

# **AGRICULTURAL POLICY CHOICES IN DEVELOPING COUNTRIES**

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The document contains ongoing work on an OECD project that examines the role of agricultural policies in raising incomes and reducing poverty in developing countries. A key focus is on ways in which the policy recommendations that the OECD has developed for its member countries might need to be qualified in the case of lower income developing countries. The paper is divided into two parts: Part 1 proposes a strategic framework for strengthening rural incomes in developing countries, and discusses the role of agricultural policies in addressing income-related objectives. Part 2 presents a model for analysing the impacts of agricultural policies on household incomes over the short to medium term. The model is being developed in collaboration with Edward Taylor and Mateusz Filipski of the University of California at Davis, and Erik Jonasson of UC Riverside. The aim over the coming months is to develop this material into a final, integrated report that will be discussed at the OECD's Global Forum on Agriculture on 29-30 November 2011, with publication envisaged in early 2011.

Comments and suggestions welcome.

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## AGRICULTURAL POLICY CHOICES IN DEVELOPING COUNTRIES

### SUMMARY

1. The overarching aim of this project is to shed light on the question of what kinds of agricultural policies are most helpful to developing countries in terms of enabling them to attain their development objectives.

2. In approaching that question it is important to recognise from the outset that developing countries are heterogeneous in terms of their structural characteristics and differ in fundamental respects from high income OECD countries. In particular, they vary widely in terms of natural resource endowments, the types of agriculture systems that are in place, farm sizes and land tenure laws, basic levels of human development in areas such as health and education, and the development of government and administrative infrastructure. Agricultural markets are often less developed than in higher income countries. For example transactions costs may be higher in product markets, meaning that many farmers are less engaged with those markets; some markets (*e.g.* for credit and insurance) may be missing altogether, and market failures (arising, for example, from insecure property rights, incomplete information, or market power) may be more endemic.

3. Equally, developing countries have a wide range of objectives that they seek to pursue. These include improving agricultural productivity, raising farm household incomes, reducing poverty and hunger, increasing food security, promoting sustainable resource use, and promoting gender equality. While high income countries may have similar objectives, the scale of the challenge may be of a higher order in low income countries, and relative priorities may differ. For example, food security, poverty and hunger are often on a different scale compared with OECD countries, while environmental issues, such as climate change and desertification, may have enormous implications for rural livelihoods.

4. Faced with these diverse objectives, and with differing structural circumstances and constraints, governments seek to choose the most appropriate instruments. Their levers over the agricultural sector and rural economy include: (1) interventions in markets for outputs and inputs, *viz.* price and trade policies, marketing policies and input subsidies (*e.g.* for seeds, fertiliser and working capital credit); (2) the provision of public goods, such as rural infrastructure; (3) income transfers; (4) changes to institutions (setting up or eliminating marketing boards, land reforms, financial sector reforms, enforcement of property rights and a legal framework); and (5) macroeconomic policies, such as exchange rate policy.

5. Given the need to focus the analysis, this project focuses primarily on the ability of agricultural policy instruments to address objectives that are related fundamentally to incomes, *i.e.* those concerning the level and distribution of incomes, poverty, inequality and food security. This subset of objectives corresponds to the first Millennium Development Goal (MDG1) of eradicating poverty and hunger, with its three subsidiary targets of reducing by half the proportion of people living on less than a dollar a day;

achieving full and productive employment and decent work for all, including women and young people, and reducing by half the proportion of people who suffer from hunger.

6. This report is presented in two parts. **Part 1** motivates and develops a strategic framework for considering the potential role of agricultural policies in improving rural incomes in developing countries, with an emphasis on the incomes of farmers and other agriculture-dependent households. A particular focus is on policies towards smallholders, who form the backbone of the rural economy in low-income countries.

7. A number of premises underpin the strategic framework. The first is that the broad objective of improving incomes in fact contains two subsidiary objectives: reducing poverty and hunger in the short term (or constraining the increases in poverty and hunger that could flow from adverse shocks), and promoting economic development and wider employment opportunities over the longer term. In the short term, economic structures and peoples' livelihood sources are relatively fixed; over the long term they can adjust. A main thesis of the strategic framework is that while some instruments can be beneficial irrespective of the time horizon, others imply difficult trade-offs between short and long term priorities. For example, subsidies to farmers may raise incomes but ultimately impede sectoral development and the adjustment into more remunerative activities.

8. The second premise is that long-term structural change is inevitable, and the role of government policy needs to be to facilitate rather than impede that process. In particular, the long term (*i.e.* inter-generational) future for the majority of agriculture-dependent households invariably lies outside the farm sector. Hence, long-term policies need to make a distinction between those who potentially have a competitive future within the sector and those who do not. In either case, many of the necessary policies will not be agriculture-specific, so it is important that agricultural policies are framed in a broader economy-wide framework.

9. For both short and long term objectives, the justifications for using agricultural policies rely mostly on second best arguments. Agricultural market interventions are not the theoretically optimal way of providing social protection (where social safety nets are to be preferred); nor, in the absence of market failures, are they the ideal way of fostering growth, since they treat the symptoms of a lack of competitiveness, rather than its underlying causes. Nevertheless, plausible reasons have been suggested why, given weak institutions, high transactions costs and endemic market failures, agriculture-specific interventions – such as market price stabilisation and input subsidies – might be desirable. In the context of the strategic framework, Part 1 discusses the pros and cons of using agricultural instruments to meet income-related objectives.

10. In order to turn this discussion of benefits and costs into a more explicit set of policy recommendations, there is a need to consider empirically how the arguments weigh up. The short to medium term ability of agricultural policies to raise the incomes of agriculture-dependent households is being addressed via modelling work compatible with that undertaken for OECD countries. Analysis using the Policy Evaluation Model (PEM) showed 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, 2003). A further finding of OECD work, based on the analysis of household level data, was 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, 2003). By contrast, targeted income payments were shown to be both more efficient and more equitable.

11. An important question to be answered is whether these conclusions hold for developing countries. These issues were partly addressed in an OECD project analysing the impacts of policy reforms across a range of countries at different levels of development (OECD, 2006). A key finding was that in developing countries it is impossible to either raise or lower prices without hurting significant numbers of households on lower incomes. For example, poor farmers with a surplus may gain from higher food prices, but others with a net food deficit may lose. Urban consumers may lose, but wage earners in rural areas may benefit from a tightening of the labour market. Hence, price policies are a very blunt instrument and probably ineffective at addressing income and poverty issues.

12. However, OECD has not hitherto undertaken an analysis that fully extends the PEM analysis to developing countries. Current modelling work to redress this gap is outlined in **Part 2**. A new model – DEVPEM – is proposed which builds on the PEM. The model retains the PEM’s explicit linkages between product and factor markets, which drive the welfare and distributional implications of alternative policies. In addition, farm household models are incorporated to capture critical aspects of developing country agriculture. These include the tendency of farm households to consume a significant share (perhaps all) of their food production; the heterogeneity of farming systems within the country (from commercial operations with hired labour to low-productivity subsistence farms); imperfect engagement with markets, due to high transactions costs, and missing markets or other aspects of market failure. The new model can also be adapted to account for risk and liquidity constraints.

13. DEVPEM contains disaggregated household groups including commercial farm households (which operate as profit maximising businesses, as in the PEM); suitably partitioned groups of producer-consumer household, from net surplus family operations to subsistence and below subsistence households and landless farm households; and households that contain agricultural workers and consumers. In the case where the only type of farm operation is commercial firms, and markets function smoothly, DEVPEM reduces to the PEM. Hence the results are comparable with those already obtained for OECD countries. Part 2 also contains a prototype of DEVPEM, developed for Malawi, together with some early simulation results.

14. The short to medium term impacts obtained from DEVPEM need to be situated in the context of other factors governing the appropriate choice of policy instrument. Work undertaken in 2010 will build on the material presented in Parts 1 and 2, with the material consolidated into a single report to be published in early 2011. Within the Strategic Framework presented in Part 1, there will be a more detailed discussion of the role of agricultural policies in addressing income-related objectives in developing countries. Specific consideration will be given to two types of policy instruments that have been receiving renewed interest from policy-makers in recent years: price stabilisation schemes (such as public stockholding programmes and price band systems) and input subsidies (notably for seeds and fertiliser). Case study analyses will be used to weigh the arguments for and against the use of such instruments by considering both the historical experiences with such measures (for example looking back to policies implemented in the 1960s and 1970s) as well as the performance of more recent policy initiatives. The aim is to provide more concrete policy recommendations on (i) whether the use of such instruments is warranted, (ii) if so under what circumstances, and then (iii) if such instruments are to be used what steps need to be taken to make sure that they effectively address their intended objectives.

15. Further modelling work will involve refining the DEVPEM prototype model of Malawi, and building five more models of a relatively stylised form based on the Rural Income Generating Activities (RIGA) datasets maintained at FAO. The provisional choice of countries is Ghana and Malawi from Africa; Bangladesh and Vietnam from Asia; and Guatemala and Nicaragua from Latin America. In each case a comparable set of policy simulations will be run for each country in order to show how structural differences between countries can condition the impacts of alternative types of policy measure. The question of the welfare and distributional effects of alternative types of agricultural policies is just one

factor determining whether the use of a particular type of instrument is warranted. Accordingly the DEVPEM results will be woven into the broader discussion of instrument choice.

16. The Strategic Framework proposed in Part 1 underlines the importance of getting the policy mix right: decisions which involve considering the trade-offs and complementarities between alternative policy instruments. Time and resources permitting, the final report will give further consideration to the interaction between agricultural and non-agricultural policies (such as investments in infrastructure and human capital), in terms of both the ways in which the latter may make the former more effective, as well as the opportunity costs of spending resources in different areas.

17. All elements of the project will be used as the basis for a meeting of the OECD's Global Forum on Agriculture in the fourth quarter of 2010. This meeting will be used to discuss the findings of the analysis, while expert contributions will be sought to broaden the discussion, for example by considering how the pursuit of income objectives complements or conflicts with other priorities such as ensuring sustainable resource use.

## PART 1. A STRATEGIC FRAMEWORK FOR STRENGTHENING RURAL INCOMES IN DEVELOPING COUNTRIES

### 1.1. Introduction

18. This section of the report motivates and proposes a strategic framework for policies to strengthen rural incomes in developing countries, and then discusses the role of different policy instruments within that framework.

19. The analysis focuses first and foremost on which policies can accelerate progress on the first Millennium Development Goal (MDG1), which calls for the eradication of extreme poverty and hunger, with a specific target of halving between 1990 and 2015 the proportion of people living on less than a dollar a day. The world as a whole may achieve this target, thanks primarily to rapid income growth in East Asia (and China in particular). But in many parts of the world, progress on MDG1 has been weak or non-existent. Using a recently updated income benchmark of USD 1.25 per day, the *number* of poor is actually increasing in Africa and South Asia (Chen and Ravallion, 2008). Between 1981 and 2005, the incidence of poverty in South Asia fell from almost 60% to 40%, but because of population growth that was not enough to bring down the numbers of poor. In Sub-Saharan Africa, the situation was even worse: the incidence of poverty was virtually unchanged between 1981 and 2005, at around 50%, which implied that the number of poor almost doubled from 214 million to over 390 million. By this measure, Africa's share of the world's poor increased from 11% in 1981 to 28% in 2005. Some modest signs of progress in recent years (since 2000) were arrested by the recent increase in world food prices, which the World Bank estimated was severe enough to throw another 100 million people into poverty (Ivanic and Martin, 2008). Prices have since fallen back, but remain considerably higher than they were in the first part of the decade.

20. If broader based progress on MDG1 is to be achieved, then average incomes will need to increase much more rapidly in the next five years than they have done in the past twenty. Given that three quarters of the world's dollar a day poor live in rural areas (corresponding to 880 million people), and most depend on agriculture for their livelihoods, there is a particular need for faster development of *rural* incomes. This in turn requires carefully thought out agricultural and rural development policies, and a specific consideration of what to do about smallholders, who form the backbone of developing country agriculture.

21. For the best part of 30 years, agriculture has been discriminated against by both national policy makers and donors. Developing countries showed an overall tendency to tax their farmers, both in terms of pricing policies (Anderson *et al.*, 2008) and through urban bias in the allocation of expenditures (Bezemer and Headey, 2008). Similarly, foreign aid to the sector declined in both absolute terms and as a proportion of total allocations, with a fall from USD 8 billion in 1980, equal to 17% of total aid, to a little over USD 3 billion in 2005, corresponding to a share of less than 4%. One reason for this "agro-scepticism" was low rates of perceived success compared with investments in other areas such as education and health (Easterly, 2008). Another was the combination of declining real agricultural prices and, in successfully developing economies, a falling share of agriculture in GDP and employment. These were interpreted by policy makers as signs of higher returns from investing in other sectors.

22. Timmer (2005) suggests that, in the poorest countries, such reasoning confused cause and effect. This is because agricultural investment was and is necessary to elicit the productivity gains that initiate the agricultural transformation (described later), which involves the release of resources from the sector and –



when part of a balanced development strategy – their more productive allocation to other sectors. Hence, the relative decline of agriculture is an implication of development success.

23. In recent years, policy thinking has come full circle. In the 1960s, policies centred on subsidies for seeds and fertiliser, and heavy investment in R&D and extension services, while in the 1970s, the emphasis shifted to integrated rural development (dealing with all the necessary inputs at once). These ideas were abandoned in favour of structural adjustment and “getting prices right” in the 1980s and 1990s (Adelman, 1999). Since the millennium, there has been a renewed focus on R&D, and in fixing market failures (specifically in input markets). The new thinking was reflected in the World Bank’s 2008 *World Development Report*, which not only called for greater agricultural investment, but also advocated the use of “market smart” subsidies for seeds and fertiliser.

24. The current paradigm, with faster agricultural and rural development seen as a pre-requisite for deeper economy-wide development, has been reflected in a range of commitments. In the case of Africa, for example, the African Union’s 2003 Common African Agricultural Development Programme (CAADP) framework sets a target of 6% for agricultural growth, while under the 2003 Maputo Declaration its members are committed to allocate at least 10% of public expenditure to agriculture and rural development. On the donor side, the G8 pledged in 2008 to provide EUR 1 billion of support for investment in African agriculture, and in 2009 increased that commitment to EUR 15 billion over three years.

25. The food price crisis also triggered international commitments to allocate more money to agriculture. The World Food Programme appealed for additional funds and had received more than USD 1 billion by the end of 2008; the World Bank launched a USD 1.2 billion Global Food Crisis Response Program in mid 2008; and the FAO presented a USD 1.7 billion Initiative on Soaring Food Prices in June 2008 (Abbott, 2009). Bilateral donor countries also pledged additional resources to address problems in developing countries stemming from the food crisis (GDPRD, 2009). As food prices have fallen back, the legacy of the crisis has been that it has drawn attention to the deeper need for short, mid and long-term measures to tackle food insecurity and poverty. The UN High-Level Task Force on the Food Security Crisis advocated a two pronged approach, focusing on emergency relief and renewed efforts to invest in agricultural development, with a particular emphasis on supporting smallholder agriculture. With prices now lower (albeit still above average levels over the past ten years), the emphasis has shifted to the chronic lack of smallholder development, with strong support for “smart” subsidies for seed and fertiliser.

26. The purpose of this section of the report is to give consideration to what constitutes an effective strategy for boosting agricultural and rural incomes, and to discuss the appropriate role for agricultural policy with respect to that objective. In the short term the income objective implies reducing poverty and hunger (and constraining any increases that would flow from adverse shocks), while over the longer term it entails promoting economic development and creating wider employment opportunities. A fundamental thesis is that while there are some instruments that can be beneficial irrespective of the time horizon, there are nevertheless difficult trade-offs between short and long term priorities, and a strategic framework needs to acknowledge those trade-offs.

27. A key focus is on policies towards smallholders, who underpin the agricultural economies of poor countries, although consideration is also given to other agriculture-dependent households (such as wage earners). The term “smallholder” refers to producers with limited resource endowments relative to other farmers in the sector. This may be insufficient farm size, although other assets, such as farm management skills may also be lacking. It is important to note that what constitutes a small farm may differ markedly from one country to the next. For example, the average farm size in many Asian countries is less than a hectare, whereas much larger operations in Latin America (ten hectares or more) may be considered as small. A defining characteristic of smallholders is that, while they may be “efficient” in their operations,

they nevertheless often struggle to be competitive, either because of their limited resource endowments, or because they confront missing or under-developed markets. Their competitiveness may also be undermined by other factors, such as subsidised exports arriving on internal markets.

28. The structure of this section of the report is as follows. Section 1.2 provides an overview of the broad experience across countries of agricultural development and structural change. This helps provide context on the evolving role of smallholders in the economy, and points to some principles that need to guide policy formulation. Section 1.3 contrasts those principles with actual agricultural policies and approaches to smallholder development. Section 1.4 proposes a strategic framework for strengthening rural incomes which seeks to reconcile the short run objective of poverty alleviation with the long-run aim of facilitating development. Section 1.5 presents some conclusions and identifies priorities for the next phase of analysis.

## **1.2. Economic development and the structural transformation**

29. The process of economic development is characterised by three empirical regularities that are of relevance when considering the strategic options for smallholder development. These are the *sectoral* transition away from an economic structure based on agriculture to one dominated by manufactures and services, the *spatial* tendency towards increased urbanisation, and an *institutional* transformation from an economy based largely on informal rules to one based on formal legislation (Jonasson, 2009). Other changes also accompany economic development, such as falling death rates and – with a lag – declining birth rates. In its 2008 *World Development Report*, the World Bank makes a useful distinction between agriculture-based, transforming and urbanised economies that captures the first two elements of this economic transformation.<sup>1</sup> Countries tend to move through these categories, although they may experience short cuts in the process, such as learning from policy experiences in urbanised economies, or take detours due to such factors as civil war, corrupt government or a misallocation of public resources. Moreover, the trajectory is not the same for each country, and will depend on the rate and composition of demand growth, as well as the sources and composition of productivity changes, which are partly determined by policies. These transformations have important implications for the design of agricultural and rural policies.

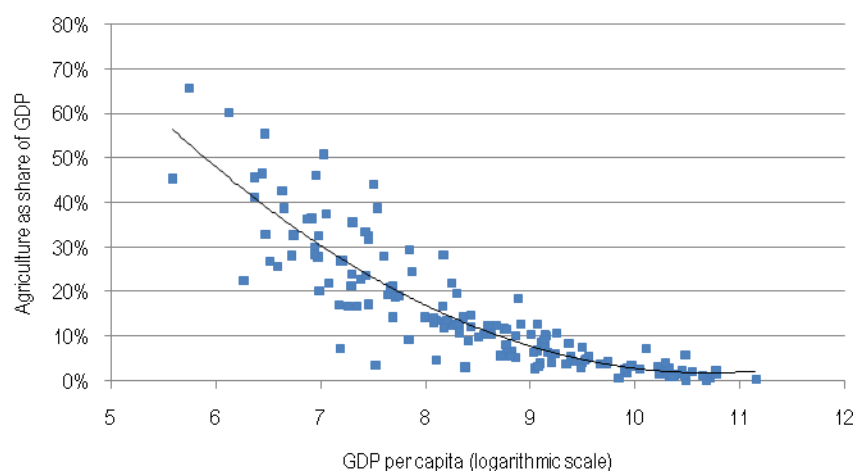
### **1.2.1. The sectoral transformation**

30. The sectoral changes associated with economic development are evident from the cross-country relationship between agriculture's share of GDP and GDP per capita. Figure 1.1 provides a scatter plot of these two indicators for 180 countries in 2005. For countries with a GDP per capita of USD 2 000 or less (approximately 7.5 on the logarithmic scale), it is still not uncommon for agriculture to constitute 30% or more of the economy. As per capita income rises above USD 10 000, practically no country has an agricultural sector that accounts for more than 10% of GDP.

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1. According to this classification, agriculture-based economies are those in which agriculture contributes 20% or more to overall economic growth; transforming economies are those in which agriculture contributes less than 20% to total growth yet 60% or more of the country's poor live in rural areas; while urbanised economies are those in which agriculture contributes less than 20% to overall growth and less than 60% of the poor live in rural areas. More than 80% of the rural poor in Sub-Saharan Africa live in agriculture-based countries, while over 90% of the poor in Asia, the Middle-East and North Africa live in transforming economies. A majority of Latin America's poor live in urbanised countries, although nearly one-half of the poor still live in rural areas. There are virtually no countries where agriculture contributes more than 20% to growth but in which the numbers of urban poor exceed the numbers of rural poor. Among developing countries, there is a strong correspondence between these three categories and three income classes for countries (low income, lower-middle income and upper-middle income) also specified by the World Bank.

