with perfect markets) or, in the case of missing markets, determine an internal "shadow price," at which the household's demand for a good equals its output (the case of household non-tradables with missing markets; Strauss, 1986; de Janvry, Fafchamps and Sadoulet, 1991).

The solution to a household-farm model yields a set of core equations for outputs, input demands, consumption demands, and either prices (for household non-tradables) or marketed surplus (for household tradables). In the case of produced goods, marketed surplus is output minus household consumption. In the case of labour, it is the household's labour demand minus its labour supply, or net wage-labour supply. The solution to the household-farm model represents all dependent or endogenous variables as functions of exogenous variables (prices of tradables, farm assets, household time constraint, other household characteristics), usually including some that may be influenced by policy (*e.g.*, market price supports). The form of this solution, particularly the interactions between production and consumption that are a trademark of household-farm models, are extremely sensitive to assumptions about the extent to which households are integrated into product and factor markets.

***Comparative Statics in an Agricultural Household Model***

A key motivation for developing agricultural household models has been to analyse agricultural policies in a less-developed country context. Like with the PEM, such analysis is based on comparative statics with parameterised models. Ideally, the parameters are estimated econometrically using household-farm survey data.

Analytically, agricultural household models resolve the apparent paradox of a positive own-price elasticity of demand for food in farm households, as well as the puzzle of sluggish marketed-surplus responses to food-price changes in less-developed countries. Empirical models, using micro-survey data, have made it possible to estimate the magnitude of supply and marketed-surplus elasticities in a number of different country settings, while confirming quantitatively the importance of using household-farm, rather than simply "household" or "farm," models to analyse rural economies.

We can illustrate comparative statics in a basic household-farm model as follows: Consider an increase in the (market or policy-determined) price of staples. The immediate effect of the price increase is to raise the marginal product of all inputs, including labour. The standard profit-maximizing rules that apply to the firm also apply to the household as producer: both hire inputs at the point where the marginal value product of the input equals the input price. Thus, the higher marginal value product of labour results in increased labour demand for staple production. In a household that uses its labour both to produce on the family farm and to sell on the labour market, an immediate effect of the staple-price increase is to allocate more labour to on-farm production and less to wage work, because the opportunity cost of labour on the farm has gone up. Alternatively (and, in the basic model, equivalently), it may continue to supply labour to the market while hiring workers needed to expand staple production and maximise profits. In any case, the on-farm production effect for the crop whose price has increased is unambiguously positive, given the usual assumptions of production economics.

As a consumer, the household now faces a higher staple price; however, it also experiences an increase in its income due to higher profits from farm production, leading to a positive income effect competing with the negative Stutsky effects outlined above. The effect on household consumption of the crop whose price has risen becomes ambiguous; it depends on the slope of the household's utility function as well as the magnitude of the profit effect. In the case of a staple-price increase and perfect hired-labour market, there is no ambiguity on the labour side: the opportunity cost of leisure remains the same, equal to the market wage; the initial increase in the marginal value product of labour on the farm, due to the staple price change, is erased by the increased demand for labour on the farm (due to the assumptions of a fixed wage plus decreasing marginal physical product of labour); and the increase in income, due to higher profit from staple production, unambiguously increases leisure demand (reducing family labour supply), assuming that leisure is a normal good.

(*continued*)

The structure of markets in which the household is embedded is critical in shaping the response to exogenous policy and other shocks. A key assumption of most agricultural household models is that the household can obtain perfect substitutes for family labour in local labour markets — and conversely, that it can sell its own labour at a given market wage. This permits the household to decouple production from leisure: in response to a policy or market change, it can increase production (and demand more labour) while at the same time consuming more leisure, by hiring workers to fill the resulting excess demand for labour.

Estimated household-farm models have been used to analyse a multitude of policy issues relating to agricultural development. The early uses were concerned primarily with farm price policy. The level at which agricultural terms of trade are set has wide implications for both efficiency and equity. Geographically diverse econometric studies (Kuroda and Yotopoulos (1978) in Japan; Lau, Yotopoulos, Chou and Lin (1978) in Taiwan; Ahn, Singh and Squire (1981) in Korea; Hazell and Roell (1983) in Malaysia and Nigeria; Strauss (1984) in Sierra Leone; Adulavidhaya, Kuroda, Lau and Yotopoulos (1984) in Thailand) demonstrate that, as expected from neoclassical models, an increase in the price of a crop increases production of that crop (the own-price supply elasticity is positive). However, they also reveal positive consumption effects through farm profits. In four out of seven studies reviewed by Singh, Squire and Strauss (1986), the consumption effect was large enough to significantly dampen the increase in marketed surplus of the crop whose price rose. This may negatively affect urban consumers, agro-industry processors and exporters.

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1. Exceptions include applied theoretical analyses by Israel Finkelshtain and James A. Chalfant (1991) on consumption risk and the dynamic three-period model in Wallace E. Huffman (2001).

In developing countries, the sequential representation of first production then consumption decisions may not be appropriate, and a farm household model may be needed to accommodate the simultaneous nature of production, consumption and labour allocation decisions. There are several possible reasons for this simultaneity, including:

- **Imperfect access to credit**. Without credit access, the household must finance its production costs out of its own income. A lack of liquidity can easily constrain a small farmer from producing at the optimal level. A result is that income affects production, in addition to the other way around.

- **Imperfect access to output markets**. If transaction costs are high, the household will not be able to obtain the market price for its output, and it may have to produce in order to satisfy its subsistence demand for food. In this case, production is influenced by the household's income and consumption demands, along with other variables.

- **Imperfect access to labour markets**. If households cannot hire labour, or if hired labour is an imperfect substitute for family labour (*e.g.*, because of high monitoring costs), the household must supply its own agricultural labour. In this case, production can be limited by the availability of family labour. Family members' own reservation or "shadow" wages determine how much labour the household will use and, consequently, its level of agricultural production. The household can increase production only by shifting time from other income activities or from leisure (the demand for which is influenced by income).

- **Imperfect land markets**. In many countries, land-market imperfections and institutional constraints (*e.g.*, communal lands) prevent the emergence of efficient structures, and thus producers' scope for maximising incomes by renting land from others, or renting land to farmers who could use it more productively. This can significantly affect the responsiveness of land use to policy changes. If there is no land market, then changes in land use can only occur on individual farms, subject to each farm's land endowment. In the long run, a lack of secure land rights also can create disincentives for productivity-enhancing investments and soil conservation.

Are the differences between agricultural sectors in developed and less-developed countries sufficiently great to justify the use of the farm household model? There are several reasons to think so:

*The dual role of households as producers and consumers*

Agricultural household models capture and important implication of the household's dual role as producer and consumer when assessing the impacts of market-price shocks. Higher prices stimulate production. They also raise the opportunity cost of consuming home-produced food. In combination, these effects tend to increase the marketed surplus, or supply of food to the market. However, farm profits also increase when food prices rise. This raises commercial agricultural households' incomes, and potentially their demand for food. Thus, price changes have conflicting effects on consumption. In 4 out of 7 country studies summarised by Singh, Squire and Strauss (1985), an increase in food prices increased food demand in agricultural households. Higher on-farm consumption can significantly dampen (and possibly even reverse) a positive effect of a price increase on the supply of food to the market. The PEM, in its current form, would overstate the true aggregate supply response to price changes.

*The heterogeneity of agricultural households*

A single model that treats all producers as homogeneous – be that the PEM or a single agricultural household model – is unlikely to depict adequately the complexity of structures in developing countries. A comprehensive model of the agricultural sector in less-developed countries must consider the behaviour of multiple agents, including: (1) the net-surplus producing family farm, typical of small owner-operated farms of medium productivity; (2) the subsistence and sub-subsistence household farm, typical of small-scale, low productivity agriculture, frequently operating under marginal conditions and incomplete markets; (3) small-scale renter and sharecropper farms (under which a landowner allows a tenant to use the land in return for a share of the crop produced on the land); and (4) the owner-operated commercial farms producing food for both domestic consumption and agro-industry and export markets, who behave more like pure firms than households. These cases describe the farming systems in which most of the rural population in the developing world is engaged.

A useful way to assess the implications of this heterogeneity is to consider net benefit ratios (NBRs), or the ratios of agricultural sales (production minus home consumption) to total income for different household groups. Deaton (1997) shows that the NBR can be considered as the elasticity of (short-term) welfare with respect to the price of the commodity (see also Minot and Goletti, 1998). Unlike the marketed surplus shares in Table 3, NBRs take into account income from non-crop activities. That is why NBRs are more useful that marketed surplus shares for exploring the welfare implications of agricultural commodity-price changes. However, neither measure takes into account changes in households' production and consumption decisions in response to the price change. For this, an agricultural household model is needed.

Table 5 reports NBRs for rural household groups in four Central American countries that recently joined the Central America Free Trade Agreement (CAFTA): El Salvador, Guatemala, Honduras and Nicaragua (Taylor, *et al.*, 2008). With few exceptions, these are small. The NBRs map neatly onto the different household groups. They are close to zero in all of the landless groups as well as in the subsistence groups with the exception of El Salvador, where small farmers market a larger share of their basic grains than in the other three countries. Not surprisingly, in all four countries, the largest NBR is that of the large commercial household-farms.