**Figure 1.1. Share of agriculture in GDP and per-capita GDP**

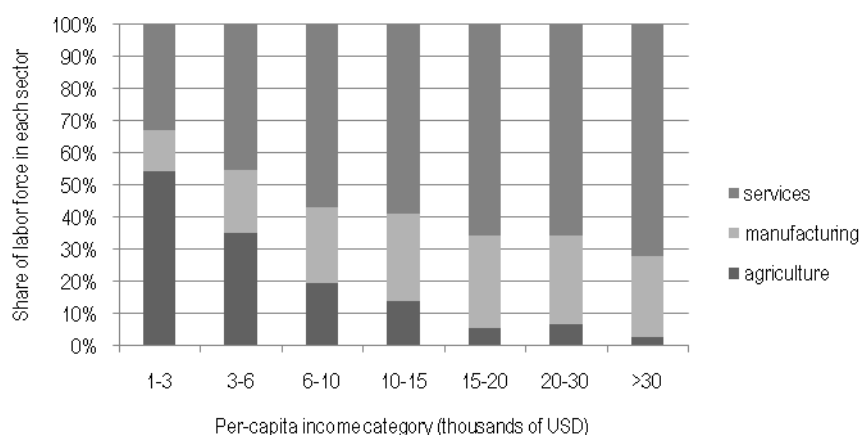


*Note:* 180 countries; GDP per capita refers to 2005 PPP USD.  
*Source:* World Development Indicators, 2009.

31. The reasons for agriculture's declining relative economic importance are well documented (for an overview, see Timmer, 1998). On the demand side, income elasticities of demand for food tend to be less than for other consumption, so the demand for food grows more slowly than the demand for other goods. On the supply side, total factor productivity typically rises faster in agriculture than in other sectors of the economy (Martin and Mitra, 2001), permitting the release of resources from the sector. Yet despite the release of resources the agricultural sector typically continues to expand in absolute terms. The pressure for farm resources to shift into other sectors may be lessened by the scope for increased exports in countries with a comparative advantage in agricultural activities, or reinforced by pressure from imports in the case of countries with a comparative disadvantage.

32. The declining share of agriculture in GDP is matched by the release of labour to other sectors. Figure 1.2 shows the average shares of employment in agriculture, manufacturing, and services for 120 countries, divided into seven income categories. On average, half of the labour force in the poorest countries is occupied in agriculture, whereas for countries that have a per-capita income of USD 15 000 or higher, the service sector generally occupies two-thirds or more of the labour force, manufacturing most of the remainder, and agriculture just a few per cent.

**Figure 1.2. Employment shares in agriculture, manufacturing, and services**



Note: 120 countries; income categories are based on GDP per capita 2005, PPP USD.

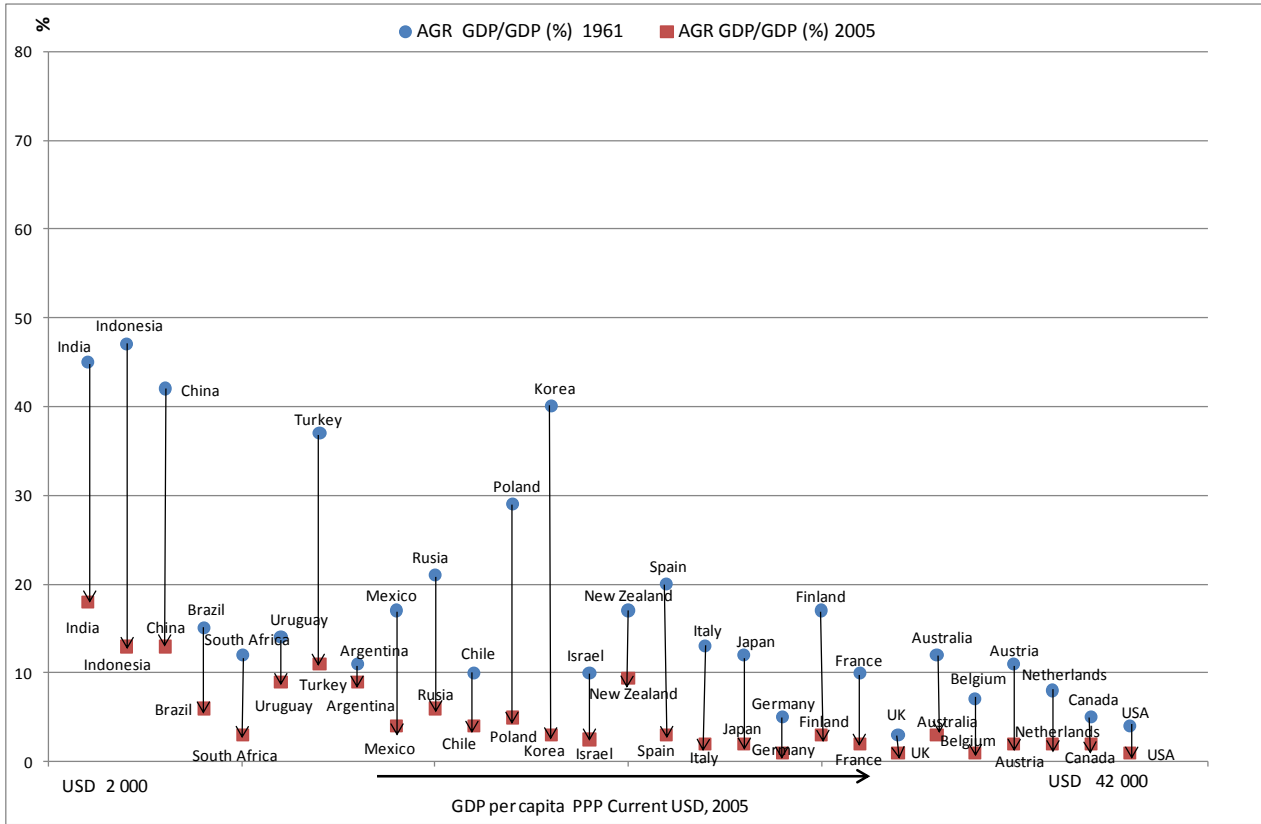
Source: Author's calculations based on World Development Indicators, 2009.

33. However, the declines in agriculture's share of GDP and its share of employment do not proceed at the same pace. In the early stages of development, non-agricultural growth outpaces agricultural growth, but resources, notably labour, are not readily absorbed by the non-farm economy. Hence agriculture's share of GDP falls more rapidly than its share of employment, a development which corresponds to increasing income inequality between the non-farm and farm sectors. At somewhat higher levels of income, however, the income gap precipitates a more rapid outflow of labour and agriculture's share of employment declines more rapidly than its share of GDP. This delayed adjustment of labour, followed by a rapid catch-up, is apparent from the historical experiences of transforming and urbanised economies.

34. For a narrower group of emerging and developed economies, Figure 1.3 shows how agriculture's share of GDP changed between 1961 and 2005, with countries ordered according to their GDP per capita. The graph re-emphasises the strong inverse correlation between agriculture's share of GDP and GDP per capita, with high income OECD countries typically having no more than 2%-3% of GDP generated by their farm sectors. A second, and consistent, feature is that agriculture's share of GDP has declined in *all* countries, including those with a strong comparative advantage in agricultural activities. A third point is that the decline of the share of resources in agriculture has been larger for countries with lower incomes, which have more scope for agricultural productivity improvements and for shifting resources into new non-farm activities (in developed countries, that shift has already occurred).<sup>2</sup>

2. There are some exceptions, such as Brazil and Chile, where the changes have been large in absolute terms, but low relative to other countries at similar income levels. In these particular countries, import substitution industrialisation policies led to a rapid growth in manufacturing prior to the base year, bringing down agriculture's share of GDP; while more recently the liberalisation of policies has mitigated the tendency of resources to shift out of agriculture, as these countries have exploited their natural comparative advantage in agricultural activities.

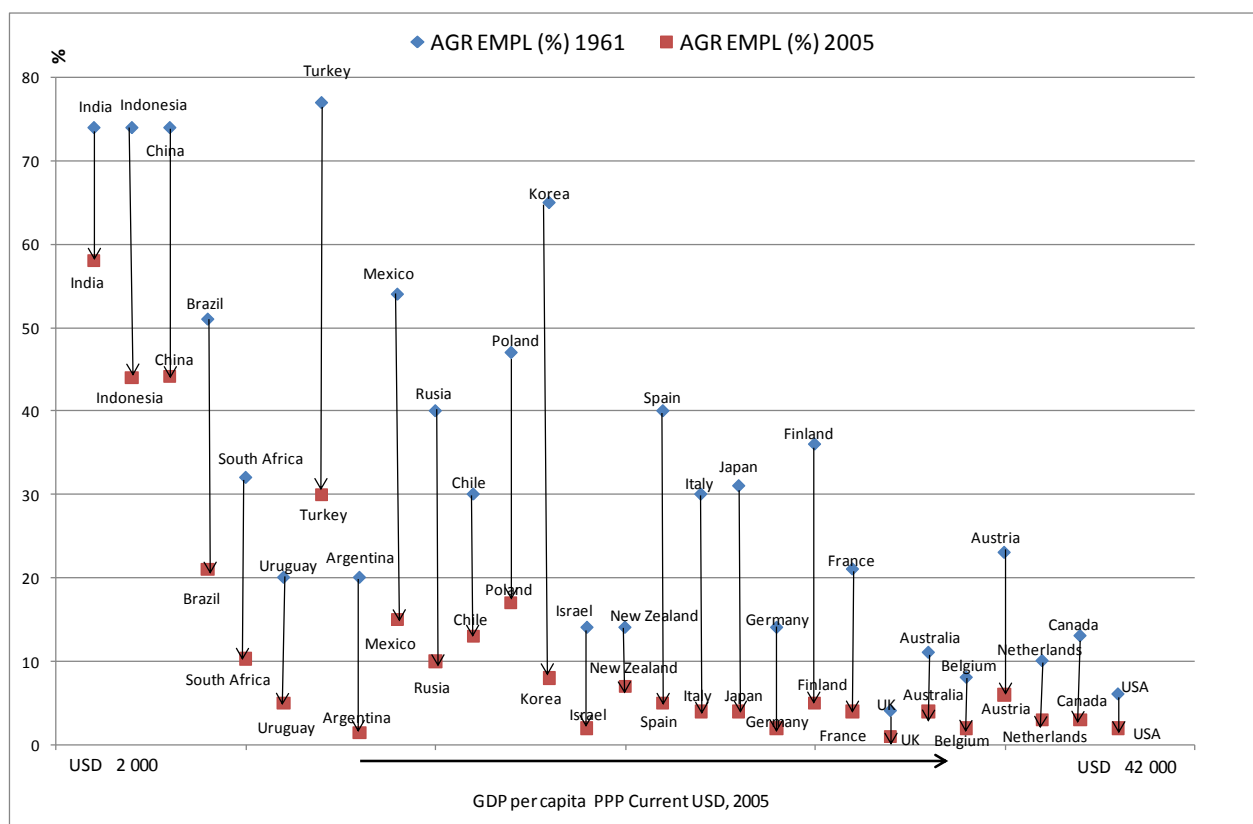
Figure 1.3. Evolution of agriculture's share of GDP in various countries (1961 and 2005)



Source: FAO (1999); WDI (2008); IMF (2008).

35. The contemporaneous changes in agriculture's share of employment are shown in Figure 1.4. For most middle income (transforming) countries, the decline in agriculture's share of employment has been more rapid than the fall in the sector's share of GDP, reflecting stronger gains in labour productivity than in other sectors (Johnson, 2000). Note that the labour adjustment has been larger for middle income countries than for lower income countries such as India, as alternative employment possibilities have become more widely available and the transition of labour out of semi-subsistence farming has really got underway.

**Figure 1.4. Evolution of agriculture's share of employment in various countries (1961 and 2005)**



Source: FAO (1999); WDI (2008); IMF (2008).

36. The sectoral transformation is influenced by the fact that the productivity and skills gap between subsistence agriculture and other manufacturing and service sectors is becoming ever larger. This explains why it may be more difficult for farm labour in poor agriculture-dependent economies to be absorbed by other sectors than it was for, say, European farmers to move into industrial jobs a century earlier. Yet once the sectoral transformation is underway, its pace is invariably more rapid than in the past (Table 1.1). Whereas it took a century or more for agriculture's share of GDP to fall from 40% to 7% in OECD countries that went through the industrial revolution early, middle income countries are effecting these changes in three decades or less. This accelerating change is matched by an even more rapid release of labour out of the sector. In Korea, agriculture's share of employment fell from 40% to 16% in just 14 years – a transition which took 53 years in the United States and 68 years in the United Kingdom (the first country to go through the industrial revolution).

**Table 1.1. Pace of adjustment in various countries, based on agriculture share of GDP and employment**

	Agriculture share of GDP			Agriculture share of employment		
	Year of 40%	Year of 7%	Years required	Year of 40%	Year of 16%	Years required
Netherlands	1800	1965	165	1855	1957	102
Denmark	1850	1969	119	1920	1962	42
UK	1788	1901	113	1800	1868	68
Chile	1875	1980	105	1950	1993	43
Mexico	1890	1992	102	1969	2000	31
USA	1854	1950	96	1897	1950	53
France	1878	1972	94	1921	1965	44
Brazil	1910	2003	93	1960	2005 (20.5%)	>45
Germany	1866	1958	92	1900	1942	42
Japan	1896	1969	73	1940	1971	31
Poland	1935	1991	56	1968	2006 (18.7%)	>31
India	1962	2006 (17.5%)	>44	2005 (58%)		--
China	1967	2006 (11.7%)	>39	2006 (43%)		--
Turkey	1970	2007 (8.9%)	>37	1998	2007 (28.7%)	>9
Korea	1965	1991	26	1977	1991	14
Indonesia	1971	1997	26	2006 (42%)		--

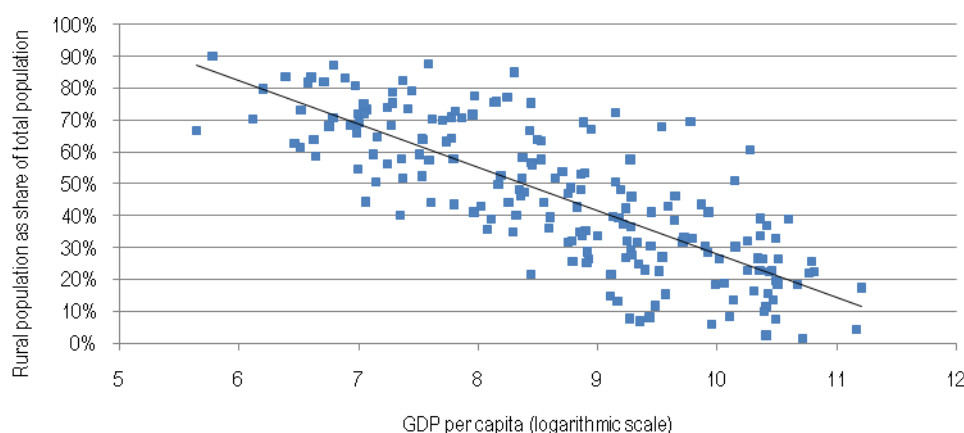
Source: Adapted from Kim, H. and Lee, Y.K. (2003).

### **1.2.2. The spatial transformation**

37. The spatial transformation from rural to predominantly urban economic activity is not as uniform as the sectoral transformation. Figure 1.5 shows that a majority of countries with a per capita income of less than USD 5 000 (approximately 8.5 on the logarithmic scale) have more than 50% of their population in rural areas. On average, this share declines to 25% when countries reach an income of USD 20 000. Urbanisation may occur both as a result of higher birth rates in urban areas compared to rural areas and as a result of rural-to-urban migration.<sup>3</sup> In China a majority (about 56%) of the population is still rural, but rapid migration from rural areas might soon change this situation. In 1983 the cumulative number of rural migrants was about 2 million in China. This number had increased to about 78 million in the year 2000. Six years later, in 2006, the estimated cumulative number of rural migrants was 132 million (OECD, 2009). In India, which has the largest rural population in the World (approximately 800 million), it is estimated that rural-to-urban migration accounts for about 30% of urbanization (Mitra and Murayama, 2008). In Brazil, rapid migration from rural areas increased the share of the population in urban areas from 15% in 1940 to 56% in 1970, and to more than 80% in 2000 (Wagner and Ward, 1980; Brazilian Demographic Census 2000).

3. Rural areas may grow “urban” if they reach the population threshold that defines an urban area. Thus, the rate of urbanization depends to a certain degree on how urban and rural areas are defined. Usually, population agglomerations of 5 000 people constitute the lower threshold for what is officially defined as an urban area (Haggblade *et al.*, 2007).

**Figure 1.5. Share of population that is rural and GDP per capita (190 countries)**



Note: 190 countries; GDP per capita refers to 2005 PPP USD.

Source: World Development Indicators, 2009.

38. The agglomeration of human activity with economic development may be inevitable, but the specific character of urbanisation is not. Rural areas may become more “urbanised” as a result of the agricultural transformation and the induced growth in non-farm activity. Alternatively, urbanisation may result from poor unskilled labour migrating to cities in the anticipation of improved prospects. In the absence of a parallel development in social infrastructure, the resulting shanty towns (common in Asia and Latin America) may impose severe social strains. Hence there is a need to plan for a sustainable form of urbanisation, which is likely to require the balanced promotion of farm and non-farm opportunities in rural areas.

### ***1.2.3. The institutional transformation***

39. A third dimension of change that developing countries tend to go through is the institutional transformation from an economy based largely on informal rules and procedures to one based on a framework of formal legislation – in short, the transformation from informal to formal institutions.<sup>4</sup> In the absence of formal rules that effectively regulate employment, property ownership, or land use, various types of informal rules and procedures are usually applied instead. Two examples from the agrarian economy are sharecropping as a means to overcome moral hazard situations in the farmer-labourer relation and “squatter’s rights”, which regulate access to land.

40. The strengthening of formal institutions may facilitate the emergence of more commercially oriented agriculture, for example by supporting the development of land rental and credit markets, and other forms of formal contracts. It may also make the use of certain policy instruments more feasible, such as social safety nets. It is thus the third element of a three-pronged strategy for smallholder development, which involves facilitating the three dimensions of structural change: adjustment away from agriculture-

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4. Institutions are understood here as the ‘rules of the game’ that shape and guide human behaviour (North, 1990). The distinction between formal and informal lies largely in the enforcement mechanism. While formal institutions are usually enforced by official entities (such as police, bureaucrats and courts), informal institutions are socially sanctioned norms of behaviour that rely primarily on self-enforcement mechanisms of obligation, expectations of reciprocity, and internalised norm adherence (de Soysa and Jütting, 2007).



dependence, a desirable form of urbanisation and concomitant institutional development. The specifics of this strategy are taken up in Section 1.4.

#### **1.2.4. Where do countries stand in the transformation process?**

41. Three-quarters of the world's dollar a day rural poor (nearly 600 million people) live in "transforming" economies, where poverty remains predominantly rural but agriculture contributes less than 20% to overall economic growth. In these countries the agricultural transformation is well underway but on average nearly two-thirds of the population remains rural and the spatial transformation has yet to work its way through (World Bank, 2008). This has two important implications: First, it points to the need for a *rural* strategy as much as an agricultural one. Second, it underlines the importance of not generalising from the circumstances of a few agriculture-dependent economies. Thus for example, while Malawi's input subsidy programme has received much attention, due to subsequent increases in production and farm productivity, it should be remembered that Malawi is an outlier in terms of agriculture's contribution to GDP (nearly 60%), and the extent to which its poverty is rural (nearly 90%). For the majority of countries, in which the agricultural transformation has already gained traction, agricultural growth seldom exceeds 5% per year, whereas in manufactures and services growth rates of 10% or more are common. Hence, for most of the world's poor, an appropriate development strategy has to focus on providing opportunities outside the farm sector at least as much as within it.

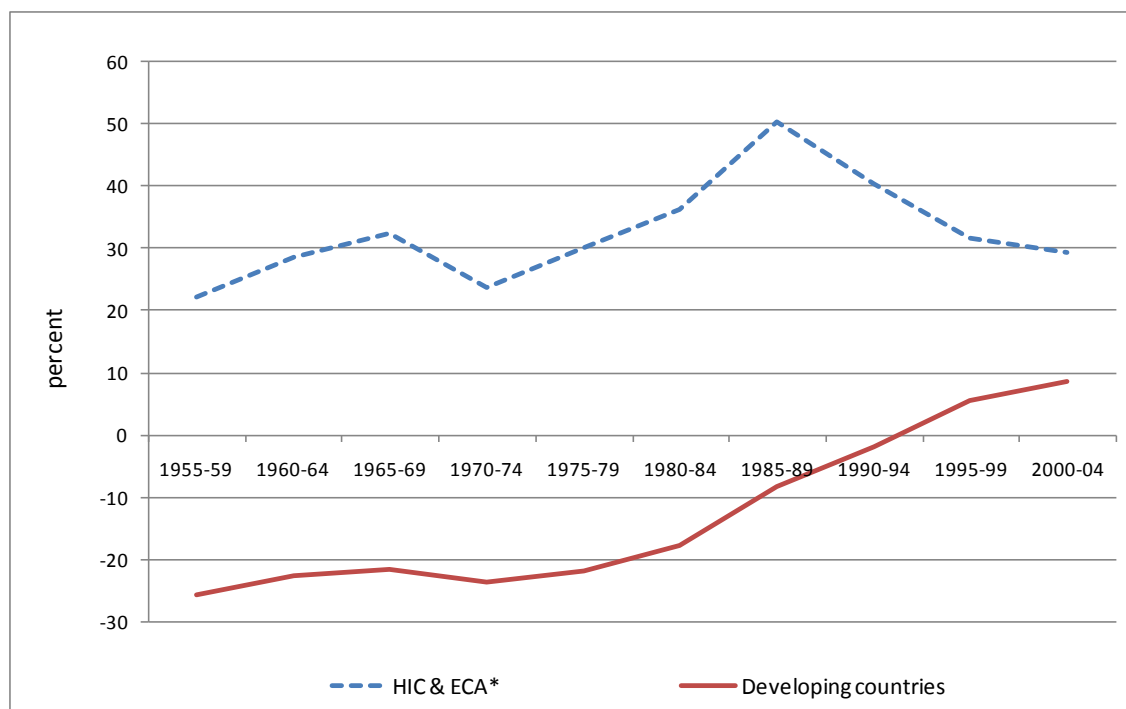
#### **1.3. Policy responses to structural change**

42. Policy makers face a number of challenges as a consequence of the structural pressures identified in the previous section. In poor countries still in the early stages of economic development (*i.e.* in agriculture-dependent economies), the paramount need is to boost average incomes in general and rural incomes in particular. In these economies most of the poor live in rural areas, so raising rural incomes tends to have the most immediate impact on poverty. Furthermore, insufficient income is the principal cause of food insecurity, which is also more prevalent in rural areas. Improvements in agricultural productivity are an effective way of boosting rural incomes and there is evidence that, due to the sector's extensive linkages, agricultural development can provide an engine for broader growth (Johnston and Mellor, 1961; Timmer, 1998). Yet even at early stages of development, the structural transformation causes resources to be released from the sector. Hence, while it is important to emphasise agricultural development in poor countries, policies need to simultaneously provide other opportunities, in particular for those who cannot become competitive and who have improved prospects in other sectors. Moreover, in the long term, the ultimate need is to shift from improving incomes in current activities to facilitating adjustment into activities that command potentially higher incomes. The balance to be struck, therefore, is between policies that support development of the agricultural sector in general, but do not prevent structural adjustment from occurring as a direct consequence of that process. In general, spending on public goods, such as infrastructure and agricultural research, can facilitate both developments, whereas direct subsidies to farm activities – notwithstanding potential benefits that are discussed later – run the risk of impeding adjustment.

43. Historically, poor countries have tended to tax their agricultural sectors rather than subsidise them (Krueger, Schiff and Valdés, 1991). They have done this both explicitly, for example via export taxes and food subsidies, and implicitly, by investing relatively less in rural areas. Since the mid-1980s, there has been some reduction in this tendency, but it still prevails (Anderson *et al.*, 2008). As incomes rise and as agriculture's share of employment decreases, countries find they can afford more easily to provide support to their agricultural sectors and the opposite tendency is observed. In the 1990s, developing countries on balance made that switch, with their average nominal rate of assistance (NRA), which measures the one

minus the ratio of domestic farm gate prices to adjusted border prices, becoming positive (Figure 1.6).<sup>5</sup> On average, they thereby joined high income OECD countries in providing protection to their agricultural sectors. Note that this measure only takes account of relative prices, and ignores subsidies to farmers or other aspects of agricultural spending. Also, some caution needs to be exercised in interpreting these numbers, as the NRAs are weighted averages for import-competing products, exportables and non-tradables, and in some cases different patterns can be observed when these categories are treated separately.

**Figure 1.6. Nominal Rate of Assistance to agriculture in developed and developing countries, 1955-2004**



\* HIC= High income countries; ECA=Eastern European and Central Asia countries.  
Source: Anderson *et al.* (2008).

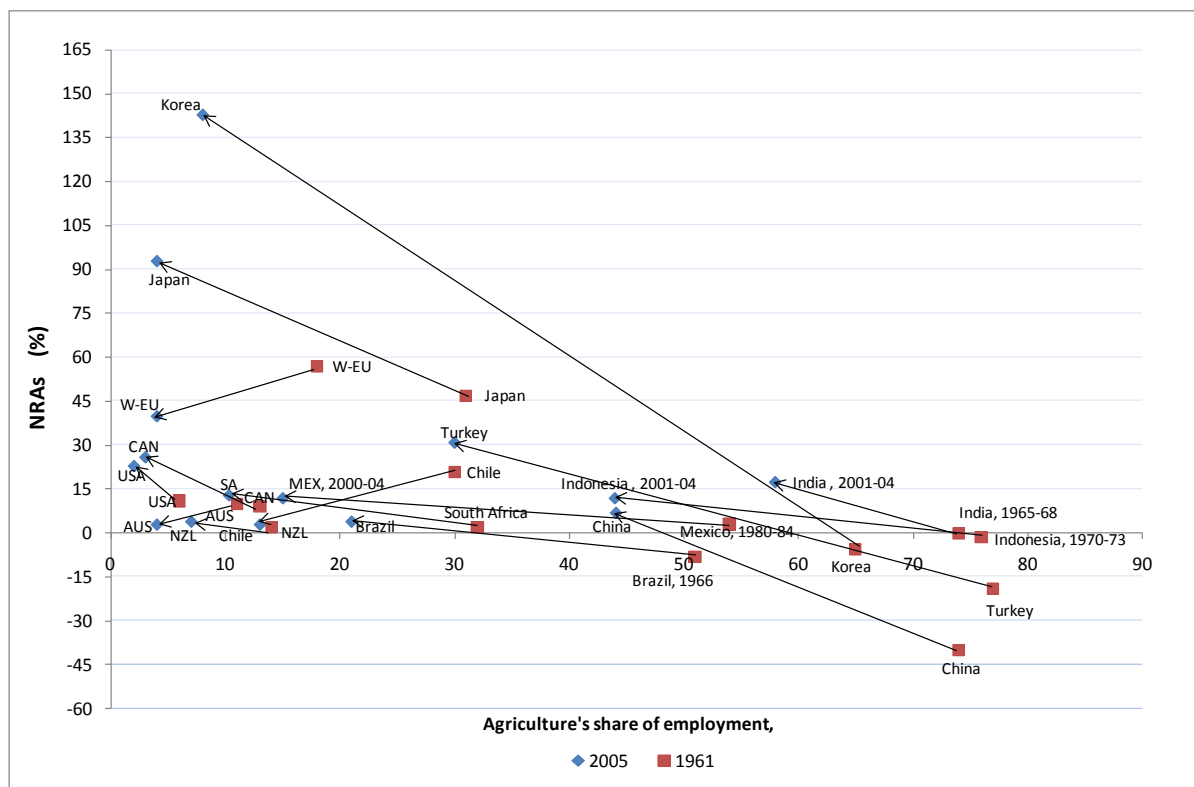
44. By implication, the level of protection is also linked to agriculture's share of employment. The horizontal axis of Figure 1.7 shows agriculture's share of total employment, while the vertical axis measures the NRA. The arrows show the movement for each country between 1961 and 2005. For nearly all developing countries, the arrow points to the north-west, indicating an increasing rate of protection as labour leaves the sector, whereas the pattern for high income OECD countries is mixed.<sup>6</sup> The arrows are also much longer for developing countries, as more dramatic structural changes have taken place, and the

5. Here the NRA is expressed in percentage terms, *i.e.* as  $NRA = 100 \cdot (1 - P_x/P_y)$ , where  $P_x$  is the domestic farm gate price and  $P_y$  is the adjusted border price.

6. The tendency of countries to protect their agriculture as they become more developed stems from the political economy of structural change. On the demand side, as consumers spend a declining share of their incomes on food they become 'rationally ignorant' that they are paying elevated prices for their food – it is not worth the effort of becoming informed and protesting. On the supply side, the release of labour from the sector means that a given transfer to each producer imposes a progressively smaller burden on the overall economy. Moreover, competitive pressures on less efficient farmers increase their incentive to lobby for government support.

associated change in protection has been larger. Interestingly, developing countries have undergone significant adjustment, seemingly irrespective of whether the rise in protection has been large or small.

**Figure 1.7. NRA and agriculture's share of employment, 1961 and 2005, selected countries**

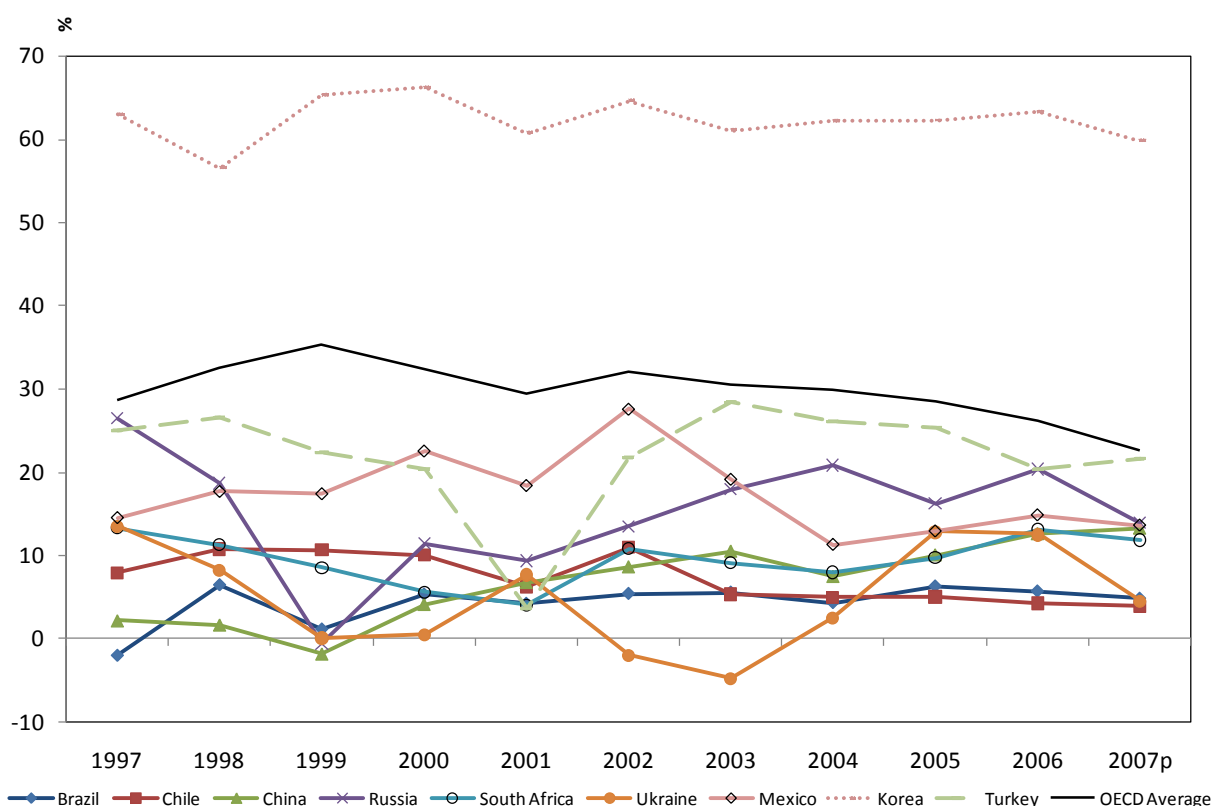


Source: Anderson *et al.* (2008); FAO (1999); WDI (2008).

45. The tendency of emerging economies (*i.e.* those transitioning away from agriculture-dependence) to provide implicit subsidies to their farmers is evident from the OECD's Monitoring and Evaluation exercise – a group which includes three OECD members (Korea, Mexico and Turkey) and six non-members (Brazil, Chile, China, Russia, South Africa and Ukraine). For all countries except Korea, the Producer Support Estimate has been on average positive but lower than the OECD average (Figure 1.8). The majority of support has been provided through market price support, which concentrates benefits among large producers when there is a spread of farm sizes and tends to put a brake on the process of adjustment rather than facilitate it.

46. Some of these countries have also instituted significant programmes targeted at smallholders. For example, both Brazil and Chile have programmes that seek to integrate smallholders into the commercial sector, notably via the use of subsidised credit and investments in farm-level infrastructure. In few cases, however, have policy makers openly acknowledged that long-term competitiveness is not a realistic goal for the majority of smallholders and decided to focus their programmes on potentially viable operations. At the same time, there is no documented case of a smallholder programme in which the majority of farmers enrolling have succeeded in progressing through the programme to successfully join the ranks of efficient commercial producers. In other words, no programme has reversed the structural tendency for smallholders to leave the sector. This suggests that these policies constitute social policies at least as much as developmental ones.

Figure 1.8. Evolution of the producer support estimate in OECD and selected countries, 1997-2007



Source: OECD PSE/CSE Database (2008).

47. In a number of developing countries, the movement away from dis-protection has been matched by commitments to allocate more resources to agricultural development. A large number of developing countries with relatively neutral pricing policies are at a critical juncture in terms of agricultural policy development. Do they spend scarce resources on supporting farmers, or do they invest in the broader underpinnings of agricultural development and economic development more generally?

48. In part, this question turns on how policy makers choose to address the issue of smallholder adjustment. Smallholders in developing countries often underpin the rural economy, yet they face systematic adjustment pressures as a necessary corollary of the development process. With technology improving, and more efficient use being made of scarce resources, including the exploitation of scale economies, smallholders that do not participate in sectoral cost improvements inevitably face pressures on their incomes. Faced with such pressures, governments can shield smallholders from this pressure, or they can help them adapt to it – either by becoming more competitive, obtaining incomes from other sources, or by finding jobs outside the sector.

49. In choosing the appropriate policy mix, the preceding discussion suggests a need for a logical framework that acknowledges three important things. First, economic structures are relatively fixed in the short term, so efforts to achieve an immediate impact on incomes need to be based on an understanding of how people currently earn their livelihoods. This suggests that there *is* a role for agricultural policies. Second, over the long-term, structures change and the structural transformation implies that the inter-generational future for the majority of smallholders cannot lie exclusively in farming; hence there is a need for policies that enhance households' opportunities outside the sector as well as within it. In other words,

agricultural policies are not enough. Third, in order to improve both agricultural competitiveness and the prospects for earning more outside the sector, the most important policies may not in fact be agricultural policies. It is therefore important that smallholder policies are framed in an economy-wide context, with agricultural policies a component of the overall policy mix. The elements of an appropriate strategy are discussed in the next section.

#### **1.4. A strategic framework for strengthening rural incomes and facilitating smallholder adjustment**

50. In proposing a strategic framework for strengthening rural incomes it is helpful to make a distinction between the short to medium term issue of how best to support incomes, reduce poverty and tackle food insecurity (beyond immediate questions of humanitarian relief), and deeper long term questions regarding how best to promote economic development. There may be a connection, with programmes that are effective in the short term sowing the seeds for longer term development, but there may equally be trade-offs, so it is conceptually helpful to keep consider the issue of social policy separate from that of development policy.

51. At the same time, a long term strategy for development needs to acknowledge the inevitability of the sectoral, spatial and institutional transformations that accompany economic development. This means acknowledging the inevitability of structural change and the need for policies that smooth adjustment across each of its dimensions. The strategy proposed below consists of: (i) enabling smallholders to become competitive or boost their incomes from other sources (diversification or exit); (ii) promoting a broader rural development strategy that does not focus exclusively on agricultural development, but seeks to create a more diversified rural economy; and (iii) strengthening institutions with a view to reducing the need for second best instruments.

52. *This section considers the role of alternative policy instruments with respect to both short term and long term objectives. The discussion is preliminary, and identifies some of the pros and cons of using alternative policies in conceptual terms. With respect to agricultural policies, the balance of these arguments will be explored more thoroughly in the next phase of the analysis.*<sup>7</sup>

##### **1.4.1. Short-to-medium term policy considerations**

53. The optimal way of addressing short term social objectives is with social policies. In countries with developed systems of social protection, agricultural policies are relatively poor at providing social protection. In the first place, a significant share of the benefits to farmers from agriculture-specific measures such as price supports and input subsidies “leaks” to unintended recipients such as providers of purchased inputs or non-farming landlords or is incurred as deadweight efficiency losses (OECD, 2003). Second, the use of such instruments typically has perverse distributional effects, with larger farmers benefiting more than smallholders. A third reason is that it is difficult to target such measures for both practical administrative and political economy reasons. For example, it is difficult to restrict price guarantees to smaller farmers without using a deficiency payment system (in which case other forms of social payment must surely be feasible), or to limit fertiliser subsidies to those who would not otherwise purchase fertiliser.

54. Across a range of developed and developing countries, population-wide social safety nets have been used to the incomes of rural households. In developing countries, conditional cash transfers (CCTs) have become particularly popular over the past decade. These programmes transfer cash to generally poor households on the condition that they make pre-specified investments in the human capital of their

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7. One component of the more formal analysis is the evaluation of the welfare and distributional impacts of alternative agricultural policies using a rural general equilibrium model which is described in Part 2.

children. CCTs have been found to be effective at increasing consumption levels among the poor, and have led to behavioural changes, although their impact on *final* outcomes in health and education has been less clear (Fiszbein and Schady, 2009). This may be due to the need for CCTs to operate in conjunction with complementary investments (*e.g.* in schools and hospitals). An issue with CCTs is when the “conditional” element is warranted. For example, it may not be worth incurring the monitoring and enforcement costs associated with the condition that parents put their children in school if they would do that anyway.

55. In the poorest countries, however, it has been argued that the necessary institutions and infrastructure do not exist for cash-based instruments to be appropriate, and second-best arguments (*i.e.* those which necessitate market distortions) have been advanced to justify the use of agricultural policies such as price supports and input subsidies. For example, there may be no registry or information base by which to establish criteria of eligibility; remote farmers may not have a convenient way of spending cash; and – with weak institutions – such programmes may be particularly susceptible to corruption.

56. The case for systemic price support is weak. Aside from the standard shortcomings of such policies described above, price support is particularly ineffective in agriculture-dependent economies, as amongst the poor there are both net buyers and net sellers of food, and many (perhaps the majority of) farm households may in fact be net buyers. However, the case for some form of price stabilisation is considerably stronger. The difficulties of designing price stabilisation programmes are well known. Formal (*ex ante*) price stabilisation induces moral hazard, with agents failing to mitigate risk, and price stabilisation can easily turn into systemic price support or suppression, depending on political pressures. Price stabilisation programmes have also proven to be costly and often financially unsustainable (Anderson and Roumasset, 1996). Yet in the short term there may be no other way of containing the impact of adverse price shocks on poverty and food security than by seeking to offset those impacts directly (for example by releasing/buying stocks, or by changing tariffs). Indeed, *ad hoc* (and *ex post*) intervention in genuinely extreme circumstances might be the best way of protecting incomes while limiting the disincentives for individuals to protect themselves against risk.

57. Input subsidies have also been suggested as a way (possibly the only way) of targeting the incomes of poor farmers, with the attraction (when markets are insulated) of lowering prices to consumers too. A host of difficulties of using input subsidies have been acknowledged. The inevitability of leakages to other agents in the supply chain, and the difficulties of targeting have already been noted. In addition such measures may crowd out the development of private input markets, may lead to the over-use of inputs, and once introduced have historically proven difficult to rescind. Nevertheless, there has been renewed optimism that a new generation of so-called “smart” subsidies, by virtue of innovative design features, such as exit strategies, can deliver income benefits while limiting their known shortcomings (Dorward, 2009).