**Table 5. Net benefit ratios, by country and household group**

| Household group | Country | | | |
|---|---|---|---|---|
| | El Salvador | Guatemala | Honduras | Nicaragua |
| Landless | 0.00 | 0.00 | 0.02 | 0.06 |
| Subsistence | 0.25 | 0.04 | 0.00 | 0.01 |
| Commercial | | | | |
| *Smallholders* | 0.12 | 0.12 | 0.24 | 0.07 |
| *Medium holders* | 0.09 | 0.21 | 0.52 | 0.14 |
| *Large holders* | 0.42 | 0.33 | 0.66 | 0.43 |

*Source:* Taylor *et al.* (2008).

*Imperfect price transmission and subsistence production*

Farmers may confront high transaction costs when selling output or purchasing inputs. In the extreme case, these transaction costs may be so high that the farmer withdraws from the market altogether, producing only for home consumption (that is, subsistence). The autarkic case has been studied using an agricultural household-modelling approach (*e.g.*, Strauss, 1984). A key difference between autarkic and commercial agricultural households is that, in the former, the prices guiding resource allocations are endogenous "shadow prices," shaped by the household's characteristics affecting supply and demand, whereas in the latter, they are exogenous, market prices.

*Liquidity and risk constraints*

Various other constraints may limit small farmers' supply response to price changes. These include liquidity constraints on purchasing inputs in poor rural economies, and risk and uncertainty, which may induce farmers to keep their scarce land and other resources spread across a "portfolio" of income activities, some with low economic returns, rather than concentrating them in activities that may be more profitable. These aspects can be built into farm household models.

***A disaggregated rural economy-wide model (DREM)***

A development by Taylor, Dyer and Yúnez-Naude "nests" models of individual households and household-farm groups within a general equilibrium model of the rural economy. The authors have called this a Disaggregated Rural Economy-Wide Model (DREM). The starting point for estimating a DREM is to construct a separate farm-household model for each rural household group. The production and demands of the various household groups are then added up to obtain the rural market supplies and demands, as well as the difference between them, which is the marketed surplus available for use outside the rural economy. When confronted by a policy or market shock, market-clearing conditions in the DREM, similar to in a PEM, allow either prices or marketed surplus to adjust in order to restore market equilibrium.

How this adjustment takes place depends on how diverse rural household groups, and indeed the rural economy as a whole, are integrated with outside markets. In an open economy, households' production and consumption decisions are guided by exogenous prices determined in outside markets. However, when transaction costs isolate local economies from outside markets, demand and supply are linked by endogenous, local prices. In this case, exogenous changes in local demands affect local prices, and thus, production decisions. The result is a web of economic linkages that transmit the influences of policy changes among households and unleash general-equilibrium effects within the rural economy.

Micro economy-wide models are flexible and may include a variety of economic actors in diverse market settings. Production activity mixes, technologies, factor endowments, and income sources vary across household groups. DREMs take into account explicitly the diverse activities in which individual rural households may be engaged, including (depending upon the context) the production of staples and cash crops, livestock, migration, and participation in rural nonfarm activities. Different households engaged in the same activity may produce with different technologies.

The structure of markets in which the household is embedded is critical in shaping the response to exogenous policy and other shocks in the real world as well as in DREMs. In particular, critical questions include whether the household can obtain perfect substitutes for family labour in local labour markets (or sell its own labour at a given market wage), whether it can obtain perfect substitutes for the goods it produces (or sell its output at a given market price), and whether it has access to credit, insurance, and information about markets and production techniques. These assumptions can be relaxed in farm household model applications (*e.g.*, Strauss, 1986; de Janvry, Fafchamps and Sadoulet, 1991; Taylor and Adelman, 2003).

When transaction costs are present, the household may not maximise its welfare simply by maximising profits. In the absence of transaction costs, the production side of a DREM reduces to a PEM. Thus, the DREM methodology has the advantage of nesting the special case where all markets work seamlessly. (See Box 3). However, as mentioned earlier, assessing the welfare impacts of policy reforms, as well as the marketed surplus available to non-agricultural households, requires that the consumption side of agricultural households be taken into account. The DREM and agricultural household methodologies do this, but the PEM does not. When rural markets do not work seamlessly, the case for the DREM methodology strengthens, because it is capable of capturing general-equilibrium interactions within the rural economy. Thus, while we do not look to build DREMs in all cases, the choice of modelling methodology depends critically on the market context as well as the questions one wishes to answer.