58. An additional (and sometimes dominant) argument that has been used for input subsidies, and to a lesser extent for price support, is that it acts as a bridge to longer term development, creating a surplus among farmers that can initiate the agricultural transformation described earlier. This argument, a justification for the policy focus on smallholder development, starts from the premise that economic development has to start with improving the profitability of existing structures. From a conceptual point of view, this argument needs to be kept separate from the short-term rationale for intervention. Over the longer term, policy makers need to consider *why* farmers are not competitive. This may be because of high transaction costs, for example due to poorly developed road systems, or market failures, such as the absence of functioning credit markets. The optimal policy solution would be to reduce transaction costs, via suitable investments and thereby correct market failures directly – in other words, treat the causes of a lack of competitiveness rather than the symptoms. However, such structural policies take time to pay-off, so direct support for smallholder development (with an emphasis on input subsidies) has similarly been advanced as a second-best alternative. In the case of the poorest of economies, this second-best component

may be part of a much broader package of specific help to improve farmers' competitiveness. Ideally, long-term development policies should be able to discriminate between those who are potentially viable in the sector and those who are not, creating improved competitive conditions for the former and facilitating adjustment via diversification or exit for the latter. Generalised agricultural policies, such as price support or sector-wide input subsidies, cannot do this. Indeed they run the risk of impeding structural adjustment.

#### ***1.4.2. Long-term priorities***

59. Elements of a long term strategy for agricultural development, with a focus on smallholder adjustment, are set out in Table 1.2. Smallholder adjustment here is understood to be the optimal path to higher long-term income, be that improved competitiveness within the sector, income diversification (from agricultural or non-agricultural sources), or exit to other sectors. Adjustment pathways are described in the columns, and policy instruments in the rows. The first column (improving competitiveness within agriculture) applies to farm households only, but the other columns may apply to both farm households and salaried (often "landless") worker households. Note that the adjustment pathways (columns) are not mutually exclusive: for example, one household member can enhance the farm's competitiveness while another provides off-farm income. Also, the instruments (rows) do not exhaust all possible policies, but focus on those with persuasive arguments.

**Table 1.2. Strategic framework for smallholder adjustment**

<i>Policy instrument</i>	<b>Help farmers become more competitive within agriculture</b>	<i>Adjustment pathway</i>			<b>Social protection for those unable to adjust</b>
		<b>Diversify income sources</b>		<b>Leave the sector for off farm work</b>	
		<b>Within agriculture</b>	<b>Outside agriculture</b>		
<b>Price policies</b>	Treats symptoms of uncompetitiveness rather than causes	May impede adjustment			Price stabilisation proposed as a 2 <sup>nd</sup> best safety net
<b>Input subsidies</b>	Treats symptoms of uncompetitiveness rather than causes		May impede adjustment		Proposed as 2 <sup>nd</sup> best instrument for the poorest countries
<b>Credit policies</b>	May correct market failures	Indirect impacts			
<b>Investment in human capital</b>	Minor effects of formal education for this generation; technical training more appropriate for productivity.	Can help farm family members and rural workers move into skilled jobs	Important for farm family members and rural workers	Important for managing inter-generation change	
<b>Investment in infrastructure</b>	Helps with market integration	Helps improve local job opportunities		Can ease migration decisions for offspring	
<b>R&amp;D and extension</b>	Public and private sector important; gains from adoption and adaptive research.	Can expand agricultural employment			
<b>Labour market reforms</b>		Important for raising employment opportunities and wage incomes			
<b>Cash transfers (possibly conditional)</b>				Conditional school attendance may complement investments in schools	Preferred policy for those unable to adjust.
<b>Regional policies</b>	Important for improving market integration	Expanded non-farm activity would raise farm wages	Important for building a diversified rural economy with wider job opportunities		
<b>Develop producer associations</b>	Reduce transaction costs and help exploit economies of scale	Indirect impacts			
<b>Land policies and property rights</b>	Need to encourage rental markets and facilitate land purchases by small farmers			Secure property rights and rental markets can ease exit decisions	

*Improving the competitiveness of farm households*

60. In respect of farm households, it is important to have a realistic view of which farmers have the potential to succeed commercially within the sector. In some regions agro-ecological conditions may be such that farming may not be inherently commercially viable. More generally, the appropriate adjustment pathway may depend on the basic type of farming system. For example, in East and Southern Africa the scope for agricultural growth in areas where a mixed maize and cash crop system dominates is inherently



stronger than the potential in areas where rainfed sorghum and millet combine with pastoral agriculture (Dixon *et al.*, 2001). Yet even when agro-ecological conditions are inherently favourable, the nature of structural change is such that farm operations tend to consolidate into fewer and more efficient enterprises, and some farmers will leave the sector.<sup>8</sup>

61. Given the need to acknowledge that some farmers will succeed while others will not, and the impossibility of identifying exactly which farmers fall into each category, main role for policy would appear to be in providing public goods that can improve competitiveness, but impose few distortions to incentives at the margin, such as investments in rural infrastructure, skills and training, and R&D.<sup>9</sup> Such investments are unlikely to crowd out the development of other activities and potential income streams, although they are likely to accelerate the shake-out between more and less competitive farmers. Most of the relevant expenditures would need to be made at the economy-wide or sectoral level rather than in the form of payments to individuals. A further role for policy is when there are endemic market failures, for example in credit markets. Access to credit is important for smallholders, and private credit markets may find it not worth their while to engage with smallholders, simply because of their size and the difficulties of becoming informed about the creditworthiness of many small operations.

62. In many developing countries land rental markets function poorly or do not exist at all. The development of rental contracts can help compensate for market failures, provide flexible responses to economic and productive incentives, allow farmers to invest in farming capital, and help the poor and young gain access to land under conditions that are less demanding than those required to participate in land sales markets. Renting land may also be a first step to future land acquisition. The underdevelopment of rental markets may prevent the consolidation of land into more productive units, thus impeding agricultural investment and making it more difficult for uncompetitive farmers to diversify out of the sector.

#### *Income diversification for farm households and salaried agricultural workers*

63. Income diversification is essential for many farm households. For the poorest farm households, this is likely to provide some insurance and is in effect a “coping” strategy. For other farm households, having one or more family members draw income from outside agriculture may be the start of a successful move into more remunerative activities. Policies that support farm income alone, such as market price support, act as a disincentive for income diversification outside agriculture, and create an obstacle to one of the key “adjustment pathways”. The key policies required to help households diversify their income sources are again those that improve human capital. Regional development policies, including the development of rural infrastructure, may also have an important role.

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8. Poulton and Wiggins (2005) present some evidence of declining farm sizes in developing countries, mostly for countries where the average farm size is a hectare or less. This is more likely to represent a fragmentation of operations, for example due to inheritance laws and property rights systems, than it is the relative efficiencies of small farms (*e.g.* ease of labour supervision; local knowledge) versus larger operations (knowledge of markets and technology; access to credit and inputs; ease of risk management; ability to assure quality).

9. There is evidence to suggest that improvements in agricultural productivity have a strong effect in reducing poverty (Irz *et al.*, 2001). There is also evidence that agricultural growth has helped support broader economic growth (for example, Tiffin and Irz, 2006), although agriculture’s role as a necessary driver of development has been questioned (Gardner and Tsakok, 2008).

### *Leaving the sector for skilled employment*

64. Ultimately, the majority of smallholders in developing countries will have stronger prospects outside the agricultural sector than within it. The most important need, if not for this generation then for the next, would therefore appear to be investment in the education and skills that would enable households to obtain higher wages.

65. Regional development programmes, by targeting economic assistance to less developed regions, may also have a role in bringing jobs to people (rather than the other way round) and so can prevent the problems associated with mass migration into cities. However, rural policies are not fundamentally agricultural policies (nor vice versa). Regional policies can boost development within and outside agriculture, but without biasing household decisions about how best to invest for the future.

66. In many middle income countries the conditions of salaried agricultural work are at least as important as the development of small scale farm entrepreneurs. In Chile, for example, two-thirds of all households receiving the majority of their income from agricultural sources are salaried workers, not farmers. Labour market policies have an important role in ensuring that core standards of employment are met, while improved labour market flexibility has been suggested as a way of reducing informality (OECD, 2008).

### *Social policies*

67. Many poor households, notably older ones, face severe limitations in their adjustment potential, irrespective of the policies that are in place (for example, resource poor and post retirement age farmers). Hence there is always a need for social programmes. Investments in human capital (notably education) and measures such as contingent cash transfer can ensure that the next generation makes a quantum leap in terms of development.

## **1.5. Conclusions**

68. This section of the report has pointed to the inevitability of structural change in the agricultural and rural economy, the consequent implications for adjustment among smallholders, and the associated need for policies that facilitate rather than impede that process. A strategic framework has been proposed to assist policy makers in choosing the appropriate mix of policy instruments.

69. A key premise of that framework is that, for the majority of agriculture-dependent households, the long term (*i.e.* inter-generational) future lies outside the sector. Hence, policies need to make a distinction between those who potentially have a competitive future in the sector and those who do not. For both types of development path, many of the necessary policies will not be agriculture-specific, so it is important that agricultural policies are framed in a broader economy-wide framework.

70. Justifications for the use of agricultural market interventions (either in output or input markets) rely on second best arguments: they do not provide a theoretically optimal way of providing social protection (where social safety nets are to be preferred); nor, in the absence of market failure, are they the ideal way of fostering growth, since they treat the symptoms of a lack of development rather than its underlying causes. By contrast, the provision of public goods (including investment in agricultural research) is not just theoretically superior but of proven value.

71. Nevertheless, plausible reasons have been advanced for why, given weak institutions, high transactions costs and endemic market failures, some agriculture-specific interventions might be desirable. For such arguments to be properly substantiated, there needs to be a clear distinction between short-term imperatives related to incomes and poverty, and long term development goals, and a recognition that there

may be trade-offs as well as complementarities between the two. For example, input subsidies may have an immediate pro-poor impact but ultimately impede agricultural development. These arguments will be explored in the second phase of the project. One particular issue which needs to be investigated is the short to medium term welfare and distributional impacts of alternative policies. These are to be investigated with a rural economy-wide model, the basic structure of which is presented in Part 2 of this report.

72. The strategic framework presented in this paper seeks to order an analysis of which types of policies are most appropriate for smallholder farmers and can contribute to faster progress on MDG1. It also attempts to delineate the role and limitations of agricultural policies in particular. A central conclusion is that it is the *policy mix* that matters, so empirical analyses of policy effectiveness need to take account of possible complementarities and trade-offs between alternative agricultural and non-agricultural instruments. The former may include the complementarities between agricultural extension and the development of infrastructure and broader investments in human capital; the latter, the opportunity cost of using different expenditure mechanisms (*e.g.* providing input subsidies versus making longer term investments in rural roads or in non-agricultural areas such as health and education). A more formal analysis of these linkages is also planned for the next phase of analysis.

## REFERENCES

- Abbot, P. (2009), "Development Dimensions of High Food Prices", Paper prepared for OECD.
- Adelman, I. (1999), "The Role of Government in Economic Development", University of California, Berkeley, Working Paper No. 890.
- Anderson, J. and J. Roumasset (1996), "Food Insecurity and Stochastic Aspects of Poverty", *Asian Journal of Agricultural Economics*, Vol. 2, No. 1, pp. 53-66.
- Anderson, K., E. Jara, M. Kurzweil, D. Sandri and E. Valenzuela (2008), *Distortions to Agricultural Incentives: A Global Perspective, 1955 to 2007*, Working Paper. DECRG-TR, World Bank, Washington, DC.
- Bezemer, D. and D. Headey (2008), "Agriculture, Development, and Urban Bias", *World Development*, Elsevier, Vol. 36(8), pages 1 342-1 364, August.
- Cervantes-Godoy, D. and J. Brooks (2008), "Smallholder Adjustment in Middle-Income Countries: Issues and Policy Responses", OECD Food, Agriculture and Fisheries Working Papers, No. 12, OECD, Paris.
- Chen, S. and M. Ravallion (2008), "The Developing World is Poorer Than we Thought, but No Less Successful in the Fight Against Poverty", Policy Research Working Paper Series 4 703, The World Bank.
- de Soysa, I. and J. Jütting (2007), "Informal Institutions and Development: How They Matter and What Makes Them Change", in J. Jütting, D. Drechsler, S. Bartsch, and I. de Soysa (Eds.), *Informal Institutions: How Social Norms Help or Hinder Development* (pp. 29–44). Paris: OECD Development Centre.
- Dixon, J., A. Gulliver and D. Gibbon (2001), *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*, FAO and World Bank, Rome and Washington, DC.
- Dorward, A. (2009), "Rethinking Agricultural Input Subsidies in a Changing World", Paper prepared for the Food and Agriculture Organisation of the United Nations.
- Easterly, W. (2008), "Planners vs Searchers in African Agricultural Aid", FAO Pro-Poor Livestock Policy Initiative, FAO, Rome.
- FAO (1999), *Improving the Income of Farmers and Rural People*, Rome.
- Fiszbein, A. and N. Schady (2009) *Conditional Cash Transfers: Reducing Present and Future Poverty*, World Bank Publications, Washington, DC.
- Gardner, B. and I. Tsakok (2007), "Agriculture in Economic Development: Primary Engine of Growth or Chicken and Egg?", *American Journal of Agricultural Economics*, 89(5), pp. 1 145-1 151.
- GDPRD (2009), *The Food Price Crisis and the Global Food Security Challenge*, Bonn: Global Donor Platform for Rural Development.
- Haggblade, S., P. Hazell, and T. Reardon (2007), "Introduction", in S. Haggblade, P. Hazell, and T. Reardon (Eds.), *Transforming the Rural Nonfarm Economy: Opportunities and Threats in the Developing World* (pp. 3–24), Baltimore: The John Hopkins University Press.

- IMF (2008), IFS International Financial Statistics Online, [www.imfstatistics.org/imf/logon.aspx](http://www.imfstatistics.org/imf/logon.aspx).
- Irz, X., S. Wiggins and C. Thirtle (2001), "Agricultural Productivity Growth and Poverty Alleviation", *Development Policy Review*, 19, pp. 449–466.
- Ivanic, M. and W. Martin,(2008), "Implications of Higher Global Food Prices for Poverty in Low-Income Countries", Policy Research Working Paper Series 4594, The World Bank.
- Johnson, D.G. (2000), "Population, Food and Knowledge", *American Economic Review*, 90(1), pp. 1-14.
- Johnston, B. and J. Mellor (1961), "The Role of Agriculture in Economic Development", *American Economic Review*, 51, pp. 566-593.
- Jonasson, E. (2009), *Labor Markets in Transformation: Case Studies of Latin America*, Lund Economic Studies, Number 155.
- Kim, H. and Lee, Y.K. (2003), "Agricultural Policy Reform and Structural Adjustment: Historical Evidence from Korean Experience", Policy Reform and Adjustment Workshop, October 23-25, 2003, Imperial College London, Wye Campus.
- Krueger, A.O., M. Schiff and A. Valdés (1991), *The Political Economy of Agricultural Pricing Policy*, Baltimore: Johns Hopkins University Press for the World Bank.
- Martin, W. and D. Mitra (2001), "Productivity Growth in Agriculture and Manufacturing", *Economic Development and Cultural Change*, 49(2), pp. 403-23.
- Mitra, A. and M. Murayama (2008), "Rural to Urban Migration: A District Level Analysis for India", IDE Discussion Paper No. 137, Institute of Developing Economies.
- North, D. (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge: Cambridge University Press.
- OECD (2003), *Farm Household Income: Issues and Policy Responses*, OECD, Paris.
- OECD (2008), *OECD Review of Agricultural Policies: Chile*, OECD, Paris.
- OECD (2009), *Agricultural Policies in Emerging Economies*, OECD, Paris.
- Poulton C. and S. Wiggins (2005), "The Future of Small Farms Achieving Pro-Poor Growth through Agriculture: the Challenges", Presentation at Overseas Development Institute, [www.odi.org.uk/events/FutureAgricultures\\_2005/meeting\\_2dec/ifpri\\_files/frame.html](http://www.odi.org.uk/events/FutureAgricultures_2005/meeting_2dec/ifpri_files/frame.html).
- Tiffin, R. and X. Irz (2006), "Is Agriculture the Engine of Growth?", *Agricultural Economics*, 35(1), pp. 79-89.
- Timmer, P.C. (1998), "The Agricultural Transformation", in Carl K. Eicher and John M. Staatz (ed.), *International Agricultural Development* (pp. 113-135). Baltimore: Johns Hopkins University Press.
- Wagner, F. E. and J. O. Ward (1980), "Urbanization and Migration in Brazil", *American Journal of Economics and Sociology*, 39(3), pp. 249–259.
- WDI (2008), World Bank Development Indicators, <http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=6>.
- World Bank (2007), *World Development Report 2008: Agriculture for Development*, Washington, DC.

**PART 2. MODELLING THE DISTRIBUTIONAL IMPACTS OF AGRICULTURAL POLICIES  
IN DEVELOPING COUNTRIES:  
THE DEVELOPMENT POLICY EVALUATION MODEL (DEVPEM)**

**2.1. Introduction**

73. The purpose of the Development Policy Evaluation Model (DEVPEM) is to provide an appropriate modelling structure for analysing the welfare and distributional implications of alternative agricultural policies in developing countries. The aim of the model is to provide illustrative results that show how structural diversity among developing countries, and systemic differences from developed OECD countries, can affect the outcomes of alternative policy interventions. The model is relatively stylised, seeking to capture, as simply as possible, four critical aspects of rural economies in developing countries that are important when evaluating the impacts of agricultural and trade policies. These are:

- (1). The role of the household as both a producer and a consumer of food crops.
- (2). High transaction costs of participating in markets, resulting in a subsistence sector that often is important in terms of the number of households and the amount of food production it encompasses.
- (3). Market linkages that can transmit impacts of policy and market shocks among heterogeneous rural producers and consumers, particularly via factor markets (for labour, land or capital, when those markets exist).
- (4). The imperfect convertibility of land from one use to another.

74. OECD already has a model – the Policy Evaluation Model (PEM) – that is used to examine the effects of agricultural policies in member countries. PEM captures some of the market linkages referred to above (3), and a major strength lies in its treatment of land use (4). However, it contains no explicit recognition of (1) and (2). In building upon the PEM to account for these features, the aims of DEVPEM are to account for some of the systemic differences that are important in developing countries and to show how these differences can affect the results of specific policy interventions. As with PEM, the results of DEVPEM should be seen as illustrative of potential outcomes rather than predictive.

75. A detailed motivation for the modelling approach and a justification for focusing on the above features in a developing country context are provided in Brooks, Dyer and Taylor (2008). The model takes as its unit of analysis the agricultural household, as in the seminal work of Singh *et al.* (1986). This “building block” makes it possible to capture (1) and (2) above, the latter by having household farms confront a “price band,” defined by the market price plus (minus) the per-unit costs of transacting in consumption (output) markets, as in Strauss (1986) and de Janvry *et al.* (1991). Heterogeneous households are then embedded in a rural economy-wide structure in order to capture (3), as in Taylor *et al.* (2005). The specific modelling of land allocation adopted in the PEM is retained in order to address (4), with a constant elasticity of transformation function capturing the imperfect convertibility of land between agricultural and livestock activities (OECD, 2005). The model is static, which means that it can be used to analyse the short to medium term impact of policy interventions on economic welfare and related indicators, such as

incomes, poverty and inequality. However, there are no dynamics, so the longer run implications for growth and development cannot be gauged using this model.

76. A prototype model is presented for one country (Malawi), together with some preliminary policy simulation results. The aim is to develop six country models in total, with two countries from Africa (Ghana and Malawi); two from Asia (Bangladesh and Vietnam); and two from Latin America (Guatemala and Nicaragua). The choice of countries is tentative and has been driven by two main considerations: first the need to reflect structural differences across countries and regions, and second the availability of harmonised and comparable household level data. The basic data input for DEVPEM is a disaggregated social accounting matrix (SAM) with individual accounts for each rural household group in the model, as well as household-specific activity accounts. The SAM is constructed with data from the United Nations Food and Agricultural Organisation's Rural Income Generation Activities (RIGA) database, which processes and harmonises national survey data, together with data from the FAOSTAT database. Indeed, DEVPEM has been designed explicitly to exploit the harmonised household level data that are available in the RIGA datasets.

77. Section 2.2 presents the model in its most general form. We begin in Sections 2.2.1 and 2.2.2 by assuming an environment of well functioning markets, as in the PEM. This is useful in illuminating the key differences between the firm-based PEM and the household-based DEVPEM when markets work well. In Section 2.2.3, we introduce transaction costs, which reflect market imperfections and result in some prices, for some household groups, diverging from market prices. Section 2.2.4 presents a simple estimable version of the model, which can be solved analytically. We also describe the structure of the SAM that will constitute the data input for DEVPEM. Section 2.3 describes the calibration of parameters in the consumption, production, and land supply functions, as well as the estimation of transaction costs. In Section 2.4, we describe a first prototype of the DEVPEM, with an application for Malawi. Simulations of price changes and input subsidies are discussed. Section 2.5 concludes the modelling exercise and discusses the next steps in the project.