**Box 3. Structure of a DREM**

The households in a DREM might include: (1) commercial farms on large landholdings, which behave more like firms than like households; (2) net-surplus producing family farms on medium and small holdings, typical of small owner-operated farms of medium productivity; (3) subsistence and infra-subsistence household farms, typical of small-scale, low productivity agriculture, frequently operating under marginal conditions and incomplete markets; and (4) landless rural households. This typology works well to describe the socioeconomic landscape of many rural economies.

Each household type has its own production technologies and access to outside markets (*i.e.*, transaction costs), as well as its own consumption demands. DREMS may include different technologies to produce grain, from subsistence methods using ox-and-plough technology to relatively capital-intensive commercial production. Households often engage in other production and labour market activities that vary from one household to another. They have different access to domestic and/or international migration. Finally, while commercial farmers are integrated with outside markets, subsistence farmers are isolated from markets by high transaction costs for their produce (see Strauss, 1986; Alain de Janvry, Marcel Fafchamps and Elizabeth Sadoulet, 1991; Key, *et al.,* 2001; and others).

Agents in a PEM are commercial farmers who maximise their profits. Those in a DREM are households assumed to maximise their utility from consumption goods, both home-produced and purchased, subject to cash income, technologies, time, access - to-migration, and self-sufficiency constraints that set consumption equal to production for subsistence maize households. The solution yields a set of demands for labour and land inputs into each activity, including migration, and consumption demands. For commercial maize households, the price of maize is given by outside markets. For subsistence households, maize production and demand are guided by an internal shadow price that follows from the subsistence constraint.

DREMs explicitly model interactions among households and add a third type of price: prices exogenous to individual households but determined by the interaction of supply and demand in local markets. Endogenous prices result when transaction costs are high outside but not within the rural economy. Land rents and wages often are endogenous in a DREM. In the textbook farm household model (Singh, Squire and Strauss, 1986), land is a fixed input and thus implicitly has a shadow price that varies across households. This may be a reasonable assumption when

policies, customs or other considerations impede the smooth functioning of local land markets, as often is the case in developing countries. However, it is not reasonable when there is significant activity in local land rental markets, as in most OECD countries.

Often, there is significant variation in the agricultural wage across the countryside and between rural and urban areas, suggesting endogenous rural wages or at least wage rigidities. Where migration is an option, access to migrant labour markets may not be uniform but rather geographically concentrated and shaped by networks of family contacts at migrant destinations and other local and household-specific variables (Munshi, 2003). Daily agricultural worker wages in Mexico ranged from 50 to 140 pesos in summer 2002.

Where farm households face high costs of market access to sell their output and/or purchase consumption goods or inputs, the prices of these goods and inputs may also be endogenous.

Both land rents and wages are treated as endogenous in a PEM. However, differences in land rents and wages among rural household groups are ignored, as is the possibility that different farm households have different market access and thus face different prices.

Endogenous local prices are incorporated into the model through general-equilibrium constraints for non-tradables. These constraints equate the local supply and demand. A nonbinding constraint would imply trade at an exogenous market price.

Potential impacts of policy shocks in a DREM are complex because of the large number of interacting agricultural households, each with its own production technology, market access, and consumption demands. They involve direct effects (*e.g.*, the effect of price changes on production by commercial farms) as well as indirect effects (changes in the commercial farm household's demand for goods and services from other households, or effects transmitted to subsistence households through local land and labour markets). Signing as well as quantifying the total impacts of policy shocks cannot be done analytically; it requires a programming approach.

The solution to a DREM includes, for each household group, a set of core equations for outputs, input demands, migration, consumption demands, and either prices (for non-tradables) or marketed surplus (for tradables). It also includes aggregate outcomes, as in a PEM. However, the aggregate outcomes are shaped by interactions among households that are not captured by the PEM. As in a PEM, once the base model is created, it becomes the starting point for policy experiments.

A summary of equations in a typical DREM appears in Taylor, Dyer and Yúnez-Naude (2005).

### A stylised model using data from Mexico

An illustrative model is used here to explore the importance of heterogeneous household groups and their interactions in shaping policy outcomes in rural areas. The model is stylised, combining key features of agricultural household models with those of the PEM, but its parameters were estimated using data from Mexico.

Mexico is atypical of OECD countries in that many of its agricultural producers are subsistence or infra-subsistence farmers. A partial though perhaps extreme solution in the PEM for Mexico has been offered by treating subsistence farmers as a distinct group, and assuming that they do not change production in response to market signals; see OECD (2006b, p. 104). In fact, supply response in Mexico appears to be more complicated than this. A recent study suggests that subsistence farms do respond, sometimes in surprising ways, to changes in output market prices (Dyer, *et al.*, 2006). Price shocks in markets for staple goods are transmitted to subsistence producers through interactions in factor markets. As a result, no agricultural producer is truly isolated from changes in market prices, and where large numbers of subsistence producers are found, their behaviour potentially has an important influence on aggregate outcomes of market as well as policy reforms.

Mexican agriculture represents a complex tapestry of diversity in other ways, as well: farm size, integration with input markets, technologies, and agricultural households producing alongside highly efficient commercial agro-enterprises. For example, irrigated maize and export-crop producers in Mexico's northwest are competitive in world markets, and their production decisions are guided by market prices,

consistent with the assumptions underlying the PEM. Smaller commercial farm-households in the interior of the country are also connected to markets - in most cases, internal rather than export ones. However, most also consume a portion of their output. Scattered throughout Mexico is a large number of small subsistence and infra-subsistence producers, whose connections with international prices are tenuous at best. To the extent that market prices influence decisions in these households, these prices are more likely to be in local rather than world markets. If local consumption prices paid in markets closely tracked commercial producer prices and international prices, the market assumptions in a PEM-type model might be defensible. However, this does not seem to be the case. A recent study finds that the decision prices that Mexican maize producers use when making their input decisions far exceed market prices in most cases. The exceptions are large commercial farmers on irrigated lands, particularly in the Northwest (Aslihan and Taylor, 2008).

The stylised model utilises a nested constant elasticity of substitution scheme for land allocation like that of the OECD PEM model for Mexico. However, instead of a single producer (or, as in OECD, 2006, a price-responsive commercial producer and an unresponsive subsistence producer), the model includes five household groups (landless, small, medium and large rural, and urban agricultural producers — most of Mexico's commercial grain production is by farmers who do not live in rural areas). One version of this model allows the heterogeneous household groups to respond to policy shocks and interact to shape rural economy-wide outcomes. A second version constrains all five groups to respond identically as commercial households, similar to the aggregate or representative commercial producer in the PEM. Both versions use the same CET functions and land-supply elasticities as in the PEM for Mexico. The illustration here is based on the disaggregated rural model for the West-Central region of Mexico.

A comparison of the results of policy experiments using the disaggregated and PEM-like versions of the model is instructive in highlighting the sensitivity of estimated impacts to modelling assumptions. Table 6 describes the direct and indirect effects of a 10% decrease in the producer price of corn on the region's economy assuming that all households respond to changes in the producer price of corn, as in a PEM-type model. The chief differences between this and the OECD PEM for Mexico are first, that the five household groups consume as well as produce maize, and second, they produce with different technologies, reflected in the parameters of their production functions. As mentioned previously, land-supply elasticities are taken from the Mexico PEM and assumed to be the same for all five groups. This is to facilitate comparisons with the PEM.

**Table 6. Percentage effects of a 10% market price support for corn in West-Central Mexico (All households are considered commercial growers)**

| | Landless Households | Households with <2 ha | Households with 2-5 ha | Households with >5ha | Rural communities | Non-rural producers | Region |
|---|---|---|---|---|---|---|---|
| *Production* | | | | | | | |
| Corn | 14.9 | 1.4 | 29.2 | 3.8 | 10.5 | 3.8 | 7.1 |
| Cash crops | -2.9 | -0.7 | -0.7 | -0.8 | -1.3 | -0.6 | -0.9 |
| Livestock | -0.6 | -0.3 | -0.6 | -0.7 | -0.6 | - | - |
| Non-ag | -2.1 | -1.2 | - | -1.2 | -1.9 | - | - |
| *Surplus* | | | | | | | |
| Corn | 154.4 | 98.1 | 759.1 | 21.6 | 76.4 | 3.8 | 16.9 |
| *Factor prices* | | | | | | | |
| Wages | | | | 1.2 | | | |
| Corn land rental | | | | 23.5 | | | |
| Cash land rental | | | | -0.4 | | | |
| Pasture rental | | | | -0.6 | | | |
| *Production and Income* | | | | | | | |
| Gross product | 0.6 | 1.3 | 5.8 | 1.4 | 1.5 | 1.9 | - |
| Wage income | 2.3 | 1.4 | -9.1 | 2.4 | 1.6 | (1.6) | - |
| Nominal income | 0.6 | 1.4 | 1.3 | 1.6 | 0.9 | 2.6 | - |
| Real income | 0.1 | 0.0 | -0.1 | 0.2 | 0.1 | 2.6 | - |
| *Remittances* | | | | | | | |
| Domestic | -0.1 | - | -0.1 | -0.1 | -0.05 | - | - |
| International | -0.2 | -0.2 | -0.2 | -0.2 | -0.16 | - | - |
| Total | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 | - | - |

SOURCE: own estimates

The top row of Table 6 presents the simulated effects of the 10% maize price increase on maize production for each of the five household groups. They are all positive. Large scale growers increase their output by 3 to 4%, but smaller growers also expand production. The simulated production increases range from 1.4% (for smallholder households) to 29% (for medium-holders). Total maize output in the region increases by 7.1%. Wages and corn-land rental rates increase by 1.2% and 23.5%, respectively.