## 2.2. The theoretical foundation of the DEVPEM

78. Here, we present the model without making assumptions on the specific functional forms. We first present the benchmark agricultural household model, in the spirit of Singh, *et al.* (1986). We then explain how imperfect land supply and transactions costs can be added to such a model.

### 2.2.1. Benchmark model with perfect markets

79. We assume an economy portrayed by a single representative household. There are  $N$  items in the economy, which for the household can be consumption goods, factors of production, or both (as in the case of household time endowment and the labour/leisure choice). Though in practice many items will either only be consumed, only be produced, or only used as factors, we keep a general notation for all items.

80. The household derives utility from consumption ( $C$ ) of items  $i$  ( $i \in I = \{1, \dots, N\}$ ). Consumption is zero for goods which cannot be consumed (such as land, for example, or fertilizer). Maximum utility is given by:

$$U^* = \max_C \{U(C)\} \quad (1)$$

where  $C$  is the  $(1 \times N)$  vector of goods and factors. The household has initial endowments  $E = \{E_i, i=1, \dots, N\}$ , each of which can be used in farm production, marketed, or consumed, as in the case of leisure. Farm production involves the use of factor endowments and product-specific intermediate inputs.

Let  $Q_{ik}^f ((i, k) \in I^2)$  be the quantity of item  $k$  used in the production of item  $i$  (superscript  $f$  indicates the factor is used on the farm), so that the production of good  $i$  depends on the  $(1 \times N)$  vector  $Q_i^f$  of inputs:

$$Q_i = Q_i(Q_i^f), \quad (i = 1, 2, \dots, N) \quad (2)$$

81. Denote  $Q_i^b$  as the quantity of item  $i$  bought on the market and  $Q_i^s$  as the quantity sold. The market balance for each item requires that the sum of endowments and total quantities produced or bought equals the sum of total quantities consumed, sold, and used as input in production:

$$E_i + Q_i + Q_i^b = C_i + Q_i^s + \sum_{k=1}^N Q_{ik}^f \quad (3)$$

82. Prices for goods and wage rates for factors are all given by the  $(N \times 1)$  price vector  $p$ . As long as all markets work seamlessly and are connected with the rest of the world, all prices are market prices, exogenous to the household economy. As a producer, the household, as the pure agricultural firm in the PEM (OECD, 2005), takes market prices as given and makes production decisions to maximize profit. Maximum profit ( $\pi^*$ ) from production of each farm good  $i$  is given by:

$$\pi_i^*(p) = \max_{Q_i^f} [p_i Q_i(Q_i^f) - p \cdot Q_i^f] \quad (4)$$

83. The household is constrained in its consumption by its farm profits and incomes from marketed factors of production. The cash constraint is expressed as:

$$\sum_{i=1}^N p_i Q_i^b = \sum_{i=1}^N p_i Q_i^s \quad (5)$$

84. Using equation (3), which we multiply by  $p_i$  and sum over  $i$ ; then using equations 4 and 5 we can write the “full income” constraint as:

$$pC = \pi^* + pE \quad (6)$$

85. In other words, the total value of goods consumed (from own production or purchased) evaluated at market prices is equal to the sum of all profits and the total market value of all endowments (also called “full income”). This is similar to the treatment of income in the agricultural household models of Singh, *et al.* (1986) and others, in which markets are assumed to work efficiently and the prices households face are determined in those markets.

86. Despite the dual nature of the household as a producer-consumer, as long as all prices are exogenous the household solves the consumer problem and the producer problem independently (Löfgren and Robinson, 1999; Singh, *et al.*, 1986; Taylor and Adelman, 2003). The household can be pictured as first maximizing its total income as a producer, given prices of inputs and outputs, and then using that income to maximize its utility, given prices of consumption goods. The profit maximization problem gives the farm output supply functions,



$$Q_i^* = Q_i(\mathbf{p}) \quad (7)$$

where  $\mathbf{p}$  denotes the exogenous vector of prices of all inputs. This solution determines the profit  $\pi^*$  and thus the full income  $y^*$ . The solutions to the utility maximization problem provide the consumer goods demand functions,

$$C_i^* = C_i(\mathbf{p}, y^*), \quad (i = 1, 2, \dots, N) \quad (8)$$

87. For each good, the surplus  $Q^*-C^*$  determines whether the household is a seller (positive surplus) or buyer (negative surplus) of the good. The same idea applies for supply and demand of factors of production.

88. In a highly commercialized agricultural economy, the consumption decisions of agricultural households have little or no impact on production or on the amount of production that enters the market. Thus it is not unreasonable to ignore them and treat agricultural production as coming from agricultural firms, as is done in the PEM. When dealing with less developed agricultural economies, however, ignoring the consumption side may seriously undermine a model's predictive power. In a context where rural households consume a large part of their agricultural output, an increase in prices has two effects: on the producer side, the household reacts as a firm and increases output; on the consumer side, the standard ambiguity between income effects and substitution effects holds. The final consumption and production decisions can differ widely from those predicted by an agricultural firm model. For example, an increase in the price of an agricultural commodity may lead to an increase in production almost fully absorbed by a similar increase in consumption: the marketed surplus effect predicted by an agricultural firm model would, in that case, be significantly overstated (Singh, *et al.*, 1986).

89. DEVPEM integrates several household models into a general equilibrium framework. Accounting for interactions among households with different asset holdings, production technologies and consumption patterns makes it possible to uncover complex responses to market shocks and heterogeneous welfare outcomes. When the agricultural economy consists of widely different actors (*e.g.*, large commercial farms, commercial smallholders and subsistence producers) unexpected outcomes can occur through the interplay of labour, land and other markets. Such can be the case when smallholders depend on commercial farms for a significant part of their income, and commercial farms rely on labour supplied by smallholders (Dyer, *et al.*, 2006).

90. This focus on heterogeneous households brought together within a general equilibrium model is the most radical difference between DEVPEM and PEM. There are, however, other differences as well as similarities between the two approaches. One important similarity is the treatment of land markets, which is a key feature of the PEM adopted into the DEVPEM.

### 2.2.2. Imperfect land transferability

91. The model just described assumes that all markets work perfectly. Many agricultural household models, however, assume that land is a fixed input in each production activity. That is,  $Q_{iT}^f = \bar{Q}_{iT}^f$  for all production activities  $i$  ( $T$  being the subscript for land). This assumption may be appropriate in the very short run, but it does not permit land to be reallocated across activities, as is likely to occur in response to policy changes. If a household's total land endowment is given but this land is perfectly transferable from one use to another, the activity-specific land constraints ( $Q_{iT}^f = \bar{Q}_{iT}^f$ ) are replaced by a total household land endowment constraint,

$$E_T = \sum_{i=1}^N Q_{iT}^f \quad (9)$$

which is a special case of the market balance stated in equation (3), with purchased, sold, produced and consumed quantities of land all constrained to zero.

92. The PEM recognizes that land may be transformable from one use to another, albeit imperfectly. Imperfect transformability of land among uses can be represented by replacing equation (9) with a continuous and convex land supply function  $S$  replacing the linear constraint on land:

$$E_T = S(Q_T^f) \quad (10)$$

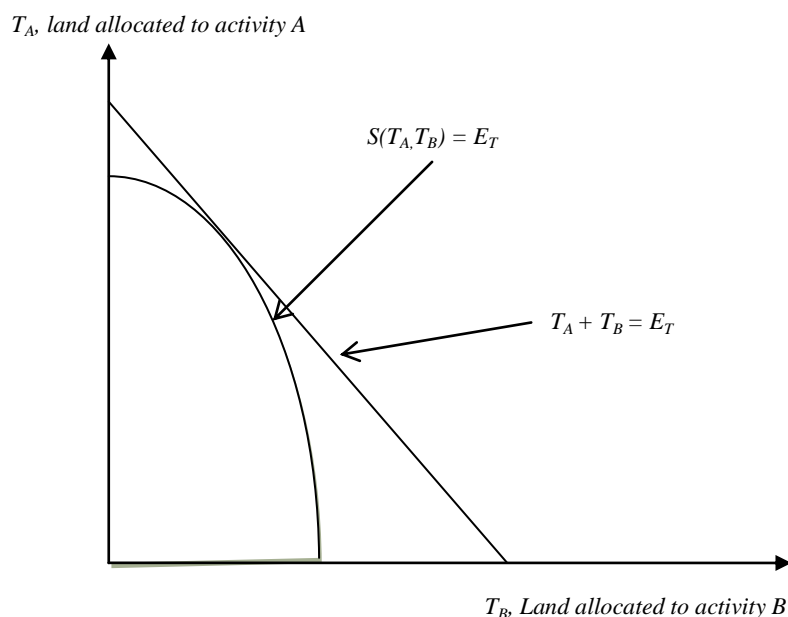
The difference between the linear and non-linear forms is illustrated in Figure 2.1.

93. It can be shown that under those additional constraints, the optimal amount of land supplied to the production of any pair of goods,  $i$  and  $j$ , will satisfy:

$$\frac{P_i \frac{\partial Q_i}{\partial Q_{iT}^f}}{P_j \frac{\partial Q_j}{\partial Q_{jT}^f}} = \frac{\partial S}{\partial Q_{iT}^f} \quad (11)$$

Equation (11) expresses that the ratio of marginal value products of land in different uses must be equal to the marginal rate of transformation of land from one use to the other. Note that when  $S$  is a simple summation function (as in equation (9)), this optimality condition reduces to the well-known equalization of marginal value products condition.

**Figure 2.1. Linear versus non-linear land supply. In the non-linear case, the maximum amount of land available for activity A and for activity B may differ.**



### 2.2.3. Accounting for transaction costs

94. The treatment of market transaction costs is a key aspect in which DEVPEM differs from PEM (and from most general equilibrium models). DEVPEM explicitly models the effects of transaction costs and endogenous market participation.

95. In Section 2.2.1 we described the household as making production and consumption decisions independently. This separability property of the utility- and profit-maximization problems relies on the assumption that all prices are exogenous to the household. As soon as the subjective value that the household places on a good (*i.e.* the “shadow price”) deviates from the market price, separability no longer holds. If a household lacks access to a market, or if it faces transaction costs so high that it withdraws from the market (the case of a subsistence producer), the shadow price is determined by the intersection of the household’s internal demand and supply functions.

96. Under what circumstances will the household choose autarky over market participation for a certain good? This generally is not an important question for developed countries (such as those modelled in the six country PEM), where most agricultural households do not consume a significant share of their own production. In developing countries, however, large distances and a lack of infrastructure can result in non-competitive market structures, imperfect information, and high costs of transportation, all of which can create an environment in which transaction costs are high and many households live in partial or total autarky.

97. The DEVPEM model assumes that the household faces an  $(N \times 1)$  vector of unit transaction costs  $t^b$  as buyers of consumption goods or production factors. As producers, they face an  $(N \times 1)$  vector  $t^s$  of transaction costs for selling their goods or tradable factors.

98. Faced with transaction costs on the consumption side, the household’s decision price increases from  $p^m_i$  to  $p^m_i + t^b_i$  ( $i = 1, 2, \dots, N$ ; superscript  $m$  added to prices to indicate the exogenous market price).

This reduces the consumption possibilities of the household for these items. Faced with transactions costs in output markets, the producing household perceives a wedge between market and farm gate price, such that the decision price decreases from  $p_i^m$  to  $p_i^m - t_i^s$ . A household's decision price thus depends on its trading status for the particular good or factor. In particular, the decision price for good  $i$  is given by:

$$p_i = \begin{cases} p_i^m - t_i^s & \text{if } Q_i^s > 0 \\ p_i^m + t_i^b & \text{if } Q_i^b > 0 \\ \tilde{p}_i & \text{if } Q_i^s = Q_i^b = 0 \end{cases} \quad (12)$$

where  $\tilde{p}$  denotes the household's internal shadow price. When the household neither buys nor sells, the shadow price is disconnected from the market price and is determined by the intersection of household supply and demand. Because the decision price is endogenous (though constrained within exogenous bounds), consumption and production decisions are inseparable from one another.

99. Aside from the price determination equation (12), transaction costs do not impose any additional restrictions on the model described by equations (1) through (6). Full income (equation (6)) can simply be re-labelled as "shadow income," since the decision price vector  $p$  is now a vector of shadow prices rather than market prices. Market participation for item  $i$  is determined by comparing the utility obtained from selling, buying, and remaining self-sufficient for that item (Key, *et al.*, 2000). Key *et al.* note that whereas the determination of market participation for a good "may become quite cumbersome when there are several commodities that can be either purchased or sold, the principle can be shown with a simplified model in which there is choice of regime for only one commodity which is produced and consumed by the household (*e.g.*, a food crop)" (p. 248).

100. Let  $V(p, y)$  denote the indirect utility of this commodity, where  $p$  is the decision price and  $y$  is household income. The utility levels to compare are:

$$V^s = \begin{cases} V[p^m - t^s, y(p^m - t^s)] & \text{if seller,} \\ V[p^m + t^b, y(p^m + t^b)] & \text{if buyer} \\ V[\tilde{p}, y(\tilde{p})] & \text{if autarkic.} \end{cases} \quad (13)$$

The lowest market price,  $\underline{p}^m$ , at which the household is willing to sell the good, satisfies:

$$V[\underline{p}^m - t^s, y(\underline{p}^m - t^s)] = V[\tilde{p}, y(\tilde{p})] \quad (14)$$

Similarly, the highest market price,  $\bar{p}^m$ , at which the household is willing to buy, satisfies:

$$V[\bar{p}^m - t^b, y(\bar{p}^m - t^b)] = V[\tilde{p}, y(\tilde{p})] \quad (15)$$

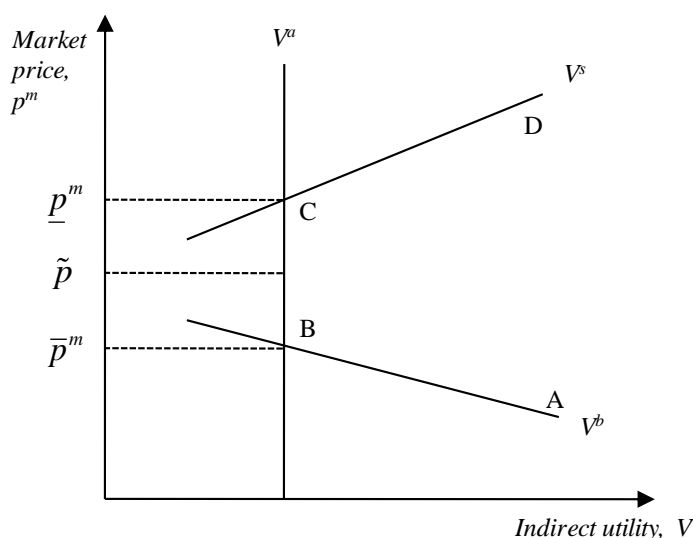
101. Figure 2.2 depicts these prices. At a market price higher than the seller price threshold  $\underline{p}^m$ , the household obtains a higher utility by being a seller than by being autarkic, shown by segment CD on the indirect utility curve  $V^s$ . At a market price lower than the buyer price threshold  $\bar{p}^m$ , the household is better off as a buyer than being autarkic, shown by segment AB on the indirect utility curve  $V^b$ . For all market

prices between the buyer price and the seller price thresholds the household is better off being autarkic, as shown by segment BC on curve  $V^a$ . The width of the “price band” – *i.e.*, the interval of market prices in which the household is better off being autarkic in the good – equals the sum of seller and buyer transactions costs:

$$\underline{p}^m - \bar{p}^m = t^s + t^b \quad (16)$$

102. It is worth noting that while this explicit accounting for the role of transaction costs may capture an important aspect of developing country agriculture, additional constraints in input markets (*e.g.*, fixed rather than proportional transaction costs, or seasonal cash or credit constraints) may impede the ability of households to respond to higher prices, even when the difference between the market price and shadow price exceeds transaction costs in the output market. One possibility is to modify the standard model to accommodate such features; a more practical option is to impose additional constraints on the model and explore their implications via sensitivity analysis.

**Figure 2.2. Indirect household utility under proportional transaction costs**



#### 2.2.4. Specification of functional forms

103. This section combines the three features discussed above in a model of a single-household rural economy with transactions costs and a sluggish land supply. Here, we specify functional forms and derive first order conditions, in order to illustrate the solvability of the model we described in the previous section.

104. For simplicity, we treat all tradable goods and factors equally, land  $T$  being the only exception, as it cannot be purchased or sold (although it can be transformed imperfectly from one use to another). Let us denote the set of tradable items  $I^- = \{1, \dots, N-1\}$ .

##### a) Consumption

105. Household welfare is described by a Linear Expenditure System (LES). This builds on a Stone-Geary utility function and assumes that there are minimum quantities below which consumption cannot

fall. It is the most frequently used system in empirical estimation of demand (Sadoulet and De Janvry, 1995). Parameters are zero for goods that are not being consumed, guaranteeing that their level of consumption will be zero in the solution. For goods consumed,  $c_i$  represents the incompressible (subsistence) consumption levels.

$$U(\mathbf{C}) = \prod_{i \in I^-} (C_i - c_i)^{\alpha_i}, \quad \text{with } 0 < c_i < C_i, \text{ and } \sum_I \alpha_i = 1 \quad (17)$$

*b) Production*

106. Production technology is described using a constant elasticity of substitution (CES) production function:

$$Q_i = \left[ \sum_{k=1}^N b_{ik} (Q_{ik}^f)^\beta \right]^{1/\beta} \quad (i \in I^-) \quad (18)$$

with known parameters  $b_{ik}$  and  $\beta$ .

*c) Market Constraints*

107. The market constraint on all items except land is of the form

$$C_i + Q_i^s + \sum_{j=1}^N Q_{ji}^f = E_i + Q_i + Q_i^b, \quad (i \in I^-) \quad (19)$$

108. As in the PEM, a constant elasticity of transformation (CET) land supply function shapes the allocation of land among production activities, as follows:

$$E_T = a_T \left( \sum_{i \in I^-} \eta_i (Q_{iT}^f)^\rho \right)^{1/\rho} \quad (20)$$

where the parameters  $a_T$ ,  $\rho$  the  $\eta$  are all known. For simplicity, we can write  $\gamma_i = (a_T)^\rho \times \eta_i$  and reduce the above equation to:

$$E_T = \left( \sum_{i \in I^-} \gamma_i (Q_{iT}^f)^\rho \right)^{1/\rho} \quad (21)$$

109. In addition, we constrain exchanged quantities to be positive:

$$Q_i^b \geq 0; \quad Q_i^s \geq 0$$

*d) Cash constraint*

110. Provided that land is the only factor for which there is no market, there exists an  $((N-1) \times 1)$  vector of market prices  $p^m$ . If households face transaction cost vectors  $t^s$  and  $t^b$  for selling and buying goods, respectively, then the cash constraint is:

$$\sum_{i=1}^{N-1} (p_i^m + t_i^b) Q_i^b = \sum_{i=1}^{N-1} (p_i^m - t_i^s) Q_i^s \quad (22)$$

### 2.3. Calibration of the model

111. The model presented above consists of a set of variables (for which we have observations) and a set of relationships among variables, defined by equations with parameters (for most of which we do not have observations). In order to make the model operational and tractable, we must calibrate it (find missing parameter values) using actual production and consumption data. The central aim of calibration procedures is to find parameter values such that the observed data represent a solution to the model. In other words, calibration consists of plugging in the observed variable values into the equations of our model to “reverse-compute” the parameter values which would have led to those observed variable values as the equilibrium solution. It is, in a sense, the mirror operation to simulations, which rely on the fixed parameter values to estimate the values of variables.

112. Our calibration procedure is based on a Social Accounting Matrix (SAM).<sup>10</sup> Computable general equilibrium (CGE) practitioners often parameterize models using SAMs because they offer a convenient framework and a simple way to use secondary data. A SAM provides a picture of all flows of money and goods in an economy in matrix form, where rows represent the incomes of economic actors and columns represent expenditures, such that row and column totals must be equal. Thus, one advantage of using a SAM is that, by construction, all cash constraints and market clearing conditions are satisfied for all accounts in the matrix. The SAM thus provides a data framework consistent with general equilibrium theory.

113. Table 2.1 provides the general structure of the SAM used to calibrate the DEVPEM model. The cells indicate which variable of DEVPEM can be read from which part of the table. The SAM is a matrix of *values* rather than quantities, but without loss of generality one can set all initial prices and rents to unity, thus implicitly converting the matrix into money-metric quantity units. Prices and rents are determined by this assumption, such that all other variables of the model appear in the SAM: quantities produced, consumed, used as factors, imported and exported. Sums along rows or columns provide us with total incomes and expenditures, total supplies and demands, all of which match to make markets clear.