Since all types of growers respond positively to the increase in the price of corn, all household groups experience an increase in their gross production value. This increase averages 1.5% for rural households, compared to 1.9% for non-rural producers. Wage income also increases, as does total nominal household income. However, unlike in a PEM model, rural households are affected negatively as consumers by the increase in the price of corn. Because of this, changes in real income are insignificant or even negative. Non-rural producers, who behave as pure firms, as in the PEM, experience a significant increase in real income, however.

The heterogeneity of the rural corn sector has an important effect on production. Household participation in local consumer markets or lack of participation in markets buffers the impact of exogenous changes on the corn sector. To illustrate, we repeated the experiment above assuming that not all household groups respond as pure firms to changes in the producer price of corn.

In West-Central Mexico, households with more than 5 hectares of land are usually well integrated into markets and have probably experienced sharp decreases in corn producer prices over the last decade, while households with less than 5 hectares probably have experienced much smaller price changes. Table 4 reports the direct and indirect simulated effects of a 10% market price support for corn on the region's economy, when the decision prices for small and medium household-farms are endogenous rather than

market-determined. This scenario is similar in spirit to the treatment of subsistence households in OECD (2006). However, in that study the supply response by subsistence farmers was assumed to be nil, whereas in the present model it is guided by consumer prices, which are determined by the interaction of supply and demand in local economies. Small-farm production decisions also are potentially influenced by changes in prices of land and labour inputs, which are used by subsistence and commercial farms alike.

**Table 7. Percentage effects of a 10% market price support for corn in West-Central Mexico (Households with fewer than 5 hectares of land are considered subsistence corn growers)**

| | Landless Households | Households with <2 ha | Households with 2-5 ha | Households with >5ha | Rural communities | Non-rural producers | Region |
|---|---|---|---|---|---|---|---|
| *Production* | | | | | | | |
| Corn | -14.0 | -8.1 | -10.7 | 8.9 | -3.9 | 8.9 | 2.5 |
| Cash crops | -1.4 | -0.3 | -0.3 | -0.3 | -0.6 | -0.4 | -0.5 |
| Livestock | -0.3 | -0.2 | -0.3 | -0.3 | -0.3 | - | - |
| Non-ag | -1.0 | -0.6 | - | -0.6 | -0.9 | - | - |
| *Surplus* | | | | | | | |
| Corn | -43.4 | 1.7 | -42.4 | 34.7 | 13.0 | 8.9 | 9.6 |
| *Factor prices* | | | | | | | |
| Wages | | | | 0.6 | | | |
| Corn land rental | | | | 11.3 | | | |
| Cash land rental | | | | -0.2 | | | |
| Pasture rental | | | | -0.3 | | | |
| *Production and Income* | | | | | | | |
| Gross product | -2.3 | -2.0 | -1.9 | 2.7 | -0.6 | 3.2 | - |
| Wage income | 3.5 | 3.0 | 5.0 | -4.6 | 2.5 | (2.5) | - |
| Nominal income | 0.0 | 0.0 | 0.0 | 1.7 | 0.3 | 2.9 | - |
| Real income | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 2.9 | - |
| *Remittances* | | | | | | | |
| Domestic | 0.0 | - | 0.0 | 0.0 | -0.02 | - | - |
| International | -0.1 | -0.1 | -0.1 | -0.1 | -0.08 | - | - |
| Total | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 | - | - |

SOURCE: own estimates

The results of this scenario are fundamentally different from the previous one, in which all farmers were treated on the supply side as commercial producers. Rural households with more than 5 hectares of land and non-rural producers increase maize production by nearly 9% as a result of the 10% increase in price, a response elasticity of nearly 1.0. However, considering all producers, the region's corn output increases by only 2.5%. This is substantially less than the 7.1% increase under the PEM-type scenario.

An increase in the producer price of corn relative to the consumer price generates a redistribution of land in corn across households, but corn acreage increases by only 1.6% due to the limited mobility of land across crops. As a result, growth of the corn sector pushes the price of land in corn upwards by 11% while having only a slight effect on the price of land in other crops and pasture.

Expansion of the commercial corn sector also generates a 0.6% increase in wages, which affects other corn production and agricultural activities negatively. Small growers decrease corn production by up to 14%. Cash crops and livestock contract slightly across the region, which results in a small net decrease in the rental price of land in cash crops and pasture. Non-agricultural activities in rural areas contract by nearly 1% in response to wage increases. Overall, rural productive activities decrease 0.6%, despite an increase in the activity of households with more than 5 hectares. In contrast, the activities of non-rural

producers, *i.e.* commercial farmers living in urban areas, increase by over 3%, driven by the expansion of corn production.

Expansion of corn production has a much smaller effect on wages and corn-land rental rates than in the first scenario. This results in a much smaller contraction of other productive activities in rural areas, and it also limits the positive wage effect of higher corn prices on rural labourer households.

As small-farm households' own activities contract, they hire out their labour, mostly in the corn sector. All rural-household groups experience wage-income increases except households with more than 5 hectares, who must hire in additional labour to expand their corn production. Higher wages and local employment compensate for nominal income losses generated by the contraction of the subsistence corn sector. They also have a marginal negative effect on migration. Higher rental rates raise the income of the owners of land and capital, namely non-rural producers and rural households with more than 5 hectares of land. However, high corn prices reduce the latter's income gains in real terms, since this group is a consumer as well as a producer of corn.

In short, our findings suggest that the heterogeneity of households matters – estimated supply responses are far too elastic when differences among rural household groups are ignored. More nuanced models are needed in settings with heterogeneous farms, many of which are consumers as well as producers, and where price transmission is imperfect. The PEM approach needs to be modified before it can be applied to less developed countries – particularly countries that are poorer than Mexico.

Our model does not explicitly account for the effects of liquidity or risk constraints. Leaving out these constraints when, in fact, they matter would almost certainly result in overly elastic estimated supply responses. A lack of liquidity to finance production and concern for income risk would reduce some households' supply elasticities, which are already low due to high transaction costs impeding market access.

**Future work**

In modelling the effects of agricultural policies in developing countries, it is important to have a modelling framework that acknowledges the heterogeneity of farm households, and can account for transaction costs and market imperfections. The findings presented above suggest that the PEM approach needs to be modified before it can be applied to developing countries.

An ambition of future work is to develop a model structure that provides a reliable basis for policy analysis, yet is feasible to construct given data limitations. The main tenets will be to combine groups of farm household models, disaggregated in a way similar to the Mexico application, with a PEM-type modelling of the interactions between product and factor markets. The farm household models should be adapted to the specific circumstances of the country under consideration, incorporating market failures when necessary. In specific terms, it is proposed to:

- Develop a general framework that is capable of capturing both the heterogeneity of farm household responses to policy changes highlighted by DREMs and the market linkages highlighted by the PEM. It should be supportable, for the most part, with existing data. The PEM in its present form would represent a special case in which agricultural producers operate like profit-maximizing commercial firms in market environments with widespread access and low transaction costs.

- Conduct a review of existing data, from LSMS surveys and other sources, which can provide a basis for constructing appropriate models. A starting point would be to work in conjunction with

the FAO and use the RIGA dataset to establish a typology of farm households, accounting for households' roles as producers and consumers, as well as factor ownership and access to markets. These survey data contain much of the information needed to calibrate appropriate models.

- On the basis of (1) and (2) parameterise several country models and use these models as a basis for estimating the welfare impacts of policy interventions and the benefits and costs of alternative agricultural and policy instruments. Comparisons of simulation results across these countries can be used to understand the factors shaping policy outcomes in different rural settings.

- Conduct a sensitivity analysis of policy simulation findings to other constraints that may limit small farmers' supply response to price changes in developing countries. These include liquidity constraints on purchasing inputs in poor rural economies where credit is not available, and risk and uncertainty, which may induce farmers to keep their scarce land and other resources spread across a "portfolio" of income activities rather than concentrate them in activities that may be more profitable. Dynamic considerations may also be important, and are often invoked as an argument for supporting farmers in developing countries. One would expect technologies, market linkages, model parameters, and possibly the distribution of households among the various rural household types to change over time in complex ways as economies reconfigure themselves around policy changes.

- This modelling effort will be situated in the context of an examination of a number of other issues germane to the appropriate choice of policy instrument. These include the feasibility of implementing alternative policies, the scarcity of budgetary resources for taxpayer as opposed to consumer financed policies, administration costs, "government failures," rent seeking and political capture.

## REFERENCES


Adulavidhaya, Kamphol, Yoshimi Kuroda, Lawrence Lau and Pan Yotopoulos (1984), "The Comparative Studies of the Behavior of Agricultural Households in Thailand", *Singapore Economic Review* 29:67-96.

Ahn, Choon Yong, Inderjit J. Singh, and Lyn Squire (1981), "A Model of an Agricultural Household in a Multicrop Economy: The Case of Korea", *Review of Economics and Statistics* 63(4):5220-525.