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10. See Pyatt (1988) for the SAM approach to modelling, and Keuning and Ruijter (1988) for how to construct a SAM.

Table 2.1. General structure of a SAM used to calibrate the DEVPEM model

<i>Incomes</i>		<i>Expenditures</i>				
		Households	Activities for each household	Goods $i$	Factors $i$	Rest of World
Households				Factor Endowments $E_i$	Exogenous income	<b>Total Income <math>y</math></b>
Activities			Domestic production $Q_i$ (maps activities with the goods they produce)			<b>Total Production Value <math>Q_i</math></b>
Goods $j$	Household Consumption $C_j$	Intermediate inputs and			Exports of goods $Q_i^s$	<b>Total demand for goods</b>
Factors $j$		Factor demands $Q_{ij}^f$			Exports of tradable factors $Q_i^s$	<b>Total factor demand</b>
Rest of World			Imports of goods $Q_i^b$	Imports of tradable factors $Q_i^b$		<b>Total imports</b>
TOTALS	<b>Total Expenditures <math>Y</math></b>	<b>Total Production Value <math>Q_i</math></b>	<b>Total supply of goods</b>	<b>Total supply of factors</b>	<b>Total exports</b>	

### 2.3.1. Calibration of the consumption function

114. In models which use the simplest functional forms (such as the Leontiev or Cobb-Douglas forms), the SAM provides all the information needed to find all the parameters. This, however, is not the case with the linear expenditure system. The utility function assumed in (17) features  $2(N-1)$  parameters: “incompressible consumption”  $c_i$  for each good and the  $\alpha$  exponents. The former will need to be determined from LSMS data, for example using consumption values for the poorest households, or using econometric estimation techniques. We then plug in the values from the SAM into the consumption demand equation with prices set to unity and obtain:

$$\alpha_i = \frac{C_i - c_i}{\left( y - \sum_I c_j \right)} \quad (23)$$

The consumption side of the model is calibrated in this way.



### 2.3.2. Calibration of the production function

115. The calibration of CES production functions also requires that some external data be used. The production function assumed in (18) features  $N+1$  parameters:  $b_{ik}$  for all  $k$  and  $\beta$ . Since we only have  $N$  observations on input values in the data, we cannot estimate this function without additional data on one of those parameters. It is convenient to use an estimated elasticity of substitution between inputs<sup>11</sup>:

$$\zeta = \frac{1}{1-\beta}$$

116. This parameter can be estimated using various forms of log-linear regressions of value added on factor inputs and costs (McFadden, 1978), but in practice it is often borrowed from other studies because the data for direct estimation usually are lacking. Once  $\beta$  is known, calibrating the  $b_{ik}$  shares is relatively straightforward. Since we scale all prices to be equal to one, the optimality condition for factor input ratios (Annex 2.1) can be written as:

$$b_{ik} = b_{il} \times \left( \frac{Q_{il,0}^f}{Q_{ik,0}^f} \right)^{\beta-1}$$

117. (The subscript 0 signifies that this relationship is only true in the calibration data.). We can then substitute this expression into the CES production function:

$$Q_{i,0} = \left[ \sum_{k=1}^N b_{il} \left( \frac{Q_{il,0}^f}{Q_{ik,0}^f} \right)^{\beta-1} \times (Q_{ik,0}^f)^\beta \right]^{1/\beta}$$

which then simplifies to:

$$b_{ik} = \frac{(Q_{i,0})^\beta}{(Q_{ik,0}^f)^{\beta-1} \times \sum_{l=1}^N Q_{il,0}^f} = \left( \frac{Q_{ik,0}^f}{Q_{i,0}} \right)^{1-\beta} \quad (24)$$

where the last equality follows from the fact that, in the calibration data, the sum of factor values is equal to the production value. This completes our calibration requirements for the CES production function.

### 2.3.3. Calibration of the land supply function

118. Calibration of CET parameters mirrors CES calibration. As we count the parameters to estimate in equation (21), there are  $N$  parameters to estimate but only have  $(N-1)$  observations from which to estimate them. The parameter to be estimated is the (constant) elasticity of transformation,  $\sigma$ :

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11. See Sancho (2007) and Rutherford (2002) for CES function calibration techniques.

$$\sigma = \frac{1}{1 - \rho}$$

119. This parameter is not usually estimated directly. Instead, we use the existing relationship between  $\sigma$ , the own-price elasticity of land supply  $\varepsilon_{ii}$ , and the share of land in a crop  $s_i$ :<sup>12</sup>

$$\varepsilon_{ii} = \sigma(1 - s_i)$$

120. Obtaining our parameter of interest thus depends on the availability of  $\varepsilon_{ii}$  which, again, is often borrowed from exiting literature, as it is in the PEM model (OECD, 2005). Once  $\sigma$  is estimated and  $\rho$  inferred, the  $\gamma_i$  parameters are estimated in the same fashion as the  $b_i$  parameters in the CES production function:

$$\gamma_i = \left( \frac{Q_{iT,0}}{E_T} \right)^{1-\rho} \quad (25)$$

#### 2.3.4. Estimating transaction costs

121. This issue relates to a rather small body of literature, namely, the estimation of transaction costs for developing rural economies.<sup>13</sup> Two published articles address this issue. The first is by Renkow *et al.* (2004), who work with Kenyan data. Using maximum likelihood estimation they find that “on average the ad valorem tax equivalent of the fixed transactions costs in the sample is 15.5%.” The second attempt is made by Cadot *et al.* (2006), who use Malagasy data and define transaction costs as the revenues foregone due to non-participation in markets. They use switching regression estimates to calculate “the opportunity cost of not switching” for the “marginal” farmer, and evaluate this cost at a surprisingly high level: “more than one year of the typical subsistence farmer's output valued at market prices.”

122. Lacking authoritative data on transaction costs, a combination of rough estimation (*e.g.*, using RIGA data, if possible) and sensitivity analysis may be required. The specific estimation method will depend on the available data for each country to which DEVPEM is applied.

#### 2.4. Prototype model for Malawi

123. This section presents an application of the model to the case of Malawi. Malawi is the first of six countries for which the DEVPEM model will be used in policy simulation exercises, the other countries being Bangladesh, Ghana, Guatemala, Nicaragua and Vietnam. Malawi and Ghana are distinguished from the other countries in terms of their considerably lower per-capita income and their high share of agriculture in GDP. Malawi also differs from the other countries by virtue of the high share of its population still living in rural areas (88% in our sample). Malawi is one of the poorest countries in the world, with households often struggling to meet their immediate consumption needs and confronting either prohibitive transaction costs, or missing markets, for outputs and inputs. It thus represents the polar opposite of the PEM model for developed countries, which can ignore the consumption side of farmers' decisions and can assume that markets function seamlessly without prohibitive transaction costs. A further

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12. This relationship becomes more complex in case of 2-level or 3-level CET functions, which is used in the PEM.

13. The empirical literature on transactions costs in staple markets of developing countries is rather limited; it is reviewed in Barrett (2008).

benefit of selecting Malawi as a prototype is the availability of earlier work on the country undertaken for OECD by Professor Andrew Dorward and others (see OECD, 2005). This makes it possible to compare the insights available from the stylised DEVPEM, which seeks to be flexible enough for application across a range of countries, with those obtainable from a more elaborate yet country-specific model. The aim is to ensure that the most important structural features of the economy are represented in DEVPEM and that no crucial determinant of policy impacts is overlooked.

124. Our main data source for the model application is the 2004 Malawi Integrated Household Survey. The survey data have been processed by the RIGA team at FAO, which has greatly facilitated the construction of the variables needed for the model (Carletto, *et al.*, 2007). FAOSTAT is used as a complementary data source for information on aggregate production and consumption of agricultural goods.

#### **2.4.1. Specifications of the Malawi prototype model**

125. The Malawi prototype model differs from the above-described analytical model in two ways, one simplifying the model, the other complicating it. First, due to lack of data, certain assumptions about missing parameters were made. We assumed the subsistence quantities in the linear expenditure system to be zero, and the substitution parameter of the production functions to be one in the limit. Both these assumptions are tantamount to assuming a Cobb-Douglas functional form, which is a special case of the more general forms we introduced.

126. Second, we specify six distinct household groups with household-specific activities, instead of the single representative household depicted in the theoretical model. The six household groups include both rural and urban households and thus represent the whole economy. The purpose of distinguishing between household groups is to capture heterogeneity in the constraints households face, which are likely to affect their response to external shocks. It is important, however, to rely on exogenous constraints while defining the household groups. This is of particular importance in the DEVPEM, which treats household market participation as an endogenous outcome, such that any information on sales or purchases has to be ignored when defining household groups. We define these household groups based on land ownership and remoteness to markets.

127. Land ownership, which is assumed to be fixed (exogenous) in the short run, is used as the main indicator to define the household categories. These differences in land ownership are assumed to capture differences in production technology, and it is well-established that land ownership is strongly correlated with market participation (Barrett and Dorosh, 1996). We distinguish between landless households and small, medium, and large landowners.

128. We also assume that households differ in the extent to which they face transaction costs in markets for goods and factors of production. Given that transaction costs are a function of distance to markets and that households are unable to relocate in the short run, these are also exogenous to the household. We define households as remote if they are above a certain threshold on a “remoteness scale”.<sup>14</sup> To limit the number of household groups, we assume that remoteness for medium-sized and large farmers have smaller effects on market participation than for small farmers and only make the remote/non-remote

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14. The Integrated Household Survey features several distance variables for each surveyed community. We selected twelve distance variables, and classified the communities into distance quintiles (5 being most remote) for each distance. We then defined as “remote” the communities whose “mean distance quintile” across the twelve distances was above 3.5. The twelve variables were the distances to nearest: asphalt road, bus stop, urban center, local government, daily market, weekly market, post office, telephone, bank, clinic, primary school and secondary school.

distinction for small farmers. The magnitude of transactions costs was estimated using the price section of the LSMS data, using the prices of select goods and services.<sup>15</sup> It was found that, on average, remote households pay 18.5% higher prices than members of the other household groups.

129. Table 2.2 summarizes the household groups. Non-agricultural households are outside the agricultural sector in the sense that they do not engage in crop or livestock production or in agricultural employment. These are a diverse group of households, including skilled and unskilled households, the majority (75%) residing in urban areas. The second group consists of households that report being landless yet engaged in agriculture – either by cultivating crops or by participating in the agricultural labour market. Their share of income originating from farming is relatively low (30%), and their primary income source is off-farm wage labour. Farm households are categorized as follows: small farmers own less than 1 hectare of land, medium-sized own 1–3 hectares, and large farmers own more than 3 hectares.

130. The share of household income derived from farm activities increases with land ownership. This pattern, also found in other developing countries, may reflect economies of scale and the related fact that farming is an insufficient income source for many small farmers, who therefore must rely on off-farm income sources to secure their livelihood. A higher farm income share in remote than non-remote small farmer households most likely reflects a greater opportunity for non-remote farmers to diversify into non-agricultural income activities.

**Table 2.2. Definition and sample sizes of household groups in the Malawi model**

<i>Household category</i>	<i>Defining characteristics</i>	<i>Sample size</i>	<i>farm income share</i>	<i>Average income</i>
1. non-agricultural	Does not cultivate	769	0%	54,854
2. landless agric.	Does not own land, but cultivates or is engaged in agricultural employment	1021	30%	55,331
3. small, non-remote	Owens < 1 ha of land; ≤ 3.5 on remoteness scale	3711	57%	34,727
4. small, remote	Owens < 1 ha of land; > 3.5 on remoteness scale	1063	72%	30,139
5. medium	Owens 1-5 ha of land	4183	73%	44,454
6. large	Owens > 5 ha of land	475	80%	58,428

*Note:* Average income is based on an annual household income (MWK) estimated by RIGA (Carletto, *et al.*, 2007), with consumption of own farm production valued at consumer prices. 100 MWK is approximately USD 1.

131. There are seven goods defined for the Malawi model: maize, rice, other food crops, tobacco, tree crops, livestock products, and a “market good” that cannot be produced on the farm. Maize and rice are treated separately from other food crops, inasmuch as they are the largest grain crops in terms of production volume (FAOSTAT) and are often the targets of agricultural and trade policies. The “other” category is primarily composed of tubers (potatoes and cassava), pulses, and other cereals (millet, sorghum). Tobacco constitutes the annual cash crop and tree crops the permanent cash crops (such as fruits, coffee etc.). The production of each farm good involves labour, physical capital, land, and intermediate inputs (such as seeds and fertilizer).

132. Further details on how the variables in the Malawi model were defined, how the data were obtained, and how the model was calibrated are presented in Annex 2.2.

15. We selected goods and services that are not produced by the rural sector and are unlikely to be subsidized or given away for free by NGO’s. The list includes batteries, cigarettes, beer, detergent, cloth, toothbrushes, and the price of transportation to the nearest local government.

### 2.4.2. Simulation of policy changes

133. To illustrate the potential insights that DEVPEM can provide into differentiated policy impacts within the rural economy, the Malawi model was used to simulate the impacts of three sets of policy shocks:

- A 10% change in price of each major food and cash crop;
- A 10% input subsidy, reflected in a lower price paid by the farmer for purchased inputs;
- The elimination of transaction costs.

134. In the case of the first two experiments, the price changes are introduced exogenously, and no account is taken of the possible need to pay for these policies from domestic resources.

135. Table 2.3 reports the findings from these simulations. For the crop price changes, the table presents for each household the marketed surplus prior to the policy shock (a useful reference when interpreting the effects of each shock), the effect on nominal income, and the effect on welfare. All of these effects reflect interactions among the diverse household groups within the rural economy. The welfare effect was calculated as the (negative of the) income transfer that would be required to maintain each household group at its welfare level prior to the policy change. This transfer, akin to a compensating variation (see Taylor *et al.* (2009)), is expressed as a percentage of each household group's base income. The table also presents a relative transfer efficiency estimate, which compares the efficiency of alternative policies in terms of generating welfare gains for rural households. It was calculated as the total welfare effect (defined above) divided by the cost of the income transfer implied by each policy.<sup>16</sup>

136. The first data column in the table presents the total or aggregate effect of each policy on rural households' income and welfare. Rather than the sum of effects across all household groups, this column was computed using a "reduced" version of the model with a single representative household and no transactions costs. This column should thus be read as a more "naive" estimation which ignores the diversity of the rural sector in Malawi. It does, however, consider both the production and consumption aspects of the household economy: it should thus be emphasized that even such aggregate household results are not available from a PEM-type model, in which firms, not households, are the key actors. Columns 2(a-f) report results separately for each of the six household groups. The last column in Table 2.3 presents the transfer efficiency estimates.

#### *Policy simulation 1: market price support*

137. The market price support (MPS) experiments simulate, in turn, the rural economy-wide effects of a 10% increase in the price of maize, rice, other staples, tobacco, tree crops, and livestock. In the aggregate, there is striking variation in the nominal income and welfare effects of these policies (Column 1). All nominal income effects are positive; however, they vary from 0.3% (rice) to 6.3% (other food) of household base income. The largest effects are for maize and other food crops. They are the only crops for which the impact exceeds 1% of base income. The welfare effects vary in both magnitude and sign, because they take into account the welfare cost of higher consumption prices, which may outweigh the positive effect of higher nominal income. The welfare effect of an agricultural price increase never exceeds the nominal income effect. The two effects are the same only for goods that rural households

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16. It does not, therefore, include the administrative costs associated with financing (*e.g.*, tax collection) or implementing each policy.

produce but do not consume. This effectively is the case for tobacco<sup>17</sup>. The divergence between nominal income and welfare effects is greatest for staples, which constitute a significant share of rural household budgets. For example, the maize MPS raises total nominal income by 1.7% but welfare by only 0.4%, and the MPS for other staples raises nominal income and welfare by 6.3% and 3.9%, respectively.

138. These aggregate results mask the impacts of MPS on individual household groups. In general, one would expect that large marketed-surplus producers will benefit most from MPS for their crop. Households that do not produce the crop and are pure consumers will lose when the market price of the crop increases. This pattern is evident when one compares columns 2(a-f) in Table 2.3. With only one exception, large and medium commercial farm households benefit from MPS in terms of both nominal income and welfare. With few exceptions, these households also enjoy the largest percentage increases in nominal income and welfare. For example, the 10% MPS for maize raises nominal income and welfare of large commercial farm households by 2.6% and 1.9%, respectively. However, it decreases the welfare of non-farm rural households (-1.8%), small farm households (-0.2%), and remote farm households (-0.7%). The MPS for other staples raises welfare by 5.8% on large commercial farms, 2.5% on small commercial farms, and 1.3% in landless agricultural households. Welfare on non-farm rural households decreases by 3.4%. A MPS for livestock produces a similar pattern, although the impacts tend to be smaller. They range from 0.3% in large commercial farm households to -0.9% in landless agricultural households and -2.4% in non-farm rural households.

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17. Cigarettes and cigars are industrial products and their purchase enters the model in the category “market good”. Smoking cannot be assimilated to consumption of a self-produced good, as the profits from transformation have leaked out of the rural sector.

Table 2.3. Policy simulation results from the Malawi DEVPEM

POLICY		(1) ALL	Disaggregated effect by households					(3) Total Cost of Subsidy	(4) Transfer efficiency	
			(2a) Non-Farm Households	(2b) Landless Agricultural Households	(2c) Small Farm Owners	(2d) Remote Farm Owners	(2e) Medium Farm Owners			(2f) Large Farm Owners
10% increase in price of maize	Marketed Surplus for maize	<b>4551</b>	-1006	-70	-1215	-925	5679	2180		
	Effect on nominal income (%)	<b>1.7%</b>	0	1.9%	1.4%	0.9%	2.0%	2.6%	2791	<b>0.25</b>
	Effect on Welfare (% of income)	<b>0.4%</b>	-1.8%	0.3%	-0.2%	-0.7%	0.9%	1.9%		
10% increase in price of rice	Marketed Surplus for rice	<b>-283</b>	-645	-607	-148	386	776	-10		
	Effect on nominal income (%)	<b>0.3%</b>	0	0.2%	0.3%	0.6%	0.3%	0.1%	454	<b>0.03</b>
	Effect on Welfare (% of income)	<b>0.007%</b>	-1.2%	-0.4%	0.01%	0.4%	0.1%	-0.02%		
10% increase in price of other staples	Marketed Surplus for staples	<b>55232</b>	-1866	-543	7203	3533	40079	7147		
	Effect on nominal income (%)	<b>6.3%</b>	0	4.3%	5.4%	6.3%	7.3%	7.6%	10130	<b>0.59</b>
	Effect on Welfare (% of income)	<b>3.9%</b>	-3.4%	1.3%	2.5%	3.5%	5.3%	5.8%		
10% increase in price of tobacco	Marketed Surplus for tobacco	<b>7629</b>	0	76	1907	1762	3815	229		
	Effect on nominal income (%)	<b>0.6%</b>	0	0.2%	0.6%	1.6%	0.5%	0.2%	968	<b>0.88</b>
	Effect on Welfare (% of income)	<b>0.6%</b>	0	0.2%	0.6%	1.6%	0.5%	0.2%		
10% increase in price of tree crops	Marketed Surplus for tree crops	<b>9141</b>	-509	-532	2497	1119	5154	1413		
	Effect on nominal income (%)	<b>1.3%</b>	0	0.6%	1.6%	1.7%	1.3%	1.6%	2115	<b>0.50</b>
	Effect on Welfare (% of income)	<b>0.7%</b>	-0.9%	-0.2%	0.8%	1.2%	0.7%	1.2%		
10% increase in price of livestock	Marketed Surplus for livestock	<b>-1584</b>	-1329	-1062	-953	11	1425	325		
	Effect on nominal income (%)	<b>0.8%</b>	0	0.7%	0.7%	0.7%	0.9%	0.9%	1287	<b>0.001</b>
	Effect on Welfare (% of income)	<b>-0.004%</b>	-2.4%	-0.9%	-0.1%	0.1%	0.3%	0.3%		
10% decrease in price of crop inputs	Effect on nominal income (%)	<b>3.3%</b>	0	2.4%	2.8%	3.2%	3.8%	4.2%		
	Effect on Welfare (% of income)	<b>3.3%</b>	0	2.4%	2.8%	3.2%	3.8%	4.2%	5442	<b>0.92</b>
10% decrease in price of livestock inputs	Effect on nominal income (%)	<b>0.4%</b>	0	0.5%	0.5%	0.4%	0.4%	0.3%		
	Effect on Welfare (% of income)	<b>0.4%</b>	0	0.5%	0.5%	0.4%	0.4%	0.3%	751	<b>0.86</b>
Removal of transactions costs	Effect on nominal income (%)	<b>NA</b>	0	0.07%	0.02%	7.8%	-0.02%	-0.02%		
	Effect on Welfare (% of income)	<b>NA</b>	0	0.07%	0.02%	5.8%	-0.02%	-0.02%	NA	<b>NA</b>

### *Policy simulation 2: an input subsidy*

139. Our input subsidy simulations explore the effects of a 10% decrease in the price of intermediate inputs. Input mixes differ between agricultural and livestock production; thus, separate simulations were performed for these two activities. The agricultural input subsidy experiment is of particular interest in light of Malawi's recent fertilizer subsidy policies. An important feature of input subsidies is that they do not produce negative welfare effects via higher consumption costs. Because of this, the percentage changes in nominal income and welfare are the same in input subsidy simulations.

140. The 10% crop input subsidy raises nominal income and welfare by 3.3%. This is higher than in any of the MPS experiments except for one (other staples). There is no effect on non-farm rural households, which do not produce crops and thus do not benefit from the input subsidy. The effects for all other household groups are positive, and they vary less than in the MPS experiments. Large holder commercial households benefit most (4.2%), but the range of effects in the other household groups is relatively small, from 2.4% to 3.8%. All of these are smaller than in the MPS experiments with the exception of other staples. For agricultural producer households, the welfare effects of the input subsidy and other-staple MPS experiments are comparable; however, the subsidy does not have a negative consumption-cost effect on non-farm rural households. It can be argued, therefore, that the crop subsidy has the most favourable distributional effects of all of the policies considered in Table 2.3. An input subsidy for livestock produces positive, equally distributed, but small income and welfare effects, ranging from 0.3% to 0.5%.

### *The relative efficiency of alternative instruments*

141. The size of each subsidy is calculated as 10% of the estimated value of the output (in the case of a MPS) or of intermediate inputs (in the case of the input subsidy). The relative transfer efficiency (TE) index offers a way to assess the efficiency of these subsidies in terms of generating welfare gains in rural households. An index greater than 1.0 would indicate that the subsidy increases rural household welfare by an amount greater than the subsidy, itself. An index of less than 1.0 implies that the welfare effect is smaller than the size of the subsidy. By this measure, the livestock, rice and maize MPS appear to be inefficient. The TE measure is 0.25 for maize, 0.03 for rice, and zero for livestock. The crop input subsidy, in contrast, has a TE of 0.92. It has the highest welfare effect of any of the subsidies considered. Two other policies, the livestock input subsidy and the tobacco MPS, also have high TEs (0.86 and 0.88, respectively). Their effects on rural household welfare are small compared to the effect of the crop input subsidy, however.

### *Policy simulation 3: eliminating transaction costs*

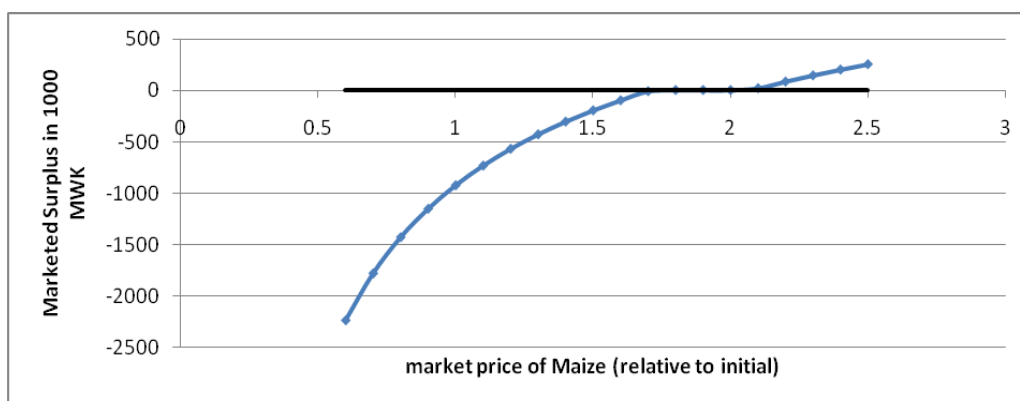
142. High transaction costs are a quintessential feature of poor rural economies, particularly for remote farm households. The DEVPEM was designed to explore the ramifications of high transaction costs that create an "output price band" for some household groups. Within this band, a household-specific shadow price replaces the exogenously determined market price as a basis for production and consumption decisions and the household does not participate in the market, producing only for subsistence. The removal of transaction costs (*e.g.*, via the development of marketing infrastructure) directly benefits the remote household group. Its nominal income rises by 7.8% and its welfare by 5.8%. Indirectly, removing transaction costs for the remote group affects other groups by way of their interactions in rural markets, particularly for factors. These indirect effects are positive but small, however, ranging from a .02% loss for large commercial households to a 0.07% gain for the landless agricultural households. These simulation results suggest that reducing transaction costs can create significant benefits for remote households without adversely affecting others in the rural economy.



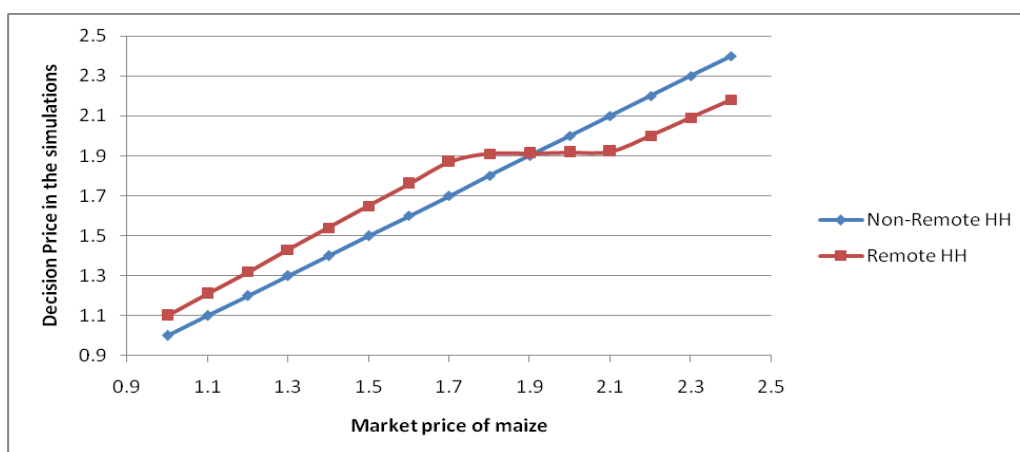
143. Figure 2.3 illustrates the effect of transaction costs on the marketed surplus produced by agricultural households in remote areas. When the market price of maize is sufficiently low (in the figure, less than approximately 1.7 times the initial or base price of maize), the household participates in the market as a net buyer, despite facing high transaction costs. When the market price is sufficiently high to overcome transaction costs on the producer side, the household participates in the market as a net seller. In between, the household's marketed surplus is zero. Over this subsistence interval, the market price has little effect on the remote household's decision price, as illustrated in Figure 2.4.

144. The removal of transaction costs (*e.g.*, via the development of marketing infrastructure) directly benefits the remote household group. Its nominal income rises by 7.8% and its welfare by 5.8%. Indirectly, removing transaction costs for the remote group affects other groups by way of their interactions in rural markets, particularly for factors. These indirect effects are positive but small, however, ranging from a .02% loss for large commercial households to a 0.07% gain for the landless agricultural households. These simulation results suggest that reducing transaction costs can create significant benefits for remote households without adversely affecting others in the rural economy.

**Figure 2.3. Marketed surplus and the market price in remote rural households**



**Figure 2.4. Decision prices of remote and market-integrated agricultural households**



## 2.5. Conclusions and next steps

145. DEVPEM is being developed as a companion to the OECD-country PEM as a tool for policy evaluation in developing countries, in which agricultural production is carried out by heterogeneous households and where market transaction costs potentially play an important role in shaping policy impacts. The models are similar in that they depict the impacts of agricultural policies on incomes over the short to medium term. However, there are important differences between the two models. In structural terms, one might view the PEM as being effectively a special case of DEVPEM, in which production is carried out not by households but, rather, by a single aggregate or representative firm, and in which transaction costs are negligible.

146. The modelling work for this project is still at the development stage, but the preliminary results for Malawi indicate that agricultural policies may have fundamentally different impacts on incomes in low income countries to those obtained in developed OECD countries. As in OECD countries, market price support is likely to be an ineffective instrument for raising the incomes of farm households, albeit for different reasons. In the PEM, market price support is ineffective because a significant share of the benefits “leaks” to non-farm factor owners (input suppliers and land owners). In the DEVPEM prototype for Malawi, market price support is similarly ineffective, not because of these leakages (farm households supply relatively more of their own inputs to production) but because farm households consume a significant share of what they produce. Indeed, net food deficit farm households could lose from higher food prices, if their production response is sufficiently limited. In the case of input subsidies, there are *a priori* reasons for believing that such measures could have a superior transfer efficiency to those obtained in OECD countries, again because farmers tend mostly to supply their own factors to the farm operation, so there is less scope for leakages to other agents. Of course, a high transfer efficiency is not by itself enough to justify the use of input subsidies. In principle, any instrument with a transfer efficiency of less than one is less efficient than a direct cash transfer. Moreover, as discussed in Part 1, a range of factors need to be considered, beyond an instrument’s immediate impact on short term incomes. Nevertheless, the possibility that a large share of the benefits of input subsidies could be retained by the farm household is significant to a broader discussion of instrument choice. Finally, the prototype model suggests that policies to reduce transaction costs can have important benefits for households whose market interactions are impeded by those costs.

147. In the near future, we plan to extend the modelling work in two directions. In the first place there is a need to refine the prototype model by considering a number of factors that were discussed at the PEM expert meeting in September, and were considered to be potentially important. For example, it was considered important to address the possibility that food prices are determined endogenously in the rural economy. Another issue raised was that seasonal cash constraints may affect farmers’ responses to changes in market prices.<sup>18</sup> Aside from developing the model structure to accommodate such possibilities, it will also be important to provide a more detailed interpretation of the results, including a mapping onto measures of poverty, inequality and food security. Further consideration will also be given to the manner in which policies are implemented and how they are financed, as well as to a wider range of policy experiments. Once the prototype model is fully developed, a series of country models will be constructed, as noted in Section 2.4, with a view to describing how structural differences between developing countries can affect the distribution of policy impacts.

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18. For example, if the price of maize rises, a cash constrained farm household may need to earn more from off-farm activities in order to meet its basic food requirements. This could result in it supplying less labour to the farm, leading to a “perverse” supply response.

## REFERENCES

- Barrett, C. B., "Smallholder Market Participation: Concepts and Evidence from Eastern and Southern Africa", *Food Policy* 33, No. 4(2008): 299-317.
- Barrett, C. B., and P. A. Dorosh, "Farmers' Welfare and Changing Food Prices: Nonparametric Evidence from Rice in Madagascar", *American Journal of Agricultural Economics* 78, No. 3(1996): 656-669.
- Brooks, J., G. Dyer and J.E. Taylor, "Modelling Agricultural Trade and Policy Impacts in Less Developed Countries", *OECD Food, Agriculture and Fisheries Working Papers* No. 11. 2008.
- Cadot, O., M. Olarreaga, and L. Dutoit, *How Costly is it for Poor Farmers to Lift Themselves out of Poverty?*: SSRN, 2006.
- Carletto, G., K. Covarrubias, and M. Krausova, "Rural Income Generating Activities (RIGA) Study: Income Aggregate Methodology", *Agricultural Sector in Economic Development Service, Food and Agriculture Organization* (2007).
- de Janvry, A., M. Fafchamps, and E. Sadoulet, "Peasant Household Behavior with Missing Markets: Some Paradoxes Explained", *University of California, Berkeley, Division of Agriculture and Natural Resources, Working Paper* No. 578(1991): [1]-[28] January 9.
- de Janvry, A. and E. Sadoulet, *Quantitative Development Policy Analysis*, Baltimore: John Hopkins University Press, 1995.
- Dyer, G. A., S. Boucher, and J. E. Taylor, "Subsistence Response to Market Shocks", *American Journal of Agricultural Economics* 88, No. 2(2006): 279-91.
- FAO (2008), "Components of Aggregate Income: Integrated Household Survey, Malawi 2004", document prepared for the Rural Income Generating Activities (RIGA) Project of the Agricultural Development Economics Division, Food and Agriculture Organization.
- Holden, S. T., J. E. Taylor, and S. Hampton, "Structural Adjustment and Market Imperfections: a Stylized Village Economy-wide Model with Non-separable Farm Households", *Environment and Development Economics* 4, No. 01(1999): 69-87.
- Keuning, S. J., and W. A. Ruijter, "Guidelines To The Construction of a Social Accounting Matrix", *Review of Income and Wealth* 34, No. 1(1988): 71-100.
- Key, N., E. Sadoulet, and A. d. Janvry, "Transactions Costs and Agricultural Household Supply Response", *American Journal of Agricultural Economics* 82, No. 2(2000): 245-259.
- Löfgren, H., and S. Robinson, "Nonseparable Farm Household Decisions in a Computable General Equilibrium Model", *American Journal of Agricultural Economics* 81, No. 3(1999): 663-670.
- McFadden, D. (1978), Estimation Techniques for the Elasticity of Substitution and Other Production Parameters, Vol. 2, McMaster University Archive for the History of Economic Thought.
- OECD, "The Six-Commodity PEM Model: Preliminary Results", 2005.
- Pyatt, G., "A SAM Approach to Modeling", *Journal of Policy Modeling* 10, No. 3(1988): 327-352.
- Renkow, M., D. G. Hallstrom, and D. D. Karanja, "Rural Infrastructure, Transactions Costs and Market Participation in Kenya", *Journal of Development Economics* 73, No. 1(2004): 349-367.
- Rutherford, T. F. (2002), Lecture Notes on Constant Elasticity Functions, Department of Economics, University of Colorado.

- Sadoulet, E., and A. De Janvry, *Quantitative Development Policy Analysis*, The John Hopkins University Press, 1995.
- Sancho, F., "Calibration of CES Functions for Real-world Multisectoral Modeling", Unitat de Fonaments de l'Anàlisi Econòmica (UAB) and Institut d'Anàlisi Econòmica (CSIC), Oct 2007.
- Singh, I., L. Squire, and J. Strauss, "A Survey of Agricultural Household Models: Recent Findings and Policy Implications", *The World Bank Economic Review* 1, No. 1(1986): 30.
- Strauss, J. (1986), "Appendix: The Theory and Comparative Statics of Agricultural Household Models: A General Approach", ed. I. Singh, L. Squire, and J. Strauss. Baltimore, The Johns Hopkins University Press.
- Taylor, J. E., and I. Adelman, "Agricultural Household Models: Genesis, Evolution, and Extensions", *Review of Economics of the Household* 1, No. 1(2003): 33-58.
- Taylor, J. E., G. A. Dyer, and A. Yúnez-Naude, "Disaggregated Rural Economywide Models for Policy Analysis", *World Development* 33, No. 10(2005): 1 671-88.
- Taylor, J. E., A. Yunez-Naude, and N. Jesurun-Clements, "Does Agricultural Liberalization Reduce Rural Welfare in Less Developed Countries? The Case of CAFTA", *Review of Agricultural Economics* (2009): (in press).

## ANNEX 2.1. SOLUTION OF THE MODEL

To solve for the first order conditions of the model, we first define the Lagrangian of the joint utility and profit-maximization problem of the household:

$$\begin{aligned}
\mathcal{L} = & \prod_{i \in I^-} (C_i - c_i)^{\alpha_i} - \sum_{i \in I} \mu_i \left( C_i + Q_i^s + \sum_{j \in I^-} Q_{ji}^f - E_i - \left[ \sum_{k \in I} b_{ik} (Q_{ik}^f)^\beta \right]^{1/\beta} - Q_i^b \right) \\
& - \lambda \left( \sum_{i \in I^-} (p_i^m + t_i^b) Q_i^b - \sum_{i \in I^-} (p_i^m - t_i^s) Q_i^s \right) \\
& - \xi \left( \left( \sum_{i \in I^-} \gamma_i (Q_{iT}^f)^\rho \right)^{1/\rho} - E_T \right)
\end{aligned} \tag{26}$$

Differentiating the Lagrangian yields the following first-order conditions:

$$\frac{\partial \mathcal{L}}{\partial C_i} = \alpha_i \frac{U}{(C_i - c_i)} - \mu_i = 0 \tag{27}$$

$$\frac{\partial \mathcal{L}}{\partial Q_{ik}} = \mu_i \left[ \sum_k b_{ik} (Q_{ik}^f)^\beta \right]^{\frac{1}{\beta}-1} b_{ik} (Q_{ik}^f)^{\beta-1} - \mu_k = 0, \quad \text{for } k \neq T \tag{28}$$

$$\frac{\partial \mathcal{L}}{\partial Q_{iT}} = \mu_i \left[ \sum_k b_{ik} (Q_{ik}^f)^\beta \right]^{\frac{1}{\beta}-1} b_{iT} (Q_{iT}^f)^{\beta-1} - \xi \left( \sum_l \gamma_l (Q_{iT}^f)^\rho \right)^{\frac{1}{\rho}-1} \times \gamma_i (Q_{iT}^f)^{\rho-1} = 0 \tag{29}$$

$$\frac{\partial \mathcal{L}}{\partial Q_i^b} = \mu_i - \lambda(p_i^m + t_i^b) \leq 0; \quad Q_i^b \geq 0; \quad Q_i^b \times (\mu_i - \lambda(p_i^m + t_i^b)) = 0 \tag{30}$$

$$\frac{\partial \mathcal{L}}{\partial Q_i^s} = \lambda(p_i^m - t_i^s) - \mu_i \leq 0; \quad Q_i^s \geq 0; \quad Q_i^s \times (\lambda(p_i^m - t_i^s) - \mu_i) = 0 \tag{31}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = \sum_{i=1}^N (p_i^m + t_i^b) Q_i^b - \sum_{i=1}^N (p_i^m - t_i^s) Q_i^s = 0 \tag{32}$$

$$\frac{\partial \mathcal{L}}{\partial \mu_i} = E_i + Q_i + Q_i^b - C_i - Q_i^s - \sum_{j=1}^N Q_{ji}^f = 0 \tag{33}$$

$$\frac{\partial \mathcal{L}}{\partial \xi} = \left( \sum_l \gamma_l (Q_{iT}^f)^\rho \right)^{\frac{1}{\rho}} - E_T = 0 \tag{34}$$

These first order conditions lead to a solvable system of equations, which we derive below. We first need to define the notion of shadow price (until now absent from the model) and spell out the constraints on decision-making prices. Let us define

$$p_i = \frac{\mu_i}{\lambda}, \quad \text{for } i \neq T \tag{35}$$

which we will call the household shadow price of good  $i$ . This then lets us re-write equations (30) and (31) as:

$$\begin{cases} p_i \leq p_i^m + t_i^b \\ p_i^m - t_i^s \leq p_i \\ Q_i^b (p_i - (p_i^m + t_i^b)) = 0 \\ Q_i^s (p_i - (p_i^m - t_i^s)) = 0 \\ Q_i^s \geq 0, Q_i^b \leq 0 \end{cases} \quad (36)$$

We then turn to the consumption side of the household economy. Using the definition of shadow prices and equation (27) yields:

$$C_i - c_i = \frac{\alpha_i}{p_i} \frac{U}{\lambda} \quad (37)$$

which, when multiplied by  $p_i$  and summed over  $i$ , yields:

$$\sum_I p_i (C_i - c_i) = \sum_I \alpha_i \frac{U}{\lambda} = \frac{U}{\lambda} \quad (38)$$

Let us define  $y = \frac{U}{\lambda} + \sum_I p_i c_i$ . Then:

$$\sum_I p_i (C_i) = y \quad (39)$$

where  $y$  can be interpreted as the shadow income of the household, that is, the shadow value (in money units) of household consumption (whether bought on the market or self-provided).<sup>19</sup> We will later show that it is also equal to the shadow value of the household's assets. This definition of  $y$  also allows us to write the demand function in the usual form used for linear expenditure systems:

$$C_i = \frac{\alpha_i}{p_i} \left( y - \sum_{j \in I} p_j c_j \right) + c_i \quad (40)$$

Having defined consumption demands, we now turn to the production side of the household economy. We first derive the optimal use of factors in production functions. Rather than explicitly writing out factor demands, it is common practice when using constant elasticity functional forms to work with relative

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19. The Lagrangian multiplier on the full-income constraint,  $\lambda$ , might be viewed as an exchange rate converting income currency (*e.g.*, dollars) into welfare currency (utils). Dividing  $U$  by  $\lambda$  thus converts utility into the income currency, *i.e.*, into what we call the shadow income. This shadow income is identical to full income when the prices of all goods are exogenous to the household. A similar approach appears in Holden *et al.* (1999).

factor ratios. Using equation (28) for two different factors  $k$  and  $l$  used in the production of good  $i$  we can write the optimality condition in terms of factor ratios in the production of good  $i$ :

$$\frac{Q_{ik}^f}{Q_{il}^f} = \left( \frac{\mu_k b_{il}}{\mu_l b_{ik}} \right)^{\frac{1}{\beta-1}} = \left( \frac{p_k b_{il}}{p_l b_{ik}} \right)^{\frac{1}{\beta-1}}, \quad k \neq T, l \neq T \quad (41)$$

Land is excluded from this condition, since we have not defined the notion of price for land, for which there is no market. To derive an equivalent factor ratio condition for optimal land use, let us take a closer look at the left-most term of equation (29), but replacing  $\mu_i$  in terms of  $p_i$ :

$$p_i \left[ \sum_k b_{ik} (Q_{ik}^f)^\beta \right]^{\frac{1}{\beta}-1} b_{iT} (Q_{iT}^f)^{\beta-1} = \frac{1}{\lambda} \times \xi \left( \sum_l \gamma_l (Q_{il}^f)^\rho \right)^{\frac{1}{\rho}-1} \times \gamma_i (Q_{iT}^f)^{\rho-1} \quad (42)$$

The left-hand term is the marginal value product of land in the production of good  $i$ , in other words the “shadow rent” of land used as a factor in this production process. Let us therefore define  $r_{iT}$  as that left-hand term:

$$r_{iT} = p_i \left[ \sum_k b_{ik} (Q_{ik}^f)^\beta \right]^{\frac{1}{\beta}-1} b_{iT} (Q_{iT}^f)^{\beta-1} \quad (43)$$

This definition allows us to write an optimality condition for land use similar to equation (41), obtained in a very similar way. Dividing equation (28) by equation (29) yields:

$$\frac{b_{ik} (Q_{ik}^f)^{\beta-1}}{b_{iT} (Q_{iT}^f)^{\beta-1}} = \frac{\mu_k}{\xi \left( \sum_l \gamma_l (Q_{il}^f)^\rho \right)^{\frac{1}{\rho}-1} \times \gamma_i (Q_{iT}^f)^{\rho-1}} = \frac{p_k}{r_{iT}} \quad (44)$$

where the second equality follows from dividing by  $\lambda$  and using the optimality condition (42). The optimality condition for factor use when one of the factors is land can thus be written:

$$\frac{Q_{ik}^f}{Q_{iT}^f} = \left( \frac{p_k b_{iT}}{r_{iT} b_{ik}} \right)^{\frac{1}{\beta-1}} \quad (45)$$

Note that if this equation is true for all goods  $i$  and all factors  $k$ , the condition in equation (41) is rendered redundant, because it follows directly from this one: By writing equation (45) for factors  $k$  and  $l$  then dividing one by the other, we obtain equation (41).