Atwood Joseph A. and Glenn A. Helmers (1998), "Examining Quantity and Quality Effects of Restricting Nitrogen Applications to Feedgrains" in *American Journal of Agricultural Economics*, N°80, pp. 369-81.

de Janvry, Alain, Marcel Fafchamps and Elizabeth Sadoulet (1991), "Peasant Household Behavior with Missing Markets: Some Paradoxes Explained", *The Economic Journal*, 101:1400 1417.

Dyer, G., S. Boucher and J.E. Taylor (2006), "Subsistence response to market shocks" in *American Journal of Agricultural Economics*, 88(2), pp. 279-291.

Gardner, B. (1987), *The Economics of Agricultural Policies*, New York, Macmillan.

Gunter, Lewell F., KI Hong Jeong and Fred C. White (1996), "Multiple Policy Goals in a Trade Model with Explicit Factor Markets" in *American Journal of Agricultural Economics*, N°78, pp. 313-330.

Hazell, Peter and Alisa Roell (1983), "Rural Growth Linkages: Household Expenditure Patterns in Malaysia and Nigeria", Washington, DC, International Food Policy Research Institute.

Hertel, T.W. (1989), "Negotiating Reductions in Agricultural Support: Implications of Technology and Factor Mobility" in *American Agricultural Economics Association Journal*, No. 71(3), pp. 559-573.

Huffman, Wallace E. (1991), "Agricultural Household Models: Survey and Critique" in *Multiple Job-Holding Among Farm Families in North America*, Milton Hallberg, *et al.*, ed., Iowa State University Press, pp. 79-111.

Key, Nigel, Elizabeth Sadoulet and Alain de Janvry (2000), "Transaction Costs and Agricultural Household Supply Response", *American Journal of Agricultural Economics* 82(2):245-259 (May).

Kuroda, Yoshimi and Pan Yotopoulos (1978), "A Microeconomic Analysis of Production Behavior of the Farm Household in Japan: A Profit Function Approach", *The Economic Review* (Japan) 29:115-129.

Lau, Lawrence J., Pan Yotopoulos, Erwin C. Chou and Wuu-Long Lin (1978), "The Microeconomics of Distribution: A Simulation of the Farm Economy", *Journal of Policy Modelling* 3:175-206.

OECD (2001), *Market Effects of Crop Support Measures*, OECD, Paris.

OECD (2003a), *Farm Household Income: Issues and Policy Responses*, OECD, Paris.

OECD (2003b), "Methodology for the Measurement of Support and Use in Policy Evaluation", AGR/CA/APM(2002)3.

OECD (2005), "The Six-Commodity PEM Model: Preliminary Results", AGR/CA/APM(2005)30.

OECD (2006a), *Agricultural Trade and Policy Reform: Potential Effects at the Global, National and Household Levels*, OECD, Paris.

OECD (2006b), *Agricultural and Fisheries Policies in Mexico: Recent Achievements, Continuing the Reform Agenda*, OECD, Paris.

Singh, Inderjit, Lyn Squire and John Strauss, eds. (1986), *Agricultural Household Models — Extensions, Applications and Policy*, Baltimore: The Johns Hopkins University Press.

Strauss, John (1986), "Appendix: The Theory and Comparative Statics of Agricultural Household Models: A General Approach" in Inderjit J. Singh, Lyn Squire and John Strauss (eds.), *Agricultural Household Models — Extensions, Applications and Policy*, Baltimore: The Johns Hopkins University Press.

Taylor, J.E. and I. Adelman (2003), "Agricultural Household Models: Genesis, Evolution and Extensions", *Review of Economics of the Household*, 1(1):33-58.

Taylor, J.E., G. Dyer and A. Yúnez-Naude (2005), "Disaggregated Rural Economy-wide Models for Policy Analysis", *World Development* 33(10), pp. 1671-1688 (October).

Taylor, J.E., A. Yúnez-Naude and N. Jesurun-Clements (2008), "Does Agricultural Liberalization Reduce Rural Welfare in Less Developed Countries? The Case of CAFTA", University of California, Davis, Department of Agricultural Economics Working Paper.

Zezza, Alberto, P. Winters, B. Davis, G. Carletto, K. Covarrubias, E. Quinones, K. Stamoulis, T. Karfakis, L. Tasciotti, S. Di Giuseppe and G. Bonomi (2007), "Rural Household Access to Assets and Agrarian Institutions: A Cross Country Comparison", ESA Working Paper No. 07-17, Agricultural Development Economics Division, The Food and Agriculture Organization of the United Nations, Rome.