This would complete the description of the production side of the economy if there was a perfectly elastic supply of all factors in our model. Land use, however, is constrained on the supply side by the CET land supply function. Using equation (29) for the use of the land factor in the production of two different goods  $i$  and  $j$ , we can write an optimality condition for the ratio of different land uses:

$$\frac{\mu_i \left[ \sum_k b_{ik} (Q_{ik}^f)^\beta \right]^{\frac{1}{\beta}-1} b_{iT} (Q_{iT}^f)^{\beta-1}}{\mu_j \left[ \sum_k b_{jk} (Q_{jk}^f)^\beta \right]^{\frac{1}{\beta}-1} b_{jT} (Q_{jT}^f)^{\beta-1}} = \frac{\gamma_i Q_{iT}^{\rho-1}}{\gamma_j Q_{jT}^{\rho-1}} \quad (46)$$

This translates into a simple condition on the ratio of land shadow rents:

$$\frac{r_{iT}}{r_{jT}} = \frac{\gamma_i Q_{iT}^{\rho-1}}{\gamma_j Q_{jT}^{\rho-1}} \quad (47)$$

The final step tying the production and consumption sides together is to derive the “shadow income” equation. Let us use equation (33) multiplied by  $p_i$  and summed over  $i$ . Equation (32) allows simplifying the quantities bought and sold away to obtain:

$$\sum_I p_i E_i + \sum_I p_i Q_i - y - \sum_{i \in I} p_i \sum_{j \in I} Q_{ji}^f = 0 \quad (48)$$

But from equation (41), which we multiply by  $p_i$  and sum over  $j$  and  $i$ , and from the fact that the beta coefficients sum to one, we can write

$$\sum_{i \in I} p_i \sum_{j \in I} Q_{ji}^f = \sum_{i \in I} p_i \sum_{j \in I} \frac{p_j \beta_{ji}}{p_i} \times Q_j = \sum_I p_j Q_j \times 1 \quad (49)$$

Using this fact, we can further simplify (48) to:

$$\sum_I p_i E_i = y \quad (50)$$

Equation (50) defines the “shadow income” of the household as the value of all endowments evaluated at shadow prices.

We have thus completed the derivation of the system of equations fully describing the solution to our model. The complete set of first order conditions is summarized in Table 2.A1.



**Table 2.A1. DEVPEM variables and equations**

Sets and parameters	Variables	Number of variables
<i>Sets</i> $i (=k), N$ goods and factors	$Q_i$ quantities produced $Q_{ik}^f$ input of $k$ into production of $i$ .	$N-1$ $N(N-1)$
<i>Parameters</i> $p_i^m$ market prices, $i \neq T$ $t_i^s$ additive sales transaction cost $t_i^b$ additive purchase transaction cost $E_i$ initial endowments (fixed in the case of land)	$Q_i^s, Q_i^b$ quantities sold or bought $C_i$ quantities consumed $p_i$ shadow price, $i \neq T$ $r_{iT}$ shadow rent $y$ shadow income	$2N-2$ $N-1$ $N-1$ $1$
<i>Function parameters</i> $\alpha_i$ exponent in consumption function $\beta_i$ exponent in production function $\gamma_i$ CET share parameters $\rho$ CET exponent	Total number of variables:	$(5 + N)N-5$

Equations	Domain restrictions	Number of equations	Description
<i>Price bounds and complementary slackness</i> $\begin{cases} p_i \leq p_i^m + t_i^b \\ p_i^m - t_i^s \leq p_i \\ Q_i^b (p_i - (p_i^m + t_i^b)) = 0 \\ Q_i^s (p_i - (p_i^m - t_i^s)) = 0 \end{cases}$	$i \neq T$	$2N-2$	Price bands
<i>Consumption block</i> $C_i = \frac{\alpha_i}{p_i} \left( y - \sum_T p_j c_j \right) + c_i$ $\sum_T p_i E_i = y$	$i \neq T$	$N-1$ $1$	Demands Shadow income
<i>Production block</i> $Q_i = \left[ \sum_{k=1}^N b_{ik} (Q_{ik}^f)^\beta \right]^{1/\beta}$ $\frac{Q_{ik}^f}{Q_{iT}^f} = \left( \frac{p_k b_{iT}}{r_{iT} b_{ik}} \right)^{\frac{1}{\beta-1}}$	$i \neq T$	$N-1$ $N(N-1)$	Production function Factor demand ratios
<i>Land Supply Block</i> $\left( \sum_{i \in I} \gamma_i (Q_{iT}^f)^\rho \right)^{1/\rho} = E_T$ $\frac{r_{iT}}{r_{jT}} = \frac{\gamma_i Q_{iT}^{\rho-1}}{\gamma_j Q_{jT}^{\rho-1}}$	$i \neq T, j \neq T$	$1$ $N-2$ (excluding redundancies)	CET land supply CET optimality condition
<i>Market Constraints</i> $E_i + Q_i + Q_i^b - C_i - Q_i^s - \sum_{j=1}^N Q_{ji}^f = 0$ $Q_i^b \geq 0; \quad Q_i^s \geq 0$	$i \neq T$	$N-1$	Market clearing
Total number of equations:		$(5+N)N-5$	

## ANNEX 2.2. DATA SOURCES AND CONSTRUCTION OF VARIABLES FOR THE MALAWI PROTOTYPE MODEL

This Annex briefly explains how the variables used in the Malawi simulations were defined. The two data sources are the 2004 Malawi Integrated Household Survey, processed by the RIGA team at FAO and FAOSTAT. The former data set is referred to below as “RIGA data”.

To obtain the information needed in the SAM described in Table 2.1, we needed to define a) adequate household groups, b) product categories, c) value of production, d) consumption, e) expenditure on input in production, and f) household income by source. FAOSTAT was used to obtain information on total value of production and consumption of each good category. The RIGA data were used to obtain all other information. The construction of each of these components is described below.

### *a) Household groups*

As described in Section 2.4, six household groups were defined, based on land ownership, production, and remoteness to markets. Category 1 does not cultivate, yet households in this category may own land. Category 2 does not own land but is engaged in cultivation either by renting land or by working on a farm. Category 3 and 4 (small landowners) both have less than 1 hectare of land. The difference between the two is their “remoteness” to markets. We defined a remoteness indicator based on 12 community variables in the Malawi survey (see footnote 14). For each variable, communities were divided into quintiles, with the 5<sup>th</sup> quintile containing the most “remote” communities. A community was defined as remote if its “average quintile” was above 3.5. Thus, households in category 4 all reside in communities defined as remote. Households in category 5 (medium land owners) own more than 1 but less than 5 hectares of land, and large land owners own 5 hectares or more.

### *b) Product categories*

Agricultural goods were defined to fit four types of land use: Food crops, annual cash crops, tree crops, and livestock products. Among food crops, we distinguish between maize (local maize, composite maize, and hybrid maize), rice, and other crops (all other food crops listed in rain-fed and dry-season cultivation in the agricultural modules of the survey). Annual cash crops are tobacco in the case of Malawi, and tree crops consist of all crops in the tree crop production module of the survey, including fruits, tea, and coffee. The livestock product category includes all meat, dairy products, and all other livestock by-products.

### *c) Value of production*

The total value of production of each product category was obtained from data on quantity and producer prices from FAOSTAT. To distribute the aggregate production value among the household groups, we used production shares derived from the RIGA data (Table 2.A2). These shares were then multiplied by the aggregate FAOSTAT production value to assign total value of production for each household group.

### *d) Value of consumption*

The value of consumption of each product category for each household group was estimated analogously to the production values. Using FAOSTAT, we multiplied consumption in tonnes by producer prices to get total consumption value of each good. Consumption shares per household group were estimated based on consumption information in the RIGA data (Table 2.A1).

**Table 2.A2. Production and consumption shares per household group**

	1. non-agricultural	2. landless agric.	3. small, non-remote	4. small, remote	5. medium	6. large	Total
<i>Production shares</i>							
Maize	0.00	0.06	0.19	0.03	0.55	0.17	1.00
Rice	0.00	0.01	0.24	0.12	0.57	0.05	1.00
Other food crops	0.00	0.03	0.17	0.06	0.53	0.21	1.00
Tobacco	0.00	0.01	0.25	0.21	0.50	0.03	1.00
Tree crops	0.00	0.01	0.22	0.19	0.47	0.11	1.00
Livestock	0.00	0.06	0.22	0.07	0.55	0.10	1.00
<i>Consumption shares</i>							
Maize	0.05	0.09	0.31	0.10	0.41	0.04	1.00
Rice	0.16	0.16	0.27	0.05	0.33	0.03	1.00
Other food crops	0.05	0.09	0.31	0.08	0.41	0.06	1.00
Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Tree crops	0.05	0.09	0.34	0.07	0.40	0.05	1.00
Livestock	0.11	0.14	0.27	0.06	0.37	0.06	1.00

*e) Value of inputs in production*

The biggest challenge in deriving variables for the SAM was to estimate the cost of each factor used in farm production, for each product and each household category. We defined five inputs – own labour, physical capital, land, hired labour, and intermediate inputs. We treated the first three as household endowments, which means that utilization of any of these factors is an implicit cost to the household. Hired labour and purchases of intermediate inputs (seeds and fertilizer), on the other hand, are explicit costs. There is some information available in the RIGA data on explicit costs, but all implicit costs needed to be estimated. We assume zero economic profit in production of each good, such that,

$$TR_i = TC_i = TIC_i + TEC_i,$$

where  $TR_i$  denotes total revenue in production of good  $i$ , and  $TC$  denotes total costs, as the sum of implicit costs ( $TIC$ ) and explicit costs ( $TEC$ ). This means that the net revenue (total revenue minus explicit costs) is equal to implicit costs. To derive implicit cost shares for own labour, capital, and land, we used the following identity:

$$TIC = r_L Q_L + r_K Q_K + r_T Q_T,$$

where  $Q_L$ ,  $Q_K$ , and  $Q_T$  denote quantities of own labour, capital, and land, respectively, and  $r_L$ ,  $r_K$ , and  $r_T$  denote the respective shadow prices. Own labour's cost share, then, is

$$s_L = r_L Q_L / TR,$$

with capital's and land's cost shares,  $s_K$  and  $s_T$ , defined analogously. While the shadow prices are unobserved, we have some information in the RIGA data on net revenue (and hence  $TIC$ ), and the quantities of each factor endowment,  $Q_L$ ,  $Q_K$ , and  $Q_T$ . We estimated the following linear regression through the origin to obtain shadow price estimates:

$$TIC = b_L Q_L + b_K Q_K + b_T Q_T + e$$

where the  $b$ 's denote coefficients to be estimated and  $e$  denotes the error term. This regression was estimated for each product category and for each household group. Information on input utilization, however, is not available on crop level in the RIGA data. We therefore used single-crop farmers as the sample for each crop-specific regression, with the assumption that multi-cropping farms use the same production technology mono-croppers.

The estimated cost shares for labour, capital, and land in crop production were defined as:

$$\hat{s}_L = \hat{b}_L Q_L / TIC \times (TIC / TR)$$

$$\hat{s}_K = \hat{b}_K Q_K / TIC \times (TIC / TR)$$

$$\hat{s}_T = (1 - \hat{s}_L - \hat{s}_K) \times (TIC / TR)$$

where “hats” indicate estimates.

Cost shares for hired labour ( $HL$ ) and intermediate inputs ( $IN$ ) were defined as:

$$s_{HL} = (1 - s_L - s_K - s_T) * (\text{expenditure on hired labour} / TEC)$$

and

$$s_{IN} = 1 - s_L - s_K - s_T - s_{HL}.$$

For livestock production, we only assumed three inputs: capital, land and one variable input. The cost share of the land and capital inputs (implicit cost share) was defined as the ratio of net revenue to total revenue. For lack of better information, the cost shares of land and capital were assumed to be equal. The cost share of the variable inputs was defined as the residual share. Table 2.A3 gives an overview of these cost shares.

#### f) Household income

In order to derive an estimate of aggregate household income for each household group that is comparable with the production and consumption values derived from FAOSTAT, we used the following relationship:

$$\text{Total household income} = \text{agprod}_{\text{FAOSTAT}} * (\text{agnet/aggross})_{\text{RIGA}} * (1 / \text{agshare}_{\text{RIGA}}),$$

where  $\text{agprod}$  is the value of the household group's total agricultural production derived from FAOSTAT,  $(\text{agnet/aggross})$  is the average ratio of net to gross agricultural incomes according to RIGA data and  $\text{agshare}$  is the share of agricultural income in total household income according to RIGA data. Subscripts were added to indicate data source.

To estimate the value of consumption of non-farm products (“market goods”), we assumed that total household income equals total household expenditure and that non-farm consumption is the difference between household income and agricultural consumption. Table 2.A4 shows shares of income spent on each good for each household group.

**Table 2.A3. Input cost shares**

	All farmers	2. landless agric.	3. small, non-remote	4. small, remote	5. medium	6. large
<i>Maize</i>						
Own labour	0.14	0.02	0.00	0.04	0.06	0.18
Physical capital	0.44	0.32	0.15	0.40	0.03	0.31
Land	0.07	0.29	0.52	0.43	0.50	0.11
Hired labour	0.09	0.09	0.07	0.02	0.11	0.11
Intermediate inputs	0.26	0.28	0.26	0.11	0.30	0.28
<i>Rice</i>						
Own labour	0.37	0.37	0.38	0.28	0.23	0.30
Physical capital	0.41	0.07	0.08	0.11	0.10	0.47
Land	0.03	0.38	0.37	0.44	0.46	0.02
Hired labour	0.06	0.08	0.07	0.06	0.05	0.05
Intermediate inputs	0.13	0.09	0.09	0.11	0.17	0.17
<i>Other food crops</i>						
Own labour	0.24	0.10	0.10	0.08	0.18	0.22
Physical capital	0.31	0.21	0.21	0.06	0.09	0.31
Land	0.05	0.27	0.27	0.57	0.34	0.07
Hired labour	0.07	0.07	0.07	0.04	0.07	0.04
Intermediate inputs	0.33	0.35	0.35	0.25	0.32	0.36
<i>Tobacco</i>						
Own labour	0.17	0.11	0.15	0.06	0.06	0.13
Physical capital	0.27	0.20	0.10	0.20	0.20	0.26
Land	0.09	0.24	0.31	0.26	0.26	0.12
Hired labour	0.05	0.04	0.04	0.05	0.05	0.05
Intermediate inputs	0.43	0.41	0.40	0.42	0.42	0.44
<i>Tree crops</i>						
Own labour	0.12	0.06	0.16	0.20	0.12	0.16
Physical capital	0.49	0.34	0.21	0.31	0.03	0.42
Land	0.02	0.32	0.51	0.13	0.43	0.02
Hired labour	0.04	0.02	0.02	0.02	0.07	0.07
Intermediate inputs	0.33	0.26	0.10	0.34	0.36	0.33
<i>Livestock</i>						
Capital	0.20	0.135	0.175	0.215	0.255	0.335
Land	0.20	0.135	0.175	0.215	0.255	0.335
Intermediate inputs	0.60	0.73	0.65	0.57	0.49	0.33

**Table 2.A4. Household budget shares**

	1. non- agricultural	2. landless agric.	3. small, non-remote	4. small, remote	5. medium	6. large
<i>Expenditure shares</i>						
Maize	..	0.14	0.15	0.15	0.09	0.03
Rice	..	0.05	0.03	0.02	0.02	0.00
Other food crops	..	0.26	0.28	0.22	0.16	0.08
Tobacco	..	0.00	0.00	0.00	0.00	0.00
Tree crops	..	0.07	0.08	0.05	0.04	0.02
Livestock	..	0.13	0.08	0.05	0.05	0.03
Non-farm goods	..	0.34	0.37	0.52	0.64	0.84
<i>Total</i>	..	1.00	1.00	1.00	1.00	1.00

**Table 2.A5. DEVPEM data requirements**

<i>Variable category</i>	<i>Information needed</i>	<i>Purpose</i>	<i>Source</i>
1. Household types	Land ownership, household education, and/or remoteness to markets	“Exogenous” (fixed) household characteristics that can distinguish between 4-6 household groups and capture heterogeneity in responses to shocks.	RIGA
2. Value of total production	National production of: a) the two or three most important food crops b) residual food crops c) annual cash crops ( <i>e.g.</i> tobacco or entire group of crops) d) permanent cash crops (tree crops) e) livestock products	National aggregate production information is used to estimate each household group’s total production of each crop. The product categories are defined to capture different types of land use.	FAOSTAT
3. Value of total consumption	National consumption of items (a) – (e)	To estimate each household group’s total consumption of each crop.	FAOSTAT
4. Production shares	The share of each household group’s production of each product defined above	Multiplied by national production of each good, these will provide the value of production of each good, for each household category.	RIGA
5. Consumption shares	The share of each household group’s consumption of each product defined above	Multiplied by national consumption of each good, these will provide the value of consumption of each good, for each household category.	RIGA
6. Input cost shares	For each product defined, explicit or implicit costs of: a) labour b) capital c) land d) intermediate inputs ( <i>e.g.</i> seeds and fertilizer)	Assuming zero economic profits, the cost shares provide costs of each input when multiplied by total agricultural gross revenue. Implicit costs are unobserved and need to be estimated with regression analysis based on input quantities or on some other method. (Number of inputs may vary between products.)	RIGA
7. Household income shares:	Share of total income for: a) net and gross farm production b) agricultural wage income c) non-agricultural income	Given the information on total agricultural production, an estimate of total household income can be derived that is consistent with the consumption and production values defined above. Non-farm income is then estimated using the corresponding income share. Assuming zero saving, total income equals total consumption. Consumption of market (non-farm) goods is given by the difference between estimated total income and total consumption on agricultural goods. If relevant, additional income sources may be defined ( <i>e.g.</i> migrant remittances).	RIGA